MTECH 2022

Discipline: Mechanical Engineering

Stream: ME4 (Computer Integrated Manufacturing, Manufacturing & Automation, Advanced Manufacturing & Mechanical System Design, Industrial Automation & Robotics)

SEMESTER I

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
A	221TME100	COMPUTATIONAL METHODS FOR ENGINEERS	40	60	3-0-0	3	3
B	221TME007	ROBOTICS AND AUTOMATION	40	60	3-0-0	3	3
C	221TME008	CAD /CAM	40	60	3-0-0	3	3
D	221EMExxx	PROGRAM ELECTIVE 1	40	60	3-0-0	3	3
E	221EMExxx	PROGRAM ELECTIVE 2	40	60	3-0-0	3	3
S	221RGE100	RESEARCH METHODOLOGY AND IPR	40	60	2-0-0	2	2
T	221LME003	ADVANCED MANUFACTURING LAB 1	100	--	0-0-2	2	1
Total			**340**	**360**		**19**	**18**

Teaching Assistance: 6 hours

PROGRAM ELECTIVE 1

PROGRAM ELECTIVE 1						
SLOT	**SL NO**	**COURSE CODE**	**COURSE NAME**	**L-T-P**	**HOURS**	**CREDIT**
D	1	221EME036	COMPOSITE MATERIALS	3-0-0	3	3
	2	221EME037	FINITE ELEMENT ANALYSIS	3-0-0	3	3
	3	221EME038	DESIGN FOR MANUFACTURING	3-0-0	3	3

PROGRAM ELECTIVE 2

PROGRAM ELECTIVE 2						
SLOT	**SL NO**	**COURSE CODE**	**COURSE NAME**	**L-T-P**	**HOURS**	**CREDIT**
E	1	221EME042	PRODUCTION AND OPERATIONS MANAGEMENT	3-0-0	3	3
	2	221EME043	SOFT COMPUTING TECHNIQUES	3-0-0	3	3
	3	221EME044	NANO MICRO MANUFACTURING	3-0-0	3	3

SEMESTER II

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
A	222TME100	DESIGN OF EXPERIMENTS	40	60	3-0-0	3	3
B	222TME004	MODERN MANUFACTURING SYSTEMS	40	60	3-0-0	3	3
C	222TMExxx	PROGRAM ELECTIVE 3	40	60	3-0-0	3	3
D	222EMExxx	PROGRAM ELECTIVE 4	40	60	3-0-0	3	3
E	222EMExxx /222EEXXX X	INDUSTRY/ INTERDISCIPLINARY ELECTIVE	40	60	3-0-0	3	3
S	222PME100	MINI PROJECT	100	--	0-0-4	4	2
T	222LME003	ADVANCED MANUFACTURING LAB 2	100	--	0-0-2	2	1
Total			**400**	**300**		**21**	**18**

Teaching Assistance: 6 hours

PROGRAM ELECTIVE 3

PROGRAM ELECTIVE 3						
SLOT	**SL NO**	**COURSE CODE**	**COURSE NAME**	**L-T-P**	**HOURS**	**CREDIT**
C	1	221EME035	CELLULAR MANUFACTURING AND GROUP TECHNOLOGY	3-0-0	3	3
	2	221EME036	ENTERPRISE RESOURCE PLANNING	3-0-0	3	3
	3	221EME037	FLEXIBLE MANUFACTURING SYSTEMS	3-0-0	3	3

PROGRAM ELECTIVE 4

PROGRAM ELECTIVE 4						
SLOT	**SL NO**	**COURSE CODE**	**COURSE NAME**	**L-T-P**	**HOURS**	**CREDIT**
D	1	222EME041	COMPUTER AIDED MEASUREMENTS	3-0-0	3	3
	2	222EME042	MODELING AND SIMULATION OF ENGINEERING SYSTEM	3-0-0	3	3
	3	222EME043	OPTIMIZATION TECHNIQUES	3-0-0	3	3

INTERDISCIPLINARY ELECTIVE

INTERDISCIPLINARY ELECTIVE						
SLOT	**SL NO**	**COURSE CODE**	**COURSE NAME**	**L-T-P**	**HOURS**	**CREDIT**
E	1	222EME103	INTERNET OF THINGS	3-0-0	3	3
	2	222EME104	DIGITAL PRODUCT DESIGN AND MANUFACTURING	3-0-0	3	3
	3	222EME105	RELIABILITY ENGINEERING	3-0-0	3	3

INDUSTRY ELECTIVE

SEMESTER III

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
TRACK 1							
A*	223MMEXXX	MOOC	To be completed successfully		--	--	2
B	223AGEXXX	AUDIT COURSE	40	60	3-0-0	3	-
C	223IME100	INTERNSHIP	50	50	--	--	3
D	223PME100	DISSERTATION PHASE 1	100	--	0-0-17	17	11
TRACK 2							
A*	223MMEXXX	MOOC	To be completed successfully		--	--	2
B	223AGEXXX	AUDIT COURSE	40	60	3-0-0	3	-
C	223IME100	INTERNSHIP	50	50	---	--	3
D	223PME001	RESEARCH PROJECT PHASE 1	100	--	0-0-17	17	11
Total			**190**	**110**		**20**	**16**

Teaching Assistance: 6 hours

*MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1).

AUDIT COURSE

AUDIT COURSE						
SLOT	**SL NO**	**COURSE CODE**	**COURSE NAME**	**L-T-P**	**HOURS**	**CREDIT**
B	1	223AGE100	ACADEMIC WRITING	3-0-0	3	-
	2	223AGE001	ADVANCED ENGINEERING MATERIALS	3-0-0	3	-
	3	223AGE002	FORENSIC ENGINEERING	3-0-0	3	-
	4	223AGE003	DATA SCIENCE FOR ENGINEERS	3-0-0	3	-
	5	223AGE004	DESIGN THINKING	3-0-0	3	-
	6	223AGE005	FUNCTIONAL PROGRAMMING IN HASKELL	3-0-0	3	-
	7	223AGE006	FRENCH LANGUAGE (A1 LEVEL)	3-0-0	3	-
	8	223AGE007	GERMAN LANGUAGE (A1 LEVEL)	3-0-0	3	-
	9	223AGE008	JAPANESE LANGUAGE (N5 LEVEL)	3-0-0	3	-
	10	223AGE009	PRINCIPLES OF AUTOMATION	3-0-0	3	-
	11	223AGE010	REUSE AND RECYCLE TECHNOLOGY	3-0-0	3	-
	12	223AGE011	SYSTEM MODELING	3-0-0	3	-
	13	223AGE012	EXPERT SYSTEMS	3-0-0	3	-

SEMESTER IV

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
TRACK 1							
A	224PME100	Dissertation Phase II	100	100	0-0-24	24	16
TRACK 2							
A	224PME001	Research Project Phase II	100	100	0-0-24	24	16
Total			**100**	**100**		**24**	**16**

Teaching Assistance: 5 hours

ASSESSMENT PATTERN

(i) CORE COURSES

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Micro project/Course based project:	20 marks
Course based task/Seminar/Quiz:	10 marks
Test paper, 1 no:	10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed

Original publications (minimum 10 — 15 marks

Publications shall be referred):

Course based task/Seminar/Data — 15 marks

Collection and interpretation:

Test paper, 1 no.: — 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

(iii) RESEARCH METHODOLOGY & IPR/AUDIT COURSE

Continuous Internal Evaluation: 40 marks

Course based task: 15 marks

Seminar/Quiz:	15 marks
Test paper, 1 no.:	10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

(iv) LABORATORY COURSES

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

(v) INTERDISCIPLINARY ELECTIVE

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latest topics. In response to their desires, the University has incorporated Industry/Interdisciplinary electives in the curriculum. Interdisciplinary knowledge is critical for connecting students with current industry trends, where multitasking is the norm. Interdisciplinary knowledge aids in the bridge- building process between academic institutions and industry. It aids pupils in expanding their knowledge and innovating by allowing them to create something new. While core engineering courses provide students with a strong foundation, evolving technology necessitates new methods and approaches to progress, prosperity, and the inculcation of problem-solving techniques. Other courses' knowledge, on the other hand, can assist them to deal with any scenario more effectively. Interdisciplinary courses may be one approach to address such needs, as they can aid in the enhancement of engineering education and the integration of desirable specialized subjects into the current engineering education system. This will enable students to fulfill the current industry demands. Students with multidisciplinary knowledge and projects are more likely to be placed in top industries, according to the placement trend. The future of developing engineers will be influenced by their understanding of emerging technology and interdisciplinary approaches such as bigdata, machine learning, and 3-D printing.

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred):	15 marks
Course based task/Seminar/Data collection and interpretation:	15 marks
Test paper, 1 no:	10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

(vi) MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but shall complete it by third semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

(vii) MINIPROJECT

Total marks: 100, only CIA

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 40 (20 marks for each review), final evaluation by a Committee (will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement): 35, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 15, Supervisor/Guide: 10

TEACHING ASSISTANCESHIP (TA)

All M Tech students irrespective of their category of admission shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master. TAs may be required to attend the instructor's lecture regularly. A TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities (specifically prohibited by University Policy).

For the tutorial session:

(i) Meet the teacher and understand your responsibilities well in advance, attend the lectures of the course for which you are a tutor, work out the solutions for all the tutorial problems yourself, approach the teacher if you find any discrepancy or if you need help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem yourself, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in your group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently under-performing, report to the faculty if you find that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session you may be required to grade the tutorials/assignments/tests. Make sure that you work out the solutions to the questions yourself, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher. Consult the teacher if you are not partial to some student/students while grading. Follow basic ethics.

Handling a laboratory Session:

(i) Meet the faculty – in- charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know there level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if they have any clarifications regarding any aspect of the laboratory session, including of course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative assessment.

Semester I

Discipline: MECHANICAL ENGINEERING

Stream: ME4

CODE	COMPUTATIONAL METHODS FOR ENGINEERS	CATEGORY	L	T	P	CREDIT
221TME100		Discipline Core	3	0	0	3

Preamble:

Numerical simulations are the most reliable tool of mechanical engineers to solve the problems in the domain and advanced computational methods are a critical component of that. This course targets to introduce the advanced numerical techniques required to solve the mechanical engineering problems.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Solve system of equations using numerical techniques
CO 2	Apply numerical schemes to integrate, differentiate and curve fit
CO 3	Determine solutions of ODE and PDE using computational methods
CO 4	Formulate a Mechanical Engineering problem and solve that using computer based numerical procedure and submit micro-project
CO 5	Apply two different numerical methods to solve (manual/computer) a problem and compare the merits and demerits of those schemes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1			3	2	3	2
CO 2			3	2	3	2
CO 3			3	2	3	2
CO 4	3	2		2	3	2
CO 5	2	2		2	3	2

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	20%
Analyse	60%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 Marks

Micro project/Course based project : 20 marks

(Formulate a mechanical engineering problem and solve that using computer based numerical procedure and submit as project. The project shall be done individually. Group projects not permitted.)
Course based task (programming)/Seminar/Quiz: 10 marks Test

paper, 1 No. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 Marks

The end semester examination will be conducted by the University for Core Courses. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

QP Code: **Total Pages:**

Reg No.:_________ **Name:___________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIRST SEMESTER M.TECH DEGREE EXAMINATION, Month & Year
Discipline: Mechanical Engineering
Course Code:
Course Name: Computational Methods for Engineers

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

	Answer all questions, each carries 5 marks.	**Marks**
1	Use Gauss elimination to solve $3x_1 - 0.1x_2 - 0.2x_3 = 7.85$ $0.1x_1 + 7x_2 - 0.3x_3 = -19.3$ $0.3x_1 - 0.2x_2 + 10x_3 = 71.4$	**(5)**
2	Explain the procedure of Newton-Raphson method and draw a flowchart.	**(5)**
3	Explain the Trapezoidal rule and derive the equation for the same.	**(5)**
4	Use the classical fourth-order RK method to integrate $f(x, y) = -2x^3 + 12x^2 - 20x + 8.5$ using a step size of h = 0.5 and an initial condition of y = 1 at x = 0.	**(5)**
5	Write a short note on any simple implicit method.	**(5)**

PART B

Answer any 5 full questions, each question carries 7 marks.

6	Use Newton- Raphson method to determine a root of the equation $f(x) = x^3 - 13x - 12$	**(7)**

7 Given these data, (7)

x	1.6	2	2.5	3.2	4	4.5
f(x)	2	8	14	15	8	2

Calculate f(2.8) using Newton's interpolating polynomials of order 1 through 3. Choose the sequence of the points for your estimates to attain the best possible accuracy.

8 Evaluate the following integral: (7)

$$\int_0^{\pi/2} (6 + 3\cos x)\, dx$$

(a) single application of Simpson's 1/3 rule

(b) multiple-application Simpson's 1/3 rule, with n = 4.

9 Solve the following initial value problem over the interval from t = 0 to 2 where y(0) = 1. Display all your results on the same graph. (7)

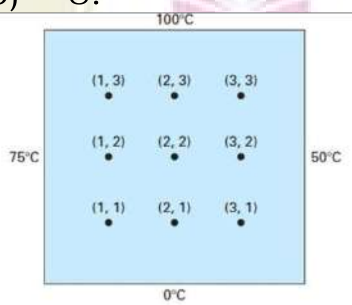
$$\frac{dy}{dt} = yt^2 - 1.1y$$

(a) Euler's method with h = 0.5 and 0.25.

(b) Fourth-order RK method with h = 0.5.

10 Use the shooting method to solve $7\, d^2y/dx^2 - 2\, dy/dx - y + x = 0$ with the boundary conditions y(0) = 5 and y(20) = 8. (7)

11 (7)



Use Liebmann's method (Gauss-Seidel) to solve for the temperature of the heated plate in figure. Employ overrelaxation with a value of 1.5 for the weighting factor and iterate to es $\varepsilon_s = 1\%$.

12	Use the simple implicit method to solve for the temperature distribution of a long, thin rod with a length of 10 cm and the following values: k' = 0.49 cal/(s . cm . ^oC), Δx = 2 cm, and Δt = 0.1 s. At t =- 0, the temperature of the rod is zero and the boundary conditions are fixed for all times at T(0) = 100^oC and T(10) = 50^oC. Note that the rod is aluminium with C = 0.2174 cal/(g . ^oC) and ρ = 2.7 g/cm^3 . Therefore, k = 0.49/ (2.7 . 0.2174) 5 0.835 cm^2 /s and λ = 0.835(0.1)/(2)^2 = 0.020875.	**(7)**

Syllabus

Module 1

Introduction to Computational methods, system of equations-Revision - Formulation of engineering problems and solution using computational methods; significant figures, accuracy, precision, round off error, truncation error,Taylor series expansion of a polynomial. Roots of equation - Bisection, Newton-Raphson, and Bairstow methods. Linear algebraic equations - Gauss Elimination method, LU decomposition. Non-linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 2

Curve fitting- Linear regression- linearization of non linear relation, linear least squares, multiple linear regression. Non linear regression- polynomial regression, Gauss- Newton method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 3

Numerical differentiation and integration- Derivatives- Newton's forward, backward, divided difference and Sterling formula. Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three point. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 4

Numerical solutions to ordinary differential equations- Taylors method, Eulers method, Runge-Kutta method fourth order, simultaneous first order, Milne's predictor corrector. Initial value problem - shooting method, Eigen values - polynomial method, power method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 5

Solution of partial differential equation & Interpolation-

Interpolation - Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation. Solution of partial differential equation - Difference equations, Elliptic equation- Laplace equation, Poisson equation, Liebmann’s iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank-Nicolson scheme, Solution of hyperbolic equation. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Course Plan

No	Topic	No. of Lectures - 40 Hrs
1	**Introduction to Computational methods, system of equations**	
1.1	Revision - Formulation of engineering problems and solution using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial	2
1.2	Roots of equation - Bisection, Newton Raphson, and Bairstow methods	2
1.3	Linear algebraic equations - Gauss Elimination method, LU decomposition. Non-linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations	3
1.4	Case studies with computer programs (Python/Scilab/ C++/Fortran/other) (Not for End Semester Examination)	2
2	**Curve fitting**	
2.1	Linear regression- linearization of non linear relation, linear least squares, multiple linear regression	2
2.2	Non linear regression- polynomial regression, Gauss- Newton method	3
2.3	Case studies with computer programs (Python/Scilab/C++/Fortran/other) (Not for End Semester Examination)	2

3	**Numerical differentiation and integration**	
3.1	Derivatives - Newton's forward, backward, divided difference and Sterling formula	3
3.2	Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three point.	3
3.3	Case studies with computer programs (Python/Scilab/ C++/Fortran/other) (Not for End Semester Examination)	2
4	**Numerical solutions to ordinary differential equations**	
4.1	Taylors method, Eulers method, Runge-Kutta method fourth order, simultaneous first order, Milne's predictor corrector	3
4.2	Initial value problem - shooting method, Eigen values -polynomial method, power method	3
4.3	Case studies with computer programs (Python/Scilab/C++/Fortran/other)(Not for End Semester Examination)	2
5	**Solution of partial differential equation & Interpolation**	
5.1	Interpolation - Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation	3
5.2	Solution of partial differential equation - Difference equations, Elliptic equation-Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank-Nicolson scheme, Solution of hyperbolic equation	3

5.3	Case studies with computer programs (Python/Scilab/ C++/Fortran/other)(Not for End Semester Examination)	2

Reference Books

1. Steven C. Chapra, Raymond P Canale, Numerical Methods for Engineering, 8e, Mc-Graw Hill Education (2020)
2. B.S. Grewal, numerical methods in engineering science with programs in C, C++ and MATLAB(10th edition) Khanna Publisher (2020)
3. E Balaguruswamy, Numerical Methods, McGraw Hill (2017)
4. P. Kandasamy , K. Thilagavathy and K. Gunavathy., Numerical Methods, S Chand & Co Ltd (2016)
5. S. P. Venkateshan, Prasanna Swaminathan, Computational Methods in Engineering, Ane Books (2014)
6. VN Vedamurthy & SN Iyengar, Numerical Methods, S Chand & Co Ltd (2014)
7. AK Jaiswal and Anju Khandelwal, Computer Based Numerical and Statistical Techniques, New Age International (2009)
8. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press (2007)
9. Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel Dekker (2001)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TME007	ROBOTICS AND AUTOMATION	PROGRAMME CORE	3	0	0	3

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basics about an industrial robot and to perform basic transformations of robot frames
CO 2	Perform forward and inverse kinematics of industrial robots
CO 3	Perform velocity and force analysis of industrial robots
CO 4	Control the trajectory of industrial robots and to program the robot
CO 5	Understand the industrial applications of robots.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓		
CO 2	✓	✓	✓			
CO 3	✓	✓	✓	✓		
CO 4	✓	✓	✓	✓		
CO 5	✓	✓	✓			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20%
Analyse	60%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no.: 10 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

MODEL QUESTION PAPER

ROBOTICS AND AUTOMATION

PART A

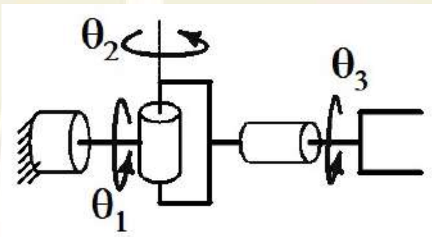
(Answer all the questions. Each question carries 5 Marks)

1. A frame {B} is rotated relative to a frame {A} about Z by 30^o and translated 10 units in X_A and 5 units in Y_A . Find ^AP where ^BP= $[3,7,0]^T$.
2. Explain the joint parameters according to D-H convention.
3. Explain the concept of manipulator jacobians.
4. What is powered lead through programming?
5. Write any four applications of robots in industries

PART B

(Answer any 5 questions. Each carry 7 Marks)

6. Explain the working principle of laser range meter.
7. Assign frames and derive the forward kinematics for the following robot configuration

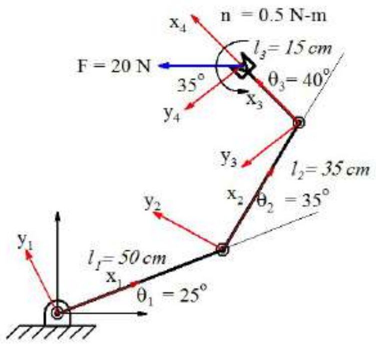


8. Calculate the inverse kinematics of a 3 link planar manipulator whose Forward kinematics and the desired position and orientation of the end effector are given by

$$^B_WT = \begin{bmatrix} C_{123} & -S_{123} & 0 & C_1L_1 + L_2C_{12} + L_3C_{123} \\ S_{123} & C_{123} & 0 & L_1S_1 + L_2S_{12} + L_3S_{123} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0.951 & 0.309 & 0 & 0.2116 \\ -0.309 & 0.951 & 0 & 0.4799 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

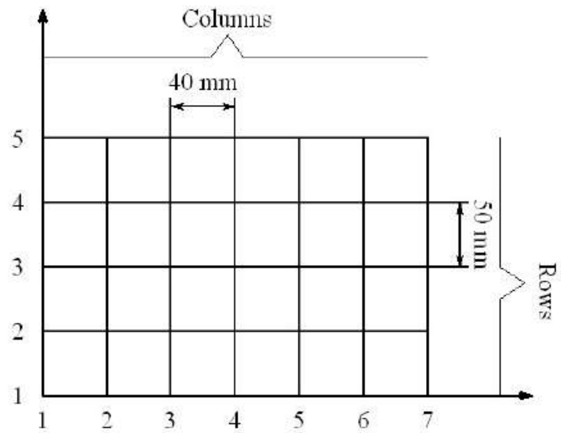
9. A 3 link planar robot is shown below. Calculate the forces and moments propagated from the tip to the base of the robot. Also determine the joint

torques.



10 A single-link robot with a rotary joint is motionless at θ = -5°. It is desired to move the joint in a smooth manner to θ = 80° in 4 seconds and stop smoothly. Compute the corresponding parameters of a linear trajectory with parabolic blends. Plot the position, velocity, and acceleration of the joint as a function of time

11 A robot is to be programmed to pick up parts from an input chute; and place them on a pallet with 35 positions. When a start signal is given, the robot begin picking up the parts and loading them into the pallet, continuing until all 35 positions on the pallet are filled. The robot then generate a signal to indicate that the pallet is full and wait for the start of the next cycle.



Pallet Configuration

12 What are required features for an arc welding robot?

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction to robotics-Classification and structure of robots, Drives systems: AC and DC servo motors, Stepper motors, Pneumatic and Hydraulic actuators, Sensors: Proximity sensors, range sensors, Encoders, Force and torque sensors, Vision sensors, basic control schemes, Spatial descriptions and transformations: Basic rotation matrices, general transformations, Workspace analysis, Euler angles	8	20
II	Forward Kinematics: DH Convention for affixing frames to links, Link parameters, Derivation of direct kinematic equations, Inverse manipulator kinematics, Solvability, algebraic and geometric solutions, Piper's solution when three axes intersect, Repeatability and accuracy	8	20
III	Velocities and static forces- Linear and rotational velocity of rigid bodies, Velocity propagation from link to link, Jacobians, Singularities, Static forces in manipulators, Jacobians in force domain, Cartesian transformation of velocities and static forces	8	20
IV	Trajectory generation: General considerations in path descriptions and generation, Joint space schemes, Cubic polynomials, Linear function with parabolic blends, Cartesian space schemes, Robot programming: Teach by showing, Textual Language Programming using AL, AML, VAL etc.,	8	20
V	Industrial applications: Spray painting, Spot welding, Arc welding, drilling, Assembly operations, loading unloading, Role of a robot in a manufacturing cell, Safety considerations.	8	20

Course Plan

No	Topic	No. of Lecture Hours
1	**Introduction to Robotics**	
1.1	Classification and structure of robots	1
1.2	Drives systems: AC and DC servo motors, Stepper motors, Pneumatic and Hydraulic actuators	1
1.3	Sensors: Proximity sensors, range sensors	1
1.4	Force and torque sensors, Vision sensors, encoders	1
1.5	Tactile sensors and basic control schemes	1
1.6	Basic rotation matrices, general transformations	2
1.7	Workspace analysis. Euler angles	1
2	**Forward and Inverse kinematics**	
2.1	DH Convention for affixing frames to links, Link parameters	2
2.2	Derivation of direct kinematic equations	2
2.3	Inverse manipulator kinematics, Solvability, algebraic and geometric solutions	2
2.4	Piper's solution when three axes intersect, Repeatability and accuracy	2
3	**Velocities and Static forces**	
3.1	Linear and rotational velocity of rigid bodies,	1
3.2	Velocity propagation from link to link	2
3.3	Jacobians, Singularities, Static forces in manipulators	2
3.4	Jacobians in force domain	1
3.5	Cartesian transformation of velocities and static forces	2
4	**Trajectory generation and Robot programming**	

4.1	General considerations in path descriptions and generation.	1
4.2	Joint space schemes, Cubic polynomials, Linear function with parabolic blends	2
4.3	Cartesian space schemes	2
4.4	Robot programming: Teach by showing,	1
4.5	Textual Language Programming using AL, AML, VAL etc.,(include sample programs)	2
5	**Industrial Applications of Robots**	
5.1	Spray-painting, Spot-welding robots	2
5.2	welding, drilling, Assembly operations using industrial robots	2
5.3	loading unloading, Role of a robot in a manufacturing cell	2
5.4	Safety considerations, precautions, and protective measures	2

Reference Books

1. John J Craig, Introduction to Robotics, Mechanics and Control, Third edition, Pearson Education International, 2005
2. Mark W. Spong & M. Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, 2004
3. Mikell P. Groover et al, “Industrial Robots-Technology, Programming and Application”, McGraw Hill Publishing Company-2013.
4. Yoram Koran, “Robotics for Engineers”, McGraw-Hill International Student Edition, 2009

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TME008	CAD/CAM	PROGRAME CORE	3	0	0	3

Preamble: Nil

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

CO 1	Understand the basic concepts of CAD
CO 2	Impact general Awareness on components of geometric modelling.
CO 3	Identify the basic concepts of solid modelling and its applications
CO 4	Solve problems raised in engineering using CAD
CO 5	Apply knowledge in Assembling solid models in manufacturing process

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	✓	✓	✓		✓	
CO 2	✓	✓	✓		✓	
CO 3	✓	✓	✓			
CO 4	✓	✓	✓			
CO 5	✓	✓	✓			

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	20
Analyse	20
Evaluate	20
Create	

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no: 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question paper

CAD/CAM

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Compare conventional and Computer Aided design process
2. Explain the basic transformations in CAD
3. Describe the functions of user interface for solid modelling
4. Explain the parametric modelling Process.
5. List out the various mating conditions in assembly modelling and explain with neat sketches.

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Draw layout representing hardware details in a CAD work station and elucidate.

7 Find the coordinates of a reflected triangle having vertices (2,4), (4,3) and (3,7) about an arbitrary line represented by y= 2x+2. Plot the transformed triangle.

8 A square having coordinates (2,2), (5,2), (5,4) and (2,4) is to be rotated about the point (2,2) in clockwise direction at an angle 60° and after that it is scaled to 3 unit in X direction and 2 unit in Y direction. Find and plot the final coordinates of the geometry.

9 Describe Regularized Boolean set operations with examples.

10 Explicate any one hidden line removing algorithm with examples.

11 Define IGES? Describe its file structure.

12 Explain the top down assembly approach with an example.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Overview of cad systems: Conventional and computer aided design process, subsystems of CAD hardware and software, Analytical and Graphics packages, CAD workstations. Networking of CAD systems, generative, cognitive and image processing graphics static and dynamic data graphics. Transport of graphic data.	8	20
II	Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotation) windowing - view ports - clipping transformation. Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve. Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface	8	20
III	Solid modelling: Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations – constructive solid Geometry - comparison of representations - user interface for solid modelling.	8	20
IV	Visual Realism: Hidden – Line – Surface – solid removal algorithms shading – colouring. Introduction to parametric and variational geometry-based software's and their principles, creation of prismatic and lofted parts using these packages.	7	20
V	Assembly modelling: interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation. Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.	8	20

Course Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	**Overview of CAD systems**	
1.1	Overview of cad systems: Conventional and computer aided design process, subsystems of CAD hardware and software, Analytical and Graphics packages, CAD workstations.	3
1.2	Networking of CAD systems, generative, cognitive and image processing graphics static and dynamic data graphics	3
1.3	Transport of graphic data.	2
2	**Output primitives Curves and Surfaces**	
2.1	Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotation) windowing - view ports - clipping transformation.	3
2.2	Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline-Bezier curve and B-Spline curve	3
2.3	Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface.	2
3	**Solid modelling**	
3.1	Regularized Boolean set operations - primitive instancing.	2
3.2	Sweep representations - boundary representations.	2
3.3	Constructive solid Geometry - comparison of representations	2
3.4	User interface for solid modelling.	2
4	**Visual Realism**	
4.1	Hidden – Line – Surface – solid removal algorithms shading – colouring.	3
4.2	Introduction to parametric and variational geometry-based software’s and their principles.	2
4.3	creation of prismatic and lofted parts using these packages.	2
5	**Assembly modelling**	

5.1	Assembly modelling: interferences of positions and orientation.	2
5.2	Tolerances analysis, mass property calculations, mechanism simulation.	2
5.3	Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.	4

Reference Books

1. David F. Rogers, James Alan Adams "Mathematical elements for computer graphics" second edition, Tata McGraw-Hill edition.2003

2. Donald Hearn and M. Pauline Baker "Computer Graphics", Prentice Hall, Inc., 1992.

3. Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003.

4. Ibrahim Zeid Mastering CAD/CAM – McGraw Hill, International Edition, 2007.

5. William M Neumann and Robert F.Sproull "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EME036	COMPOSITE MATERIALS	PROGRAMME ELECTIVE 1	3	0	0	3

Preamble: Nil

Course Outcomes: The COs shown are only indicative.

After the completion of the course the student will be able to

CO 1	Summarize the significance of advanced materials
CO 2	Compare the set of technological properties of the advanced materials with the conventional materials.
CO 3	Distinguish the construction, constituent's phases & characteristics of the composite materials.
CO 4	Extract the fabrication techniques of different types of composite materials
CO 5	Select and apply the appropriate polymer matrix composites material for recent industrial applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓		✓	
CO 2	✓	✓	✓		✓	
CO 3	✓	✓	✓			
CO 4	✓	✓	✓			
CO 5	✓	✓	✓			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20%
Analyse	60%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum
10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

COMPOSITE MATERIALS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Classify composite materials based on reinforcement.
2. Differentiate short and continuous fibers.
3. What are the advantages of PMC'S over MMC's
4. Differentiate CVD & CVI
5. List down some of the applications of nano composites.

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Explain in details, the different types of reinforcements in Composite materials. List out the advantages and applications of each.

7 With the help of a neat sketch, explain the fabrication of Carbon – glass – carbon fiber reinforced epoxy hybrid composite.

8 Explain the process of rotational moulding with neat sketch.

9 With the help of neat sketch, explain hand layup and spray layup techniques of polymer matrix composites.

10 Explain the process of diffusion bonding in the manufacturing of MMC's.

11 Explain the environmental advantage of using natural fibers as the reinforcement.

12 Explain with neat sketch the manufacturing of a surface metal matrix composite.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction to Composites: Matrices, Reinforcements, Classifications, Applications, Comparison with Metals and Importance over other materials, design fabrication and economic consideration, General requirements. Classification of composites based on reinforcement and matrix, Classification of Reinforcement, Form and functions of reinforcement, Functions of matrices. Dispersion strengthened, particle strengthened and fiber-reinforced composites.	8	20
II	Strengthening mechanisms, Aspect Ratio, Rule of Mixture, discontinuous and continuous fiber composites and their comparison, Characteristics and materials of reinforcements and matrices. Critical Fiber Length, Short and Continuous Fibres, Fibre Orientation. Major composite classes: polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites. Hybrid composites, Laminated composites. Examples of each class of composites.	7	20
III	Manufacturing of Polymer matrix composites (PMC)Hand and spray lay - up, injection molding, resin injection, filament winding, pultrusion, centrifugal casting, Rotational	8	20

	moulding and prepregs. Fibre/Matrix Interface. Measurement of interface strength. Characterization of systems; carbon fibre/epoxy, glass fibre/polyester, etc.		
IV	Fabrication of CMC's: Hot-Pressing, Infiltration, In Situ Chemical Reaction Techniques. CVD & CVI, Sol-gel. Fabrication of MMC'S: Liquid Infiltration-Casting, Solid State Processes-Diffusion Bonding & In Situ Technique.	8	20
V	Applications of advanced composite materials. Environmental effects in Composites, Green composites, Synthesis and Properties of Nanocomposites. Surface Composites & Surface metal matrix composites: Need, Synthesis, Properties, and applications	8	20

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Composites**	
1.1	Matrices, Reinforcements, Classifications, Applications, Comparison with Metals and Importance over other materials, design fabrication and economic consideration, General requirements	2
1.2	Classification of composites based on reinforcement and matrix	2
1.3	Classification of Reinforcement, Form and functions of reinforcement, Functions of matrices	2
1.4	Dispersion strengthened, particle strengthened and fiber-reinforced composites.	2
2	**Major composite classes**	
2.1	Strengthening mechanisms, Aspect Ratio, Rule of Mixture, discontinuous and continuous fiber composites and their comparison, Characteristics and materials of reinforcements and matrices. Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation.	2
2.2	Polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites.	3
2.3	Hybrid composites, Laminated composites. Examples of each class of composites.	2
3	**Manufacturing of Polymer matrix composites**	
3.1	Hand and spray lay - up, injection molding.	1
3.2	Injection molding, resin injection.	1
3.3	Filament winding, pultrusion, centrifugal casting, Rotational moulding and prepregs.	2
3.4	Fibre/Matrix Interface. Measurement of interface strength.	2
3.5	Characterization of systems; carbon fibre/epoxy, glass fibre/polyester, etc	2
4	**Fabrication of CMC's**	
4.1	Hot-Pressing, Infilration, In Situ Chemical Reaction Techniques.	2
4.2	CVD & CVI, Sol-gel.	2
4.3	Liquid Infiltration- Casting	2
4.4	Solid State Processes-Diffusion Bonding & In Situ Technique.	2

5	**Applications of advanced composite materials**	
5.1	Environmental effects in Composites, Green composites.	2
5.2	Synthesis and Properties of Nanocomposites.	2
5.3	Surface Composites &amp.	2
5.4	Surface metal matrix composites Need, Synthesis, Properties, and applications.	2

Reference Books

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005
2. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012
3. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.
4. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press,2004
5. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009
6. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993
7. Hand Book of Composites, P.C. Mallik, Marcel Decker, 1993

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EME037	FINITE ELEMENT ANALYSIS	PROGRAMME ELECTIVE 1	3	0	0	3

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	To familiarize computational procedures in linear finite element analysis.
CO 2	To understand the basic mathematics of finite element analysis and equip the students to formulate finite element procedures for engineering problems in structural, thermal and fluid flow domain.
CO 3	To impart knowledge in co-ordinate transformation and error estimation.
CO 4	To make the students aware of computational methods applicable for finite element analysis.
CO 5	To apply FEA in advanced Engineering problems.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	✓	✓				
CO 2	✓	✓				
CO 3	✓	✓				
CO 4	✓	✓			✓	
CO 5	✓	✓			✓	

Assessment Pattern

Bloom's Category	**End Semester Examination (marks)**
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	3 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum
10 publications shall be referred): 15 marks
Course based task/Seminar: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

FINITE ELEMENT ANALYSIS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Compare with figure CST element and LST element

2. Explain how the rise of temperature causes stress in a body?

3. Formulate the finite element equation for truss element?

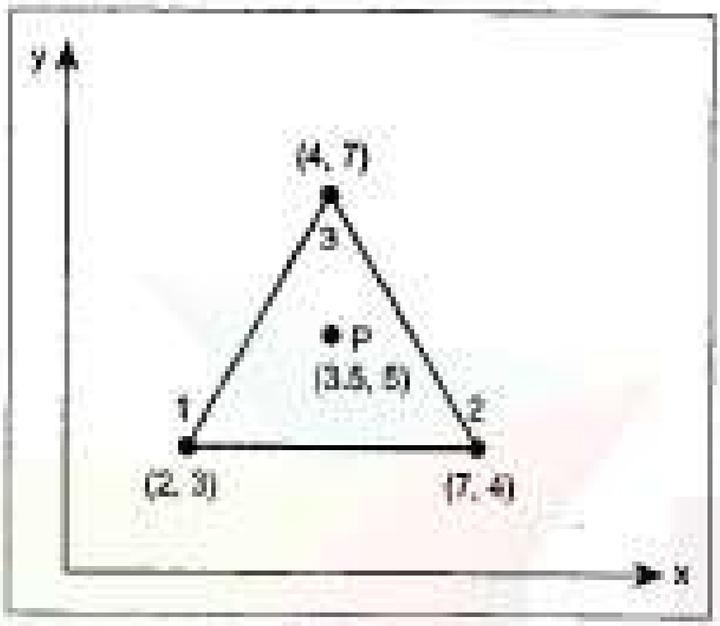
4. Write the steps for finding solution using Rayleigh-Ritz method?

5. Write the criteria of convergence of Newton-Raphson method?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6. Determine the shape functions N1, N2 and N3 at the interior point P for the triangular element shown in Figure. $(x_1, y_1) = (2,3)$, $(x_2, y_2) = (7,4)$, $(x_3, y_3) = (4,7)$,



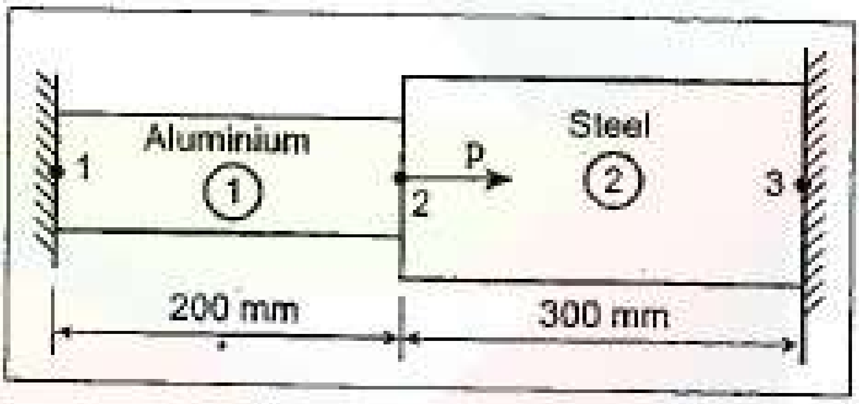
7. An axial load of 4 x10^5 N is applied at 30^0C to the rod as shown in Figure. The temperature is then raised to 60^0C. Calculate the following

   a. Assemble the K and F matrices
   b. Nodal displacements
   c. Stresses in each material

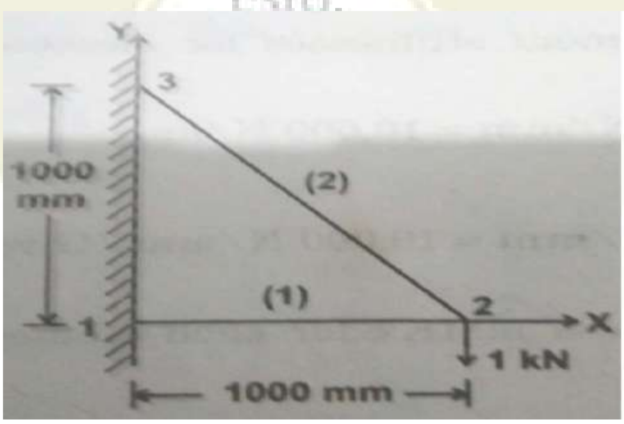
For Aluminum A_1= 1000 mm^2 For Steel A_2= 1500 mm^2

E_1= 0.7 × 10^5 N/mm^2 E_2= 2 × 10^5 N/mm^2

α_1 = 23 ×10^{-6} A_2 = 12 ×10^{-6}

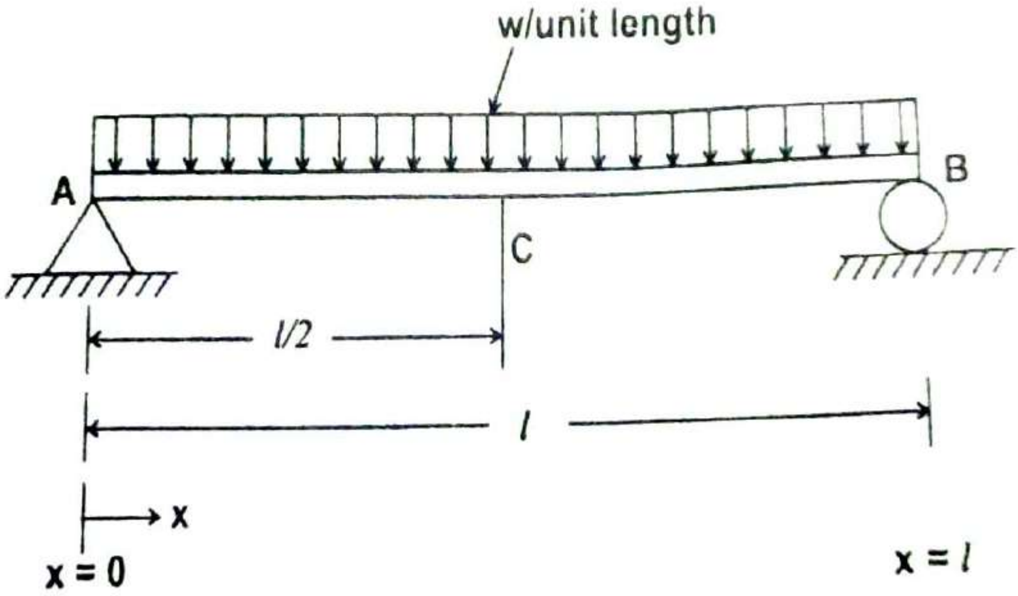


8. A truss structure is subjected to a load of 1 KN as shown in Figure. Calculate the nodal displacements and forces if the element stiffness of the truss is 10 kN/mm



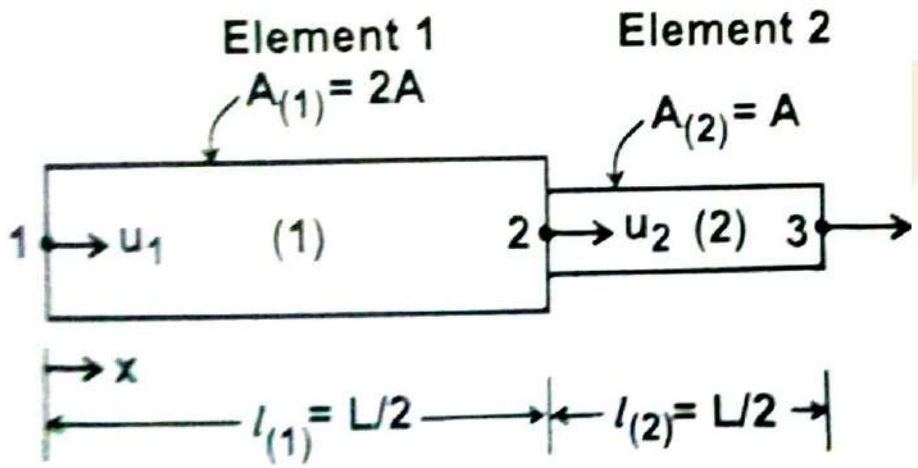
9. For a simply supported beam of span length *l* subjected to uniformly

distributed load throughout its length as shown in Figure, Find the deflection at the centre of the beam using one term trigonometric trial function in Rayleigh – Ritz method



10 Explain any four weighted residual methods

11 Find the natural frequencies of longitudinal vibration of the unconstrained stepped bar as shown in Figure?



12 Find the positive root of x^4-x= 10 correct to three places using Newton-Raphson method

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	FEA introduction: Discretization- Co-ordinates- Stiffness Matrix-Review of computational procedures with 1-D elements –Interpolation and shape functions – 2-D elements – Plane stress and plane strain analysis – CST and LST elements	8	20
II	Heat transfer and fluid flow problems – Choice of interpolation functions – Numerical integration. Axi–Symmetric problems, Modelling considerations – Symmetry – Applications – Iso-parametric formulation – 1-D and 2-D elements	8	20
III	Analysis of trusses- Coordinate transformation – Transformation of characteristic matrix–Lagrange multiplier and penalty function methods– Error – Sources of error –Convergence–Error estimates.	8	20
IV	Boundary value problems – Weak and strong forms – Functional –Euler-Lagrange equations – Rayleigh-Ritz method-Weighted-residual methods – Galerkin, Least-square and collocation methods – Galerkin finite element formulation – Applications to structural, Thermal and fluid flow problems.	8	20
V	Finite element formulation for non-linear problems – Solution methods– Method of false position- Newton-Raphson method – Modified Newton-Raphson method – Convergence criteria – Applications- FEA in vibration analysis–Fluid structure interaction–Thermo-mechanical problems and contact problems.	8	20

Course Plan

No	Topic	No. of Lecture Hours
1	**FEA Procedure**	
1.1	FEA introduction:	1
1.2	Discretization, Co-ordinates- (Local, Global, Natural)	1
1.3	Stiffness Matrix	1
1.4	Review of computational procedures with 1-D elements	1
1.5	Interpolation and shape functions	1
1.6	2-D elements	1
1.7	Plane stress and plane strain analysis	1
1.8	CST and LST elements	1
2	**Numerical integration and modelling consideration**	
2.1	Heat transfer and fluid flow problems	1
2.2	Choice of interpolation functions	1
2.3	Numerical integration	2
2.4	Axi–Symmetric problems	1
2.5	Modelling considerations	2
2.6	Iso-parametric formulation of 1-D and 2-D elements	1
3	**Coordinate transformation and error estimation**	
3.1	Analysis of trusses	1
3.2	Coordinate transformation	1
3.3	Transformation of characteristic matrix	1
3.4	Lagrange multiplier and penalty function methods	1
3.5	Error –Sources of error	1
3.6	Convergence	1
3.7	Error estimates.	2
4	**Finite element formulation**	
4.1	Boundary value problems	1
4.2	Weak and strong forms	1
4.3	Functional –Euler-Lagrange equations	1
4.4	Rayleigh-Ritz method	1
4.5	Weighted-residual methods	1
4.6	Galerkin, Least-square and collocation methods	1
4.7	Galerkin finite element formulation – Applications to structural, Thermal and fluid flow problems.	2

5	**Solution methods and advanced applications**	
5.1	Finite element formulation for non-linear problems, – Solution methods	1
5.2	Method of false position	1
5.3	Newton-Raphson method	1
5.4	Modified Newton-Raphson method	1
5.5	Convergence criteria	1
5.6	Applications of FEA in vibration analysis	1
5.7	Fluid structure interaction	1
5.8	Thermo-mechanical problems and contact problems.	1

Reference Books

1. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, Concepts & Applications of Finite Element Analysis, John Wiley & Sons, Fourth Edition, 2007
2. D. V. Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill, 2005.
3. S. S. Rao, The Finite Element Method in Engineering, Butterworth Heinemann,5/E, 2010
4. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill International, Third Edition, 2009
5. K. J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 2014.
6. O. C. Zienkiewicz, R. L. Taylor, The Finite Element Method, McGraw Hill, 7/E, 2013.
7. Dr. Sudhir K. Pundir, Numerical methods in science and Engineering, CBS publishers and distributers

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EME038	**DESIGN FOR MANUFACTURING**	**PROGRAMME ELECTIVE 1**	**3**	**0**	**0**	**3**

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Recognize the need to transform an industrial scenario from the traditional approach of no interaction between design and manufacturing engineers towards DFM.
CO 2	Design formed metal components with their manufacturing requirements in mind.
CO 3	Design machined components with their manufacturing requirements in mind.
CO 4	Design castings & non-metallic parts with their manufacturing requirements in mind.
CO 5	Design weldments with their assembly requirements in mind.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			✓	✓		✓
CO 2			✓	✓		✓
CO 3			✓	✓		✓
CO 4			✓	✓		✓
CO 5			✓	✓		✓

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	20
Evaluate	20
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum
10 publications shall be referred): 15 marks
Course based task/Seminar: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

DESIGN FOR MANUFACTURING

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Describe the important factors to be considered while analysing the alternative methods for production?
2. Illustrate the process of Extrusion and comment on the economic production quantities for Extrusion?
3. Explain the typical applications of Automatic - Screw – Machine parts?
4. Illustrate the typical characteristics of Sand-Cast parts?
5. Explain the common in-process industrial cleaning operations?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Discuss the processes of training and indoctrination with respect to managing the DFM in an engineering industry?

7 Explain the significance of Concurrent Engineering approach in managing the DFM?

8 Illustrate the important design recommendations for Powder Metallurgy parts?

9 For a design engineer, identify the important points for consideration applicable to machined, moulded, cast, formed, or stamped gears? Explain in details the important design recommendations?

10 Explain the Thermoset-moulding processes and summarize the important design recommendations for Thermosetting-Plastic parts?

11 Describe the important design recommendations for industrial cleaning processes?

12 Summarize the various industrial cleaning processes and their applications?

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Economics of process selection – General design principles for manufacturability – History of Design for Manufacturability (DFM) – Managing DFM – Evaluating design proposals – Economical use of raw materials: Design recommendations for utilizing ferrous metals, nonferrous metals and non-metallic materials.	8	20
II	**Formed Metal Components**: Process description and Design recommendations for Metal extrusions, Metal stampings, Fine-blanked parts, Four-slide parts, Springs and wire forms, Spun-metal parts, Cold-headed parts, Cod extruded parts, Rotary-swaged parts, Tube and section bends, Roll-formed sections, Powder metallurgy parts, Forging, Electroformed parts, Metal injection-moulded parts.	8	20
III	**Machined Components**: General guidelines for Designing for Machining – Process description and Design recommendations for parts cut to length, Screw machine products, Other turned parts, Machined round holes, Parts produced on Milling, Planning, Shaping and Slotting machines, Screw threads, Broached parts, Internally ground parts, Cylindrically ground parts, Flat-ground surfaces, Honed, Lapped and Superfinished parts, Parts by Electrical Discharge Machining, Electrochemically machined parts, Gears - Designing parts for economical Deburring.	8	20
IV	**Castings**: Process description and Design recommendations for castings made in sand moulds, Permanent-mould castings, Centrifugal castings, Plaster-mould castings, Ceramic-mould castings, Investment castings, Die castings. **Non-metallic Parts**: Process description and Design recommendations for Thermosetting-	8	20

	plastic parts, Injection-moulded thermoplastic parts, Structural-foam-moulded parts, Rotationally moulded plastic parts, Blow-moulded plastic parts, Reinforced-Plastic/Composite parts, Plastic profile extrusions, Thermoformed-plastic parts, Welded plastic assemblies, Rubber parts, Ceramic and glass parts.		
V	**Assemblies:** Design for Assembly (DFA) – Process description and Design recommendations for Arc weldments and other weldments, Resistance weldments, Soldered and brazed assemblies, adhesively bonded assemblies. **Finishes:** Designing for cleaning - Process description and Design recommendations for Polished and plated surfaces, Hot-dip metallic coatings, Thermal-sprayed coatings, Vacuum-metallized surfaces, Heat treatments, Organic finishes. DFM for low quantity production – Guidelines.	**8**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Design For Manufacturability (DFM)**	
1.1	Economics of process selection	1
1.2	General design principles for manufacturability, History of Design for Manufacturability (DFM)	1
1.3	Managing DFM, Evaluating design proposals – Economical use of raw materials	1
1.4	Design recommendations for utilizing ferrous metals	2
1.5	Design recommendations for utilizing nonferrous metals	2
1.6	Design recommendations for utilizing non-metallic materials.	1
2	**Process description and Design recommendations for Formed Metal Components**	
2.1	Process description and Design recommendations for Metal extrusions	1
2.2	Process description and Design recommendations for Metal stampings, Fine-blanked parts,	1
2.3	Process description and Design recommendations for Four-slide parts, Springs and wire forms	1
2.4	Process description and Design recommendations for Spun-metal parts, Cold-headed parts	1
2.5	Process description and Design recommendations for Cold extruded parts, Rotary-swaged parts,	1
2.6	Process description and Design recommendations for Tube and section bends, Roll-formed sections	1
2.7	Process description and Design recommendations for Powder metallurgy parts, Forging, Electroformed parts,	1
2.8	Process description and Design recommendations for Metal injection-moulded parts.	1
3	**Process description and Design recommendations for Machined Components**	
3.1	General guidelines for Designing for Machining	1
3.2	Process description and Design recommendations for parts cut to length, Screw machine products,	1
3.3	Process description and Design recommendations for Other turned parts, Machined round holes,	1
3.4	Process description and Design recommendations for	1

	Parts produced on Milling, Planning, Shaping and Slotting machines	
3.5	Process description and Design recommendations for Screw threads, Broached parts, internally ground parts, cylindrically ground parts,	1
3.6	Process description and Design recommendations for Flat-ground surfaces, Honed, Lapped and Superfinished parts,	1
3.7	Process description and Design recommendations for Parts by Electrical Discharge Machining, electrochemically machined parts,	1
3.8	Process description and Design recommendations for Gears; Designing parts for economical Deburring.	1
4	**Process description and Design recommendations for Castings & Non-metallic Parts**	
4.1	Process description and Design recommendations for castings made in sand moulds, Permanent-mould castings	1
4.2	Process description and Design recommendations for Centrifugal castings, Plaster-mould castings	1
4.3	Process description and Design recommendations for Ceramic-mould castings, Investment castings, Die castings.	1
4.4	Process description and Design recommendations for Thermosetting-plastic parts, Injection-moulded thermoplastic parts,	1
4.5	Process description and Design recommendations for Structural-foam-moulded parts, rotationally moulded plastic parts,	1
4.6	Process description and Design recommendations for Blow-moulded plastic parts, Reinforced-Plastic/Composite parts,	1
4.7	Process description and Design recommendations for Plastic profile extrusions, Thermoformed-plastic parts,	1
4.8	Process description and Design recommendations for Welded plastic assemblies, Rubber parts, Ceramic and glass parts.	1
5	**Design For Assembly (DFA) & Finishes**	
5.1	Design For Assembly (DFA)	1
5.2	Process description and Design recommendations for Arc weldments and other weldments,	1

5.3	Process description and Design recommendations for Resistance weldments, Soldered and brazed assemblies	1
5.4	Process description and Design recommendations for Adhesively bonded assemblies.	1
5.5	Designing for cleaning - Process description and Design recommendations for Polished and plated surfaces,	1
5.6	Process description and Design recommendations for Hot-dip metallic coatings, Thermal-sprayed coatings, Vacuum-metallized surfaces,	1
5.7	Process description and Design recommendations for Heat treatments, Organic finishes	1
5.8	DFM for low quantity production – Guidelines.	1

Reference Books

1. “Design for Manufacturability Handbook”, JAMES G. BRALLA, 2nd Edition, McGraw Hill, 1998

2. “Product Design for Manufacture and Assembly”, GEOFFREY BOOTHROYD, PETER DEWHURST, WINSTON A. KNIGHT, CRC Press; 3rd edition, 2010

3. “Design for Manufacturing and assembly”, O. Molloy, S. Tilley and E.A. Warman, First Edition, Chapman &Hall, London, UK, 1998

4. “Engineering Design”, G. E. Dieter and L. C. Schmidt, Fourth edition, McGraw-Hill companies, New York, USA, 2009

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EME042	PRODUCTION AND OPERATIONS MANAGEMENT	PROGRAMME ELECTIVE 2	3	0	0	3

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop manufacturing planning and control system and an appropriate forecasting strategy for atypical manufacturing industry.
CO 2	Design an appropriate SOP and MPS for an organization
CO 3	Develop an appropriate MRP and ERP strategies for an organization
CO 4	Solve the company wide problems in plant layout, line balancing and quality.
CO 5	Design an ideal strategy to establish quality on a companywide basis.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓		
CO 2	✓	✓	✓			
CO 3	✓	✓	✓	✓		
CO 4	✓	✓	✓	✓		
CO 5	✓	✓	✓			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20%
Analyse	60%
Evaluate	20%
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum
10 publications shall be referred): 15 marks
Course based task/Seminar: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

PRODUCTION AND OPERATIONS MANAGEMENT

PART A (Answer all the questions. Each question carries 5 Marks)

1. Explain the importance of forecasting in manufacturing industry?

2. Discuss the need of a balance between demand and supply?

3. Clarify the term Economic Order quantity?

4. Explain how the calculation of bill of materials helps in manufacturing a product?

5. Summarize the benefits of QFD?

PART B (Answer any 5 questions. Each carry 7 Marks)

6. Company ABC manufacturing safety shoe has a forecast of 165 units every month. The demand for each moth is given in the following table. Calculate (i)

Mean Deviation (ii) Mean absolute deviation (iii) Mean square error and (iv) Mean absolute percentage error

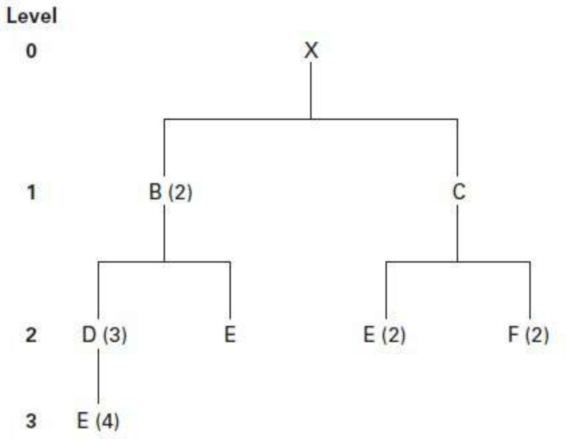
Month	1	2	3	4	5
Demand	150	160	165	175	180

7. Company EFG is manufacturing plastic chairs. Demand for each month is shown in the following table. A weight of 0.50 is assigned to the most recent demand value. A weight of 0.30 is assigned to the next most recent demand value and a weight of 0.20 is assigned to the oldest of the demand value included in the average. Calculate the weighted moving average

1	2	3	4	5	6
120	130	110	140	110	130

8. Differentiate between chase strategy, level strategy and mixed strategy

9. Utilize the information presented in Figure to compute the following:
   i. Compute the quantities of B, C, D, E, and F needed to assemble one X.
   ii. Compute the quantities of these components that will be required to assemble 10 Xs, taking into account the quantities on hand (i.e., in inventory) of various components:



Component	On Hand
B	4
C	10
D	8
E	60

10 Consider the following 2 machines and five jobs flow shop problem. Apply Johnson's algorithm to obtain optimal sequence which will minimize the makes span

Job(i)	Processing Time	
	Machine 1	Machine 2
A	6	8
B	11	6
C	7	3
D	9	7
E	5	10

11 Substantiate benchmarking as a potential manufacturing strategy

12 Demonstrate the concept of lean manufacturing.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Manufacturing Planning and Control (MPC) system framework -Matching MPC system with the needs of the firm -Demand management in MPC System -Nature and Use of Forecast -Demand patterns -Forecasting Models -Measures of Forecast accuracy	8	20
II	Sales and operation planning (SOP) process-Managerial inputs to SOP -Planning strategies -Master Production Scheduling Process -MPS Techniques -Time fencing and MPS stability	8	20
III	Bill of materials (BOM)- MRP Concept -Lot sizing methods in MRP- Enterprise Resource Planning (ERP)and functional units-Performance measures	8	20
IV	Single machine scheduling - Flow Shop scheduling, Johnson's problem -Computerized layout planning, ALDEP, CRAFT -Line balancing - TQM -TPM - Quality audits	8	20
V	Quality costs – Direct and indirect costs – SERVQUAL- Quality function deployment – Kaizen – Benchmarking – 5 S Principle –Elements of JIT manufacturing – Introduction to lean and agile manufacturing	8	20

Course Plan

No	Topic	No. of Lecture Hours
1	Manufacturing Planning and Control and Forecasting	
1.1	Manufacturing Planning and Control (MPC) system framework	1
1.2	Matching MPC system with the needs of the firm	1
1.3	Demand management in MPC System	1
1.4	Nature and Use of Forecast	1
1.5	Demand patterns	1
1.6	Forecasting Models	2
1.7	Measures of Forecast accuracy	1
2	Sales and operation planning and Master Production Schedule (MPS)	
2.1	Sales and operation planning (SOP) process	1
2.2	Managerial inputs to SOP	1
2.3	Planning strategies	3
2.4	Master Production Scheduling Process	1
2.5	MPS Techniques	1
2.6	Time fencing and MPS stability	1
3	Material Requirement Planning (MRP) and Enterprise Resource Planning (ERP)	
3.1	Bill of materials (BOM)	2
3.2	MRP Concept	1
3.3	Lot sizing methods in MRP	3
3.4	Enterprise Resource Planning (ERP)and functional units	1
3.5	Performance measures	1
4	Production management and quality systems	
4.1	Single machine scheduling.	1
4.2	. Flow Shop scheduling, Johnson’s problem	1
4.3	Computerized layout planning ALDEP, CRAFT	2
4.4	Line balancing	1
4.5	TQM	1
4.6	TPM	1

4.7	Quality audits	1
5	Quality performance measures	
5.1	Quality costs – Direct and indirect costs	1
5.2	SERVQUAL	1
5.3	Quality function deployment	1
5.4	Kaizen	1
5.5	Benchmarking	1
5.6	5 S Principle	1
5.7	Elements of JIT manufacturing	1
5.8	Introduction to lean and agile manufacturing	1

Reference Books

1. Thomas E. Vollmann, William L. Berry, D Clay Whybark, and F. Robert Jacobs, Manufacturing Planning and Control for Supply Chain Management, Mc Graw Hill Int. Ed., 2010.
2. Edward A. Silver, David F. Pyke and Rein Peterson, "Inventory Management and Production Planning and Scheduling", 3rd Ed., John Wiley & Sons, 1998.
3. S N Chary, Production and Operations Management, Tata McGraw-Hill, 2012
4. R Panneerselvam, Production and Operations Management, PHI Learning pvt Ltd., 2012
5. Francis, R.L. and White, J.A., Facility Layout and Location: An Analytical Approach Prentice-Hall Inc., New Jersey, 2010.
6. Apple, J.M., Plant Layout and Material Handling, Kreiger Publishing, 3rd Edition, 2005
7. Dale H Besterield, Total quality Management, Pearson Education, 3rd Edition, 2011
8. William J Stevenson, Operations management, Tata McGraw Hill, 2014.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EME043	SOFT COMPUTING TECHNIQUES	PROGRAMME ELECTIVE 2	3	0	0	3

Preamble: Nil

Course Outcomes:

CO 1	Develop a Genetic Algorithm to optimize the given single objective optimization problem.
CO 2	Design a Genetic Algorithm to optimize the given multi-objective optimization problem.
CO 3	Solve a multi-variable single objective optimization problem using Simulated Annealing.
CO 4	Develop a Fuzzy Inference System (FIS) to model input-output relationship with respect to a given real life problem.
CO 5	Design an optimized Artificial Neural Network (ANN) model for establishing input-output relationship with respect to a given engineering problem.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	20
Analyse	40
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

SOFT COMPUTING TECHNIQUES

PART A

(Answer all the questions. Each question carries 5 Marks)

1. How do you select a suitable scheme of computing (either soft computing or hard computing or hybrid computing) to solve a particular problem?

2. Define Pareto-optimal front of solutions in connection with multi-objective optimization?

3. Discuss the principle of Particle Swarm Optimization (PSO) algorithm as an optimizer? How does it differ from the Genetic Algorithm?
4. Explain the principle of Takagi and Sugeno's approach of Fuzzy Logic Controller (FLC)?

5. State the differences between Incremental and Batch modes of training of a neural network?

PART B

(Answer any 5 questions. Each carries 7 Marks)

6. A binary-coded Genetic Algorithm (GA) is to be used to solve an optimization problem involving one real and another integer variable. The real and integer variables are allowed to vary in the ranges of (0.2, 10.44) and (0, 63), respectively. Design a suitable GA-string to ensure a precision level of 0.01 for the real variable?

7. Use a binary-coded GA to minimize the function

$$f(x_1,x_2) = x_1 + x_2 - 2x_1^2 - x_2^2 + x_1x_2, \text{ in the range of } 0.0 \leq x_1,x_2 \leq 5.0.$$

Use a random population of size N = 6, tournament selection, a single-point crossover with probability $p_c = 1.0$ and neglect mutation. Assume 3 bits for each variable and thus, the GA-string will be 6-bits long. Show only one iteration.

8. Use Distance-based Pareto-GA (DPGA) to update non-dominated front of solutions for a few solution points: (2.0, 5.0), (6.5, 2.5), (8.0, 1.5), (3.2, 7.8) through hand-calculations in order to solve the two-objective optimization problem as given below.

$$\text{Minimize } f_1(x_1,x_2) = x_1 + x_2;\ \text{Minimize } f_2(x_1,x_2) = \frac{1}{x_1} + \frac{1}{x_2}$$

$$\text{Subject to } \quad 1.0 \le x_1, x_2 \le 10.0$$

9. Use simulated annealing to solve the optimization problem given below.

$$\text{Minimize } y = E(X) = f(x_1,x_2) = (x_1 - 3)^2 + (x_2 - 5)^2$$

$$\text{Subject to } 0.0 \le x_1, x_2 \le 8.0$$

Assume, the initial temperature of molten metal $T_0 = 3600^o K$; initial solution selected at random $X_0 = \binom{1.0}{1.5}$ and termination criterion $\varepsilon = 0.002$. Let us assume the random numbers varying in the range of (0.0, 1.0) are as follows: 0.2,0.8,0.5,0.4,0.7,0.9,0.3,0.1,0.6,0.3,0.5,0.7,0.9,0.3,0.4,0.7,0.2,0.6, and so on. Show three iterations only.

10 Let us consider a fuzzy set A(x) in a discrete universe of discourse as follows:

$A(x) = \{(x_1, 0.2), (x_2, 0.25), (x_3, 0.3), (x_4, 0.4), (x_5, 0.6)\}$. Calculate its entropy value?

11 What is Fuzzy C-Means Clustering? Explain the algorithm for Fuzzy C-Means Clustering?

12 A Radial Basis Function Network (RBFN) is to be used to model input-output relationships of a manufacturing process having three inputs and one output. Fig. 1 shows the RBFN with one hidden layer containing three

neurons. The hidden neurons are assume to have Gaussian Transfer Functions of the form: $y = f(x) = \exp\left[-\frac{(x-\mu)^2}{2\sigma^2}\right]$ with the values of mean μ and standard deviation σ as follows: $(\mu_1 = 4.0, \sigma_1 = 0.4)$; $(\mu_2 = 4.5, \sigma_2 = 0.6)$; $(\mu_3 = 5.0, \sigma_3 = 0.8)$. Assume initial weights as $w_{11} = 0.2, w_{21} = 0.1, w_{31} = 0.3$. Use incremental training scheme with the help of a scenario: $x_{11} = 0.8, x_{12} = 1.5, x_{13} = 2.5$ and output O=0.5. Use back-propagation algorithm with a learning ratio $\eta = 0.2$. Calculate the updated values of $w_{11}, w_{21}, w_{31}, \mu s$ and σs. Show only one iteration.

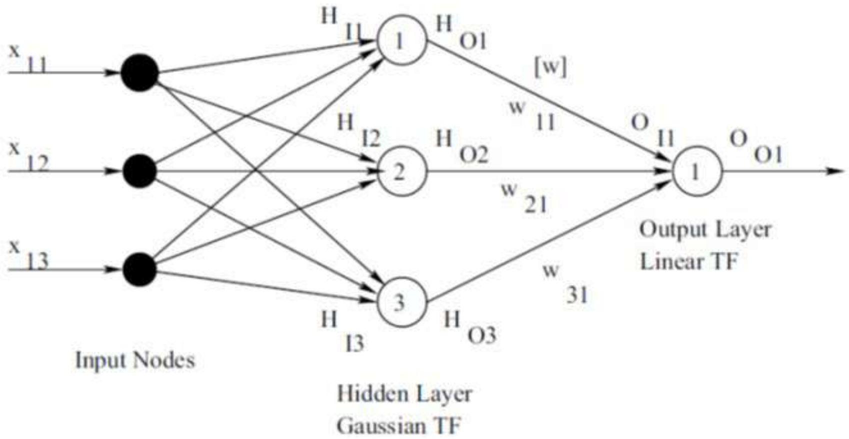


Fig. 1 A Radial Basis Function Neural network

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Hard computing, Soft computing, Hybrid computing; Principle of optimization, Traditional methods of optimization; Genetic Algorithm (GA): Binary-coded GA, Parameters setting, Constraints handling, Real-coded GA, Micro-GA, Visualized interactive GA, Scheduling GA.	8	20
II	Multi-objective optimization: Different approaches – Weighted sum approach, Goal/Target programming, Vector Evaluated GA, Distance-based Pareto-GA, Non-dominated sorting GA.	8	20
III	Simulated Annealing (SA): Introduction, Working principle, Examples, Applications; Particle Swarm Optimization (PSO): Introduction, Algorithm, Examples, Comparison between GA and PSO.	8	20
IV	Fuzzy Logic: Crisp sets - Operations, Properties; Fuzzy sets – Operations, Properties; Measures of fuzziness and inaccuracy of fuzzy sets; Fuzzy logic controller – Mamdani approach, Takagi and Sugeno's approach, Hierarchical fuzzy logic controller, Sensitivity analysis; Fuzzy clustering – Fuzzy C-Means clustering, Entropy-based Fuzzy clustering.	8	20
V	Artificial Neural Network (ANN): Biological neuron, Artificial neuron, Static and dynamic neural networks, Supervised learning, Un-supervised learning, Incremental training, Batch mode of training; Multi-Layer Feed-Forward Neural Network (MLFFNN); Radial Basis Function Neural Network (RBFNN); Self-Organizing Map (SOM); Counter-Propagation Neural Network (CPNN); Recurrent Neural Network (RNN) – Elman network, Jordan network, Combined Elman and Jordan network; Introduction to Neuro-fuzzy systems - ANFIS.	8	20

Course Plan

No	Topic	No. of Lecture Hours
1	**Introduction to Genetic Algorithm**	
1.1	Hard computing, Soft computing, Hybrid computing	1
1.2	Principle of optimization	1
1.3	Traditional methods of optimization; Genetic Algorithm (GA)	1
1.4	Binary-coded GA	1
1.5	Parameters setting, Constraints handling	1
1.6	Real-coded GA, Micro-GA	1
1.7	Visualized interactive GA	1
1.8	Scheduling GA	1
2	**Multi-objective Genetic Algorithm**	
2.1	Multi-objective optimization	2
2.2	Different approaches – Weighted sum approach	1
2.3	Goal/Target programming	1
2.4	Vector Evaluated GA	1
2.5	Distance-based Pareto-GA	2
2.6	Non-dominated sorting GA	1
3	**Simulated Annealing (SA) and Particle Swarm Optimization (PSO)**	
3.1	Simulated Annealing (SA)	1
3.2	Introduction, Working principle	1
3.3	Examples, Applications	1
3.4	Particle Swarm Optimization (PSO)	1
3.5	Introduction, Algorithm	1
3.6	Examples	2
3.7	Comparison between GA and PSO	1
4	**Fuzzy Logic**	
4.1	Fuzzy Logic: Crisp sets, Operations, Properties	1
4.2	Fuzzy sets – Operations, Properties	1
4.3	Measures of fuzziness and inaccuracy of fuzzy sets	1
4.4	Fuzzy logic controller – Mamdani approach	1
4.5	Takagi and Sugeno's approach	1
4.6	Hierarchical fuzzy logic controller; Sensitivity analysis	1
4.7	Fuzzy clustering – Fuzzy C-Means clustering	1

4.8	Entropy-based Fuzzy clustering	1
5	**Artificial Neural Network (ANN)**	
5.1	Artificial Neural Network (ANN): Biological neuron	1
5.2	Artificial neuron, Static and dynamic neural networks	1
5.3	Supervised learning, Un-supervised learning	1
5.4	Incremental training, Batch mode of training	1
5.5	Multi-Layer Feed-Forward Neural Network (MLFFNN)	1
5.6	Radial Basis Function Neural Network (RBFNN)	1
5.7	Self-Organizing Map (SOM); Counter-Propagation Neural Network (CPNN)	1
5.8	Recurrent Neural Network (RNN) – Elman network, Jordan network, Combined Elman and Jordan network, Introduction to Neuro-fuzzy systems - ANFIS.	1

Reference Books

1. Dilip K. Pratihar, *Soft Computing: Fundamentals and applications,* Alpha Science International Ltd., Oxford, UK, 2014

2. Deb, Kalyanmoy, *Optimization for engineering design: Algorithms and examples.* PHI Learning Pvt. Ltd., 2012.

3. Deb, Kalyanmoy, *Multi-objective optimization using evolutionary algorithms.* John Wiley & Sons, 2001

4. Schalkoff ,R.J., *Artificial Neural Networks,* McGraw-Hill Companies Inc., 1997.

5. Sundareswaran, K, *A Learner 's Guide to Fuzzy Logic Systems,* Jaico Publishing House, 2005.

6. Randy L. Haupt & Sue Ellen Haupt, *Practical Genetic Algorithms*, Wiley-Interscience, 2nd edition, 2004.

7. Yegnanarayanan, B., *Artificial Neural Networks,* Prentice Hall of India, 1999

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EME044	NANO AND MICRO MANUFACTURING	PROGRAMME ELECTIVE 2	3	0	0	3

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the need and requirements of micro and nano manufacturing systems to address evolving challenges in materials and designs
CO 2	Understand some of the conventional and non-conventional micro-nano manufacturing systems
CO 3	Understand the concept of nano level manufacturing-Nano structured materials-Size effects. Synthesis of nano particles
CO 4	Understand various characterisation, quantification and imaging techniques needed for micro and nano manufacturing
CO 5	Understand various advanced finishing techniques for micro nano level manufacturing

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓		✓
CO 2	✓		✓	✓		✓
CO 3	✓		✓	✓		✓
CO 4	✓		✓	✓		✓
CO 5	✓		✓	✓		✓

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	20
Analyse	40
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

MICRO AND NANO MANUFACTURING

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is the need for precision manufacturing? Explain in the contexts of dimensions and tolerances?
2. Explain the method of making tools for micro milling
3. Describe Ion beam machining system with sketches?
4. With the help of schematic sketch, explain how PVD coating is deposited?
5. Explain the mechanism of material removal in magneto rheological abrasive flow finishing process?

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Compare top-down and bottom-up techniques of nano manufacturing with ONE example each.

7 List special features of diamond turning in comparison with conventional turning? What is the tool used in diamond turning

8 Prepare a schematic layout of focussed ion beam (FIB) machining? How FIB system can be used for imaging

9 Explain the synthesis of single walled carbon nanotubes?

10 How thin coatings can be deposited by physical vapor deposition? Explain the process with ONE example

11 Explain with sketch, Magneto Rheological Abrasive Flow Finishing (MRAFF) process, List process parameters affecting the finish

12 Explain the working principle of atomic force microscope (AFM) with sketch, How the tip of AFM is made

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction: Need for precision manufacturing. Classification of micro and nano manufacturing systems. Requirements of micro-machining systems – MEMS and NEMS devices, Top down and bottom-up approach for micro and nano manufacturing	8	20
II	Micro-machining methods: Micro turning, Diamond turning -drilling and milling -. Micro EDM and micro ECM, mechanism of material removal, difference between macro scale machining	8	20
III	Lithography, LIGA, Laser beam machining - Effect of process parameters, Heat affected zone, Electron beam machining - Ion beam machining, Principle of operation, Material removal mechanisms	8	20
IV	Nano structured material- thin wires-films-Quantum dots. plasma coating-CVD, PVD techniques and applications. Synthesis of carbon nanotubes	8	20
V	Advanced finishing techniques- Need for advanced finishing- Magneto Rheological finishing -Magneto Rheological Abrasive Flow Finishing Characterizations methods at micro and nano levels- Electron microscopy-SEM, STM-Atomic force microscopy-Confocal microscopy- Micro and nano hardness determination	8	20

Course Plan

No	Topic	No. of Lectures
1	**Introduction to precision engineering, MEMS, NEMS devices, Approaches to micro/nano manufacturing**	
1.1	Need for precision manufacturing, new materials, geometry, tolerances	1
1.2	Classifications of micro/nano manufacturing, Conventional, non conventional, thermal energy, electro chemical methods	2
1.3	Requirements of micro/nano manufacturing, characterization, metrology systems	2
1.4	Microelectromechanical systems and nanoelectromechanical devices	1
1.5	Top down and bottom-up approaches with case studies	2
2	**Mechanical and electric discharge type micro and nano manufacturing methods**	
2.1	Micro turning and diamond turning systems	2
2.2	Micro drilling and micro milling-tools and fabrication methods	2
2.3	Micro EDM, difference between EDM and micro EDM, Micro WEDM	2
2.4	Micro ECM, differences from ECM, features and tolerances, advantages	2
3	**Lithography and High energy beam micro/nano manufacturing methods**	
3.1	Lithography, LIGA	2
3.2	Laser beam machining, Types, Pulsed laser, Heat affected zone	2
3.3	Focused ion beam machining, principle, Uses and advantages	2
3.4	Micro Electron beam machining	2
4	**Nano structured materials and coatings, Methods of coating, Synthesis of CNT**	
4.1	Nano structured materials, Bulk and surface structures	2
4.2	Thin wires and films, quantum dots	2
4.3	Plasma coating methods CVD, PVD coatings	2
4.4	Synthesis of single and multi-walled carbon nano tubes	2

5	**Advanced finishing techniques and metrology**	
5.1	Introduction to Micro and Nano Finishing Processes	1
5.2	Abrasive flow machining, process, advantages	1
5.3	Magnetorheological Finishing (MRF) processes, Material removal mechanism	1
5.4	Magnetorheological Abrasive Flow Finishing (MRAFF) processes, Material removal mechanism	1
5.5	Micro and nano metrology, defining the scale, uncertainty	1
5.6	Scanning Electron Microscopy, Scanning tunnelling microscopy – description, principle of atomic force microscopy - description, different modes of operation application, confocal microscopy	2
5.7	Estimation of hardness at micro and nano level, depth sensing indentation methods and stiffness estimation	1

Reference Books

J. Mc Geough, Micromachining of engineering materials, CRC press, 1st Edition, 2002

2. N. Taniguchi, Nanotechnology: Integrated processing systems for ultra-precision and ultra-fine products, Oxford University Press Inc, 1996

3. V. K. Jain, Introduction to micro machining, Narosa publishing house, 2014

4. Mark J Jackson, Micro and Nano manufacturing, Springer, 2nd Edition, 2008

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221LME003	ADVANCED MANUFACTURING LAB 1	LABORATORY	0	0	2	1

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	To gather knowledge on 2D drawing using any software package
CO 2	To gather knowledge on 3D modelling using any software package
CO 3	To impart gather knowledge on static Finite Element analysis
CO 4	To impart gather knowledge on dynamic Finite Element analysis
CO 5	To gather knowledge on assembling of various parts, fits tolerance, surface quality and measurements
CO 6	To gather knowledge onsynthesis of mechanism design for manufacturing systems and robotics:

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	√	√	√	√	√	
CO 2	√	√	√	√	√	
CO 3	√	√	√	√	√	
CO 4	√	√	√	√	√	
CO 5	√	√	√	√	√	
CO 6	√	√	√	√	√	

Continuous Internal Evaluation (CIE) Pattern: Total Marks: 100

Attendance	15 marks
Regular class work/Modelling and Simulation Lab Record and Class Performance	60 marks
Continuous Assessment Test (Minimum 1 Test)	25 marks

Syllabus

1. Exercises on solid modelling: Introduction to computer graphics - viewing transformations, curves and surfaces generation, curve fitting and curve fairing techniques - 2D, wire frame
2. 3D shading - familiarity with Boolean operations - sweep, revolve, loft, extrude, filleting, chamfer, splines etc. - windowing, view point, clipping, scaling and rotation transformations using commercial solid modelling packages
3. Exercises on finite element analysis: Introduction to FEM - 1D, 2D and 3D elements - shape functions – pre-processing - boundary conditions, structured and free mesh generation - analysis - linear and non-linear analysis - static analysis - post processing - display, animation, extraction of nodal data - exercises on heat conduction and elasticity may be given using commercial FEM packages
4. Dynamic analysis using FE package-Modal and harmonic analysis. Impact analysis.
5. Exercises on Assembly and mechanism design: Assembling of various parts and tolerance analysis - synthesis and design of mechanisms - animations - exercises on various mechanisms like four bar linkages and its variations - cam and follower – Limits fits and tolerances-Surface Measurements-Parameters
6. Synthesis of mechanisms-Programming techniques for analytical synthesis-Robotic arm motion synthesis

No	List of Exercise	Course Outcomes
1	Preparation of 2D drawing using basic operations	**CO 1**
2	Preparation of 2D drawing using basic operations	**CO 1**
3	Preparation of 2D drawing using basic operations	**CO 1**
4	Preparation of 3D drawing using Boolean operations	**CO 2**
5	Preparation of 3D drawing using Extrude operations	**CO 2**
6	Preparation of 3D drawing using Mirror/copy operations	**CO 2**
7	Preparation of 3D drawing using rotation operations	**CO 2**
8	FE analysis static problems	**CO 3**
9	FE analysis static problems	**CO 3**
10	FE analysis static and thermal problems	**CO 3**
11	FE analysis static and thermal problems	**CO 3**
12	FE analysis dynamic problems	**CO 4**
13	FE analysis dynamic problems	**CO 4**
14	Exercises on limits fits and tolerances	**CO 5**

15	Exercises on surface measurements	**CO 5**
16	Exercise on synthesis of mechanisms involving linkages	**CO 6**

References:

1. ANSYS Software manual-ANSYS Inc

2. P.Radhakrishnan, Computer Numerical Control and Computer Aided Manufacture, New Age International Publishers, 2012

3. K. J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 2014

SEMESTER II

Discipline : Mechanical Engineering

Stream : ME4

CODE 222TME100	COURSE NAME DESIGN OF EXPERIMENTS	CATEGORY	L	T	P	CREDIT
		Discipline Core	3	0	0	3

Preamble:

Investigators perform experiments in virtually all fields of inquiry, usually to discover something about a particular process or system. In this course, you will learn the basic concepts of experimental design, and the statistical analysis of data. On completion of the course, you would be able to plan and conduct experiments, and analyse the resulting data so that valid conclusions can be drawn.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Perform statistical analysis of data.
CO 2	Conduct statistical hypothesis tests on mean and variance of populations.
CO 3	Design and analyse single factor experiments.
CO 4	Design and analyse full and fractional factorial experiments.
CO 5	Apply Response Surface Methodology to optimise the response in an experiment.
CO 6	Carry out an experimental project and analyse the results using a statistical software.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
CO 1	3	3	3	3	3	1	2
CO 2	3	3	3	3	3	1	2
CO 3	3	1	3	3	3		1
CO 4	3	1	3	3	3		1
CO 5	3	1	3	3	3		3
CO 6	3	2	3	3	3	1	3

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	20
Analyse	20
Evaluate	10
Create	10

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 Marks

Course based project/Mini project: 20 Marks.

(Identify a relevant problem and design experiments to be carried out. Analyse the results using a software package like R, Minitab, Design Expert, Python etc. and establish the results between the dependent and independent variables.)

Course based task/ Quiz: 10 Marks

Test paper: 10 Marks

(Test paper shall include minimum 80% of the syllabus.)

End Semester Examination Pattern: 60 Marks

The end semester examination will be conducted by the University for Core Courses. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION

MECHANICAL ENGINEERING

222TME100: DESIGN OF EXPERIMENTS

Max. Marks: 60 Duration: 2.5 Hours

PART A

Answer all the questions. Each question carries 5 marks Marks

1 Following data refer to 6 observations on natural frequency (in Hertz) of beams subjected to a load in an experiment: 230.66, 233.05, 232.58, 229.48, and 232.58. Construct a 90% confidence interval for the data. (5)

2 A cement manufacturer claims that the mean settling time of his cement is not more than 45 minutes. A random sample of 20 bags of cement selected and tested showed an average settling time of 49.5 minutes with a standard deviation of 3 minutes. Test whether the company's claim is true. Use 5 % level of significance. (5)

3 Describe the roles of randomization, replication and blocking in experimental design. (5)

4 What are the model adequacy checks generally carried out in a factorial experimental design? (5)

5 What are the advantages and limitations of fractional factorial designs? (5)

PART B

Answer any five full questions. Each question carries 7 marks.

6 (a) The following data refer to the weights of 10 students (kg) in a class: 63, 64, 59, 58, 65, 70, 56, 68, 60 and 62. Construct a normal probability plot of the data. Does it seem reasonable to assume that the students' weight is normally distributed? (4)

(b) The following data refer to the number of sales of cakes on different days in a season. Represent the data as a box plot. (3)

54, 60, 65, 66, 67, 69, 70, 72, 73, 75, 76

7 Fifteen adults between the ages of 35 and 50 participated in a study to evaluate the effect of diet and exercise on blood cholesterol levels. The total cholesterol was measured for each person initially, and then three months after participating in an aerobic exercise program and switching to a low-fat diet. The blood cholesterol level data are shown in the following table. (7)

Subject	1	2	3	4	5	6	7	8	9	10	11	12
Before	265	240	258	295	251	245	287	314	260	279	283	240
After	229	231	227	240	238	241	234	256	247	239	246	218

8 An agricultural officer wants to study the effect of four different fertilizers on the yield (in tons) of a specific crop. Since there might be variability from one plot to another plot, he decides to use the randomized complete block design. The data are presented in the table. Test whether the type of fertilizer used has significant effect on the yield of the crop. (7)

Plot	**Fertilizer**			
	A	B	C	D
1	100	150	120	70
2	80	70	110	100
3	68	90	85	78
4	125	138	60	124

9 An oil company wants to test the effect of four different blends of gasoline (A, B, C, D) on fuel efficiency. The company has used four cars for testing the four types of fuel. To control the variability due to cars and drivers, Latin square design has been used. The collected data from the experiment is shown in the table below. Analyse the data and test whether the four blends of gasoline, cars and the drivers significantly affect the fuel efficiency. (7)

Driver	Cars			
	I	II	III	IV
1	D = 15.5	B = 33.9	C = 13.2	A = 29.1
2	B = 16.3	C = 26.6	A=19.4	D = 22.8
3	C = 10.8	A = 31.1	D = 17.1	B = 30.3
4	A = 14.7	D = 34.0	B = 19.7	C = 21.6

10 The yield of a chemical process is being studied. The two most important variables are thought to be the pressure and temperature. Three levels of each factor are selected, and a factorial experiment with two replicates is performed. The yield data are given in the table below. Analyse the data and draw conclusions. Use $\alpha = 0.05$ (7)

Temperature (^oC)	Pressure (psi)		
	200	215	230
150	90.4	90.7	90.2
	90.2	90.6	90.4
160	90.1	90.5	89.9
	90.3	90.6	90.1
170	90.5	90.8	90.4
	90.7	90.9	90.1

11 A 2^3 factorial design was used to develop a nitride etch process on a plasma etching tool. The design factors are the gap between the electrodes (A), the gas flow (B), and the power applied to the cathode (C). Each factor is run at two levels, and the design is replicated twice. The response variable is the etch rate for silicon nitride. The data are given in the table below. Analyse the data to identify the significant factors and interactions. (7)

Coded factors			Etch rate	
A	**B**	**C**	**Replication 1**	**Replication 2**
-1	-1	-1	550	604
1	-1	-1	669	650
-1	1	-1	633	601
1	1	-1	642	635
-1	-1	1	1037	1052
1	-1	1	749	868
-1	1	1	1075	1063
1	1	1	729	860

12 The yield of a melting furnace in a foundry is suspected to be affected by the temperature ‘T’ and melting time ‘M’. The data of this experiment with one replication in different treatment combinations are summarized in the table below. Further, five replications are taken at the centre point. Fit a first order response surface for this problem to determine the optimum settings for the temperature and melting time at a significance level of 0.05. (7)

		Melting time	
		60 min.	66 min.
Temperature	$400^{o}C$	75	77
	$410^{o}C$	80	84
Centre point replications Temperature ($405^{o}C$) Melting time (63 min)	1	79	
	2	78	
	3	76	
	4	79	
	5	80	

Syllabus:

Module 1

Introduction to Design of Experiments: One factor at a time experiments and designed experiments; Role of DoE in experimentation. Application of software packages for designing experiments.

Basic statistical concepts: Probability distributions; pdf and cdf; mean and variance. Normal and Student’s *t* distributions; Normal probability plot. Tables and charts to represent data; Stem and leaf; Box plot; Pareto chart.

Sampling distribution of the mean: Central Limit Theorem. Constructing Confidence Intervals for a single mean, variance, and difference of two means.

Module 2

Hypothesis Testing: Hypothesis testing of single means. Testing of two means - with known and unknown population variance. Paired t-test. Testing of variances. Analysis of Variance (ANOVA).

Module 3

Single Factor Experiments: Completely randomized design. Replication, Randomization, Blocking. Randomized complete block design. Latin square design.

Model adequacy checking: Residual plots.

Module 4

Factorial experiments: Two and three factors full factorial experiments. 2-level full factorial experiments. Effects and contrasts; Yate's algorithm. Single replicate case. Addition of central points to the 2^k design. Blocking and confounding in the 2^k factorial design.

Module 5

Fractional Factorial Experiments: 2-level fractional factorial design. One-half fraction of the 2^k design. Alias structures in fractional factorial designs; Confounding; Design resolutions.

Response Surface Methodology: Central Composite Design.

Course Plan

No.	Topic	No. of Lectures
1	**Introduction to Design of Experiments**	
1.1	One factor at a time experiments and designed experiments; Role of DoE in experimentation.	1
1.2	Application of software packages for designing experiments.	1
1.3	Basic statistical concepts; Probability distributions; pdf and cdf; mean and variance.	1
1.4	Normal and Student's *t* distributions; Normal probability plot.	1
1.5	Tables and charts to represent data; Stem and leaf; Box plot; Pareto chart.	1
1.6	Sampling distribution of the mean; Central Limit Theorem.	1
1.7	Constructing Confidence Intervals for a single mean, variance, and difference of two means.	2
2	**Hypothesis Testing**	
2.1	Hypothesis testing of single means.	2
	Testing of two means - with known and unknown population variance.	2
2.2	Paired t-test.	1
2.3	Testing of variances.	1
2.4	Analysis of Variance.	2
3	**Single Factor Experiments**	

3.1	Completely randomized design.	2
3.2	Replication, Randomization, Blocking.	1
3.3	Randomized complete block design.	2
3.4	Latin square design.	1
3.5	Model adequacy checking; residual plots.	2
4	**Factorial experiments**	
4.1	Two and three factors full factorial experiments.	2
4.2	2^k full factorial experiments.	2
4.3	Effects and contrasts; Yate's algorithm.	1
4.4	Single replicate case.	1
4.5	Addition of central points to the 2^k design.	1
4.6	Blocking and confounding in the 2^k factorial design.	1
5	**Fractional Factorial Experiments**	
5.1	2-level fractional factorial design.	2
5.2	Alias structures in fractional factorial designs; Confounding; Design resolutions.	2
5.3	Response Surface Methodology.	2
5.4	Central Composite Design.	2

Reference Books

1. Montgomery, D. C. (2001). Design and analysis of experiments, John Wiley, New York.
2. Montgomery, D. C. & Runger, G. C. (2007). Applied Statistics and Probability for Engineers, John Wiley, New York.
3. Krishnaiah, K. & Shahabudeen, P. (2012). Applied Design of Experiments and Taguchi Methods, PHI, New Delhi.
4. George, E. P., et al. (2005). Statistics for experimenters: design, innovation, and discovery, John Wiley, New York.
5. Panneerselvam, R. (2012), Design and Analysis of Experiments, PHI, New Delhi

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TME004	**Modern Manufacturing systems**	**PROGRAM CORE**	**3**	**0**	**0**	**3**

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Analyse the fundamental machining principles
CO 2	Demonstrate the mechanisms in the non-traditional machining processes
CO 3	Understand various advanced metal cutting and forming operations
CO 4	Understand experimental methods using various computational methods
CO 5	Demonstrate the concept of Explosive forming Process.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	**End Semester Examination (marks)**
Apply	**20**
Analyse	**40**
Evaluate	
Create	

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus. The project shall be done individually. Group projects not permitted.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question paper

222TME004 MODERN MANUFACTURING SYSTEMS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the need and characteristics of non-traditional machining?
2. Mention the advantages and disadvantages of ultrasonic machining?
3. What are the process variables that affect the performance of water jet machining process?
4. What are the functions of dielectric fluid?
5. Explain the types of explosive forming?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 What are the advantages of non-traditional machining process?

7 With a neat sketch explain the working principle of ultrasonic machining process?

8 Explain the following variables that influence the metal removal and accuracy of machining in abrasive jet machining, carrier gas, types of abrasives and standoff distance?

9 Explain with neat sketch Electron beam machining process?

10 Explain flushing and explain any two methods of flushing in EDM process?

11 Explain with sketch, the mechanism of metal removal in laser beam machining process?

12 Explain the principle of plasma generation and mechanism of metal removal in plasma arc machining?

Syllabus

MODULE	CONTENT
I	Mechanical Processes: Ultrasonic Machining- Elements of process, cutting tool system design, effect of parameters, economic considerations, applications, limitations of the process, advantages and disadvantages. Abrasive Jet Machining- Variables in AJM, metal removal rate in AJM. Water Jet Machining- Jet cutting equipment, process details, advantages and applications
II	Electrochemical and Chemical Metal Removal Processes: Electrochemical Machining- Elements of ECM process, tool work gap, chemistry of the process, metal removal rate, accuracy, surface finish and other work material characteristics, economics, advantages, applications, limitations. Electrochemical Grinding– Material removal, surface finish, accuracy, advantages, applications
III	Thermal Metal Removal Processes: Electric Discharge Machining (EDM) or spark erosion machining processes, mechanism of metal removal, spark erosion generators; electrode feed control, dielectric fluids, flushing, electrodes for spark erosion, selection of electrode material, tool electrode design, surface finish, machining accuracy, machine tool selection, applications, Wire cut EDM. Laser beam machining (LBM)- Apparatus, material removal, cutting speed and accuracy of cut, metallurgical effects, advantages and limitations
IV	Plasma Arc Machining (PAM): Plasma, non-thermal generation of plasma, mechanism of metal removal, PAM parameters, equipment for D.C. plasma torch unit, safety precautions, economics, other applications of plasma jets, Electron Beam Machining (EBM) – Generation and control of electron beam, theory of electron beam machining, process capabilities and limitations. High Velocity Forming Processes: - Conventional versus High velocity forming methods – Material behaviour – stress waves and deformation in solids – Stress wave

	induced fractures – Applications
V	Explosive Forming Processes: - Principles – Explosives – Length of reactions – Energy in plastic deformations – Expression for change in size required for deforming a flat disc into a bulged form – Effect of process in material properties – Types of Explosives forming – die construction. Magnetic Pulse Forming Processes: - General principles – Applications

Course Plan

No	Topic	No. of Lectures
1	**Introduction to mechanical processes**	
1.1	Mechanical Processes: Ultrasonic Machining- Elements of process	1
1.2	Cutting tool system design, effect of parameters, economic considerations	1
1.3	Applications, limitations of the process, advantages and disadvantages	1
1.4	Abrasive Jet Machining- Variables in AJM, metal removal rate in AJM	1
1.5	Water Jet Machining- Jet cutting equipment, process details, advantages and applications	2
2	**Electrochemical and Chemical Metal Removal Processes**	
2.1	Electrochemical and Chemical Metal Removal Processes: Electrochemical Machining	2
2.2	Elements of ECM process, tool work gap, chemistry of the process, metal removal rate	2
2.3	accuracy, surface finish and other work material characteristics, economics, advantages, applications, limitations	2
2.4	Electrochemical Grinding– Material removal, surface finish, accuracy, advantages, applications	2
3	**Thermal Metal Removal Processes**	
3.1	Thermal Metal Removal Processes: Electric Discharge Machining (EDM) or spark erosion machining processes	2
3.2	Mechanism of metal removal, spark erosion generators; electrode feed control, dielectric fluids	1
3.3	Flushing, electrodes for spark erosion, selection of electrode material, tool electrode design, surface finish	2
3.4	Machining accuracy, machine tool selection, applications, Wire cut EDM	1
3.5	Laser beam machining (LBM)- Apparatus, material removal, cutting speed and accuracy of cut, metallurgical effects, advantages and limitations	2
4	**Plasma Arc Machining (PAM), Electron Beam Machining (EBM) and High Velocity Forming Processes**	

4.1	Plasma Arc Machining (PAM): Plasma, non-thermal generation of plasma, mechanism of metal removal	2
4.2	PAM parameters, equipment for D.C. plasma torch unit, safety precautions, economics, other applications of plasma jets	2
4.3	Electron Beam Machining (EBM) – Generation and control of electron beam, theory of electron beam machining, process capabilities and limitations	2
4.4	High Velocity Forming Processes: - Conventional versus High velocity forming methods – Material behaviour – stress waves and deformation in solids	2
4.5	Stress wave induced fractures – Applications	1
5	**Explosive Forming Processes**	
5.1	Explosive Forming Processes: - Principles – Explosives – Length of reactions	1
5.2	Energy in plastic deformations – Expression for change in size required for deforming a flat disc into a bulged form	2
5.3	Effect of process in material properties, Types of Explosives forming – die construction	2
5.4	Magnetic Pulse Forming Processes: - General principles – Applications	2

Reference Books

1. J. Ghosh and Mallik, Manufacturing Science, East West Press, (2006)
2. HMT, Production Technology, Tata McGraw Hill, New Delhi. (2005)
3. C. Pandey, H.S. Shan, Modern Machining Processes, Tata McGraw Hill, (2008)
4. Mc Geongh J. A., Advanced Methods of Machining, Chapman and Hall, (2006)

Program Elective 3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME035	CELLULAR MANUFACTURING AND GROUP TECHNOLOGY	PROGRAMME ELECTIVE - 3	3	0	0	3

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Develop an understanding about Group Technology and part classification and coding
CO 2	Understand the algorithms and methods for part grouping
CO 3	Understand the concepts of cellular manufacturing
CO 4	Understand about the design methods of Cellular manufacturing systems
CO 5	Understand about quantitative analysis of cellular manufacturing

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	**20**
Analyse	**40**
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

222EME035 CELLULAR MANUFACTURING AND GROUP TECHNOLOGY

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Justify the need of Group Technology citing the limitations in traditional manufacturing systems.
2. Explain about methods for cell formation.
3. Describe key machine concept in cellular manufacturing
4. Explain about machine component group analysis.
5. Explain briefly about the parametric analysis of GT.

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Explain in detail about the OPITZ multiclass coding system citing an example.

7 Explain in detail about part classification based on design attributes and manufacturing attributes citing relevant examples.

8 Explain in detail about the different machine cell layouts in cellular manufacturing systems.

9 Explain how the concepts of genetic algorithms can be implemented for design and modelling of a cellular manufacturing system.

10 Explain the Application of Genetic algorithm in CMS

11 Explain various life cycle issues in GT/CMS.

12 Describe the following terms Inter and Intra cell layout, cost and non-cost-based models,

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Limitations of traditional manufacturing systems, Introduction to Group Technology, GT concepts, Advantages of GT, Part family formation –Part classification and coding systems. GT and Economics of GT. Features of part classification and coding- examples- OPITZ multiclass coding system, Benefits of GT and issues in GT.	8	20
II	Design attributes, manufacturing attributes, characteristics, and design of groups, PFA, FFA. Part machine group analysis, Methods for cell formation, Use of different algorithms, mathematical programming, and graph theoretic model approach for part grouping.	8	20

III	Cellular Manufacturing- composite part concept- examples machine cell design- types of machine cell and layout, Types of manufacturing cell, Design of cellular manufacturing systems, determination of best cell arrangement, key machine concept.	**8**	**20**
IV	Cell formation approach- Machine component group analysis, similarity coefficient-based approach, exceptional parts and bottleneck machines, Problems in GT/CMS - Design of CMS - Models, traditional approaches and non-traditional approaches - Genetic Algorithms, Simulated Annealing, Neural networks	**8**	**20**
V	Quantitative analysis in cellular manufacturing- arranging machines in GT cell- examples. Inter and Intra cell layout, cost and non-cost-based models, batch sequencing and sizing, life cycle issues in GT/CMS. Measuring CMS performance - Parametric analysis - PBC in GT/CMS, Human aspects of GT/CMS	**8**	**20**

Corse Plan

No	Topic	No. of Lectures
1	**Introduction to group technology and basics of part classification and coding**	
1.1	Limitations of traditional manufacturing systems, Introduction to Group Technology	1
1.2	GT concepts, Advantages of GT, Part classification and coding systems	2
1.3	GT and Economics of GT	1
1.4	OPITZ multiclass coding system	2
1.5	Benefits of GT and issues in GT.	2
2	**Part grouping analysis**	
2.1	Design attributes, manufacturing attributes	1
2.2	Characteristics, and design of groups	2
2.3	Production flow analysis and factory flow analysis	1
2.3	Methods for cell formation, Use of different algorithms	2
2.4	Mathematical programming, and graph theoretic model approach for part grouping.	2
3	**Concepts of cellular manufacturing**	
3.1	Composite part concept in cellular manufacturing and examples	2
3.2	Types of machine cell and layout	1
3.3	Types of manufacturing cell	1

3.4	Design of cellular manufacturing systems, determination of best cell arrangement,	2
3.5	Key machine concept	2
4	**Methods of cell formation, problems in GT/CMS, Design of CMS**	
4.1	Cell formation approach- Machine component group analysis	1
4.2	similarity coefficient-based approach, exceptional parts and bottleneck machines	2
4.3	Problems in GT/CMS	1
4.4	Design and Modelling of CMS-traditional approaches and non-traditional approaches	2
4.5	Use of Genetic Algorithms, Simulated Annealing, Neural networks in CMS design	2
5	**Quantitative analysis in cellular manufacturing**	
5.1	arranging machines in GT cell- examples	1
5.2	Inter and Intra cell layout, cost and non-cost based models	2
5.3	batch sequencing and sizing	1
5.4	life cycle issues in GT/CMS.	2
5.5	Parametric analysis - PBC in GT/CMS,	1
5.6	Human aspects of GT/CMS	1

Reference Books

1. Mikell P. Groover, "Automation, Production systems and Computer integrated manufacturing", Prentice hall of India private limited.

2. Ali Kamrani, Hamid R Parsaei, Donald H Liles, "Planning, Design and Analysis of cellular manufacturing system", Elsevier, 1995

3. Manua Singh, "Systems approach to Computer Integrated Design and Manufacturing", John Wiley & Sons Inc, 1996

4. Irani.S.A, "Cellular Manufacturing Systems", Hand Book 5. Kamrani, A.K, and Nasr, E.A. (Eds), "Collaborative Engineering: Theory and Practice Springer science, business media, 2008.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME036	**ENTERPRISE RESOURCE PLANNING**	**PROGRAMME ELECTIVE - 3**	**3**	**0**	**0**	**3**

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand the fundamental concepts of enterprise resource planning
CO 2	Apply the basic knowledge of the subject to design various modules as well as an integrated ERP system for an enterprise.
CO 3	Design and implement the various ERP modules as per the requirements of the clients
CO 4	Analyse the fitting requirements of ERP packages in different industrial domains.
CO 5	Understand how companies have implemented ERP successfully.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	✓		✓	✓	?	✓
CO 2	✓		✓	✓	?	✓
CO 3	✓		✓	✓	?	✓
CO 4	✓		✓	✓	?	✓
CO 5	✓		✓	✓	?	✓

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

222EME036 Enterprise Resource Planning

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the role of enterprise in business modelling.

2. Illustrate Business Process Reengineering.

3. Write shote notes on Basic modules of ERP Package.

4. Write shot note on ERP in manufacturing industry.

5. What are the implementation methodologies of ERP software?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6. Explain the conceptual model of ERP.

7. Explain in detail about following terms in ERP environment i) Data Warehousing and Data mining ii) Data extraction and transformation

8. Explain the various performance measures of ERP

9. Describe about the ERP functional modules i) Human capital Management ii) Financial management iii) Supply chain planning iv) Sales and service.

10. Explain in detail about application of ERP in service industries

11. Explain the terms in ERP Related technology

    (i)Data base Management System (ii) Decision Support Systems

12. Explain in detail about ERP implementation methodology.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction of ERP: Concept of Enterprise, ERP Overview, Integrated information system, The role of Enterprise, Business Modelling, Myths about ERP, Basic ERP Concepts. Enabling Technologies, Conceptual Model of ERP, Structure of ERP, Intangible benefits of ERP, Justifying ERP investment, Risks of ERP, Benefits of ERP.	8	20
II	ERP and related Technology: Business Process Reengineering (BPR), Management Information System (MIS), Data base Management System (DBMS), Decision Support Systems (DSS), Executive Support Systems (ESS), Data Warehousing and Data Mining, Online Analytical Processing (OLTP), Supply Chain Management (SCM), Customer Relationship	8	20

	Management (CRM).		
III	Modules of ERP: Basic modules of ERP Package-Human Resources Management, Financial Management, Inventory Management, Quality Management, Sales and Distribution.	**8**	**20**
IV	ERP packages and Cases: ERP for manufacturing Industries, ERP for Service Industries. Performance measures for ERP, Cloud ERP.	**8**	**20**
V	ERP Implementation: ERP Implementation Strategies, ERP Implementation Life Cycle, Implementation Methodologies, ERP package selection, ERP Projects Teams, Vendors and Consultants, Reasons for failure and reasons for success of ERP implementation, Dealing with employee resistance, Training and Education, data migration, Project Management and monitoring, Post Implementation activities.	**8**	**20**

Corse Plan

No	**Topic**	**No. of Lectures**
1	**Introduction of ERP**	
1.1	Concept of Enterprise, ERP Overview, Integrated information system	1
1.2	The role of Enterprise, Business Modelling	1
1.3	Myths about ERP	1
1.4	Basic ERP Concepts.	1
1.5	Enabling Technologies	1
1.6	Conceptual Model of ERP& Structure of ERP	1
1.7	Intangible benefits of ERP	1
1.8	Justifying ERP investment, Risks of ERP, Benefits of ERP	1
2	**ERP and related Technology**	
2.1	Business Process Reengineering (BPR), Management Information System (MIS).	2
2.2	Data base Management System (DBMS), Decision Support Systems (DSS).	2
2.3	Executive Support Systems (ESS), Data Warehousing and Data Mining, Online Analytical Processing (OLTP).	2
2.4	Supply Chain Management (SCM), Customer Relationship Management (CRM).	2
3	**Modules of ERP**	

3.1	Basic modules of ERP Package, Human Resources Management.	2
3.2	Financial Management, Inventory Management.	2
3.3	Quality Management.	2
3.4	Sales and Distribution.	2
4	**ERP packages and Cases**	
4.1	ERP for manufacturing Industries.	2
4.2	ERP for Service Industries.	2
4.3	Performance measures for ERP	2
4.4	Cloud ERP.	2
5	**ERP Implementation**	
5.1	ERP Implementation Strategies, ERP Implementation Life Cycle.	1
5.2	Implementation Methodologies, ERP package selection, ERP Projects Teams.	2
5.3	ERP Projects Teams, Vendors and Consultants, Reasons for failure and reasons for success of ERP implementation.	1
5.4	Dealing with employee resistance, Training and Education, data migration.	2
5.5	Project Management and monitoring, Post Implementation activities.	2

Reference Books

1. Rajesh Ray “Enterprise Resource Planning’’, Tata McGraw Hill Education Private Limited, New Delhi.
2. Vinod Kumar Garg and Venkitakrishnan N K,“Enterprise Resource Planning-Concepts and Practice”. PHI, 2006
3. David L. Olson, “Managerial issues of Enterprise Resource Planning systems” TMH Edition 2008.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME037	**FLEXIBLE MANUFACTURING SYSTEMS**	**PROGRAMME ELECTIVE - 3**	**3**	**0**	**0**	**3**

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Demonstrate in detail about FMS, types and equipment
CO 2	Understand some of the flexibility achievements and economic justification and functional requirements for FMS
CO 3	Understand the concept of FMS processing and QA equipment
CO 4	Evaluate the types of storage systems and cutting tool management
CO 5	Analyse various work holding considerations in FMS environment

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	**20**
Analyse	**40**
Evaluate	
Create	

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

222EME037 FLEXIBLE MANUFACTURING SYSTEMS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is the need for FMS? Explain in the context of evolution of FMS?
2. Enumerate the economic justification for FMS and functional requirements for FMS equipment?
3. Describe material handling principles in FMS?
4. Differentiate Conventional and Automated storage systems
5. Describe the fixture considerations in FMS environment?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 What are the different types of flexibilities. Mention its measurement?

7 Define a flexible manufacturing system. Also, explain its evolution from mechanized machine to a contemporary flexible manufacturing system?

8 Enumerate components structure of FMS and their functions with neat sketch?

9 Explain AGV and its types in detail with a neat sketch?

10 Discuss the problems involved in implantation of FMS?

11 Describe the use of deterministic models for quantitative analysis of FMS?

12 List out the typical data handled by an FMS. Explain their role in detail

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction: Introduction to FMS, FMS definition, evolution, equipment, and classification of FMS - configuration of FMS-application of FMS, Automated production cycle, Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement. FMS Equipment: Why FMS, Factors responsible for the growth of FMS	9	20
II	FMS types and applications, user- host supplier flexibilities- flexibility achievement-how to develop FMS, Economic justification for FMS, Functional requirements for FMS equipments	8	20
III	FMS processing and QA equipment, e.g., turning and machining centers, Coordinate measuring machines, Cleaning and deburring machines, FMS system support equipment, Material handling principles- transport system-industrial truck, Automated material handling, AGV- monorail and other guided vehicle-conveyor-crane- hoist	9	20
IV	Storage system- performance- location strategies- conventional and automated storage systems- equipment	7	20

	used for storage, engineering analysis. Cutting tool and tool management		
V	Work holding considerations, Fixture considerations in FMS environment, FMS production, and its importance, Manufacturing support system- process planning for parts and assemblies- CAPP retrieval and generative	**7**	**20**

Corse Plan

No	Topic	No. of Lectures
1	**Introduction: Introduction to FMS, FMS definition, evolution, equipment and classification of FMS**	
1.1	Introduction: Introduction to FMS, FMS definition, evolution, equipment and classification of FMS	2
1.2	Configuration of FMS	1
1.3	Application of FMS Automated production cycle	2
1.4	Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement	2
1.5	FMS Equipment: Why FMS, Factors responsible for the growth of FMS	2
2	**FMS types, applications and equipment**	
2.1	FMS types and applications	2
2.2	User- host supplier flexibilities	2
2.3	Flexibility achievement-how to develop FMS	2
2.4	Economic justification for FMS, Functional requirements for FMS equipment	2
3	**FMS processing and QA equipment and AGV**	
3.1	FMS processing and QA equipment, e.g., turning and machining centres	2
3.2	Coordinate measuring machines, Cleaning and deburring machines	2
3.3	FMS system support equipment	1
3.4	Material handling-principles- transport system-industrial truck Automated material handling	2
3.5	AGV- monorail and other guided vehicle-conveyor- crane- hoist	2
4	**Storage system and Cutting tool, equipment and management**	
4.1	Storage system- performance- location strategies	2
4.2	Conventional and automated storage systems	2
4.3	Equipments used for storage, engineering analysis	1
4.4	Cutting tool and tool management	2
5	Work holding considerations, Manufacturing support systems and CAPP retrieval	
5.1	Work holding considerations	1

5.2	Fixture considerations in FMS environment	1
5.3	FMS production and its importance	1
5.4	Manufacturing support system	1
5.5	process planning for parts and assemblies	1
5.6	CAPP retrieval and generative	2

Reference Books

1. D. J. Parrish. Butterworth Heinmann; Flexible manufacturing systems
2. Groover, M.P., "Automation, Production System and CIM", Prentice-Hall of India, 2006.3. V. K. Jain, Introduction to micro machining, Narosa publishing house, 2014
3. David Bedworth, "Computer Integrated Design and Manufacturing", TMH, New Delhi, III Edition 2005

Program Elective 4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME041	**COMPUTER AIDED MEASUREMENTS**	**PROGRAME ELECTIVE - 4**	**3**	**0**	**0**	**3**

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Under stand the fundamentals of measurements and its dynamics
CO 2	Identify the use of sensors and transducers in measurement.
CO 3	Evaluate the basic concepts for measuring the displacement and pressure,
CO 4	Analyse the importance of temperature and flow measurement.
CO 5	Knowledge and skills in using sensors with conditioning circuits for automation systems which has applications in diverse areas of process and manufacturing automation

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	✓	✓	✓		✓	
CO 2	✓	✓	✓		✓	
CO 3	✓	✓	✓			
CO 4	✓	✓	✓			
CO 5	✓	✓	✓			

Assessment Pattern

Bloom's Category	**End Semester Examination**
Apply	20%
Analyse	60%
Evaluate	20%
Create	

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum

10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

222EME041 COMPUTER AIDED MEASUREMENTS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is measurement? State and explain the requirements to be satisfied in the act of measurement.
2. What is a passive transducer? Give examples. How does it differ from an active transducer.
3. Describe, in brief, a variable resistance transducer used for measurement of small displacements.
4. Suggest and explain about an instrumentation circuit which will produce a linear output with temperature.

5. Explain the basic working principle of any one magnetic sensor with a neat diagram.

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Define dynamic system response of a measuring system and explain. (i) Amplitude response (ii) phase response (iii) delay or rise time (iv) bandwidth of frequency response

7 With the aid of a block diagram explain the generalised measuring system.

8 Define what is meant by a transducer and state their desirable operational characteristics. Explain why all transducers are designed to give electrical output by linking primary mechanical detectors to electrical secondary sensors give reasons.

9 What are the three major classes of digital displacement transducers? Draw diagrams of each of them. Discuss their relative merits and demerits.

10 What is process loading? If a potentiometer is used as displacement sensor, then prove that the relation ship between load voltage and fractional displacement of wiper is nonlinear.

11 Describe the principle of operation of a head -type flowmeter based on differential pressure measurement. what is Reynolds number?

12 With the aid of neat sketches explain briefly any two radiation sensors used for measurement.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction to Measurement: Significance of measurement, Different methods of measurement, Classification of measuring instruments, Application of measurement systems, typical measurement schemes. Dynamic Characteristics: Dynamic response; Transient response; speed of response, fidelity, measuring lag etc, Linear approximation, Introduction to compensation techniques. Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures-primary, secondary, direct, indirect, routine calibration, Calibration setup: pressure gauge, level etc.	8	20
II	Introduction to Sensors: Definition and differences of sensors and transducers, Classification, static and dynamic characteristics, electrical characterization, mechanical and thermal characterization including bathtub curve. Introduction to Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non-linear potentiometer, Feedback transducer system, Inverse transducer, Self-balancing transducer, Servo- operated manometer, Feedback pneumatic load cell, integrating servo.	8	20
III	Displacement Measurement: Linear /Angular displacement, Pneumatic/Electric/ Optical/ Ultrasonic/Electronic Displacement Transducers, Tactile and Proximity Sensors, Typical application schemes, Tacho-generators. Pressure Measurement: Pressure Units, Force Summing Devices, Secondary Transducers, Vacuum Measurement, Torque Measurement, Resistance/Bonded Type Strain Gauge.	8	20
IV	Temperature Measurement: Electric Method, Change in Electrical Properties, RTD, Thermocouples, Thermistors,	8	20

	Thermowells. Nuclear thermometers, resistance change type thermometric sensors. Flow Measurement: Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Mass flow measurement type flow meters.		
V	Magnetic sensors: Basic working principles, Magneto-strictive, Hall effect, Eddy current type. Radiation sensors: Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors. Electroanalytical sensors: Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes.	**8**	**20**

Corse Plan

No	Topic	No. of Lectures
1	**Introduction to Measurement & Dynamic Characteristics**	
1.1	Significance of measurement, Different methods of measurement, Classification of measuring instruments, Application of measurement systems, typical measurement schemes.	2
1.2	Dynamic response; Transient response; speed of response, fidelity, measuring lag etc,	2
1.3	Linear approximation, Introduction to compensation techniques.	1
1.4	Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures- primary, secondary, direct, indirect, routine calibration, Calibration setup: pressure gauge, level etc.	3
2	**Introduction to Sensors and Transducers**	
2.1	Definition and differences of sensors and transducers, Classification.	2
2.2	Static and dynamic characteristics, electrical characterization, mechanical and thermal characterization including bathtub curve.	2
2.3	Introduction to Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non-linear potentiometer, Feedback transducer system, Inverse transducer, Self-balancing transducer.	2
2.4	Servo- operated manometer, Feedback pneumatic load cell, integrating servo.	2
3	**Displacement and Pressure Measurements**	

3.1	Linear /Angular displacement, Pneumatic/Electric/ Optical/ Ultrasonic/Electronic Displacement Transducers.	2
3.2	Tactile and Proximity Sensors, Typical application schemes, Tacho-generators.	2
3.3	Pressure Units, Force Summing Devices, Secondary Transducers.	2
3.4	Vacuum Measurement, Torque Measurement, Resistance/Bonded Type Strain Gauge.	2
4	**Temperature and flow Measurements**	
4.1	Electric Method, Change in Electrical Properties, RTD, Thermocouples, Thermistors, Thermowells.	3
4.2	Nuclear thermometers, resistance change type thermometric sensors	2
4.3	Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Mass flow measurement type flow meters.	2
5	**Magnetic, Radiation and Electroanalytical sensors**	
5.1	Basic working principles, Magneto-strictive, Hall effect, Eddy current type.	2
5.2	Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors	2
5.3	Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes.	4

Reference Books

1. K.L. Kishore, Electronic Measurement and Instrumentation, Pearson.
2. D. Patranabis, Sensors and Transducers, PHI Learning Pvt. Ltd., 2nd Edition
3. A. K. Ghosh, Introduction to Measurements and Instrumentation, 4th Edition, PHI.
4. D V S Murty, Transducers and Instrumentation, PHI Learning Pvt. Ltd.
5. B. C. Nakra, K. K. Chaudhry, Instrumentation, Measurement and Analysis, 4th Edition, Tata McGraw Hill.
6. W. D. Cooper, Modern Electronics Instrumentation & Measurement Techniques, PHI.
7. John. P. Bentley, Principles of Measurement Systems, Pearson
8. E. O. Doebelin, Dhanesh N Manik, Measurement Systems, 6th Edition, McGraw Hill.
9. Bolton W, Mechatronics- Electronic Control Systems in Mechanical & Electrical Engineering, 2nd Edition, Longman Publishers, 2002.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME042	**MODELING AND SIMULATION OF ENGINEERING SYSTEM**	**Program Elective 4**	3	0	0	3

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand in detail about fundamental concepts in mathematical modeling
CO 2	Demonstrate some of the lumped element modeling
CO 3	Understand the modelling of first order and second order systems
CO 4	Analyse the frequency response of linear and time invariant systems
CO 5	Understand various feedback systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓		✓
CO 2	✓		✓	✓		✓
CO 3	✓		✓	✓		✓
CO 4	✓		✓	✓		✓
CO 5	✓		✓	✓		✓

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	**20**
Analyse	**40**
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

222EME042 -MODELING AND SIMULATION OF ENGINEERING SYSTEM

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the fundamental concepts in Mathematical modeling?
2. Explain the thermal systems and hydraulic systems in lumped element modelling?
3. Describe time domain and frequency domain?
4. Explain Conventional and Automated storage systems in detail?
5. Explain the phase and gain margins?

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Explain balance and conservation laws and system boundary approach?

7 Explain various lumped element modelling techniques?

8 Derive the governing equation for first order free responses?

9 Derive the governing equations for forced responses?

10 Derive the equations for frequency response of the first order system?

11 Derive the equations for frequency response of the second order system?

12 Discuss feedback systems with block diagram?

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Fundamental Concepts in Mathematical Modelling: Abstraction – linearity and superposition – balance and conservation laws and the system – boundary approach.	8	20
II	Lumped – Element Modeling: Mechanical systems – Translational, rotational. Hydraulic systems. Thermal systems. RLC Electrical Systems.	7	20
III	Modeling of First–order and Second–order Systems: Governing equations for free and forced responses – transient response specifications – experimental determination – Laplace transform. Time Domain, Frequency Domain and State Space.	9	20
IV	Frequency response of Linear, Time invariant systems – frequency response of first–order and second–order systems – state space formulations of systems problems relating frequency response to pole location – transient	9	20

	response-poles and frequency response.		
V	Feedback systems: Systems with feedback – block diagrams – properties of feedback systems – relative stability – phase and gain margins.	7	20

Corse Plan

No	Topic	No. of Lectures
1	**Fundamental Concepts in Mathematical Modelling:**	
1.1	Fundamental Concepts in Mathematical Modelling	1
1.2	Fundamental Concepts in Mathematical Modelling: Abstraction	1
1.3	Linearity and superposition	2
1.4	Balance and conservation laws and the system	2
1.5	Boundary approach	2
2	**Mechanical, Hydraulic, Thermal & Electrical systems**	
2.1	Lumped – Element Modeling	2
2.2	Mechanical systems – Translational, rotational	2
2.3	Hydraulic systems	1
2.4	Thermal systems. RLC Electrical Systems	2
3	**Modeling of First–order and Second–order Systems**	
3.1	Modeling of First–order and Second–order Systems	2
3.2	Governing equations for free and forced responses	2
3.3	Transient response specifications – experimental determination	2
3.4	Laplace transform	1
3.5	Time Domain, Frequency Domain and State Space.	2
4	**Frequency response**	
4.1	Frequency response of Linear, Time invariant systems	2
4.2	Frequency response of first–order and second–order systems	2
4.3	State space formulations of systems	1
4.4	Problems relating frequency response to pole location	2
4.5	Transient response-poles and frequency response	2
5	**Feedback systems**	
5.1	Feedback systems	1
5.2	Systems with feedback – block diagrams	1
5.3	Systems with feedback – block diagrams	1
5.4	properties of feedback systems	1
5.5	relative stability	1
5.6	phase and gain margins	2

Reference Books

1. Cha P. D., Rosenberg J. J. and Dym C. L. – 'Fundamentals of Modeling and Analyzing Engineering Systems'- Cambridge University – 2000

2. Woods Robert L. and Kent L.- 'Modeling and Simulation of Dynamic Systems'- Prentice Hall – 1997

3. Mukherjee A. and Karmakar R. – 'Modeling and Simulation of Engineering Systems through Bondgraphs' – Narosa – 2000

4. Frederick C. – 'Modeling and Analysis of Dynamic Systems' – Wiley – 2001 – 3rd Edition

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EME043	OPTIMIZATION TECHNIQUES	PROGRAMME ELECTIVE - 4	3	0	0	3

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand the theory of simplex method
CO 2	Understand the concepts of non-linear programming in manufacturing process
CO 3	Identify algorithms for unconstrained optimization.
CO 4	Understand the basic concepts of multi-objective decision making and sequential decision making.
CO 5	Solve a multi-variable single objective optimization problem using Metaheuristics.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	**20**
Analyse	**40**
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

222EME043 OPTIMIZATION TECHNIQUES

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain various theorems of duality.
2. Explain the necessity conditions for constrained multivariable optimization with equality and inequality constraints.
3. Explain the various step by step procedure for Fibonacci search for find the maximum and minimum of a unimodal univariate objective function.
4. Explain the various steps involved in goal programming.

5. Explain the difference between heuristics and Metaheuristics

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Find the values of basic variables for the following LPP if the optimum solution is having Basic variable set $X_B = [X_1, X_2]$ using revised simplex method. Also find the range of b_1 (right hand side value of the first constant) so that the solution set will have same optimum basic variables.

$$Max\ Z = 4X_1 + 6X_2 + 2X_3$$

Sub to

$$X_1 + X_2 + X_3 \le 3$$

$$X_1 + 4X_2 + 7X_3 \le 9$$

$$X_1, X2, X_3 \ge 0$$

7 Solve the following LPP by Duel Simplex method.

$$Min\ Z = 2X_1 + 4X_2$$

Sub to

$$2X_1 + X_2 \ge 4$$

$$X_1 + 2X_2 \ge 3$$

$$2X_1 + 2X_2 \le 12$$

$$X_1, X_2 \ge 0$$

8 Determine the maximum or minimum point (if any) for the function

$f(X) = 2X_1^2 + X_2^2 + X_3^2 + 2X_1 X_2 - 8X_1 - 4X_2 - 6 X_3 + 37$

9 Market state of a product for the next month can be Strong Moderate or Weak (S, M, W) and depends only on the market condition of the current month. One step transient probabilities for the market states are given. The manufacturing company has to adopt one of the three marketing strategies namely Aggressive, Basic or Cautions (A , B, C).he returns per month for each of the strategies given a particular state of the market occurs in that month is also given , assuming the state f the product follows a Markov chain, determine the ideal long term marketing strategy to

adopt in order to maximize the expected returns per month.

One step Transient Probabilities

		Next month		
		S	M	W
Current Month	S	0.7	0.3	0.0
	M	0.0	0.6	0.4
	W	02	0.0	0.8

Returns per month in

Lakhs of Rs

		Market State		
		S	M	W
Marketing Strategy	A	43	32	25
	B	35	40	30
	C	20	28	32

10 Minimize

$f(x) = x^4 + 15x^3 + 7x^2 - 1135x$

Terminate when ,

$|f(x_n) - f(x_{(n-1)})| \leq 0.5$

Using Golden search method

11 Explain the principles of Simulated Annealing Algorithm used in optimization.

12 Explain the principles of Genetic Algorithm used in optimization

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Theory of simplex method, Duality Theory, Duality theorems, Dual simplex method, Revised simplex method – Bounded variables algorithm, Sensitivity analysis, Parametric programming. Integer programming: Cutting plane method, Branch and bound method. Network models and solutions: Shortest route problems, Minimal spanning tree problems, Maximal flow problems.	8	20
II	Non-linear programming problems: General non-linear programming problems; Convex, Quasi-convex, Concave and uni-modal functions, Theory of unconstrained optimization – Necessary and sufficient conditions for extrema, Theory of constrained optimization –Lagrange multipliers and Lagrangian optimization, Inequality constraints, Kuhn-Tucker conditions.	8	20
III	Algorithms for unconstrained optimization: Fibonacci search method, Golden section search method, Cauchy's (steepest descent) method. Algorithms for constrained optimization: Quadratic programming, Separable convex programming.	8	20
IV	Multi-objective decision models: Introduction to multi-objective decision making, Concept of pareto-optimality, Goal programming formulation, The weighting method of	8	20

	solution, Analytic hierarchy process. Sequential decision making (stochastic case): Stochastic processes, Markov processes, Markov chains, Markov decision problems, Algorithms for solving Markov decision problems.		
V	Metaheuristics: Nature of metaheuristics, Tabu search, Simulated annealing, Genetic algorithm. Complexity of algorithms: Complexity of algorithms for combinatorial optimization problems.	**8**	**20**

Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	**Parametric programming. Integer programming:**	
1.1	Theory of simplex method, Duality Theory, Duality theorems, Dual simplex method, Revised simplex method.	2
1.2	Bounded variables algorithm, Sensitivity analysis, Parametric programming.	2
1.3	Integer programming: Cutting plane method, Branch and bound method.	2
1.4	Network models and solutions: Shortest route problems, Minimal spanning tree problems, Maximal flow problems.	2
2	**Non-linear programming problems**	
2.1	General non-linear programming problems; Convex, Quasi-convex, Concave and uni-modal functions.	2
2.2	Theory of unconstrained optimization − Necessary and sufficient conditions for extrema.	2
2.3	Theory of constrained optimization −Lagrange multipliers and Lagrangian optimization, Inequality constraints, Kuhn-Tucker conditions.	4
3	**Algorithms for unconstrained optimization**	
3.1	Fibonacci search method.	2
3.2	Golden section search method.	2
3.3	Cauchy's (steepest descent) method.	2
3.4	Quadratic programming, Separable convex programming.	2
4	**Multi-objective decision models & Sequential decision making**	
4.1	Introduction to multi-objective decision making, Concept of pareto-optimality, Goal programming formulation, The weighting method of solution.	2

4.2	Analytic hierarchy process.	2
4.3	Stochastic processes, Markov processes, Markov chains, Markov decision problems.	2
4.4	Algorithms for solving Markov decision problems.	2
5	**Metaheuristics**	
5.1	Nature of metaheuristics.	1
5.2	Tabu search.	2
5.3	Simulated annealing.	1
5.4	Genetic algorithm.	2
5.5	Complexity of algorithms for combinatorial optimization problems	2

Reference Books

4. Rao S.S, Optimization: Theory and Applications, Wiley Eastern, Fourth edition, 2009.

5. Ravindran A., Philips D.T. and Solberg J.J., Operations Research: Principles and Practice, John Wiley & Sons, 4th Edition, 2009.

6. Taha H.A., Operations Research: An Introduction, Pearson Education, 9th Edition, 2013

7. Deb K., Optimization for Engineering Design: Algorithms and Examples, Prentice-Hall of India, 2nd 2012

8. Papadimitriou C.H. and Steghtz K., Combinatorial Optimization: Algorithms and Complexity, Dover Publications Inc, 2000 .

9. Hillier F.S. and Liberman G.J., Introduction to Operations Research, McGraw-Hill International, 10th edition, 2014

10. Reklatis G.V., Ravindran A. and Ragsdell K.M., Engineering Optimization: Methods and applications, John Wiley and Sons, 2nd Edition, 2006

INTERDISCIPLINARY ELECTIVE

CODE 222EME103	**Internet of Things**	CATEGORY	L	T	P	CREDIT
		INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Evaluate IoT enabling technologies
CO 2	Analyse protocols implemented for IoT connected devices.
CO 3	Design and develop Smart Devices using IoT
CO 4	Analyse the vulnerabilities for IoT and security requirements of IoT
CO 5	Apply IoT for various domains

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		2			
CO 2	2		2			
CO 3	2		2			
CO 4	2		2			
CO 5	3	3	3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	80%
Analyse	10%
Evaluate	10%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks
Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: (60 Marks)

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus

Module 1

Introduction to Internet of Things: An overview; Definition, scope and characteristics of IoT; IoT enabling technologies; Structure of IoT; Major components. Sensor technology: sensor types and applications, Actuators: principles and properties. Basics of IoT Networking, Communication Protocols: MQTT, CoAP, AMQP

Module 2

Connectivity Technologies: Zigbee, Bluetooth, RFID. Wireless Sensor Network (WSN) technology- concepts and applications. Machine-to-Machine Communications, IoT and M2M, Interoperability in IoT.

Module 3

IoT device- definition and building blocks; Embedded platforms for prototyping, features and IoT applications; Connecting things to embedded devices. Introduction to Arduino Programming using an IDE (basics only), Integration of Sensors and Actuators with Arduino.

Module 4

Introduction to Raspberry Pi; Python programming; Interfacing Raspberry Pi with basic peripherals; Implementation of IoT with Raspberry Pi (basics only). Cloud platforms for IoT; Cloud security requirements

Module 5

Sensor-cloud, Industrial IoT(IIoT): Requirements of IIoT, applications. Case studies: Smart grid, Smart parking, Remote vehicle diagnostics, Smart Irrigation, Health and fitness monitoring.

Corse Plan

No	Topic	No. of Lectures
1	The Internet of Things: An overview	
1.1	Introduction to Internet of Things, Definition, scope and characteristics of IoT	1
1.2	IoT enabling technologies, Structure of IoT, Major components	2
1.3	Sensor technology, Actuators, principles and properties	2
1.4	Basics of IoT Networking, Communication Protocols	2
2	Architecture, design and connectivity principles	
2.1	Connectivity Technologies	2
2.2	Wireless Sensor Network (WSN) technology, concepts and applications	2
2.3	Machine-to-Machine Communications, IoT and M2M	2
2.4	Interoperability in IoT	1
3	Development of IoT platforms	
3.1	IoT device, definition and building blocks	1
3.2	Embedded platforms for prototyping, Connecting things to embedded devices	2
3.3	Introduction to Arduino Programming using an IDE	3
3.4	Integration of Sensors and Actuators with Arduino	3
4	IoT prototyping and security	
4.1	Introduction to Raspberry Pi, Python programming	2
4.2	Interfacing Raspberry Pi with basic peripherals	3
4.3	Implementation of IoT with Raspberry Pi	2
4.4	Cloud platforms for IoT, Cloud security requirements	2
5	Case studies	
5.1	Sensor-cloud	1
5.2	Industrial IoT(IIoT), Requirements of IIoT, applications	2
5.3	Case studies: Smart grid, Smart parking, Remote vehicle diagnostics	3
5.4	Case studies: Smart Irrigation, Health and fitness monitoring.	2

Reference Books

1. Internet of Things: A Hands-On Approach by Arshdeep Bahga, Vijay Madisetti. Universities press (India)
2. Internet of Things: Architecture and Design principles by Raj Kamal, Publisher: Mc Graw Hill Education
3. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, by Pethuru Raj and Anupama C. Raman , CRC Press.
4. The Internet of Things by Samuel Greengard, The MIT Press Essential Knowledge series.

222EME104	DIGITAL PRODUCT DESIGN AND MANUFACTURING	CATEGORY	L	T	P	CREDIT
		INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble:

The focus of digital product design and manufacturing is the integration of digital technology in design and manufacturing functions in creating new products. It also envisages the use of digital tools such as virtual-augmented reality and additive manufacturing in product design and manufacturing.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Demonstrate the principles of product development process and the role of computers in it.
CO 2	Implement the principles of industrial design to develop new products
CO 3	Apply the innovative digital tools in product design and development
CO 4	Apply the innovative digital tools in simulation and analysis at the design stage
CO 5	Summarize the innovative prototyping techniques in design and understand the industrial practices.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3	2		
CO 3			3			
CO 4			3	2		
CO 5			3		2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	√
Analyse	√
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration

100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

ELECTIVE COURSES

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: (60 Marks)

The end semester examination will be conducted by the respective Colleges. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

QP Code: **Total Pages:**

Reg No.:_______________ **Name:__________________________**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION, Month & Year

Stream: MACHINE DESIGN

Course Code: 222EME104

Course Name: DIGITAL PRODUCT DESIGN AND MANUFACTURING

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions, each carries 5 marks. Marks

1	Elaborate different phases in design.	(5)
2	Explain the role of planning for product distribution.	(5)
3	Explain how VR can be utilised in product development.	(5)
4	Illustrate the role of virtual human in product development.	(5)
5	Differentiate between material extrusion and material jetting additive manufacturing techniques.	(5)

PART B

Answer any 5 full question, each question carries 7 marks.

6	Explain the concept of standardization in product design with the help of an example.	(7)
7	Explain the various aspects of human factors to be considered in product development.	(7)
8	Explain the importance of break-even analysis during design.	(7)
9	Illustrate with examples how VR and AR can be useful in product development.	(7)
10	Demonstrate the significance of product digitalisation in analysis and simulation.	(7)

11	Explain the role of aesthetics in product design.	(7)
12	With the help of neat sketch explain the direct energy deposition method.	(7)

Syllabus:

Module 1

Concept of Product Design: Definition of engineering design, design constraints, different phases in design- conceptual design, embodiment design, detail design, planning for manufacture, planning for distribution, planning for use, Human factors design- ergonomics, anthropometry, comfort criteria, concepts of size, texture and colour, Introduction to product design, product design practices in industry.

Module 2

Tools for product design- drafting-modelling software CAE/CAD, computer aided styling, production process- CAM interface, product development- time and costs. Description of planning for product distribution, Economic factors affecting design.

Module 3

Digital tool enabled design -I: Evolution of digital tools for product design and manufacturing, 2D/3D models to digital mock-up and virtual prototyping (VP). Virtual reality (VR), augmented reality (AR) and Mixed reality, Implementation in product design and manufacturing. Interaction technology, Visualisation technology, Visual display-types- head mounted, organic LEDs, large volume displays, wall type, equipments, characteristics.

Module 4

Digital tool enabled design-II: AR-, tangible, collaborative; examples; AR tracking technology and devices; interaction techniques, haptic technology, olfactory technology. Product digitalization, analysis and simulation. Virtual humans (VH)- for clothing, for ergonomics analysis, biomechanical models.

Module 5

Digital manufacturing: 3D printing- additive manufacturing technology- Classification of additive manufacturing technologies: vat- photo polymerisation, powder bed fusion, material jetting, sheet lamination, material extrusion and direct energy deposition, infill lattice structures.

Corse Plan

No	Topic	No. of lectures
1	**Product development process:**	
1.1	Concept of Product Design: Definition of engineering design, design constraints	2
1.2	Different phases in design- conceptual design, embodiment design, detail design, planning for manufacture, planning for distribution, planning for use	3
	Human factors design- ergonomics, anthropometry, comfort criteria, concepts of size, texture and colour	1
1.3	Introduction to product design, product design practices in industry.	2
2	**Embodiment design:**	
2.1	Tools for product design- drafting-modelling software CAE/CAD, computer aided styling, production process-CAM interface, product development- time and costs.	4
2.2	Description of planning for product distribution, economic factors affecting design.	4
3	**Digital tool enabled design-I**	
3.1	Evolution of digital tools for product design and manufacturing, 2D/3D models to digital mock-up, virtual prototyping (VP).	2
3.2	Virtual reality (VR), augmented reality (AR) and Mixed reality implementation in product design and manufacturing.	3
3.3	Interaction technology, VR- immersive, non-immersive, Visualisation technology, Visual display-types- head mounted, organic LEDs, large volume displays, wall type, equipments, characteristics.	3
4	**Digital tool enabled design-II**	
4.1	AR- tangible, collaborative; examples; AR tracking technology and devices; Interaction techniques, Haptic technology, Olfactory technology	3
4.2	Product digitalization, Analysis and simulation.	2
4.3	Virtual humans (VH)- for clothing, for ergonomics analysis, Biomechanical models.	2
5	**Digital manufacturing**	
5.1	3D printing- additive manufacturing technology- Classification of additive manufacturing technologies: Vat- photo polymerisation, powder bed fusion, material jetting, sheet lamination,	4

5.2	Material extrusion and direct energy deposition, Infill lattice structures	3

Reference Books

1. George Dieter and Linda C. Schmidt, Engineering Design, 4th Edition, Published by McGraw-Hill.
2. Monica Bordegoni and Caterina Rizzi, “Innovation In Product Design From CAD To Virtual Prototyping”, Springer.
3. Karl T Ulrich and Steven D Eppinger, “Product Design & Development.” Tata Mc- Graw Hill, 2003.
4. Ian Gibson, David Rosen and Brent Stucker, “Additive Manufacturing Technologies-3D Printing, Rapid Prototyping, and Direct Digital Manufacturing.” Springer.
5. Fei Tao, Meng Zhang and A. Y. C. Nee, “Digital Twin Driven Smart Manufacturing”, Academic Press, Elsevier.
6. D. T. Pham, S.S. Dimov, Rapid Manufacturing-The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer – Verlag, London, 2001.
7. Kevin Otto & Kristin Wood Product Design: “Techniques in Reverse Engineering and New Product Development.”, Pearson Education New Delhi, 2000.
8. N J M Roozenberg , J Ekels , N F M Roozenberg “ Product Design Fundamentals and Methods”. John Wiley & Sons.
9. AK Chitale & RC Gupta, “Product Design and Manufacturing”, PHI, 2000.

CODE 222EME105	RELIABILITY ENGINEERING	CATEGORY	L	T	P	CREDIT
		Inter Disciplinary Elective	3	0	0	3

Preamble:

Reliability engineering fundamentals and applications, Failure data analysis - Basics of Reliability Prediction Hazard models -System reliability models - Fault-tree analysis

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Explain the tools of statistics and probability to determine the reliability of an item or a system.
CO 2	Discuss the methods of reliability prediction and maintenance strategies according to system characteristics and design transition programs to implement these strategies.
CO 3	Develop ability in formulating suitable strategies to enhance system reliability of a manufacturing system.
CO 4	Implement the concepts of RCM, FTA, FMEA and FMECA in managing the manufacturing organisation with highest possible levels of reliability/ availability.
CO 5	Differentiate various strategies adopted for life testing and maintenance.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2		2	2	
CO 2			3	2	
CO 3			2		2
CO 4			2	3	2
CO 5			2		2

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	30%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Corse Plan

No	Topic	No. of Lectures
1	**Probability and reliability**	
1.1	Probability: Conditional probability, Bayes theorem	1
1.2	Probability distributions – Normal, Lognormal, Poisson, Exponential and Weibull distributions – relationship between them and their significance	2
1.3	Central tendency and dispersion of Normal, Lognormal, Poisson, Exponential and Weibull distributions	1
1.4	Reliability: Definitions, Importance, Quality and reliability,	1
1.5	Bath tub curve -Failure data analysis: Hazard rate, failure rate,	1
1.6	MTTF, MTBF, reliability functions, hazard functions,	1
1.7	Availability and Maintainability	1
2	**Hazard models and system reliability**	
2.1	Reliability hazard models: Parts stress model	1
2.2	Constant and linearly increasing models	1
2.3	Time dependent failure rates, Weibull model	1
2.4	Distribution functions and reliability analysis	1
2.5	System Reliability: Series system configuration	1
2.6	Parallel system configurations	1
2.7	Mixed configurations	1
2.8	k out of m system, standby systems	1
3	**Reliability evaluation and system analysis**	
3.1	Reliability evaluation using Markov model - Development of logic diagram	1
3.2	Set theory, optimal cut set and tie set methods, Markov analysis	2

3.3	Fault-tree analysis: Fault tree construction, calculation of reliability from fault tree	2
3.4	Event tree analysis	1
3.5	FMEA	1
3.6	FMECA	1
4	**Design for reliability**	
4.1	Load – strength interference - Distributed load and strength	1
4.2	Analysis of interference – Effect of safety margin	2
4.3	Software Reliability – software errors – fault tolerance – data reliability – hardware / software interfaces	2
4.4	Reliability prediction of equipments and systems using MIL-217 standards	1
4.5	Reliability prediction of equipments and systems using and NSWC standards	1
4.6	Human Reliability	1
5	**Life testing and maintenance**	
5.1	Maintenance and reliability – Preventive and predictive maintenance	1
5.2	Reliability cantered maintenance	1
5.3	Life Testing – Objectives, Types - Censoring, replacement,	2
5.4	Accelerated life testing – Temperature stress and failure rates – stress combinations, accelerated cycling	2
5.5	HALT	1
5.6	HASS	1

Reference Books

1. Patrick O'Connor, Andre Kleyner, Practical Reliability Engineering, 5th Edition, Wiley India, 2012
2. A Birolini, Reliability Engineering, 8th edition Springer, 2017
3. Naikan V. N. A., Reliability Engineering and Life Testing, PHI, New Delhi, 2009
4. Ebling C. E., "An introduction to Reliability and Maintainability Engineering" Waveland Press, 2019.
5. Balagurusamy E., Reliability Engineering, McGraw Hill Education India P Ltd, 2017
6. Kapoor K. C., Pecht M., Reliability Engineering, Wiley, 2014
7. LS Srinath , Reliability Engineering, East West Press,2017

CODE 222EME106	INDUSTRIAL SAFETY IN ENGINEERING	CATEGORY	L	T	P	CREDIT
		Inter disciplinary Elective	3	0	0	3

Preamble:
The course is intended to give knowledge of various safety management systems, accident prevention techniques, various machine guarding devices, different types of hazards and fire prevention methods. Students will be able to understand the impact of safe industrial operations and become aware of safety responsibilities.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Discuss the basic concepts of Safety Management.
CO 2	Explain the factors contributing to accidents and how that can be controlled.
CO 3	Summarize general safety precautions and safe practices to be followed in Engineering Industries.
CO 4	Explain the occupational health hazards and the methods of control.
CO 5	Implement the firefighting techniques and understand the methods of pollution control.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1		2	3		
CO 2			3		
CO 3			3		
CO 4	2		3		
CO 5		2	3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	40%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to safety and safety management - Objectives and principles of safety management - Need for integration of safety, health and environment	2
1.2	Management's safety policy and Formulation – Safety auditing – Safety budget	2
1.3	Safety committees and its functions - Safety education and training - Motivation and communicating safety	2
1.4	Significance of health and safety culture - 4 E's in industrial safety - Role of management in Industrial Safety - Factors impeding safety.	2
2	**Module II**	
2.1	Accidents and Hazard control - Accident causation - Classification of accidents	2
2.2	Accident proneness - Cost of accidents - Accident investigation – Hazard control programme	2
2.3	Risk analysis - Quantitative risk assessment- Roles and functions of safety professional- Job safety analysis	3
3	**Module III**	
3.1	Machine Guarding - Types of guards	1
3.2	Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping.	2
3.3	Personal protective equipments and personal safety	2
3.4	General safety considerations in material handling - Manual and mechanical - Safety in machine shop	2
3.5	Safety in sewage disposal and cleaning - Disaster management plan for industrial plant.	2
4	**Module IV**	
4.1	Occupational health and industrial hygiene - Functions of occupational health services	1
4.2	Occupational health risks - Functional units of OHS	1
4.3	Occupational diseases - Silicosis - Asbestosis - lead poisoning - Nickel toxicity - Chromium toxicity	2
4.4	Hearing conservation programme - First aid and CPR	1

4.5	Types of industrial hazards and their control - Physical, Mechanical, Electrical, Chemical and Ergonomic hazards	3
5	**Module V**	
5.1	Industrial fire prevention -Methods of extinguishing fire - Classification of fires	1
5.2	Factors contributing towards fire - Fire risk assessment - Fire load	1
5.3	Fire safety plan	1
5.4	Fire detection systems – Fire protection systems	1
5.5	Pollution control in engineering industry - Recent development of safety engineering approaches	2

Reference Books

1. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2. Ronald P. Blake. (1973). *Industrial safety*. Prentice Hall, New Delhi.
3. Krishnan, N.V. (1997). *Safety management in Industry*. Jaico Publishing House, New Delhi.
4. Frank P Lees, 'Loss prevention in process industries',Vol I, II, III, Butterworth, London 1980
5. Heinrich H.W, 'Industrial accident prevention', McGraw Hill Company, New York, 1980.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SECOND SEMESTER M.TECH DEGREE EXAMINATION
222EME106 – **Industrial Safety in Engineering**

Time: 2.5 hrs Max. Marks: 60

Part A

(Answer all questions. Each question carries five marks)

1. Discuss the significance of a safety committee in improving the safety performance of an industry
2. What are the functions of safety professional
3. Which are five 'S' used in housekeeping?
4. Discuss the functions of occupational health services
5. Describe the importance of fire detection systems

Part B

(Answer any five questions. Each question carries seven marks)

6. Discuss the significance of safety policy in reducing the accidents.
7. Differentiate Hazard and Risk with examples
8. Which are the various types of machine guarding devices used industries.
9. Classify the personal protective equipment. List the suitability of at least ten types of PPEs.
10. Discuss the important types of ergonomic hazards associated with industries
11. Describe the selection of different types of fire extinguishers accordance to type of fire
12. Discuss about different types of chemical hazards

COURSE CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222PME100	MINI PROJECT	PROJECT	0	0	4	2

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs.The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee – Programme Coordinator, One Senior Professor and Guide.

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
	Total Marks	100	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222LME003	ADVANCED MANUFACTURING LAB II	Laboratory	0	0	2	1

Preamble: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	To gather knowledge on CNC part programming
CO 2	To gather knowledge on CNC machine tool operations
CO 3	To impart knowledge on surface quality of machined parts
CO 4	To impart gather knowledge on measurement of tool wear and machine vision-based inspection
CO 5	To gather knowledge on software and hardware aspects of additive manufacturing
CO 6	To gather knowledge on programming of industrial robots

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓	✓
CO 4	✓	✓	✓	✓	✓	✓
CO 5	✓	✓	✓	✓	✓	✓
CO 6	✓	✓	✓	✓	✓	✓

Continuous Internal Evaluation (CIE) Pattern:
Total Marks: 100

Attendance	15 marks
Regular class work/Modelling and Simulation Lab Record and Class Performance	60 marks
Continuous Assessment Test (Minimum 1 Test)	25 marks

Continuous Assessment Test Pattern

Bloom’s Taxonomy	Continuous Assessment Test (Marks)
Apply	15
Analyse	10

Syllabus

1. Exercises on Computer aided manufacturing: Part programming fundamentals – manual part programming and computer aided part programming -Simulations
2. Hands on training in computer controlled turning and milling operations - exercises on CNC lathe and machining centre /milling machines.
3. Practical study on surface quality of machined surfaces: Exercises on grinding /turning of components and measurement of surface finish and study of influence of cutting variables on surface quality
4. Study on thread angle measurements/Inspection of tool wear using tool makers microscope. Exercises on machine vision systems–- Machine vision – Computer imaging systems, Image Analysis, Preprocessing, Image model, Image enhancement, gray scale models, Image Transforms.
5. Additive manufacturing basics- Part Consolidation - Topology Optimization - CAD Modeling - Data Formats - Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation. Exercises on 3D printing
6. Exercises on Programming of industrial robots: Introduction to robotics - structure, workspace analysis and various components - hands on training on industrial robots - manual and programmed path planning

No	List of Exercise	Course Outcomes
1	Part programming to do basic turning operations	**CO 1**
2	Part programming to do basic milling operations	**CO 1**
3	Exercises on CNC Lathe/drilling machine operations	**CO 2**
4	Exercises on CNC milling operations	**CO 2**
5	Study on surface quality assessment using Talysurf/other surface metrology instruments	**CO 3**
6	Exercises on tool wear measurements and thread angle measurements	**CO 4**
7	Exercises on machine vision systems-part quality inspection	**CO 4**
8	Exercises on machine vision systems-image enhancement and analysis	**CO 4**
9	Exercises on additive manufacturing; CAD modelling and data formats	**CO 5**
10	Exercises on additive manufacturing; polymer/metal 3D printing	**CO 5**
11	Exercises on industrial robots- study of sensors and actuators	**CO 6**
12	Exercises on industrial robots- manual and programmed path planning	**CO 6**

(Minimum 8 experiments to be done)

References:

1. Chang T.C., Wysk, R.A. and Wang.H.P., “Computer Aided Manufacturing”, Pearson Prentice Hall, India ,2009, ISBN: 978-0131429192

2. Andreas Gebhardt and Jan-Steffen Hotter, “Additive Manufacturing:3D Printing for Prototyping and Manufacturing”, Hanser publications Munchen, Germany, 2016. ISBN:978-1-56990-582-1

3. P. Radhakrishnan, Computer Numerical Control and Computer Aided Manufacture, New Age International Publishers, 2012

4. Deb, S.R.” Robotics Technology and Flexible Automation”, Tata McGraw-Hill, 2009

SEMESTER I

Discipline : CIVIL ENGINEERING
Stream : CE4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE100	PROBABILITY AND STATISTICS	DISCIPLINE CORE	3	0	0	3

Preamble: The objective of this course is to expose the students to the fundamental concepts of probability and statistics. The course aims to equip the students to find solutions for many real-world civil engineering problems and to understand basic data analysis tools by applying the principles of statistics.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	To create an awareness of the concepts of statistics and probability distributions
CO 2	To formulate and test hypotheses for civil engineering problems
CO 3	To apply statistical data analysis tools such as ANOVA and experimental designs
CO 4	To build regression models for civil engineering applications and to identify the principal components
CO5	To apply the concepts of data analysis for a time series

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2		3			2
CO 2	3	2	2	3	3		2
CO 3	3	2	2	3	3		2
CO 4	3	2	2	3	3		2
CO5							

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	25
Evaluate	5
Create	5

Mark distribution

Total Marks	CIA	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Micro project/Course based project	:	20 marks
Course based task/Seminar/Quiz	:	10 marks
Test paper, 1 no.	:	10 marks

The project shall be done individually. Group projects are not permitted. The project may include the implementation of theoretical computation using software packages.
The test papers hall include a minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Syllabus

Module 1- Introduction to probability distributions

Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence. Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.

Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.

Module 2- Statistical Inference

Populations and samples. Sampling distribution of the mean(sigma known and unknown), Sampling distribution of the variance(sigma known and unknown).Interval estimation:-Confidence interval for mean and variance.-Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.-Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence

Module 3- Analysis of variance

Analysis of variance. Completely randomized designs and randomized block designs.-Latin square designs -Factorial experiments: Two-factor experiments (overview only)

Module 4- Correlation and regression models

Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient- Multiple linear regression, normal equations -Principal components (brief overview only)

Module 5-Time Series Models

Components of time series. Identifying linear trend: semi averages method and least squares method. Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient. Forecasting, measuring forecasting accuracy

Course Plan

No	Topic	No. of Lectures
1	**Introduction to probability distributions**	
1.1	Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence.	1
1.2	Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.	2
1.3	Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.	5
2	**Statistical Inference**	
2.1	Populations and samples. Sampling distribution of the mean(sigma known and unknown), Sampling distribution of the variance(sigma known and unknown).Interval estimation:-Confidence interval for mean and variance.	2
2.2	Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.	2

2.3	Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence	4
3	**Analysis of variance**	
3.1	Analysis of variance. Completely randomized designs and randomized block designs.	4
3.2	Latin square designs	2
3.3	Factorial experiments: Two-factor experiments (overview only)	2
4	**Correlation and regression models**	
4.1	Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient	4
4.2	Multiple linear regression, normal equations	2
4.3	Principal components (brief overview only)	2
5	**Time Series Models**	
5.1	Components of time series. Identifying linear trend: semi averages method and least squares method.	2
5.2	Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient.	3
5.3	Forecasting, measuring forecasting accuracy	3
	Total hours	40

Reference Books

1. Gupta. S. C. and Kapoor. V. K, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2020
2. Benjamin, Jack.R and Comell.C, Allin, Probability, Statistics and Decision for Civil Engineers, Mc- McGraw-Hill.
3. Johnson RA , Miller I, Freund J. Miller and Freund's Probability and Statistics for Engineers (9th edition) Pearson. 2018.
4. Response Surface Methodology: Process and Product Optimization Using Designed Experiments, 4th EditionRaymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook ISBN: 978-1-118-91601-8 February 2016.
5. Introduction to Time Series Analysis and Forecasting Second Edition, DOUGLAS C. MONTGOMERY, CHERYL L. JENNINGS, MURAT KULAHCI, John Wiley & Sons, 2015.
6. Papoulis A, Pillai SU Probability, Random Variables and Stochastic Processes McGraw Hill 2022
7. Schiller J, Srinivasan RA, Spiegal M Schaum's Outline of Probability and Statistics, 2012 McGraw Hill
8. Ross S Introduction to Probability and Statistics for Engineers and Scientists Elsevier 6th Edition 2021

Model Question Paper

XXXX PROBABILITY AND STATISTICS

Time: 3 Hrs Max. Marks:60

PART A

(Answer all Questions: Each question carries 5 marks)

1. Explain the concept of mean, median and mode, and its applicability in various contexts with suitable examples.

2. Explain Type I and Type II errors with example.

3. What are the assumptions involved in Analysis of Variance (ANOVA)?

4. Obtain Karl Pearson's correlation coefficient for Stress and Performance.

Observation no.	1	2	3	4	5
Performance	75	80	85	90	95
Stress	80	75	80	60	55

5. Explain briefly the components of time series.

PART B

(Answer any five questions: Each carry 7 marks)

6. The number of products sold by a shop keeper follows Poisson distribution, with a mean of 2 per week. (i) Find the Probability that in the next 4 weeks the shop keeper sells exactly 3 products. (ii) The shop keeper monitors sales in periods of 5 weeks. Find the probability that in the next 15 of these 5-week period, there are exactly 10 periods in which more than 5 products are sold.

7. After conducting series test on ProbabilityandStatistics the following scores were obtained for Batch A and Batch B. Conduct a hypothesis testing for checking the equality of variance in scores of two batchesat a significant level corresponding to a β error probability of 0.9.

A	35	40	42	30	12	50	45	28	26	30
B	20	24	28	26	18	50	50	48	48	09

8. In order to evaluate safety performance of employees across 3 departments, 5 employees across each department were randomly monitored and their safety behaviour on a hundred scale is given below. Do the departments differ in their safety behaviour?

Department	1	2	3	4	5
A1	68	73	75	65	78
A2	85	85	78	86	79
A3	73	77	72	70	76

9. Develop a Regression Equation between A and Busing Method of Least Square. Consider B as the dependent variable. Explain the significance of estimated slope.

Observation no.	1	2	3	4	5
A	75	80	85	90	95
B	80	75	80	60	55

10. Foodgrain production (in lakh tones) is given below. Find the Trend by using 3-yearly and 4-yearly movingaverage method, tabulate the trend values and predict the production for the year 2022.

Years	Production
2008	40
2009	60
2010	45
2011	85
2012	130
2013	135
2014	150
2015	120
2016	200

11. An evaluation of teaching methods shows the following outcomes.

Method of Teaching	No of students	Average marks obtained	Population Standard Deviation
Chalk and Talk Method	32	70	5
PPT and Talk Method	29	65	8

Conduct hypothesis testing for the mean difference of the teaching methods at a significant level corresponding to a Type I error probability of 0.01.

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE007	**THEORY OF ELASTICITY**	**PROGRAM CORE 1**	**3**	**0**	**0**	**3**

Preamble: This course advances students from the one-dimensional and linear solid mechanics problems, conventionally treated in courses of strength of materials, into more general, two and three-dimensional problems. Students will be introduced to rectangular and polar coordinate systems to describe stress and strain in an elastic continuum and also solve various 2D linear elastic problems.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply knowledge of mechanics and mathematics to model elastic bodies as continuum.
CO 2	Formulate boundary value problems; and calculate stresses and strains.
CO 3	Comprehend constitutive relations for elastic solids and compatibility constraints.
CO 4	Solve two-dimensional problems (plane stress and plane strain) using the concept of stress function.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	3	3	3	1
CO 2	3	2	3	3	3	3	1
CO 3	3	2	3	3	3	3	1
CO 4	3	2	3	3	3	3	1

Assessment Pattern

Bloom's Category	Continuous Assessment test	End Semester Examination
Understand	10	15
Apply	10	15
Analyse	20	30
Evaluate	-	-
Create	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

Max. Marks: 60 Duration: 2.5 Hours

PART A

Answer all questions; each question carries 5 marks

1. A rectangular metal bar of cross-section 30 mm × 25mm is subjected to an axial tensile force of 150 kN. Calculate the normal, shear and resultant stresses on a plane whose normal has the following direction cosines: $l = m = 1/\sqrt{2}$ and $n = 0$.

2. Demonstrate the systematic reduction in the number of independent elastic constants from a general anisotropic material to isotropic material.

3. State and explain the principal of stationary potential energy and complementary energy.

4. Show that the function $\phi = A\left(xy^3 - \frac{3}{4} xyh^2 \right)$ is an Airy's stress function. Also calculate and define the stress components on a rectangular domain of width *b* and depth *h*.

5. Determine the shear stress induced and the angle of twist per unit length of a hollow shaft of uniform wall thickness 5 mm with cross section dimensions 80 mm (width) × 20 mm (depth), when subjected to a torque of 1kN-m. The modulus of rigidity $G = 1.3 \times 10^4\ MPa$.

PART B

Answer any five questions; each question carries 7 marks

6. The state of stress at a point in a stressed body is given below:

$$\sigma = \begin{bmatrix} 10 & 4 & 6 \\ 4 & 2 & 8 \\ 6 & 8 & 6 \end{bmatrix} MPa$$

(i) Find the principal planes and principal stresses corresponding to the above stress state. (4 marks)

(ii) Also determine the normal and shear stresses on an octahedral plane. (3 marks)

7. The displacement field in a homogenous isotropic elastic body is given by $u = 1\times 10^{-6}\left[\left(3x^2z + 60x\right)i + \left(5z^2 + 10xy\right)j + \left(6z^2 + 2xyz\right)k\right]$.

(i) Determine the strain components. (3 marks)

(ii) If the coordinate axes are rotated about the z-axis through 45° in the anticlockwise direction, determine the new strain components. (4 marks)

8. Derive the Navier equations for 3D elasticity problems. (7 marks)

9. Explain in detail any three failure theories. (7 marks)

10. Using stress function approach, derive an expression for the maximum deflection of a simply supported beam of length l and depth '2c', if the beam is subjected to a uniformly distributed load of intensity q. (7 marks)

11. Derive the expressions for the maximum shear stress in a bar of elliptical cross-section subjected to torque. Also plot the contour lines for displacement. (7 marks)

12. Figure 1 shows a two cell tubular section having one interior web. An external torque of 10,000 N-m is acting in a clockwise direction. Determine the distribution of internal shear flow. The peripheral lengths are as shown I figure. The cell areas are as follows: A_1 = 800 cm^2 and A_2 = 1780 cm^2.

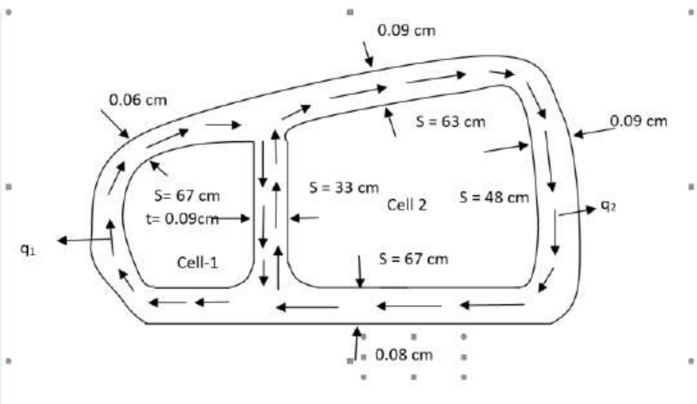


Fig.1

Syllabus and Course Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
	Review of the topics in the undergraduate course Mechanics of Solids from a slightly advanced point of view.	1 Hr.
1	**Analysis of 3D state of stress**	
1.1	Definition of stress at a point – Notation and sign conventions for stress Stress tensor.	1 Hr.
1.2	Differential equations of equilibrium and numerical examples	1 Hr.
1.3	Stress components on an arbitrary plane – stress transformations.	1 Hr.
1.4	Numerical examples on stress transformations and Traction boundary conditions	1 Hr.
1.5	Principal planes and principal stresses -stress invariants.	1 Hr.
1.6	State of stress referred to the principal coordinate system – stress ellipsoid – octahedral stresses.	1 Hr.
1.7	Maximum shear stress, Hydrostatic and Deviatoric Stress, Numerical examples	1 Hr.
2	**Analysis of 3D state of strain and Constitutive relations**	
2.1	Displacement field and strain field – elementary concept of strain.	1 Hr.
2.2	Strain-displacement relations for small deformations,	1 Hr.
2.3	Compatibility conditions – numerical examples	1 Hr.
2.4	Strain transformations; Principal strains	1 Hr.
2.5	Strain invariants, Octahedral strains, Hydrostatic and deviatoric components of strain.	1 Hr.
2.6	Generalized Hooke’s law: Reduction in number of elastic constants: general anisotropy, orthotropy and isotropy.	1 Hr.
3	**Boundary value problems of elasticity, energy theorems and failure theories**	
3.1	Boundary value problems of elasticity- Displacement, Traction and Mixed types.	1 Hr.
3.2	Navier equations and Beltrami-Michell’s Equations.	1 Hr.
3.3	St.Venant’s principle, Uniqueness of solutions.	1 Hr.
3.3	Energy theorems - Strain energy and Complimentary energy.	1 Hr.
3.4	Principle of stationary potential energy and minimum complementary energy.	1 Hr.
3.5	Principle of virtual work for deformable bodies – illustrative examples	1 Hr.
3.6	Failure theories or Yield criteria: Maximum principle stress theory, Maximum shear stress theory, Maximum normal strain theory.	1 Hr.
3.7	Octahedral shear stress theory, Maximum elastic energy theory, Maximum distortion energy theory.	1 Hr.
4	**Two-Dimensional Problems of Elasticity**	

4.1	Plane stress and plane strain problems	1 Hr.
4.2	Solution of plane problems in rectangular coordinates- stress function approach	1 Hr.
4.3	Airy’s stress function and Biharmonic equation in rectangular coordinates; Solution by polynomials – Numerical examples.	1 Hr.
4.4	Elasticity solution for bending of cantilever loaded at free end	1 Hr.
4.5	Elasticity solution for bending of Uniformly loaded simply supported beam.	1 Hr.
4.6	2D problems in polar coordinates - Equations of equilibrium in polar coordinates	1 Hr.
4.7	Strain displacement, compatibility and stress-strain relations in polar coordinates	1 Hr.
4.8	Stress function approach for solution of 2D problems in polar coordinates- Airy’s stress function and Biharmonic equations	1 Hr.
4.9	Problems of axisymmetric stress distributions- Thick cylinders subjected to internal and external pressures.	1 Hr.
4.10	Stress concentrations due to circular hole in plates	1 Hr.
5	**Torsion of noncircular bars**	
5.1	St.Venant’s Semi-inverse method	1 Hr.
5.2	Prandtl’s stress function approach	1 Hr.
5.3	Stress function approach for solution of torsion of bars of elliptical cross section	1 Hr.
5.4	Stress function approach for solution of torsion of bars with triangular cross section	1 Hr.
5.5	Prandtl’s membrane analogy.	1 Hr.
5.6	Membrane analogy application to prismatic bars of narrow rectangular cross-section and thin-walled open sections.	1 Hr.
5.7	Torsion of thin-walled single cell hollow closed sections	1 Hr.
5.8	Torsion of thin-walled multiple cell closed sections.	1 Hr.

Reference Books

1. Timoshenko S.P. and J. Goodier, McGraw-Hill.
2. Ugural A. C. and S. K. Fenster, “Advanced Strength and Applied Elasticity”, Prentice Hall.
3. Ragab A.R. and S.E. Bayoumi, Engineering Solid Mechanics, Fundamentals and Applications, CRC Press New York.

3. Boresi A.P. and R. J. Shimidt, Advanced Mechanics of Materials, John Wiley & Sons, Pvt. Ltd.
4. Srinath L.S., Advanced Mechanics of Solids, Tata McGraw-Hill publishing company, NewDelhi.
5. Sadd. M., Elasticity: Theory, Applications and Numerics, Elsevier.
6. C. T. Wang, “Applied Elasticity”, Mc-Graw Hill Book Company, New York.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE008	**STRUCTURAL DYNAMICS**	**PROGRAM CORE 2**	**3**	**0**	**0**	**3**

Preamble: The course provides the basic concepts of structural dynamics and the theoretical background to perform dynamic analysis of structures. The course focuses on analysis of single and multi-degree of freedom systems. An introduction to distributed parameter system is also included. The course also provides an introduction to earthquake analysis of structures.

Course Outcomes: After the completion of the course on Structural Dynamics, the student will be able to

CO 1	Model single and multi-degree freedom systems for dynamic analysis and develop equations of motion
CO 2	Estimate parameters of dynamic systems
CO 3	Perform dynamic analysis of single degree freedom systems
CO 4	Perform dynamic analysis of multi - degree freedom systems
CO 5	Analyse and design vibration isolation systems
CO 6	Perform dynamic analysis of distributed parameter systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3		2				
CO 2	3		2				
CO 3	2		2		1		
CO 4	1		1		1		
CO 5	1		1	1	1		
CO 6	1		1		1		

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	46
Analyse	14
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no.: 10 marks

The project shall be done individually. Group projects not permitted.

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

QP CODE:

Reg No.:__________________________

Name:____________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION,

MONTH & YEAR

Course Code: 221TCE008

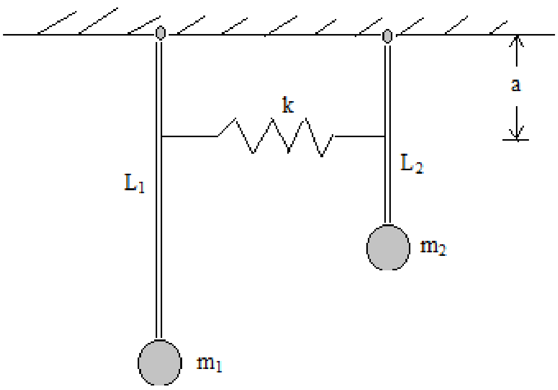
STRUCTURAL DYNAMICS

Max. Marks: 60 Duration: 2.5 hours

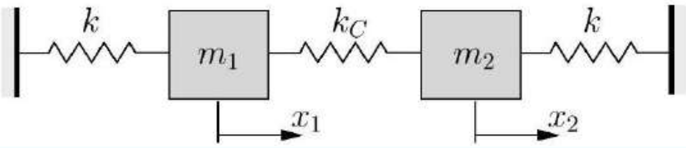
PART A

(Answer ***ALL*** questions; each question carries 5 marks)

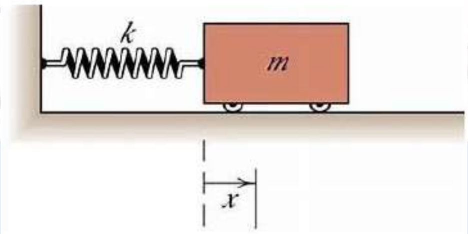
1. Calculate the natural frequency of transverse vibrations of a cantilever beam 40mm diameter circular cross section, carrying a load of 500N at the free end. Span of the cantilever is 800mm. E = 200GPa. If a spring of stiffness 52.75kN/m is introduced between the mass and the beam calculate the change in natural frequency.
2. A sieving machine weighs 2500kg and when operating at full capacity, it exerts a harmonic force of 3kN amplitude at 20Hz on its supports. After mounting the machine on spring type vibration isolators, it was found that the harmonic force exerted on the supports had been reduced to a 250N amplitude. Determine the stiffness of the isolator springs. Take $\zeta = 10\%$.
3. Two pendulum bobs are suspended from the ceiling using massless rigid bars and the bars are connected using a spring as shown in figure. Derive the equation of motion for small oscillations. Write down the mass and stiffness matrices of thesystem. Take $m_1 = 2.0$kg, $m_2 = 1.5$kg, $L_1 = 1.5$m, $L_2 = 1.0$m, a = 0.5m, k = 150N/m.



4. Establish the equation of motion for the frame shown in figure, if it is subjected to a suddenly applied constant acceleration 0.28g at its base. Take m_1 = 10kg, m_2 = 20kg, k = 1500N/m, k_c = 2000N/m.



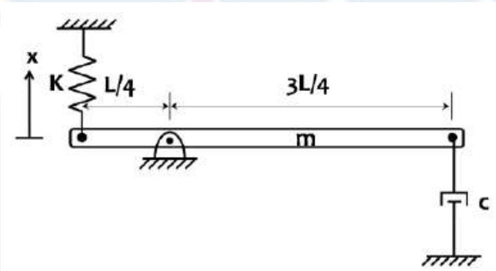
5. Obtain the equation of motion of a SDOF system shown in figure using Lagrange's equation. Take m = 10kg and k = 5000N/m.



PART B

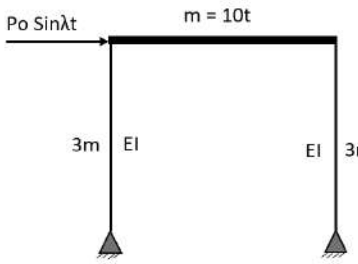
(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Determine the parameters in an equivalent model of the system as shown in the figure when θ, the clockwise angular displacement of the bar from the system's equilibrium position, is used as generalized coordinate. Assume small θ.



7. One of the construction companies hires you to determine the dynamic properties of a frame system for which it has lost the original blue prints. Being a civil engineer, you were assigned to do a free vibration test of the frame system. Supplied with a hydraulic jack, you were able to apply a jacking force to displace the frame. With a jacking force of 134kN, you noted down that the frame has displaced 0.76cm. On the first return swing after release, the frame did not come back to the release point but rather it stopped at 0.64cm towards it. You recorded time between the release and the first return as 2s. Determine the following
   a. Weight of the frame
   b. Natural frequency
   c. Logarithmic decrement
   d. Damping ratio
   e. Damping frequency
   f. Amplitude of the frame after 6 cycles

8. A frame is subjected to harmonic loading as shown in figure. If Po = 20kN, calculate the dynamic amplification factor and amplitude of steady state response for the following cases. (i) λ = 10rad/s, (ii) λ = 15rad/s, (iii) λ = 20rad/s. Comment on the results. Take ζ = 5% and EI = 10^{10}kNmm^2.



9. Derive the expression for the response of a SDOF system subjected to a rectangular impulse of duration t_1 and magnitude P_0.
10. State and prove the orthogonality condition of normal modes in a MDOF system.
11. Explain mode superposition method of analysis.
12. Derive the differential equation governing the flexural vibration of beams. How will you find the undamped free vibration solution? Demonstrate for a simply supported beam of span L having uniform flexural rigidity EI and �mass per unit length.

****

Syllabus

Module 1

Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion. Undamped and damped free vibration of single degree of freedom system. Measurement of damping from free vibration response - Logarithmic decrement.

Module 2

Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band width method. Impulse response function, Response of single degree of freedom systems subjected to impulse, periodic and general loading- Duhamel integral. Single degree freedom subjected to support motion. Vibration isolation –Transmissibility.

Module 3

Multi-degree of freedom systems – Equation of motion. Shear building concept and models for dynamic analysis –Evaluation of natural frequencies and mode shapes by solution of characteristic equation. Co-ordinate coupling - Orthogonality of normal modes.

Module 4

Forced vibration analysis of multi-degree of freedom systems - Mode superposition method of analysis. Response of multi degree of freedom systems to support motion.

Module 5

Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods. Flexural vibration of beams, natural frequencies and mode shapes of simply supported beam. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only) –Variational formulation of the equation of motion – Hamilton's principle - Lagrange's equation.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Dynamics and Free Vibration of SDOF Systems (9)**	
1.1	Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion.	4
1.2	Undamped and damped free vibration of single degree of freedom system.	4
1.3	Measurement of damping from free vibration response - Logarithmic decrement.	1
2	**Forced Vibration of SDOF Systems (11)**	
2.1	Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band width method.	3
2.2	Impulse response function, Response of single degree of freedom systems subjected to impulse (rectangular, triangular and half sine wave), periodic and general loading- Duhamel integral.	4
2.3	Single degree freedom subjected to support motion.	2
2.4	Vibration isolation –Transmissibility	2
3	**Free vibration of MDOF Systems (7)**	
3.1	Multi-degree of freedom systems – Equation of motion.	1
3.2	Shear building concept and models for dynamic analysis – Evaluation of natural frequencies and mode shapes by solution of characteristic equation.	5
3.3	Co-ordinate coupling - Orthogonality of normal modes.	1
4	**Forced Vibration of MDOF Systems (7)**	

4.1	Forced vibration analysis of multi-degree of freedom systems - Mode superposition method of analysis.	4
4.2	Response of multi degree of freedom systems to support motion.	3
5	**Distributed Parameter Systems (6)**	
5.1	Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods.	1
5.2	Flexural vibration of beams, natural frequencies and mode shapes of simply supported beam. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only).	4
5.3	Variational formulation of the equation of motion – Hamilton's principle - Lagrange's equation.	1

Reference Books

1. Clough R W and Penzien J, Dynamics of Structures, McGraw Hill, New Delhi.
2. Biggs J M, Introduction to Structural dynamics, McGraw Hill, New Delhi.
3. Mario Paz, Structural Dynamics – Theory and Computation, CBS Publishers and Distributors, Delhi.
4. Mukhopadhyay M, Structural Dynamics - Vibrations and Systems, Ane Books India, Delhi.
5. Humar J, Dynamics of Structures, CRC Press, Netherlands.
6. Anil K Chopra, Dynamics of Structures- Theory and Application to Earthquake Engineering,
7. Pearson Education, New Delhi.
8. Roy R Craig, Structural Dynamics – An Introduction to Computer Method, John Wiley & Sons, Newyork.
9. Thomson W T, Theory of Vibration with Application, Pearson Education, New Delhi.
10. Weaver W, Timoshenko S P, Young D H, Vibration Problems in Engineering, John Wiley & Sons, USA.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221LCE003	ADVANCED STRUCTURAL ENGINEERING LAB	LABORATORY	0	0	2	1

Preamble: To familiarize the students with the different sophisticated instrumentations used in the laboratory and field for measuring/monitoring stress, strain, deflection etc. in structures. New construction materials, their testing and construction practices are introduced. It also provides the students to observe the behaviour of reinforced concrete structural elements and steel sections. It also encompasses to develop a firm foundation for research and practice in Civil Engineering.

General Instructions to Faculty:

1. Any 10 of the 13 experiments included in the list of experiments need to be performed mandatorily. Virtual Lab facility cannot be used to substitute the conduct of these mandatory experiments.

2. The laboratory should have possession of modern testing equipment such as Linear variable differential transducer -Hydraulic jack-load cells-indicators- crack detection microscope - Data logger-Rebound hammer, ultrasonic pulse velocity- rebar locator, core cutter, concrete penetrometer.

3. Periodic maintenance and calibration of various testing instruments needs to be made.

Course Outcomes:

After the completion of the course on Advanced Structural Engineering Lab, the student will be able to:

CO 1	Understand basic test for the materials,
CO 2	Compute the mix proportion for various types of concrete as per IS guidelines.
CO 3	Evaluate the mechanical properties of concrete
CO 4	Analyse the behaviour of reinforced concrete elements.
CO 5	Analyse the behaviour of steel members
CO 6	Familiarise modern instruments.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	2	2	3	2	2	
CO 2	2	2	2	3	2	2	
CO 3	3	3	2	3	3	2	
CO 4	3	3	3	3	3	2	
CO 5	3	3	3	3	3	2	
CO 6	3	3	3	3	3	2	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	100	–	–

Continuous Internal Evaluation Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Syllabus and Course Plan

Mix design of concrete

Material characterisation-Mix design of normal-fibre reinforced and self-compacting concrete as per IS code guidelines.

Study of instruments

Mechanical strain gauges-Electrical strain gauges - Linear variable differential transducer - Hydraulic jack-load cells-indicators-Data logger- crack detection microscope -Non-destructive testing

Testing of Reinforced concrete elements and Structural steel sections

Behaviour of under-reinforced concrete beams under flexure-shear- Behaviour of short reinforced concrete columns under axial compression-Steel bending tests on steel joists-Buckling of steel angles- Torsion of closed and open sections- Behaviour of bolted connections.

List of Experiments

Expt. No.	Title	Hours Allotted
1	Determination of properties of constituent materials in concrete.	2
2	Study on the mix design of normal and high strength concrete as per IS code. Introduction to fibre reinforced concrete.	2
3	Casting of cubes, beams and cylinders with designed normal strength concrete and fibre reinforced concrete.	2

4	Introduction to self-compacting concrete. Study on the mix design and flow properties of self-compacting concrete as per IS code.	2
5	Study on the working of mechanical strain gauges-Electrical strain gauges - Linear variable differential transducer - Hydraulic jack-load cells-indicators- crack detection microscope -Data logger.	
6	Behaviour of under-reinforced concrete beams under flexure	2
7	Behaviour of reinforced concrete beams under shear	2
8	Bending tests on steel joists	2
9	Behaviour of short reinforced concrete columns under axial compression	2
10	Buckling of steel angles	2
11	Torsion of closed and open sections	2
12	Behaviour of bolted connections	2
13	Non-destructive testing	2

Reference Books/Resources:

1. Pillai S.U &Menon D – Reinforced Concrete Design, Tata McGraw Hill Book Co., 2009.
2. "Concrete Technology"- Neville – Pearson Publishers, 2000
3. Subramanian, N., "Design of Steel Structures", Oxford University Press.
4. Iyengar, N.G.R., "Elastic Stability of Structural Elements", Macmillan India Ltd., New Delhi, 2007.
5. IS 456:2000, "PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE", Bureau of Indian Standards New Delhi.
6. IS 10262 : 2019-Concrete Mix Proportioning-Guidelines.
7. IS 800:2007, "GENERAL CONSTRUCTION IN STEEL - CODE OF PRACTICE", Bureau of Indian Standards New Delhi.
8. SP 6(1) Hand book for structural Engineers.
9. IS 4000 (1992): Code of practice for high strength bolts in steel structures [CED 7: Structural Engineering and structural section.

SEMESTER I

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE036	ADVANCED THEORY AND DESIGN OF CONCRETE STRUCTURES	PROGRAMME ELECTIVE 1	3	0	0	3

Preamble: Design of an advanced reinforced concrete structures are one of the primary requisites of any structural engineer. Hence the course aims to provide a detailed theoretical background of various design philosophies and their applications using national and international design guidelines. Therefore, at the end of the course the student is expected to analyse and design various special reinforced concrete structures. The students are also able to apply the knowledge in real civil engineering problems and to design new and advanced reinforced concrete structures.

Course Outcomes: After the completion of the course on Advanced Theory and Design of Reinforced Concrete Structures, the student will be able to

CO 1	Understand the behaviour of reinforced concrete and its components.
CO 2	Familiarise the various advanced reinforced concrete structural elements.
CO 3	Analyse the various advanced reinforced concrete structural elements.
CO 4	Design the advanced reinforced concrete structural elements like deep beam, slender column.
CO 5	Design the special reinforced concrete structural elements like corbel and beam column joint.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1		2	3	2	1	1
CO 2	1		2	3	2	1	1
CO 3	3	2	3	3	3	2	1
CO 4	3	2	3	3	3	2	1
CO 5	3	2	3	3	3	2	1

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	10
Apply	25
Analyse	15
Evaluate	–
Create	–

Mark Distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper CIVIL ENGINEERING-CE4

Max. Marks: 60 **Duration: 2.5 hours**

PART A

(Answer ALL questions; each question carries 5 marks)

1. (a) Write short notes on
   i) Confined concrete
   ii) Bauschinger effect
2. Draw the design bending moment envelop allowing 30% redistribution for the beam fixed at both ends of span 8m and carrying a udl of 25kN/m.
3. Sketch the strut and tie model for a corbel and describe how the load is carried by corbel.
4. What is the purpose of shear wall? Discuss the classification of shear walls.
5. Explain with a sketch the forces acting on a beam column joint.

PART B

(Answer any FIVE questions; each question carries 7 marks)

6. Determine the short-term deflection of a simply supported beam having a span of 6m.and a cross section of 300x600mm. it is subjected to a udl of 30kN/m. The tension reinforcement consists of three 25 mm dia bars and compression reinforcement as two 20mm dia. Bars both at an effective cover of 40 mm. The grade of concrete is M25 and steel used is Fe415.
7. A beam of size 250mmx600mm with 25mm clear cover to steel is reinforced with 3x25mm dia. As tension steel and 3x16mm dia. as compression steel. The section is subjected to a maximum bending moment of 220KN-m. use M20 and Fe415. Determine the maximum probable crack width at the soffit of the beam.
8. A transfer girder carries two square column of size 600mm each with factored load 7500kN located at 1/3rd of the span. The beam has thickness 600mm and total depth 4m. Use fck = 35N/mm2 and fy = 415N/mm2. The girder has a span of 12m. Design the beam for given loads ignoring self-weight Use Strut and Tie.
9. A column of size 400 mm x 600 mm subjected to factored load Pu = 2000 kN, Mux = 160 kNm and Muy = 120 kNm. The unsupported length of column is 4m. Design the reinforcements in the column, assuming M20 concrete and Fe415 steel. Provide 60mm effective cover to reinforcement
10. Design an exterior Type I joint for the following data:
    Column 500 x 500mm with 8 Nos. 25mm longitudinal bars, maximum load on column is 5000 kN.
    Main beam 450 x 500 mm with ultimate capacity 390 kNm and tension steel 4 Nos. 25mm.
    Spandrel beam cross section 450 x 600 mm, Storey height 3 m.
    Assume M20 concrete and Fe 415 steel.
11. How the beam column joints are classified into different categories? Explain with neat sketch each one of them.
12. Explain classical theory of cracking.What are the factors affecting the crack width?

Syllabus

Module 1

Stress-strain characteristics of concrete under single and multi- axial stresses- confined concrete--Effect of cyclic loading on concrete and reinforcing steel- Ultimate Deformation and ductility of members with flexure strength and deformation of members under shear--Moment-curvature relationship of RCC flexural members- Tension stiffening effect of concrete in flexural members, and corresponding equivalent moment of inertia-Codal procedures on immediate and long-term deflections in reinforced concrete beam and slab as per IS.

Module 2

Classical theory of cracking-factors affecting crack width-control of cracking- Codal procedures on crack width computation in reinforced concrete beams in flexure as per IS-Inelastic behaviour of reinforced concrete beams – plastic hinge formation-length of plastic hinge-Conditions for moment redistribution-redistribution of moment in reinforced concrete fixed and two span continuous beams (numerical problems).

Module 3

Development- Design methodology- selecting dimensions for struts, tie and nodal zones-compression fans- ACI 318 Provisions- Design of deep beam as per ACI 318 provisions-Design of Corbel as per ACI 318 provisions.

Module 4

Biaxial bending of columns- interaction diagrams-IS method of design-Analysis and Design of slender RCC columns- Types of shear walls-Loads in shear walls-Principle of shear wall analysis-Distribution of lateral loads in uncoupled shear walls- Equivalent Stiffness Method-Shear Wall Frame Interactions.

Module 5

Beam column joint- classification –Type 1 and Type 2 joint- failures in joint-forces acting on joint- Ductile detailing as per IS code- joint shear strength as per ACI 318 code (numerical problem is not required)- Design of an exterior type I beam-column joint.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to behaviour of reinforced concrete structural elements and Limit state of Deflection (9)**	
1.1	Stress-strain characteristics of concrete under single and multi-axial stresses- confined concrete--Effect of cyclic loading on concrete and reinforcing steel	3
1.2	Ultimate Deformation and ductility of members with flexure	2

	strength and deformation of members under shear--Moment-curvature relationship of RCC flexural members.	
1.3	Tension stiffening effect of concrete in flexural members, and corresponding equivalent moment of inertia	1
1.4	Codal procedures on immediate and long-term deflections in reinforced concrete beam as per IS	2
1.5	Codal procedures on immediate and long-term deflections in reinforced concreteslab as per IS.	1
2	**Limit state of crackingand redistribution of moments. (7)**	
2.1	Classical theory of cracking-factors affecting crack width-control of cracking	2
2.2	Codal procedures on crack width computation in reinforced concretebeams in flexure as per IS	2
2.3	Inelastic behaviour of reinforced concrete beams – plastic hinge formation-length of plastic hinge.	1
2.4	Conditions for moment redistribution-redistribution of moment in reinforced concretefixed and two span continuous beams (numerical problems)	2
3	**Strut and Tie Models (8)**	
3.1	Development- Design methodology- selecting dimensions for struts,tie and nodal zones-compression fans	2
3.2	ACI 318 Provisions	1
3.3	Design of deep beam as per ACI 318 provisions	2
3.4	Design of Corbel as per ACI 318 provisions	3
4	**Slender Columns and Shear wall (9)**	
4.1	Biaxial bending of columns- interaction diagrams	2
4.2	IS method of design-Analysis and Design of slender RCC columns.	2
4.3	Types of shear walls-Loads in shear walls-Principle of shear wall analysis- Distribution of lateral loads in uncoupled shear walls	3
4.4	Equivalent Stiffness Method- Shear Wall Frame Interactions.	2
5	**Beam-column joint (7)**	
5.1	Beam column joint- classification –Type 1 and Type 2 joint-failures in joint-forces acting on joint.	3
5.2	Ductile detailing as per IS code- joint shear strength as per ACI 318 code (numerical problem is not required)	2
5.3	Design of an exterior type I beam-column joint	2

Reference Books

1. Varghese P.C, Advanced Reinforced Concrete Design, Prentice Hall of India Pvt Ltd, 2008.
2. Park,R and Paulay T, “Reinforced Concrete Structures”, (John Wiley & Sons, New York).
3. Arthur. H. Nilson, David Darwin and Charles W Dolan, “Design of Concrete Structures”, Tata McGraw Hill, 2004
4. Pillai S.U & Menon D – Reinforced Concrete Design, Tata McGraw Hill Book Co., 2009.
5. Purushothaman.P. “Reinforced Concrete Structural Elements”, Behaviour , Analysis and Design (Tata McGraw Hill 1986)
6. Relevant IS codes (IS 456, IS 13920)
7. ACI 318-11, Building Code Requirements for Structural Concrete and Commentary, ACI Michigan.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE037	HIGH RISE BUILDINGS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: Due to urbanization and lack of land, it has become inevitable to construct high rise structures. This subject will make the students aware of the various structural systems for high rise structures and the suitability of each towards different varying parameters. The course provides the basic principles involved in the design of high-rise structures. Different types of loads acting on a high-rise building are to be discussed after which the structural system required to take these loads are to be dealt with. The methods of analysis of high-rise structure are also to be discussed.

Course Outcomes: After the completion of the course on High-Rise Structures the student will be able to

CO 1	Describe the design philosophy and design criteria for tall buildings.
CO 2	Identify the characteristics of wind and earthquake loads acting on high rise structure.
CO 3	Choose and apply appropriate structural systems for different sizes and heights of structures
CO 4	Analyse the effect of gravity and lateral loads on structural members of tall structures.
CO 5	Analyse the behaviour of different structural forms and systems to carry lateral loads of high-rise structures
CO 6	Apply modelling and analysis methods for high rise buildings.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			2				
CO 2	1		2				
CO 3	1		3	2	1		
CO 4	1		2				
CO 5	1		2				
CO 6	2		3		1		

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Preparing a review article based on peer reviewed original publications (Minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 marks

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper CIVIL ENGINEERING-CE4

QP CODE:

Reg No.:_______________

Name:______________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE037

HIGH-RISE BUILDINGS

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer *ALL* questions; each question carries 5 marks)

1. Explain the factors affecting the growth, height and structural forms of tall buildings.
2. Discuss the different types of gravity loads and associated parameters to be considered for the analysis and design of a tall building.
3. List with sketches, three floor systems suitable for high rise structures.
4. Explain the behaviour of high-rise structures with braced frames.
5. Discuss the advantages of outrigger braced structure over core structure.

PART B

(Answer *any FIVE* questions; each question carries 7 marks)

6. Discuss the design criteria for high rise structures.
7. Explain the need of wind tunnel test. What are the different types of wind tunnel experiments for high rise buildings.
8. Explain the different performance levels of building considered in Performance based seismic design.
9. A three-span beam each of 4m span carries a dead load of 6 kN/m for all the spans and 4kN/m for the two consecutive spans from right. Determine the support moments for the beams, if it is simply supported through out.
10. Discuss the advantage of a wall frame structure over framed or wall structures.
11. Discuss the different types of modelling for high rise structures.

****

No	Topic	No. of Lectures
Module – 1		
1.1	Definition and need of tall building - Historic background - factors affecting growth	1
1.2	Design Criteria, Design Philosophy of High-Rise structures	2
1.3	Materials	2
2.1	Dead and live load, live load reduction techniques	2
Module – 2		
2.2	Sequential loading, Impact loading	1
2.3	Wind Loading - Wind Characteristics, Static and Dynamic wind effects - Analytical and wind tunnel experimental method	3
2.4	Seismic Loading - Earthquake loading-equivalent lateral force method, modal analysis, Introduction to Performance based seismic design	3
Module – 3		
3.1	Structural form, Floor systems, Rigid frame Structures, rigid frame behaviour	3
3.2	Approximate determination of member forces by gravity loading-two cycle moment distribution	3
3.3	Approximate determination of member forces by lateral loading-Portal method, Cantilever method	2
Module – 4		
4.1	Braced frames- Types of bracings-behaviour of bracings, behaviour of braced bents-method of member force analysis-method of drift analysis	2
4.2	Infilled frames, behaviour of infilled frames-stresses in infill-forces in frame- design of infill and frame (no numerical)-horizontal deflection	2
4.3	Shear wall Structures-behaviour of shear wall structures - proportionate wall systems, non-proportionate wall systems (no analysis required)- horizontal deflection, Coupled shear walls - behaviour of coupled wall structures	2
4.4	Wall frame structures- behaviour of wall frames	2
Module – 5		
5.1	Tubular structures-framed tube structures-bundled tube structures-braced tube structures	1
5.2	Core structures, Outrigger-Braced Structures	1
5.3	Foundations for tall structures-pile foundation-mat foundation	2
5.4	Modelling for analysis for high rise structures – approximate analysis, accurate analysis and reduction technique.	2

5.5	Discussion of various Finite Element Packages for the analysis of High-Rise Structures	

Text Books

1. Bryan Stafford Smith and Alex Coull, Tall Building structures: Analysis and Design, Wiley-Interscience, New York, 1991.

2. Bungale S Taranath, Structural Analysis and Design of Tall Buildings, Tata McGraw Hill,1988.

Reference Books

1. Robert L Wiegel, Earthquake Engineering. Prentice Hall, 1970.

2. Kolousek V, Pimer M, Fischer O and Naprstek J, Wind effects on Civil Engineering Structures. Elsevier Publications, 1984

3. IS 16700:2017, Criteria for Structural Safety for Tall Concrete Buildings, BIS

4. High Rise Building Structures, Wolfgang Schueller, Wiley

5. Designing and installation of services in building complexes and high rise buildings, Jain, V.K., Khanna Publishers, New Delhi.

6. High rise structures; design and constructions practices for middle level cities, Gupta, Y.P., New Age International Publishers, New Delhi.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE038	EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The proposed course is expected to enhance and strengthen the knowledge on conducting laboratory experiments on structures. Purpose and structure of measurement system, strain gauge types, LVDT, photo elasticity, Nondestructive testing methods, Computer based data acquisition systems, Errors in measurement will be discussed.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand characteristics of a measurement system
CO 2	Understand working and types of strain gauges and force transducers
CO 3	Understand working and types of potentiometers and accelerometers
CO 4	Understand different types of Non destructive testing methods
CO 5	Understand the application of Two-dimensional photoelasticity in analysing stress or strain.
CO 6	Understand working of recording instruments like chart recorders and CROs.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	2	3	2	2	1	1
CO 2	1	2	3	2	2	1	1
CO 3	1	2	3	2	2	1	1
CO 4	1	2	3	2	2	1	1
CO 5	1	2	3	2	2	1	1
CO 6	1	2	3	2	2	1	3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25%
Analyse	25%
Evaluate	20%
Create	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %

Model Question Paper CIVIL ENGINEERING-CE4

Pages: 2 **D**

Reg. No……………… Name:…...…………………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION

STRUCTURAL ENGINEERING

221ECE038: EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERING

Max. Marks: 60 Duration: 3 Hours

PART A

Answer all questions. Each question carries 5 marks (5x 5=25Marks)

1. Explain measurement system and its structure with a diagram.
2. Explain terms: Repeatability, Sensitivity and Precision
3. Explain ideal characteristics of a strain gauge.
4. Explain strain gauge construction.
5. Explain the types of potentiometers.

PART B

Answer any five questions (5x7=35Marks)

6. Explain any seven static performance characteristics of a measurement system.
7. Explain electrical resistance strain gauges- it's working with figure, advantages and disadvantages.
8. Explain Vibrating wire resistance strain gauges- it's working with figure, advantages and disadvantages.
9. Explain Piezo electricaccelerometers - it's working with figure, advantages and disadvantages.
10. Explain the principle, working, advantages and disadvantages of LVDT with a figure.
11. Explain principle, working, correlation with quality of concrete, advantages and disadvantages of Rebound hammer method with a figure.
12. Explain principle, components and working of Cathode ray oscilloscope with a figure.

……………………

No	Topic	No. of Lectures
1	**Measurement system**	
1.1	measurement system – structure , purpose, components	1
1.2	Static Characteristics - Accuracy, Precision, Repeatability / Reproducibility , Threshold,	1
1.3	Static Characteristics - Resolution, Sensitivity, Discrimination, Static error ,Tolerance	1
1.4	Static Characteristics - Span, Range, Dead space, Hysteresis, Drift, Linearity	1
1.5	Dynamic Characteristics – Fidelity, Dynamic error, speed of response, measuring lag.	1
1.6	zero order, first order and second order instruments, Calibration – Standards and evaluation	1
2	**Measurement of Strain and Force transducers**	
2.1	Strain gauge – Ideal characteristics – Types: Mechanical, Electrical resistance, Optical gauges;	1
2.2	Electrical resistance strain gauges: working and types.	1
2.3	Gauge materials: foils, backing, adhesives. Gauge construction – gauge factor;	1
2.4	Vibrating wire strain gauges- working.	1
2.5	Strain gauge bridges – Potentiometric and Wheatstone bridge – strain sensitivity; forms of wheat stone bridge.	1
2.6	Strain gauge Rosette – two elements, three elements – rectangular, star- delta.	1
2.7	Force transducers: working principle – Load cells: different types.	1
2.8	Pressure transducer: working- types.	1
3	**Measurement of displacement and acceleration**	
3.1	Potentiometers – principle, working, different types- linear, rotary;	1
3.2	Linear variable differential transformer – principle, working, advantages	1
3.3	Accelerometers – Application- Characteristics of Accelerometers	1
3.4	Working of Piezo electric and Piezo resistive accelerometer	1
3.5	Working of Capacitive accelerometer	1

3.6	Working of LVDT Type accelerometer	1
3.7	Working of potentiometric accelerometer	1
3.8	Calibration techniques.	1
4	**Non Destructive Testing Methods and Statistical Analysis**	
4.1	uses- advantages and disadvantages of NDT methods –	1
4.2	Ultrasonic pulse velocity Method- principle, working, advantages and disadvantages, correlation of each method with quality of concrete:	1
4.3	Hardness methods - Rebound Hammer - principle, working, advantages and disadvantages, correlation of each method with quality of concrete	1
4.4	Core sampling technique- principle, working, advantages and disadvantages, correlation of each method with quality of concrete	1
4.5	Pullout experiment - principle, working, advantages and disadvantages	1
4.6	Detection of embedded reinforcement – acoustic emission and electromagnetic method- principle, advantages, Limitations, application.	2
4.7	- Errors in measurement: Systematic and Random;	1
4.8	Uncertainties in measurement- Types; Normal Distribution	1
4.9	Confidence level- determination.	1
5	**Photo elasticity and Indicating & recording elements**	
5.1	uses of polarised light - Maxwell's stress optic law – Two-dimensional photo elasticity.	1
5.2	polariscopes – use, components, working and Types.	1
5.3	Photo elastic model materials- properties; Isoclinics and Iso chromatics – properties.	1
5.4	Moire fringe method of stress or strain analysis- techniques and its use. Advantages and disadvantages of Moire fringe method.	2
5.5	Chart recorders – Types, working.	1
5.6	Cathode ray oscilloscope – principle, components, working.	1
5.7	Computer based data acquisition systems – structure and	1

	components, working.	

Reference Books

1. Bently JP - Principles of Measurement Systems – Longman, 1995
2. Nakra B. C. &Chaudhry - Instrumentation Measurement & Analysis - Tata McCraw Hill, 2004
3. Adams L F - Engineering Measurements and Instrumentation – English University Press, 1975
4. Doebelin E O - Measurement Systems Application & Design - McGraw Hill, 2003
5. Dally JW & Riley WF – Experimental stress Analysis - McGraw Hill, 1991

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE039	**STRUCTURAL OPTIMIZATION AND RELIABILITY OF STRUCTURES**	**PROGRAM ELECTIVE 1**	**3**	**0**	**0**	**3**

Preamble: Uncertainty is inherent in the design of structural systems, whether it be on the loading front or be on the material strength front or even on the analysis model. Optimization and Reliability techniques help engineers arrive at an optimal design solution for engineering structures in an uncertain environment. This course is designed to introduce structural optimization and structural reliability methods to graduate students. The course, through first two modules introduces conventional techniques as well as genetic algorithm methods for structural optimization application. Modules III & IV covers the elementary probability theory, random variables and univariate and bivariate distributions. Level 2 reliability methods and simulation techniques are introduced in Module V.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Formulate optimization problems in structural engineering
CO 2	Apply appropriate algorithms for the solution of optimization problems in structural engineering
CO 3	Identify the various sources of uncertainty in variables encountered in structural design / assessment and apply the mathematical theory of probability for modelling uncertainties encountered in engineering systems.
CO 4	Evaluate the probability of failure / reliability of structural elements and simple structural components using level 2 reliability methods as well as simulation techniques.

Mapping of course outcomes with program outcomes

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
CO 1	3	1	3	3	3	2	3
CO 2	3	1	3	3	3	2	3
CO 3	3	1	3	3	3	2	3
CO 4	3	1	3	3	3	2	3

Assessment Pattern

Bloom's Category	Continuous Assessment Test	End Semester Examination
Understand		10
Apply		25
Analyse		15
Evaluate		10
Create		-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 70% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B.

Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

PART A

Answer all questions.

All Questions carry equal (5) marks

1. A contractor is considering two general pits from which he may purchase materials to supply for a project. The unit cost to load and deliver the material to project site is Rs 500/m^3 from pit 1 and Rs 300/m^3 from pit 2. He must deliver a minimum of 10,000 m^3 to the site. The mix that he delivers must consist of at least 50% sand, not more than 60% gravel, not more than 8% silt. The material at pit 1 consists of 30% sand and 70 % gravel. The material at pit 2 consists of 60% sand, 30% gravel and 10% silt. Formulate a minimum cost model.

2. Explain the solution procedure of an unconstrained Geometric programming problem using differential calculus. Illustration should be based on the standard form of a geometric programming problem.

3. A building may fail by excessive settlement of the foundation or by collapse of the superstructure. Over the life of the building, the probability of excessive settlement of the foundation is estimated to be 0.10, whereas the probability of collapse of the superstructure is 0.05. Also, if there is excessive settlement of the foundation, the probability of superstructure collapse will be increased to 0.20.

   (a) What is the probability that building failure will occur over its life ?.

   (b) If the building failure should occur during its life, what is the probability that the failure is due to superstructure collapse?

4. If X is maximum annual wind speed with the probability density function

$$f_X(x) = \lambda . e^{-\lambda x}; x \geq 0$$

   Where, λ is the parameter of the distribution. The wind record shows that the probability of the maximum annual wind velocity less than 70 mph is 0.9. Determine the parameter λ. Also determine the mean, standard deviation.

5. The axial load carrying capacity of a column *R*, is normally distributed with $\mu_R = 1000kN$ and $\delta_R = 0.2$. The column is subjected to an axial load *S*, which is normally distributed with $\mu_S = 700kN$ and $\delta_S = 0.43$. Calculate the probability of failure of the column assuming *R* and *S* to be independent.

PART B

Answer any FIVE questions

6. Find the ultimate plastic moment capacities M_b and M_c of the steel frame ABCD for minimum weight. The weight of the frame may be assumed to vary linearly with the plastic moment capacity. Column AB and CD are identical. AB=CD=4m, BC=6m. At midspan of beam BC, 140 KN load acts downwards. A lateral load of 70 KN load acts at joint B towards right. Assume supports A and D as fixed.

7. Solve the geometric programming problem

Minimize $z = \frac{1}{x_1 x_2 x_3} + 2x_2x_3+3x_1x_3+4x_1x_2$

Subject to the condition that all variables have positive values.

8. The problem of finding the equilibrium configuration of a two bar pendulum subjected to horizontal force is coined as an optimization problem involving minimization of potential energy. The problem is proposed to be solved using Genetic Algorithm. The inclinations of the bars to the vertical (α_1 and α_2) are treated as the decision variables. The integer values assigned to the different possible angles are listed in table 1.

TABLE 1

Sl.no:	Angle	Integer	Sl. no:	Angle	Integer
1	0	0	9	48	8
2	6	1	10	54	9
3	12	2	11	60	10
4	18	3	12	66	11
5	24	4	13	72	12
6	30	5	14	78	13
7	36	6	15	84	14
8	42	7	16	90	15

An initial population of variables (α_1 and α_2) was randomly generated as given in table 2. Tabulate its binary encoding (8 bit string with 2 substrings of 4 bit each representing each variable). The fitness of the individual strings are also given in table 2. Calculate the expected count. Based on the expected count, judiciously create a mating pool after reproduction.

TABLE 2

Population No:	Angles		Fitness
	α_1	α_2	
1	0	0	1
2	12	18	1.8
3	84	72	1.92
4	36	60	4.58
5	6	30	3.01
6	42	72	4.6
7	84	60	1.92
8	12	6	2.11

9. a. Write a note on the common probability distributions used in modelling uncertainties in the context of structural reliability analysis. (3 marks)

b. A bridge can be damaged by failure in foundation (F) or in the superstructure (S). The corresponding failure probabilities for a particular bridge are estimated to be 0.05 and 0.01 respectively. Also, if there is a foundation failure, then the probability that the superstructure will also suffer some damage is 0.50.

(i) find the probability of damage to the bridge

(ii) If the events F and S are statistically independent, what is the probability of damage to the bridge. (4 marks)

10. a. What are joint probability distributions? Develop expressions for absolute and central moments related to continuous joint distributions. (3 marks)

b. Given $f_{XY}(x,y) = A.x\,;\quad for\ 0 \le y \le x \le 1.0.$

find (i) the constant A, (ii) the marginal density functions $f_X(x)$ and $f_Y(y)$ and

(iii)The conditional densities $f_{X|Y}(x|y)$ and $f_{Y|X}(y|x)$ (4 marks)

11. a. Derive the exact solution for the probability of failure when the demand and capacity variables (*R* and *S*) and uncorrelated and lognormally distributed. (3 marks)

b. The buckling strength of a column is given by

$$R = \frac{\pi^2 EI}{l^2}$$

Where, *E* is the Young's modulus, *I* the moment of Inertia and *l* the length of the column.

The column is subjected to a load Q. The mean and coefficient of variations of all the random variables are given below.

$$\mu_E = 2.03 \times 10^5\ N/mm^2;\ \delta_E = 0.1;\quad \mu_I = 12.5 \times 10^6\ mm^4;\ \ \delta_I = 0.05$$

$$\mu_l = 5000mm;\ \ \delta_l = 0.05;\ \mu_Q = 700\ kN;\ \ \delta_Q = 0.3$$

If all the variables are lognormally distributed and uncorrelated, define a suitable performance function and hence determine the probability of failure of the column.

12. a. Explain the procedure for generation of samples of a random variable following an arbitrary distribution. (2 marks)

b. Estimate the Hasofer-Lind reliability index corresponding to shear mode of failure a simply supported steel I beam. The beam is subjected to a point load Q at midspan. The following statistics are known about the load and resistance variables.

$$\mu_Q = 4000\ N;\ \ \sigma_Q = 1000\ N;\ \mu_F = 95\ Mpa;\ \ \sigma_F = 10\ MPa$$

$$\mu_D = 50\ mm;\ \ \sigma_D = 2.5\ mm$$

Web thickness, t_w = 1.25 mm (deterministic)

Where D is the overall depth of beam and F is the shear strength of material. Q, F and D are uncorrelated normal random variables.

NB: Two cycles of iterations alone expected. (5 marks)

Syllabus and Course Plan

(For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Engineering application of Optimization- statement of an optimization problem-Design vector, design constraints, objective function-classification of optimization problems.	1 Hr.
1.2	Classification of optimization problem based on nature of objective function- linear and nonlinear programming problems-standard form of linear programming problems.	1 Hr.
1.3	Simplex algorithm-identifying an optimal point	1 Hr.
1.4	Duality in linear programming, symmetric primal-dual relation.	1 Hr.
1.5	Primal dual relation when the primal is in standard form-degeneracy	1 Hr.
1.6	Application of linear programming in Civil Engineering	1 Hr.
1.7	Linear programming problem examples on design of tubular column	1 Hr.
1.8	Limit design of steel portal frames-graphical method of solution	1 Hr.
2	**Module II**	
2.1	Dynamic programming-multistage decision process-conversion of a numerical system in to a serial system	1 Hr.
2.2	Concept of sub optimization and the principle of optimality	1 Hr.
2.3	Computational procedure in dynamic programming	1 Hr.
2.4	Unconstrained minimization problem-solution of an unconstrained geometric programming problem using differential calculus	1 Hr.
2.5	History and development of genetic algorithm-basic concepts-biological background	1 Hr.
2.6	Genetic modelling-Representation of design variables, objective function and constraints. Creation of off springs-search space-binary encoding-fitness function	1 Hr.
2.7	Genetic operators-reproduction-roulette wheel selection-cross over-mutation	1 Hr.
2.8	Convergence of genetic algorithm. Comparison of Genetic algorithm with other metaheuristic approaches	1 Hr.
2.9	Solution of constrained optimization problems using genetic	1 Hr.

	algorithm	
	Numerical example using genetic algorithm	1 Hr.
3	**Module III**	
3.1	Uncertainties in engineering design- sources; Need for reliability analysis; **Review of fundamental theory of probability**- events & associated probability; Combination of events; De Morgan's rule; Axioms of probability, conditional probability, statistical independence and total probability theorem Note: examples related to structural engineering for illustration to be given as hand out and discussion on the solved example.	1 Hr.
3.2	Random events and random variables- Probability structure of discrete & continuous random variables	1 Hr.
3.3	Main descriptors of random variables; Moments of random variables	1Hr.
3.4	Common continuous probability distributions (Continuous & Discrete) - Binomial, Poisson, Exponential, Gamma, Uniform, Normal and lognormal distributions- Note: examples related to structural engineering for illustration to be given as hand out and discussion on the solved example.	2Hr.
4	**Module IV**	
4.1	Joint probability distributions– Discrete random variables (bivariate case) – Marginals and conditional distributions - illustrative examples from structural engineering.	1 Hr
4.2	Joint probability distributions– Continuous random variables (bivariate case) Marginal and conditional distributions- illustrative examples from structural engineering.	1 Hr
4.3	Correlation and correlation coefficients - discrete and continuous RV case	1 Hr.
4.4	Functions of random variables- one linear function of multiple random variables – second moment statistics - illustrative examples from structural engineering.	2 Hr
4.5	Nonlinear function of multiple random variables- second moment statistics - illustrative examples from structural engineering.	1 Hr
`5	**Module V**	
5.1	Basics of structural reliability- concept of limit states/ performance functions; Space of state variables.	1 Hr.
5.2	Probability failure for performance function involving normally distributed random variables and lognormally distributed random variables.	1 Hr.
5.3	Definition of reliability in standard Normal space (Cornell's reliability index).	1 Hr.
5.4	FORM for linear performance functions.	1 Hr.
5.5	MVFOSM for non-linear performance functions.	1 Hr.
5.6	Hasofer-Lind's definition of reliability.	1 Hr.
5.7	Rackwitz-Feissler algorithm.	1 Hr.

5.8	Second order reliability methods.	1 Hrs
5.9	Simulation based reliability estimation-Monte-Carlo Methods-simulation of random numbers with arbitrary distributions – estimation of failure probability.	2 Hrs

Reference Books

1. Singiresu S. Rao, “Engineering Optimization (Theory and Practice)” 3rd Edition, New Age International (P) Ltd.
2. Kirsch U., “Optimum Structural Design”, McGraw Hill
3. Fox R.L., “Optimization Methods for Engineering Design”, Addison Wesley
4. Goldberg D.E., “Genetic Algorithms in Search, Optimisation and Machine Learning”,Addison Wesley Publishing Company.
5. Rajasekaran, S. & Vijayalakshmi, G.A., “Neural Networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications”, PHI Learning Private Ltd, 2012
6. Krishnamoorthy E.V. and Sen S.K., “Numerical Algorithms”, Affiliated East West Press
7. Haldar A & Mahadevan S. Probability, Reliability and Statistical Methods in Engineering Design, John Wiley & Sons, Inc. NewYork, 2000
8. Haldar A & Mahadevan S. Reliability Assessment Using Stochastic Finite Element Analysis, John- Wiely & Sons Inc., New York, USA, 2000
9. Ayyub B M, McCuen R H. Probability, Statistics and Reliability for Engineers and Scientists, Chapman & Hall, Florida, USA, 2000.
10. Ang A H S & Tang W H. Probability Concepts in Engineering Planning and Design, Vol I, John Wiley, New York, 1984
11. Nowak A.S. and Collins K.R. Reliability of Structures, McGraw-Hill International Editions, USA, 2000.
12. Papoulis A. Probability, Random Variables and Stochastic Processes, McGraw-Hill, New York, USA, 1991.
13. Ranganathan R. Structural Reliability Analysis & Design. Jaico Publishing House, Mumbai, India, 1999.
14. Melchers R E. Structural Reliability: Analysis and Prediction, John Wiley, Chichester, 1999

SEMESTER I

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE042	ADVANCED DESIGN OF STEEL STRUCTURES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The proposed course is expected to enhance and strengthen the knowledge on detailed design methods for steel structures, in compliance with Indian and International codes. Analysis and design of bolted and welded connections, Design of steel members under special loads like fire and blast loads, design of industrial structures with gantry girders and design of light gauge structures will be discussed.

Course Outcomes; After the completion of the course the student will be able to

CO 1	Design bolted joints
CO 2	Design of welded joints
CO 3	Design light gauge columns, beams, and tension members
CO 4	Understand fire and blast loads
CO 5	Understand various elements in an industrial building and Design gantry girders
CO 6	Draw structural details of bolted and welded joints, light gauge sections and gantry girder.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	2	3	2	2	1	1
CO 2	1	2	3	2	2	1	1
CO 3	1	2	3	2	2	1	1
CO 4	1	2	3	2	2	1	1
CO 5	1	2	3	2	2	1	1
CO 6	1	2	3	2	2	1	1

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25%
Analyse	25%
Evaluate	20%
Create	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %

Model Question Paper CIVIL ENGINEERING-CE4

Pages: 2 **E**

Reg. No……………… Name:…..…………………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION

ADVANCED DESIGN OF STEEL STRUCTURES

Max. Marks: 60 Duration: 3 Hours

PART A

Answer all questions. Each question carries 5 marks (5× 5=25Marks)

1. Why are HSFG bolts preferred in joints subjected to fatigue?What do you mean by Prying action?
2. Discuss the advantages and disadvantages of welded connections over bolted connections.
3. What is local buckling of thin elements and what do you mean by post buckling strength of light gauge steel members?
4. Draw a plot showing the stress-strain relationships of structural steel marking salient points.
5. Explain sway and non-sway frames. Include at least two examples of each type using appropriate figures.

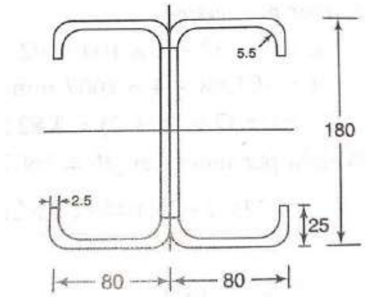
PART B

Answer any five questions (5×7=35Marks)

6. Design a seat connection for a factored beam end reaction of 110kN. The beam section is ISMB 250 @ 36.6 kg/m connected to the flange of column section ISHB 200 @ 36.6 kg/m. Use Fe 410 grade steel and bolt 4.6 grade.

7. Design a welded stiffened seat and clip connection for an ISMB 350 @ 51.4 kg/m to transmit a factored end reaction 320 kN to a column ISHB 300 @ 57.6 kg/m. Steel Fe 410 grade and use fillet weld of required size.

8. Two channels of 180 mm x 80 mm section with bent lips as shown in figure 1 are connected with webs to act as beam. The thickness of the plate is 2.5 mm and the depth of the lip is 25mm. The beam has an effective span of 4.1 m. Determine the allowable load per m run on the beam. The dimensions in the figure 2 are in mm. Use fy = 235 N/mm^2 .



9. A light gauge rectangular box- section with overall cross-sectional dimensions of 200 mm x150 mm (out- to-out), thickness 2.5 mm and fillets of radius 2.5 mm at each of the 4 inside corners, is being employed as a column over an effective length of 3.2 m. Compute the safe load on the column is steel used is having yield stress of 2400 kg/cm^2.

10. Explain the design principles for design of structures against fire, blast and impact loads.

11. Explain the knees and valleys in the steel structures with neat figures.

12. A hand operated 50 kN overhead crane is provided in a workshop. The details are given below: i) Centre to centre between gantry girders = 16 m (ii) Span of the gantry girder = 6 m (iii) Weight of the crane = 40 kN Gantry (iv) Wheel spacing = 3 m (v) Weight of the crab = 10 kN (vi) Maximum edge distance = 1 m. Design a simply supported gantry girder, assuming the flange is laterally supported.

Syllabus

Module 1

Bolted Connections: Classification (Simple, Rigid, Semi rigid)–Moment rotation Characteristics–Failure modes of a joint Types of bolts–Bearing and High strength bolts–Prying force–Beam to Column connections–Design of seat angle–Unstiffened–Design of seat angle–StiffenedWeb angle & end plate connections, Beam and column bolted splices–Design of framed beam connection–continuous beam to beam connection.

Module 2

Welded Connections: Structure and properties of weld metal. Beam to-column connections–Angle seatStiffened beam seat connection–Web angle and end plate connections–Beam and column welded splicesTubular connections–Parameters of an in plane joint Welds in tubular joints–Curved weld length at intersection of tubes–SHS and RHS tubes–design parameters–Weld defects.

Module 3

Design of Light Gauge Structures: Design of light gauge steel structures: Introduction–Types of cross sections–Materials Local and post buckling of thin elements–Stiffened and multiple stiffened compression elements–Tension members– Beams and deflection of beams–Combined stresses and connections.

Module 4

Design of Blast, Impact, Snow and Fire-resistant structures: Blast loads–impact loads–Ice-infested loads on structures–Fire loads–Fire-resistant design–Simple problems in Fire loads calculations.

Module 5

Design of Industrial buildings and Gantry girders: Design of members subjected to lateral loads and axial loads–Sway and non-sway frames, bracings, and bents–Rigid frame joints–Knees for rectangular frames andpitched roofs - Knees with curved flanges–Valley joints - Rigid joints in multistorey buildings–Vierendeel girders–Design of gantry girders–Introduction–Loading consideration–Selection of gantry girder–Position of moving load for maximum effects, profile of gantry girder, limitation on vertical deflection–Design of gantry girders.

Course Plan

No	Topic	No. of Lectures
1	**Bolted Connections (9)**	
1.1	Classification (Simple, Rigid, semi rigid)–Moment rotation Characteristics–Failure modes of a joint.	1
1.2	Types of bolts - Bearing and High strength bolts- Prying force–Beam to Column connections.	1
1.3	Design of seat angle – Unstiffened.	1
1.4	Design of seat angle – Stiffened.	1
1.5	Web angle and end plate connections.	1
1.6	Beam and column bolted splices.	1
1.7	Design of framed beam connection – continuous beam to beamconnection.	1
2	**Welded Connections (8)**	
2.1	Structure and properties of weld metal–Beam to-column connections–Angle seat.	2
2.2	Stiffened beam seat connection.	1
2.3	Web angle and end plate connections.	2
2.4	Beam and column welded splices.	1
2.5	Tubular connections - Parameters of an in plane joint Welds in tubular joints.	1
2.6	- Curved weld length at intersection of tubes – SHS and RHS tubes - design parameters- Weld defects.	1
3	**Design of Light Gauge Structures (9)**	
3.1	Design of light gauge steel structures: Introduction – Types of crosssections – Materials.	1
3.2	Local and post buckling of thin elements.	1
3.3	Stiffened and multiple stiffened compression elements.	2
3.4	Tension members.	2
3.5	Beams and deflection of beams.	2
3.6	Combined stresses and connections.	1
4	**Design of Blast, Impact, Snow and Fire-resistant structures (7)**	
4.1	Blast loads - impact loads.	1
4.2	Ice-infested loads on structures.	1
4.3	Fire loads.	1
4.4	Fire-resistant design.	2
4.5	Simple problems in Fire loads calculations.	2
5	**Design of Industrial buildings and Gantry girders (7)**	
5.1	Design of members subjected to lateral loads and axial loads.	1
5.2	Swayand non-sway frames, bracings, and bents.	1
5.3	Rigid frame joints - Knees for rectangular frames and pitched roofs - Knees with curved flanges.	1

5.4	Valley joints - Rigid joints in multistorey buildings - Vierendeel girders.	1
5.5	Design of gantry girders - Introduction - Loading consideration-Selection of gantry girder.	1
5.6	Position of moving load for maximum effects, profile of gantry girder, limitation on vertical deflection.	1
5.7	Design of gantry girders.	1

Reference Books

1. Gaylord, Design of steel structures, McGraw Hill, New York.
2. Duggal.S.K., Limit state design of steel structures, McGraw-Hill.
3. Subramanian.N, Design of steel structures, Oxford.
4. Wie-Wen Yu.,Cold-Formed Steel Structures, McGraw Hill Book Company.
5. Hetherington John and Smith P. D., Blast, and ballistic loading of structures.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE043	FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The proposed course is expected to enhance and strengthen the knowledge on role and responsibility of a forensic engineer, different cause of deterioration in structures and its prevention, the uses of different NDT equipment's, awareness regarding the structural health monitoring, knowledge in Different modern techniques of retrofitting will be discussed.

Course Outcomes: After the completion of the course the student will be able to

CO 1	To understand role and responsibility of a forensic engineer
CO 2	To understand different cause of deterioration in structures and its prevention
CO 3	To gain adequate knowledge for the uses of different NDT equipments
CO 4	To get awareness regarding the structural health monitoring
CO 5	To gain adequate knowledge in Different modern techniques of retrofitting

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	2	3	2	2	1	1
CO 2	1	2	3	2	2	1	1
CO 3	1	2	3	2	2	1	1
CO 4	1	2	3	2	2	1	1
CO 5	1	2	3	2	2	1	1
CO 6	1	2	3	2	2	1	3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25%
Analyse	25%
Evaluate	20%
Create	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

Pages: 2 **E**

Reg. No……………… Name: …..…………………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M.TECH DEGREE EXAMINATION

STRUCTURAL ENGINEERING

221ECE043 FORENSIC ENGINEERING AND REHABILITATION OF STRUCTURES

Maximum Marks: 60 **Duration : 3 Hours**

PART A

Answer all questions. Each question carries 5 marks (5 × 5=25 Marks)

1 Give the qualities expected for a Forensic Engineer.

2 Give a classified list of common causes of deterioration of concrete structures.

3 What are non-destructive tests? Discuss the usefulness and significance of NDT.

4 Explain the needs and benefits of Structural Health Monitoring.

5 Explain how cracking is treated by external pre-stressing.

PART B

Answer any five questions (5 × 7=35 Marks)

6 i) What are the duties and responsibilities of a Forensic Engineer?

ii) In the context of construction industry, explain the terms responsibility and accountability.

7 i) Discuss the errors in design and mistakes in construction those may lead to the premature failure of concrete structures.

ii) How does i) acid attack and ii) freezing and thawing affect the health of reinforced concrete structures?

8 i) What are the different types of maintenances? Discuss the importance of each one.

ii) Give a classified list of environmental factors causing deterioration in concrete structures.

9 i) What is meant by acid attack? How does it occur? What are its effects on concrete structures?

ii) Describe the principle, procedure, advantages and limitations of ultrasonic pulse velocity test.

10 i) Explain Fibre Optic method for prediction of structural weakness.

ii) Give a list of methods for repair of concrete structures.

11 i) As a forensic engineer, how will you select a method for your client?

ii) Explain how cracking is treated by external pre-stressing.

…………………………………

Syllabus and Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

Syllabus:

Failure of Structures: Review of the construction theory – performance problems – responsibility and accountability– Causes of distress in structural members– Design and material deficiencies – over loading. Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment– Preventive measures, maintenance and inspection. Diagnosis and Assessment of Distress: Visual inspection – non-destructive tests – ultrasonic pulse velocity method– Rebound hammer technique – pull-out tests – Windsor probe test– Crack detection techniques. Structural Health Monitoring: Introduction – Needs and Benefits of Structural Health Monitoring– Fibre Optic method for prediction of structural weakness –Methods of repair of cracks Modern Techniques of Retrofitting: Structural first aid after a disaster – guniting, jacketing – use of chemicals in repair–Strengthening by prestressing. Repair of steel structures.

Course Plan:

No	Topic	No. of Lectures
1	**Failure of Structures**	
1.1	Review of the construction theory – performance problems – responsibility and accountability	4
1.2	Causes of distress in structural members	3
1.3	Design and material deficiencies – over loading	4
2	**Environmental Problems and Natural Hazards**	
2.1	Effect of corrosive, chemical and marine environment	4
2.2	Preventive measures, maintenance and inspection	3
3	**Diagnosis and Assessment of Distress**	
3.1	Visual inspection – non-destructive tests – ultrasonic pulse velocity method	4
3.2	Rebound hammer technique – pull-out tests – Windsor probe test	3

3.3	Crack detection techniques	2
4	**Structural Health Monitoring**	
4.1	Introduction – Needs and Benefits of Structural Health Monitoring	2
4.2	Fibre Optic method for prediction of structural weakness – Methods of repair of cracks	4
5	**Modern Techniques of Retrofitting**	
5.1	Structural first aid after a disaster – guniting, jacketing – use of chemicals in repair	4
5.2	Strengthening by prestressing. Repair of steel structures.	3

Reference Books

1. Sidney M Johnson, Deterioration, Maintenance and Repairs of Structures, Mc Graw Hill Book Company, New York

2. Dovkaminetzky, Design and Construction Failures, Galgotia Publication., NewDelhi

3. Jacob Field and Kennenth L Carper, Structural Failures, Wiley Europe

4. Design and Construction Failures, Dovkaminetzky, Galgotia Publication, New Delhi, 2009.

5.Concrete – Building Pathology, Macdonald S, John Wiley and Sons, 2002.

6.Forensic Structural Engineering Handbook, Robert. T Ratay, Mc Graw Hill, 2009.

7.Understanding Building Failures, James Douglas and Bill Ransom, Taylor and Francis Group, 2007.

8.Concrete Repair and Maintenance, Peter H Emmons, Galgotia Publications, 2010.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE044	**DESIGN OF OFFSHORE STRUCTURES**	**PROGRAM ELECTIVE 2**	**3**	**0**	**0**	**3**

Preamble: The course aims to provide a basic understating of the theory and concepts of analysis and design of Offshore Structures. After the completion of the subject the student is expected to apply the knowledge to design Jacket Platforms which is most relevant for Indian Offshore Region.

Course outcomes: After the completion of the course the student will be able to

CO 1	Understand the basics of wave mechanics and estimate the wave kinematics for regular and random waves
CO 2	Estimate the functional and environmental loads acting on offshore structures.
CO 3	Apply theoretical principles and analytical models in the design of offshore structures conforming to code provisions
CO 4	Design tubular members and joints following API specifications
CO 5	Evaluate the fatigue life of Tubular joints of Jacket Platforms
CO 6	Practice the profession of Structural engineering with adequate proficiency in analysis and design of Offshore Structures

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			3	3	3	3	
CO 2			3	3	3	3	
CO 3			3	3	3	3	
CO 4			3	3	3	3	
CO 5			3	3	3	3	
CO 6			3	3	3	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	10
Analyse	10
Evaluate	20
Create	20

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40 + 20 = 60 %.

Model Question Paper CIVIL ENGINEERING-CE4

PART A

(Answer all questions-Each question carries 5 marks)

1. What is a non-linear wave theory? How are they classified? Differentiate with small- amplitude wave theory.

2. Explain the procedure for estimating wind force on an offshore structure.

3. What are the methods of estimating maximum global wave forces on a jacket structure, Explain

4. Why tubular members are commonly used in offshore structures? What are the important factors affecting the strength of a tubular structure?

5. What is stress concentration? Describe the methods for reducing it in tubular joints?

PART B

(Answer any Five questions-Each question carries 7 marks)

1. (a) Explain the classification of offshore structures with sketches.
   (b) A wave flume is filled with fresh water to a depth of 5 m. A wave of height 1 m and period 4 s is generated. Calculate the celerity, group celerity, energy and power.

2. If a pressure sensing instrument is set up at 5 m below SWL in a water depth of 20 m, determine the phase distribution of pressure head. Determine the maximum dynamic pressure. The wave height is 3 m and period is 8s and γ= 10 kN/m3. Also determine the above for a wave with period 4 s.

3. A pile of diameter 0.75m is to be installed in a water depth of 100m. The wave height and wave period are 6m and 10s respectively with Cd = 1 and Cm= 2. Compute the maximum drag force per unit length at a depth of 20m below SWL.

4. Describe the linear diffraction theory. What are the assumptions and boundary conditions?

5. Main leg member of a jacket platform is 1500mm OD x 25mm thick. Effective length of the member is 18m. If the actual axial load is 75% of the maximum permissible axial load, find the additional bending moment that can be resisted by it. Take Fy=250MPa, E=200GPa

6. Tubular member of an offshore structure is subjected to nominal stresses,corresponding number of cycles per year is given below. S_f for member is

found to be 2.9. determine the fatigue life of the member. The S-N curve is represented by logN = 12.164 - 3logS where S is the hot spot stress range in

Nominal stress (N/mm^2)	59	50	40	28	10
Cycles per year	6	150	3340	64050	1142800

N/mm^2.

7. K- joint with the chord and brace details shown below is subjected to axial in plane and out of plane BM. Neglect the stress in the chord member. Yield strength of the connection shall be taken as 345Mpa. Check the safety of the joint.

Data :

Brace 1 d1 = 508 mm t1 = 15.88 mm θ1 = 45°

Brace 2 d2 = 406 mm t2 = 12.7 mm θ2 = 30°

Chord D= 762mm T= 19mm

Gap between braces g = 50mm

Brace 1 P= 900 kN Mip = 275 kNm Mop = 125 kNm

Brace 2 P= 1275 kN Mip = 225 kNm Mop = 145 kNm

Syllabus

Module -I

Basics of Wave Mechanics – Introduction to Offshore structures-classification-fixed, compliant-floating platforms-examples- Wave Theories: Basics of wave motion- Small amplitude wave theory- velocity potential- dispersion relationship- wave kinematics-Pressure under wave-wave energy and power (Numerical exercises to be done)- Finite amplitude waves- classification- Random waves-Wave spectral density-Mathematical spectrum models- Design Wave Method-Spectral Method.

Module -II

Loads on Offshore Structures- Loads on Off shore Structures: Functional loads-Environmental loads-Wave, Wind, and Current Forces- Estimation as per API recommendations - Morison equation- force on vertical and inclined piles- Numerical examples -Wave forces on large structures-linear diffraction theory.

Module- III

Analysis and Design Concepts of Jacket Platforms- Concepts of Fixed Platform Jacket: Components and Funcions, Design Wave Method-Spectral Method- Extreme and Operating Conditions -Estimation of Maximum Wave forces and Moments Maximum Base Shear Method- In-service and Pre-service loads- Principles of Static and dynamic analyses of fixed platforms-In-Place Analysis-Analytical modelling of jacket platforms-deck, jacket and foundation

Module- IV

Steel Tubular Member Design- Principles of WSD and LRFD; Allowable stresses and Partial Safety Factors API specifications for steel-allowable stresses-Design procedure Tubular Members, Slenderness effects; Column Buckling- Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines)-Numerical Examples- Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines)-Numerical Examples.

Module- V

Fatigue in Tubular Joints - Tubular Joints-Classification-Analysis of Joints- Stress Concentration in Tubular joints, S-N curves-Cumulative damage ratio-Fatigue analysis methods- Palmgren- Miner rule- evaluation of Fatigue life of components-numerical examples

Course Plan

No	Topic	No. of Lectures 40
1	**Basics of Wave Mechanics 9**	
1.1	Introduction to Offshore structures-classification-fixed, compliant-floating platforms-examples	2
1.2	Wave Theories: Basics of wave motion- Small amplitude wave theory- velocity potential- dispersion relationship- wave kinematics- Pressure under wave-wave energy and power (Numerical exercises to be done)- Finite amplitude waves-Classification	4
1.3	Random waves-Wave spectral density-Mathematical spectrum models- Design Wave Method-Spectral Method	3
2	**Loads on Offshore Structures 7**	
2.1	Loads on Off shore Structures: Functional loads- Environmental loads-Wave, Wind, and Current Forces- Estimation as per API recommendations	3
2.2	Morison equation- force on vertical and inclined piles- Numerical examples	3

2.3	Wave forces on large structures-linear diffraction theory	1
3	**Analysis and Design Concepts of Jacket Platforms**	**8**
3.1	Concepts of Fixed Platform Jacket: Components and Funcions, Design Wave Method-Spectral Method- Extreme and Operating Conditions -Estimation of Maximum Wave forces and Moments Maximum Base Shear Method	3
3.2	In-service and Pre-service loads- Principles of Static and dynamic analyses of fixed platforms-In-Place Analysis	2
3.3	Analytical modelling of jacket platforms-deck, jacket and foundation	3
4	**Steel Tubular Member Design**	**8**
4-1	Principles of WSD and LRFD; Allowable stresses and Partial Safety Factors API specifications for steel-allowable stresses	2
4.2	Design-procedure Tubular Members, Slenderness effects; Column Buckling.	3
4.3	Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines)-Numerical Examples	3
5	**Fatigue in Tubular Joints**	**8**
5.1	Tubular Joints-Classification-Analysis of Joints	2
5.2	Stress Concentration in Tubular joints, S-N curves- Cumulative damage ratio-Fatigue analysis methods	3
5.3	Palmgren- Miner rule- evaluation of Fatigue life of components- numerical examples	3

Reference Books

1. Dr. Sundar V.," Ocean Wave Mechanics -Applications in Marine Structures" John Wiley and Sons Ltd

2. Chakrabarti,S.K., "Hydrodynamics of Offshore Structures", Computational Mechanics Publications, Southampton, Boston

3. Sreenivasan Chandrasekharan," Dynamic Analysis and Design of Offshore Structures" Second Edition, Springer

4. API-Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms.API-RP2A-WSD (2014)-API-RP2A-LRFD (1993)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE045	ANALYSIS AND DESIGN OF SUBSTRUCTURES	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: Goal of this course is to expose the students to the concepts of soil structure interaction and design of various sub structures. By the completion of this course the students will be able to analyse and design different types of substructures and thereby develop solutions for real world problems.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the soil-structure interaction
CO 2	Analyse and Design shallow foundation
CO 3	Design Pile foundation and Pile cap
CO 4	Analyse and Design Retaining walls
CO5	Design various components of Well foundation
CO6	Analysis and Design Machine foundation

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1			3	1	2	
CO 2	2			3	3	3	
CO 3	3			3	3	3	
CO 4	3			3	3	3	

Assessment Pattern

Bloom's Category	End Semester Examination (Marks)
Understand	20
Apply	20
Analyse	10
Evaluate	10

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum10 publications shall be referred) : 15 marks

Course based task/Seminar/Datacollection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper CIVIL ENGINEERING-CE4

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION, Month & Year

221ECE045: Analysis and Design of Substructures

Maximum: 60marks Time 2.5 hrs

PART A (*Answer all questions: Each question carries 5 marks*)

1. Draw the contact stress distribution below a rigid circular footing and explain

2. What is a pile cap. Specify the functions of a pile cap.

3. Explain the different types of retaining walls

4. Define scour depth and grip length

5. Explain vibration isolation

PART B (Answer any 5 questions: Each question carries 7 marks)

6. Design the strap footing to carry two column loads of 1100kN and 2020kN. The columns are 6m between the centres . The sizes of the columns are 500 x 500 mm and 600 x 600 mm respectively. The footing areas under the columns are respectively 1.2 mx3m and 3m x 3m connected by the suitable strap. The safe bearing capacity of the soil is 205 kN/m2, use M20 concrete and Fe 415 steel

7. Design a reinforced concrete combined rectangular footing for two columns located 3m apart. The overall size of the column are 40 x 40 cm and 60 x 60 cm and the loads on them are 120 tones and 160 tones respectively. The space available for the width of the footing is restricted to 10cm. The safe bearing capacity of the soil is 30 tones per m2. Use M15 concrete and Mild steel for reinforcement.

8. The foundation of a structure consist of 16 piles. It carry a total load of 10,000 kN. The piles are 400 mm x 400 mm size and are 8m long. They are spaced at 1m centre to centre. Design one of the piles. Use M20 concrete and Fe 415 steel.

9. Design a pile cap for a column size 500 mm x 500 mm carrying a load of 3000kN supported by 4 piles. The size of the piles may be taken as 300 mm x 300 mm. The c/c distance between the piles is 1.5m. Use M20 concrete and Fe 415 steel

10. The stem of the cantilever retaining wall is 4.5 m, retains soil of specific weight 20000 N/m3 and having angle of repose of 30° Top surface of the retained soil is level. Design the retaining wall. The safe bearing of the soil is 200kN/m2. Use M20 concrete and Fe 415 steel.

11. Design the outside well diameter of a caisson to be sunk through 40m of sand and water bed rock if the allowable bearing capacity is 2200 kN/m2. The caisson receives a load of 5000kN from the super structure. The mantle friction is 32kN/m2. Test the feasibility of sinking. Also calculate the thickness of seal.

12. The exciting force in a constant force amplitude excitation is 100 kN. The natural frequency of the machine foundation is 3 Hz. The damping factor is 0.30. Evaluate the magnification factor and the transmitted force at an operating frequency of 6 Hz

Syllabus

Module 1

Soil-structure interaction: Introduction to soil-structure interaction - Soil-structure interaction problems. Contact pressure distribution beneath rigid and flexible footing on sand and clay. Contact pressure distribution beneath raft. Selection of foundation .
Shallow foundations: Structural design of spread footing, combined footing and raft foundation.

Module 2

Pile foundation: Introduction- load carrying capacity -Settlement of single pile-Laterally loaded piles-Borm’s method-Ultimate lateral resistance of piles- Structural Design of straight Piles and Structural Design of pile cap

Module 3

Retaining walls: Types-Stability analysis of cantilever retaining wall against overturning and sliding-Bearing capacity considerations-structural design of retaining walls.

Module 4

Well foundation: Introduction to well foundations-Types-Elements of well foundations-Grip length- depth of scour-load carrying capacity-Design of well cap, well steining, well curb, cutting edge and bottom plug.

Module 5

Machine foundation: Types of machine foundation-Basic principles of design of machine foundation-Dynamic properties of soil-vibration analysis of machine foundation-Design of foundation for reciprocating machines and impact machines-Vibration isolation

Course Plan

No	Topic	No. of Lectures
1	**Soil-structure interaction and Shallow foundations**	
1.1	Introduction to soil-structure interaction - Soil-structure interaction problems.	2
1.2	Contact pressure distribution beneath rigid and flexible footing on sand and clay. Contact pressure distribution beneath raft.	3
1.3	Types and Selection of foundation. Structural design of spread footing, combined footing and raft foundation.	3
2	**Pile foundation**	
2.1	Pile foundation: Introduction- load carrying capacity - Settlement of single pile-	2
2.2	Laterally loaded piles-Borm's method-Ultimate lateral resistance of piles-	3
2.3	Structural Design of straight Piles and Structural Design of pile cap	4
3	**Retaining walls**	
3.1	Retaining walls-Types-Stability analysis of cantilever retaining wall against overturning and sliding	3
3.2	Bearing capacity considerations-structural design of retaining walls	4
4.	**Well foundation**	
4.1	Well foundation: Introduction to well foundations-Types-Elements of well foundations-	2
4.2	Grip length- depth of scour-load carrying capacity-	2
4.3	Design of well cap,well steining,well curb,cutting edge and bottom plug	4
5	**Machine foundation**	
5.1	Machine foundation: Types of machine foundation-Basic principles of design of machine foundation	2
5.2	Dynamic properties of soil-vibration analysis of machine foundation-	3
5.3	Design of foundation for reciprocating machines and impact machines-vibration isolation	3

Total hours-8+9+7+8+8=40 hrs

Reference Books

1. Bowles. J.E., " Foundation Analysis and Design", McGraww Hill Publishing co., New York, 1997.
2. Swamy Saran, Analysis and Design of substructures, Oxford and IBH Publishing Co. Pvt.Ltd., 2006.

3.Tomilson.M.J, "Foundation Design and Construction", Longman, Sixth Edition, Ne Delhi-2009

4. Varghese.P.C, "Design of Reinforced Concrete Foundations"-PHI learning private limited, New Delhi-2009

SEMESTER II

Discipline:CIVIL ENGINEERING

Stream : CE4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TCE100	ADVANCED NUMERICAL METHODS	DISCIPLINE CORE 2	3	0	0	3

Preamble: For solving complex problems in mechanics and engineering, a post-graduate student must be well versed in numerical methods along with skills to apply them. This course equips the student with various numerical techniques that finds applications in civil engineering, across various streams (specialisations). Special focus is given to finite element method, explaining the relevance, versatility and fundamental concepts of this numerical tool.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Obtain the solution of simultaneous Linear system of equations
CO 2	Obtain the numerical solutions of ordinary differential equations
CO 3	Obtain the numerical solutions for solving boundary value problems of partial differential equations
CO 4	Describe the terminologies, applications or procedure of finite element method
CO 5	Describe or apply the concept of finite element method

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3			3			
CO 2	3			3			
CO 3	3			3			
CO 4	1		2	2	2	2	
CO 5	3			2	2	2	

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	25
Evaluate	5
Create	5

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Preparing a review article based on peer reviewed original publications (Minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

Note: Enough opportunity to explore the practical examples from specialization should be given to the students. One assignment/course project should be based on the coding or use of packages

End Semester Examination Pattern: 60 marks

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

QP CODE:

Reg No.:_______________

Name:___________________________ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: XXXXXX

ADVANCED NUMERICAL METHODS

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Explain the procedure of solution of Tridiagonal systems
2. Explain single shooting method for solving Boundary value problems
3. Explain the parabolic and elliptic partial differential equations with examples
4. Explain any five practical applications of Finite element in the con
5. Explain Generalised coordinates and Natural coordinates in Finite Element analysis

PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Solve the system of equations by Jacobi's iteration considering initial approximation as $[0.5, -0.5, 0.5]^T$

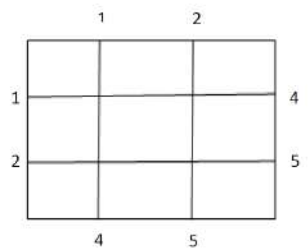
$$4x_1 + x_2 + x_3 = 2$$

$$x_1 + 5x_2 + 2x_3 = -6$$

$$x_1 + 2x_2 + 3x_3 = -4$$

7. Solve $y' = x^2 + y$ for y=0.1, given that $y(0)$=1 considering h=0.05 using (i) Eulers method and (ii) Runge Kutta method

8. Solve the equation $u_{xx} + u_{yy} = 0$ for the square mesh with boundary value as shown in figure



9. Solve $\left(\frac{\partial u}{\partial t}\right)=\left(\frac{\partial^2 u}{\partial x^2}\right)$ subject to the conditions $u(x,0)=\sin(\pi x)$ for $0 \le x \le 1$ $u(0, t)=u(1, t)=0$. Perform the computations of two levels taking $h=1/3$ and $t=1/36$ using Crank Nicolson implicit scheme

10. Explain in detail the steps of finite element analysis

11. Explain forms of shape functions in finite element analysis

12. Explain the convergence criteria in finite element applications in detail

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Syllabus

Module 1 **(7 hours)**

Solutions of simultaneous Linear Systems of Equations- Solution of linear systems – Direct methods, Gauss-Jordan Method-Method of factorization- Solution of Tridiagonal Systems. Solution by matrix decomposition Iterative methods: Jacobi, Gauss-Siedel iteration for ordinary and sparse systems, Convergence of iterative solution schemes with examples.

Module 2 **(7 hours)**

Solving Ordinary Differential Equations- The Elementary Theory of Initial-Value Problems -Euler's Method- Higher-Order Taylor Methods. Runge-Kutta Method- Introduction to solution methods for differential algebraic equations- Single shooting method for solving ODE-BVPs.

Module 3 **(7 hours)**

Partial differential equations in two dimensions- Parabolic equations- Explicit finite difference method. Crank-Nicholson implicit method - Ellipse equations- Finite difference method-Problems with irregular boundaries.

Module 4 **(7 hours)**

Introduction to Finite Element Method – Historical Background — Mathematical Modeling of field problems in Engineering — Governing Equations — Discrete and continuous models — Boundary, Initial and Eigen Value problems– Basic concepts of the Finite Element Method- Displacement approach-Concept of Stiffness Matrix and Boundary Condition-- General procedure of FEA

Module5 **(7 hours)**

Concept of Finite Element Method- Concept of Nodes, elements, Generalised coordinates and Natural coordinates in FEA. Shape functions – Polynomials - Lagrangian and Hermitian Interpolation –- Compatibility - C0 and C1 elements - Convergence criteria - Conforming & nonconforming elements. Development of element matrices for one dimensional elements.

Text Books

1.Gupta,S.K. Numerical Methods for Engineers. Wiley Eastern, New Delhi, 1995.

2. Cook, RD. Concepts and Applications of Finite Element Analysis , Wiley.

Reference Books

1. Gilbert Strang, Linear Algebra and its Applications (4th Ed.), Wellesley Cambridge Press 2009
2. Gourdin, A. and M Boumhrat. Applied Numerical Methods.Prentice Hall India, New Delhi 2000
3. Chopra S.C. and Canale R.P. Numerical Methods for Engineers,McGraw Hill 2006
4. Krishnamoorthy C S, *Finite Element Analysis- Theory and Programming*, Tata McGraw Hill, New Delhi., 1994
5. Rao, SS. Finite Element Analysis, Elsevier Butterworth-Heinemann
6. Gerald and Wheatly*, Applied Numerical Analysis,* Pearson Education.
7. Rajasekharan S., *Numerical Methods in Science and Engineering,* S Chand & Company, 2003.
8. Bathe K J, *Finite Element Procedures in Engineering Analysis*, Prentice Hall, New Delhi. 1982
9. Chandrupatla T R and Belegundu A D, *Introduction to Finite Elements in Engineering*, Pearson Education, New Delhi 1998
10. Rajasekharan S, *Finite Element Analysis in Engineering Design*, Wheeler, New Delhi
11. Hutton D V, *Fundamentals of Finite Element Analysis*, Tata McGraw Hill Education Private Ltd, New Delhi

.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TCE103	FINITE ELEMENT METHOD	PROGRAM CORE 3	3	0	0	3

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop approximate solution to boundary value problems in structural mechanics using method of weighted residuals and variational methods.
CO 2	Develop field approximations for various one- and two-dimensional finite elements.
CO 3	Formulate element equilibrium equations for 1D and 2D finite elements for solution of structural mechanics problems using energy principles.
CO 4	Understand the computational techniques for numerical integrations, large system of equation solvers etc. and apply the same for implementation of finite element method.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	3	3	3	1
CO 2	3	2	3	3	3	3	1
CO 3	3	2	3	3	3	3	1
CO 4	3	2	3	3	3	3	1

Assessment Pattern

Bloom's Category	Continuous Assessment test	End Semester Examination
Understand	10	15
Apply	10	15
Analyse	20	30
Evaluate	-	-
Create	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Model Question Paper

Max. Marks: 60
Duration: 2.5 Hours

PART A

Answer all questions; each question carries 5 marks

1. The stress components at a point in a body are given by

   $\sigma_x = 2xy^2z + 2x;\ \sigma_y = 5xyz + 3y;\ \sigma_z = x^2y + y^2z;\ \tau_{xy} = 0;\ \tau_{yz} = \tau_{xz} = 2xy^2z + 2xy$

   Check whether these stress components satisfy the conditions of equilibrium or not at the point (1,-1,2). If not, determine the suitable body force components required at this point so that the stress components satisfy equilibrium.

2. What are conforming and non-conforming elements? Briefly explain the convergence characteristics of both.

3. Starting from the Hermitian shape functions develop the consistent load vector for a two node 1D beam element subjected to a uniformly distributed of intensity w covering full span.

4. Evaluate the following integrals using two point Gauss quadrature.

(i) $\int_{-1}^{1}\int_{-1}^{1} xy\, dx dy$

(ii) $\int_1^3 \frac{dx}{(x^4+1)^{1/2}}$

5. Write short notes on:
   (i) Shear locking (ii) Storage schemes in FEA

PART B

Answer any five questions; each question carries 7 marks

6. Using modified Galerkin method obtain an approximate solution of the following boundary value problem

$$2u''(x) + 3u(x) = 0, \qquad 1 < x < 3$$

$$u(1) = 1 \qquad \text{Essential boundary condition}$$

$$u'(3) = 1 \qquad \text{Natural boundary condition}$$

Assume a quadratic polynomial satisfying the essential boundary condition as a trial solution.

7. A two-member truss is loaded as shown in Fig.2. The area of cross section of each element is 500 mm² and E = 200 GPa. Compute the displacement components at node 3, reactions at supports and member stresses

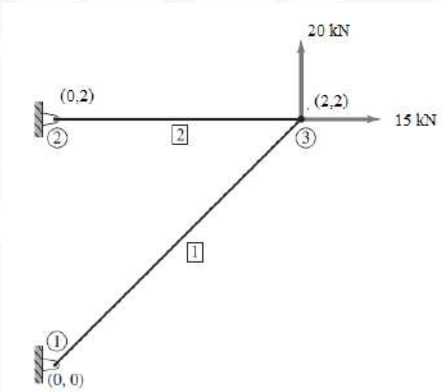


Fig. 2

8. The nodal displacement components (in mm units) of a triangular element from the finite element analysis of a thin plate is shown in Fig.3. Develop appropriate approximations for the u and v fields within the element in terms of area coordinates .

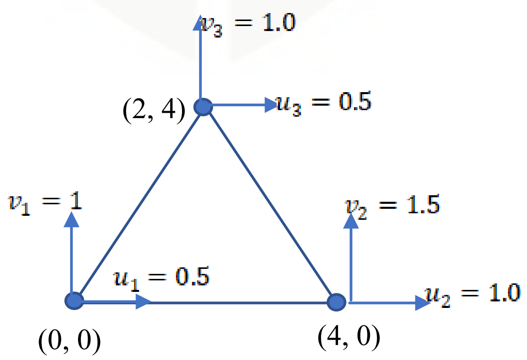


Fig.3.

9. (i) Differentiate between Lagrangian and Hermitian interpolation. (2 marks)

   (ii) Compute the consistent nodal load vector when a surface traction of uniform intensity w N/m length acts normal to the edge containing nodes with coordinates (4,0) and (2,4) of the triangular element shown in Fig.3.

   (5 marks)

10. Develop the FE formulation for an isoparametric 4 node quadratic element for solution of 2D elasticity problems.

11. Develop the Finite element formulation for a Resinner-Mindlin plate element.

12. Write short notes on:

    (i) Spurious energy modes. (4 marks)

    (ii) Frontal solver in FEA. (3 marks)

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Module I: Classical approximate solution of boundary value problems & Introduction to FEA**	
1.1	Idealization of physical problems & mathematical modelling;	1
1.2	Basic equations of elasticity: Equilibrium, traction boundary conditions, Strain – Displacement relations — Constitutive relations; 2D idealization – Plane stress & Plane strain conditions	1
1.3	Approximate solution of boundary value problems – method of least squares,	1
1.4	Approximate solution of BVP-Weighted residual methods-structural mechanics applications.	2
1.5	Approximate solution of BVP -Variational approach (Rayleigh-Ritz method)- structural mechanics applications.	2
1.6	Introduction to Finite Element Method – History of development – Advantages – Disadvantages - General description of the method.	1
2	**Module II: Review of direct stiffness method & field approximations in FEA**	
2.1	Direct stiffness method – Review of basic concepts of matrix displacement analysis – formulation element stiffness matrices and load vectors for truss & beam	2

	elements	
2.2	Coordinate transformations, global assembly, global equilibrium solution, estimation of element forces.	2
2.3	Field approximation in FEA: Polynomial approximations - Convergence & Compatibility requirements	1
2.4	Polynomial approximation for 1D & 2D fields in global coordinates; continuity requirements.	1
2.5	1D & 2D Field approximation using Lagrange polynomials	1
2.6	Area coordinates and field approximation for CST & LST elements	1
2.7	Shape functions for serendipity elements	1
3	**Module III: Formulation of element equations**	
3.1	Development of equilibrium equations for finite elements– using principle of virtual work	1
3.2	Formulation of element equations (including consistent load vector) for 1D bar element for modelling axial behaviour.	1
3.3	Formulation of element equations (including consistent load vector) for 1D beam (Euler-Bernoulli) element for modelling flexural behaviour	2
3.4	Formulation of element equations (including consistent load vector) for CST element for modelling plane stress/strain problems	2
3.5	Formulation of LST & 4 node quadrilateral elements for modelling plane stress/strain problems	1
4	**Module IV: Isoparametric formulations & Numerical Integrations**	
4.1	Geometric approximation – concept of mapping – Isoparametric, sub-parametric and super-parametric mapping. Isoparametric Mapping/formulations for 1D line elements	2
4.2	Isoparametric mapping for planar bilinear elements; formulation of element equations for four node isoparametric quadrilateral element	2
4.3	Restrictions in mapping	1
4.4	Numerical integrations – introduction to Newton-Cotes and Gauss quadrature - Gauss quadrature formulae for 1D integration	2
4.5	Gauss quadrature formulae for 2D	1
5	**Module V: Plate elements, Storage & solution schemes for large system of equations**	
5.1	Introduction to plate bending – Kirchoff and Mindlin plate theories	2
5.2	FE formulations for Kirchoff and Mindlin Plate elements;	2
5.3	Shear locking, reduced and selective reduced integrations; Spurious energy modes;	1
5.4	Global assembly of element equations; Storage schemes in FEA – Banded and Skyline storage; Calculation of semi-band width – node numbering for optimal bandwidth	2
5.5	Solution schemes in FEA – Frontal solver; Discussion of modelling and analysis using recent commercial finite	1

	element software packages	

Reference Books

1. *Cook R D et al., Concepts and Applications of Finite Element Analysis, John Wiley & Sons, Singapore.*
2. *Logan D L, A First Course in Element Method,* Thomson, 2007.
3. *M. Asghar Bhatti, Fundamentals of Finite Element Analysis and Applications, John Wiley &Sons NewJersy, U.S.*
4. *J.N. Reddy, An Introduction to Finite Element Method, Tata McGraw Hill Publishing Company Ltd., New Delhi.*
5. *Hutton D V, Fundamentals of Finite Element Analysis, Tata McGraw Hill Education Private Ltd. New Delhi.*
6. *Krishnamoorthy C S, Finite Element Analysis- Theory and Programming, Tata McGraw Hill, New Delhi*
7. *Rajasekharan S, Finite Element Analysis in Engineering Design, Wheeler, New Delhi*
8. *Chandrupatla T R and Belegundu A D, Introduction to Finite Elements in Engineering, Pearson Education, New Delhi*
9. *Bathe K J, Finite Element Procedures in Engineering Analysis, Prentice Hall, New Delhi*
10. *Zienkiewicz O C and Taylor R W., Finite Element Method, Elsevier Butterworth-Heinemann, UK*

COURSE CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222PCE100	**MINI PROJECT**	**PROJECT**	**0**	**0**	**4**	**2**

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs.The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
	Total Marks	100	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222LCE003	COMPUTATIONAL LAB	LABORATORY	0	0	2	1

Preamble: The course is intended to provide the students with an ability to model, analyse and interpret results by analysing and design various structural elements/whole structure using software packages such as SAP2000, ETABS, STAAD, ANSYS,ABAQUS, MATLAB, MATHCAD, MATHEMATICA, MS-EXCEL, MIDAS CIVIL, CSI BRIDGE, TEKLA, AUTOCAD, REVIT and. It also encompasses to develop a firm foundation for research and practice in StructuralEngineering. It also enables students to familiarize with industry standards projects with the help of cutting-edge technology and software available in the field at presentto have no gap between academia and industry. All design and detailing shall be done as per the latest BIS, IRC and other relevant Codes of Practice.

Course Outcomes: After the completion of the course on Computational Lab, the student will be able to:

CO 1	Model structural elements/ whole structures using finite element packages.
CO 2	Analyse and design structural elements/ whole structures using finite element packages.
CO 3	Interpret results from finite element analysis packages.
CO 4	Draw structural details using AutoCAD.
CO 5	Write design reports.
CO 6	Develop bar bending schedule and bill of quantities from the structural drawings.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	3	3	2	2	2	1
CO 2	2	3	3	2	2	2	1
CO 3	3	3	3	3	2	2	1
CO 4	2	3	3	2	2	2	1
CO 5	2	3	3	2	2	2	3
CO 6	2	3	3	2	2	2	3

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	100	–	–

Continuous Internal Evaluation Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Syllabus and Course Plan

Concrete Structures

Analysis, design and detailing of a G + 10 residential building – Analysis, design and detailing of an overhead circular and rectangular water tanks with staging – Analysis, design and detailing of a ribbed slab floor system–Analysis, design and detailing of shear walls –Application of strut-and-tie method to design and detail various RC elements and junctions – Develop a spreadsheet for generation of interaction curves for RC rectangular columns– Design of slab bridge.

Steel Structures

Design of Steel Industrial Building –Design of Steel Multi-storey Building.

List of Experiments

Expt. No.	**Title**	**Hours Allotted**
1	Analysis, design and detailing of a G + 10 residential building without shear wall.	2
2	Analysis, design and detailing of an overhead circular water tank with staging.	2
3	Analysis, design and detailing of an overhead rectangular water tank with staging using LSM and IS 1893(Part 2)	2
4	Analysis, design and detailing of a ribbed slab floor system.	2
5	Analysis, design and detailing of a G + 10 residential building with shear wall.	2
6	Using strut-and-tie method, design and detail various RC elements and beam-column joints.	2
7	Develop a spreadsheet for generation of interaction curves for RC rectangular columns.	2
8	Design and detail a simply supported slab bridge of spans less than or equal to 6 m.	2
9	Design and detail a Multi-storey Steel Building.	2
10	Design and detail a Steel industrial building.	2
11	Design and detail a single span, straight RC Slab bridge.	2

Reference Books/Resources:

1. Manuals of SAP2000, ETABS, STAAD, ANYSYS, MATLAB, MATHCAD, MATHEMATICA, MS-EXCEL, MIDAS CIVIL, CSI BRIDGE, TEKLA, AUTOCAD, REVIT and ABAQUS.

2. IS 456:2000, “PLAIN AND REINFORCED CONCRETE - CODE OF PRACTICE”, Bureau of Indian Standards New Delhi.

3. IS800:2007, “GENERAL CONSTRUCTION IN STEEL - CODE OF PRACTICE”, Bureau of Indian Standards New Delhi.

4. IS 3370 (Part 1 to 4), “Concrete Structures for Retaining Aqueous Liquids - Code of Practice”, Bureau of Indian Standards New Delhi.

5. IS 1893 (Part 1 to 6), “Criteria for Earthquake Resistant Design of Structures”, Bureau of Indian Standards New Delhi.

6. IRC:112-2020,“Code of Practice for Concrete Road Bridges”, Indian Roads CongressNew Delhi.

7. V. L. Shah and S. R. Karve,“Illustrated Design of Reinforced Concrete Buildings”, Assorted Editorial.

SEMESTER II

PROGRAM ELECTIVE III

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE036	STRUCTURAL HEALTH MONITORING	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: This subject is taught to impart knowledge about the Structural Health Monitoring Concepts.Diagnosis the distress in the structure by understanding the causes and factors.Assess the health of structure using static field methods and dynamic field tests.Suggest repairs and rehabilitation measures of the structure

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

CO 1	Know the causes of Distress in structures, factors effecting structural health, need of regular maintenance of structures
CO 2	Understand the concept of structural health monitoring and various methods applied for monitoring of structures and structural safety
CO 3	Understand the importance of structural audit and Assessment of Health Structure, Collapse and Investigation, Investigation Management, SHM Procedures
CO 4	Know The Importance of Static field testing, Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement
CO 5	Understand the Dynamic Field testing, stress History Data, Dynamic Response Methods, Hardware for Remote Data Acquisition systems, Remote Structural Health Monitoring.
CO 6	Introduction to Repairs and Rehabilitations of Structures impedance (EMI) technique, Adaptations of EMI technique

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	-	-	-	1	-	-
CO 2	-	-	-	1	2	-	-
CO 3	3	-	-	1	2	-	-
CO 4	-	-	-	-	1	-	-
CO 5	-	-	-	-	1	-	-
CO 6	-	2	-	-	2	-	-

Assessment Pattern

Bloom's Category	Continuous Assessment test	End Semester Examination
Remember	10	15
Understand	20	30
Apply	10	15
Create		

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall includeminimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts;Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful inthe testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluationand understanding of the students), with 1 question from each module, having 5 marks foreach question. Students shall answer all questions. Part B contains 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of the students ina course, through long answer questions relating to theoretical/practical knowledge,derivations, problem solving and quantitative evaluation), with minimum one question fromeach module of which student shall answer any five. Each question can carry 7 marks. Totalduration of the examination will be 150 minutes.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State the factors affecting Health of Structures

2.Write short notes on division of maintenance.

3.Define distress

4.Name different types of distress

5. What do you mean by deterioration? Explain themechanism of deterioration in concrete structures?

6. Discuss in detail various construction stage defects & their preventive measures?

7. Explain preventive maintenance of structures? Explainthem in detail

8. Write the different reasons for development of cracksdue to errors in design and detailing. Give preventivemeasures.

Course Outcome 2 (CO2)

1. Define the concept of health monitoring of structures

2. Explain the working system of components of structural health monitoring in detail.

3. Explain Active and Passive Smart Materials

4. What are SHM Technologies? Explain briefly.

5. Enumerate the dynamic response analysis using Laser Doppler Vibrometer

6. What are the challenges in Implementation of SHM

Course Outcome 3(CO3):

1. What are the importance and need of Non-Destructive Testing
2. Basic Methods for NDT of Concrete Structures. Explain
3. What are quality control tests
4. Explain fundamental principle of partial destructive tests
5. Visual Inspection Test
6. Schmidt Rebound Hammer Test

Course Outcome 4 (CO4):

1. Explain the different Types of Static Tests in detail.
2. Discuss Simulation and Loading Methods in staticstructural health monitoring.
3. Explain the role of sensor systems in static structuralhealth monitoring.
4. What are the functions of hardware tools in staticstructural health monitoring?
5. Explain about Static Response Measurement Remember
6. Explain long-Term static structural health monitoring?
7. What is seismic structural health monitoring?
8. Write short notes on intelligent structural healthmonitoring?
9. List out the applications of structural health monitoring in post-earth quake controls.
10. What are smart material and explain their applications in structural health monitoring

Course Outcome 5 (CO5):

1. Explain the application and Adaptations of EMItechnique in structural health monitoring.

2.Write a short notes on data based techniques invibration based structural health monitoring.

3. Define and explain in detail about electro–mechanicalimpedance (EMI) technique

4. Explain the procedure for Adaptations of EMItechnique.

5. Name the types of Dynamic Field Test

6. What is vibration based structural health monitoring.

7. State the different forms of Dynamic ResponseMethods

8. What is Dynamic Response Method remember

9. Name different types of sensors used in structuralhealth monitoring

10. Define epoxy resins.

Course Outcome 6 (CO6):

1. Define repair in a structure

2.Discuss the method of underpinning in detail.

3. Discuss the various types of blanket repair techniques.

4. Enumerate the different methods available for repairsof concrete works. Discuss the any one in detail.

Model Question Paper

Time 2.5 hrs Maximum: 60marks

PART A

Answer all questions; each question carries 5 marks

1. What is the structural health monitoring? Explain scope of structural health monitoring?

2. Explain the role of piezoelectric sensors in structural health monitoring

3. Fundamental Principle of Partial Destructive Tests

4. What are the pros and cons of static structural healthmonitoring system

5.Explain about Electrical-Mechanical Impedance (EMI) Method?

PART B

Answer any five questions; each question carries 7 marks

6. What is distress? Give its classification.

7. Explain the Role of Smart Materials in Structural Health Monitoring System and Discuss aboutActive and Passive Smart Materials?

8. Explain in detail assessment of a health of a structure by NDT's equipment.

9.Describe the procedure of behavioral test and its importance.

10.Explain stress history data of dynamic field testing

11.Enumerate the different methods available for repairsof concrete works. Discuss the any one in detail.

12.Explain the Process of Guniting in Detail With Figure.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to Structural Health Monitoring**:	
1.1	Definition of Structural Health Monitoring SHM – Principle and Organization of a SHM System – SHM versus NDE – Advantages of SHM - Factors affecting Health of Structures	2hr
1.2	Repair and Rehabilitation - Facets of Maintenance – importance of Maintenance	1hr
1.3	Various aspects of Inspection - Assessment procedure for evaluating a damaged structure – causes of deterioration	1.5hr
2	**Structural Health Monitoring :**	
2.1	Concepts, Various Measures, Structural Safety in Alteration	1hr
2.2	Active and Passive Smart Materials – SHM Technologies – Piezoelectric Sensors – Magneto strictive Sensors – Optical Fibre Sensors	2hr
2.3	Dynamic Response Analysis using Laser Doppler Vibrometer – Challenges in Implementation of SHM	1hr
3	**Structural Audit :**	
3.1	Assessment of Health of Structure- Assessment by NDT equipment's	1hr
3.2	Introduction to NDT – Importance and Need of Non-Destructive Testing – Basic Methods for NDT of Concrete Structures – Testing of Concrete – Quality Control Tests	2hr
3.3	Partial Destructive Tests – Fundamental Principle – Equipment –General Procedure - Visual Inspection Test-Schmidt Rebound Hammer Test	2hr
3.4	Collapse and Investigation Management, SHM Procedures	1hr
4	**Static Field Testing :**	
4.1	Types of Static Tests, Static Testing- Static field testing-types of static tests loading methods	2hr
4.2	Behavioral/ Diagnostic tests - Proof tests -Static response measurement – strain gauges, LVDTs, dial gauges	2hr
4.3	Case study	2hr
5	**Dynamic Field Testing and rehabilitation:**	
5.1	Types of dynamic tests - Stress history data -Dynamic load allowance tests Ambient vibration tests – Forced Vibration Method - Dynamic response methods - Impact hammer testing- Shaker testing - Periodic and continuous monitoring	3hr
5.2	Introduction to Repairs and Rehabilitations of Structures:	3hr

	Repair of Structure – Common types of Repairs – Repair in Concrete Structures – Repairs in Under Water Structures – Guniting– Shot Create – Underpinning. Strengthening of Structures – Strengthening Methods – Retrofitting– Jacketing.	
5.3	Case Studies(Site Visits) electro mechanical impedance (EMI) technique, adaptations of EMI technique	1hr

Reference Books

1. Hua-Peng Chen, Structural Health Monitoring of Large Civil Engineering Structures ,John Wiley & Sons Ltd, Year: 2018

2. Douglas E Adams, Health Monitoring of Structural Materials and Component -Methods with Applications, John Wiley and Sons, 2007.

3. Bhattacharjee, Concrete Structures Repair Rehabilitation and Retrofitting, CBS; first edition (2019).

4. J. P. Ou, H. Li and Z. D. Duan, Taylor, Structural Health Monitoring and Intelligent Infrastructure, Vol1, and Francis Group, London, UK, 2006

5. Victor Giurglutiu, Structural Health Monitoring with Wafer Active Sensors, Academic Press Inc, 2007

6. Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes, Structural Health Monitoring,John Wiley and Sons, 2006

7. Fu-Kuo, Chang Structural Health Monitoring: Current Status and Perspectives CRC Press; 1 edition (24 April 1998)

8. Structural Health Monitoring of Civil Infrastructure System, Vistasp M. Karbhari and Farhad Ansari, Wood Head Publishing Limited, Cambridge, 2009.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE037	DESIGN OF BRIDGES	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: The course aims to provide a basic understanding of the concepts and design of both concrete and steel bridges as per the latest Indian Road Congress (IRC) and Indian Railway Standard (IRS) specifications. The student is expected to independently plan, analyse, design, and detail various types and components of bridges after completion of this course. The students will be exposed through field visits (whenever feasible) to real-life bridge design and construction practices.

Course Outcomes: After the completion of the course on Design of Bridges, the student will be able to

CO 1	Review bridge specifications as per current IRC and IRS standards for bridges.
CO 2	Design and detail slab and T beam bridges.
CO 3	Design and detail box culvert and Prestressed Concrete bridges.
CO 4	Design and detail plate girder and composite bridges
CO 5	Design elastomeric bearings in bridges.
CO 6	Analyse substructures and foundations in bridges.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	3	2	2	1
CO 2	3	3	3	3	2	2	1
CO 3	3	3	3	3	2	2	1
CO 4	3	3	3	3	2	2	1
CO 5	3	3	3	3	2	2	1
CO 6	3	3	3	3	2	2	1

Assessment Pattern

Bloom's Category	Continuous Evaluation (Marks)	End Semester Examination(Marks)
Remember	10	15
Understand	10	15
Apply	15	25
Analyse	5	5
Evaluate	–	–
Create	–	–

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

C

PART A

(Answer *ALL* questions)

1. What are impact factors? How these factors vary with respect to the type of loading, span, and type of bridge?
2. List the live loads to be considered in the design of road bridges?
3. Explain the effective width procedure for finding moments due to concentrated loads acting on one-way slabs.
4. Explain Courbon's method of finding reaction factors in a T beam girder bridge using an example.
5. Sketch a single cell box culvert and mark the components.

PART B

(Answer Any *FIVE* questions only)

6. (a) Explain the classification of bridges with sketches.
   (b) Explain the importance of site investigation in bridge engineering.

12. Design an interior cross girder for a T beam bridge for the following data: Effective span = 16 m, Live load – IRC Class 70R tracked; Materials – M25 concrete and Fe 415 steel; spacing of cross girders 5 m c/c; width of carriage way 7.5m; thickness of wearing coat = 80 mm; kerbs on either side = 600 mm wide × 300 mm deep; width of main girder = 300 mm; width of cross girder = 300 mm; spacing of main girders = 2.5 m c/c. Sketch reinforcement details.

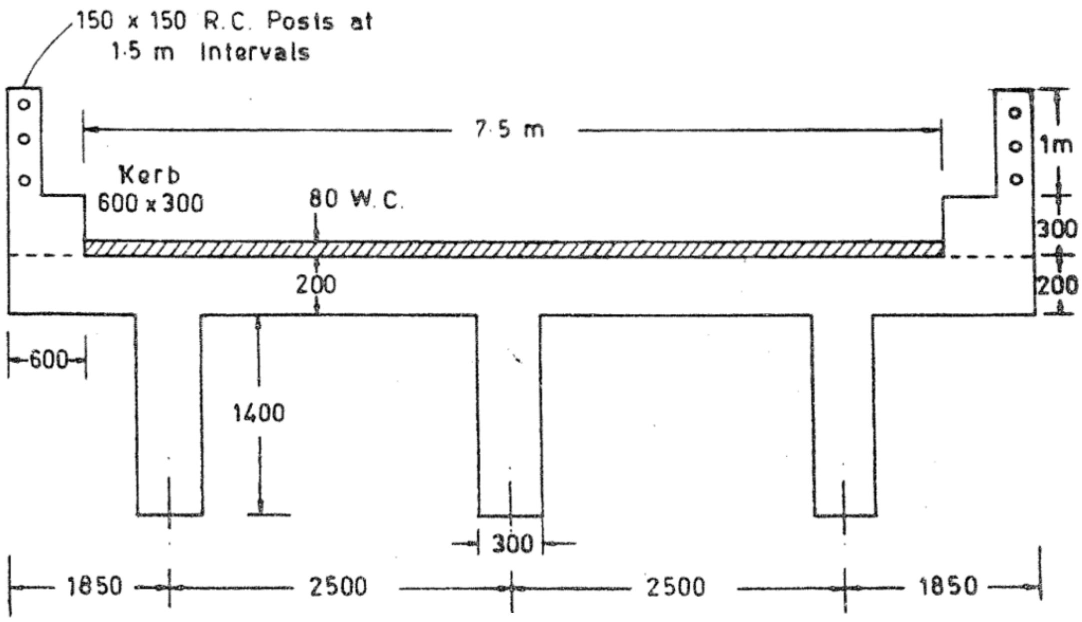
13. Design an interior longitudinal girder of a post tensioned prestressed concrete T beam bridge with the following data: Effective span = 24 m; Width of carriageway = 7.5 m; Kerbs 600 mm wide on either side; Spacing of main girders = 2 m; Spacing of cross girders = 4 m; Loading is IRC Class 70R tracked vehicle; Adopt M50 concrete and high tensile steel strands of 7 ply – 15.2 mm diameter with ultimate strength of 1800 MPa. Use Fe 415 grade steel for supplementary reinforcements. Assume loss ratio = 0.85.

14. Design a welded deck type plate girder bridge for a BG track to suit the following data: Effective span = 40 m; Dead load of track = 10 kN/m; Equivalent uniformly distributed load for bending moment calculations/track = 3498 kN; Equivalent uniformly distributed load for shear force calculations/track = 3815 kN. Take CDA = 0.324. Use plates of Fe410 grade.
15. Design an elastomeric bearing as per IRC 83 Part 2:2018 with the following data.

    Maximum vertical design force = 1009 kN

Minimum vertical design force = 666 kN
Horizontal force along span direction = 10.39 kN
Horizontal force along width direction = 41.56 kN
Resultant of all horizontal forces = 42.84 kN
Relative displacement in the direction of dimension '*a*' = 3.77 mm
Relative displacement in the direction of dimension '*b*' = 1.88 mm
Angle of rotation across the width 'a' of bearing = 0.00381
Angle of rotation across the length 'b' of bearing = 0.001
Adopt an elastomeric bearing (based on International Standards) of dimension 250 mm(*a*) × 400 mm(*b*)
Yield strength of steel laminate = 500 MPa

16. Design the main girder of a steel-concrete composite bridge as per relevant IRC standards to cover a span of 36m and for a three-lane carriage way. Use IRC- Class A loading.
17. Find out the distribution coefficient for the outer and central girder having the same moment of inertia as shown in the figure below, when single lane of class AA tracked loading is placed on the deck with maximum eccentricity. The distance between centre lines of bearing of the deck is 16 meters.



All dimensions are in mm.

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Syllabus

Module 1

Introduction to bridges: Importance of site investigation–Classification and components of bridges–Review of road (IRC) and railway (IRS) bridge specifications.

Module 2

Slab and T Beam Bridges: Loads on slabs, Effective width method–Design of straight and skew slab bridges as per relevant IRC loads–Design of interior panel of deck slab, Pigeauds curves–Distribution of loads on Girders – Courbon's method–Design of T beam bridges (up to three girders only) as per relevant IRC loads.

Module 3

Box culvert and Prestressed Concrete Bridges: Box culvert bridges–General aspects–Design of box culvert bridges (single cell) as per relevant IRC loads–Pre-stressed Concrete Bridges: Design of single span bridges–Introduction to various forms-Slab bridges-girder bridges-box girder bridges.

Module 4

Steel and Composite bridges: Design of plate girder (bolted and welded connection)–Design of Composite bridge (RCC slab over steel girder)–Theory-Load carrying action of folded plates.

Module 5

Bearings, substructures, and foundations in bridges: Design of elastomeric bearings–Abutments – General features, Loads on abutments, Stability analysis of abutments–Piers – Types, Loads on Piers, Stability analysis of Piers–Bridge Foundations – Types, selection criteria and suitability.

Course Plan

No	Topic	No. of Lectures
1	**Introduction to bridges (6)**	
1.1	Importance of site investigation	1
1.2	Classification and components of bridges	2
1.3	Review of road (IRC) and railway (IRS) bridge specifications	3
2	**Slab and T Beam Bridges (10)**	
2.1	Loads on slabs, Effective width method	1
2.2	Design of straight and skew slab bridges as per relevant IRC loads	3
2.3	Design of interior panel of deck slab, Pigeauds curves	1
2.4	Distribution of loads on Girders – Courbon's method	1

2.5	Design of T beam bridges (up to three girders only)as per relevant IRC loads	4
3	**Box culvert and Prestressed Concrete Bridges (9)**	
3.1	Box culvert bridges **-** General aspects	1
3.2	Design of box culvert bridges (single cell) as per relevant IRC loads	3
3.3	Pre- stressed Concrete Bridges: Design of single span bridges-	3
3.4	Introduction to various forms-Slab bridges-girder bridges-box girder bridges	2
4	**Steel and Composite bridges (6)**	
4.1	Design of plate girder [bolted and welded connection]	3
4.2	Design of Composite bridge (RCC slab over steel girder)	3
5	**Bearings, substructures, and foundations in bridges (9)**	
5.1	Design of elastomeric bearings	3
5.2	Abutments – General features, Loads on abutments, Stability analysis of abutments	3
5.3	Piers – Types, Loads on Piers, Stability analysis of Piers	2
5.4	Bridge Foundations – Types, selection criteria and suitability	1

Reference Books

1.Johnson Victor. D, “Essentials of Bridge Engineering”, Oxford.
2.N Krishna Raju, “Design of Bridges, Oxford and IBH publishing.
3.Jagadeesh T. R. and Jayaram M. A., “Design of bridge structures”, Prentice Hall of India.
4.Praveen Nagarajan, “Design of Concrete Bridges”, Wiley India Pvt. Ltd.
5. S. Ponnuswamy, “Bridge Engineering”, McGraw Hill Education.
6. Wai-Fah Chen, “Bridge Engineering Handbook: Substructure Design”, CRC Press.
7. V. K. Raina, Raina's Guiding Principles for Design, Construction, Load Capacity Evaluation, Load Testing, & Approximate Costing of 99% of All Bridges, Shroff Publisher.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE038	STABILITY OF STRUCTURES	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: The course aims to provide anin-depth understanding on how and under what loading condition, a structure becomes unstable. The student is expected to learn stabilty analysis of various structures and how this theoretical knowledge can be transferred to design methods and guidelines. The students will be able to appreciate all structural design standards and confidentally design various structures.

Course Outcomes: After the completion of the course on Stability of Structures, the student will be able to

CO 1	To Identify the relevance of Stability analysis in structures
CO 2	Perform Stabilty Analysis of Columns
CO 3	Perform Stabilty Analysis of Beam - Columns
CO 4	Carryout Stability analysis of Frames with various Boundary and loading conditions
CO 5	To analyse the lateral stability of beams & Buckling of Thin-Walled Open Sections
CO 6	Perform Stability analysis of Plated and shell structures

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	1	2	2	2	1	1
CO 2	1	1	2	2	2	1	1
CO 3	1	1	2	2	2	1	1
CO 4	1	1	2	2	2	1	1
CO 5	1	1	2	3	3	1	1
CO 6	1	1	2	3	3	1	1

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	15
Apply	25
Analyse	10
Evaluate	–
Create	–

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewedoriginal publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

Max Marks 60 **Duration 2.5 Hours**

PART A

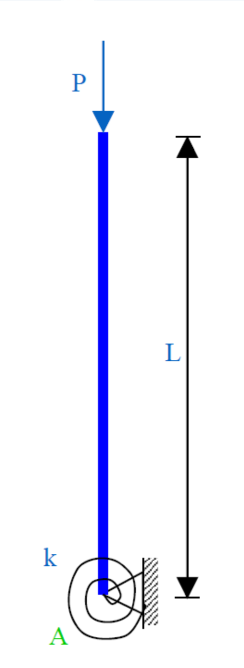
(Answer *ALL* questions , each question carries 5 marks)

1. Explain bifurcation buckling and limit load buckling.
2. Explain Rayleigh-Ritz method for estimation of buckling load of columns.
3. Derive the differential equation for a beam-column.
4. Describe in detail torsional and torsional-flexural buckling.
5. Differentiate between thin and thick plates.

PART B

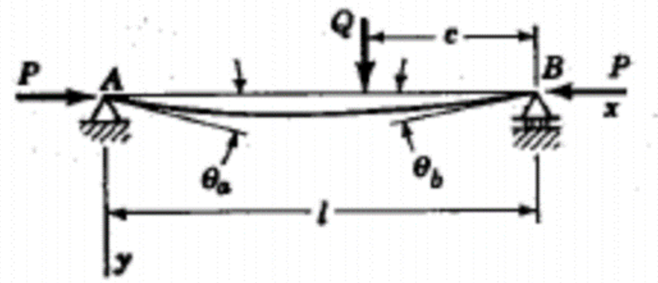
(Answer Any *FIVE* questions only, each question carries 7 marks)

6. Obtain the elastic buckling load of the system composed of a rigid bar partially fixed at the base by a rotational spring as shown in the figure. Use energy approach.



7. Using higher order differential equation representing the buckling behaviour of columns , estimate the buckling load for a column with fixed-fixed conditions

8. Find the buckling load of given beam- column



9. Explain post buckling strength.
10. Describe various buckling modes of Thin-walled open sections
11. Find the buckling load of cylindrical shell subjected to uniform external pressure.
12. Find the critical load for a simply supported plate uniformly compressed in one direction.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Concepts of Stability (6)**	
1.1	Introduction - Stability Criteria – Stable, unstable and neutral Equilibrium	2
1.2	Fourth order Elastic- largedeflection of bars - differential equation for generalizedbending problems	2
1.3	Elastic instability of columns-Euler's theory-assumptions and limitations-Energy principles	2
2	**Compression Members (9)**	
2.1	Higher order Differential equations - analysis for various boundary conditions	2
2.2	Behaviour of imperfect column -initially bent column - eccentrically loaded column	2
2.3	Energy method- Rayleigh Ritz, Galerkin methods	1
2.4	Effect of shear on buckling – Large deflection ofcolumns.	2
2.5	Matrix Stiffness Method – Flexural members and compression members	2
3	**Beam Columns & Buckling of Frames (7)**	
3.1	Beam Columns:Introduction – Differential Equation forBeam-columns	1
3.2	Solution of differential equation forconcentrated lateral loads - distributed loads – differentend conditions - bottom fixed-bottom hinged	3
3.3	Buckling of frames: Solutions for various end conditions	2
3.4	Horizontal compressionmembers	1
4	**Lateral Stability of Beams & Buckling of Thin-Walled Open Sections (7)**	
4.1	Lateral Stability of Beams: Differential equations forlateral buckling	2
4.2	Lateral buckling of beams in purebending	1
4.3	Lateral buckling of cantilever and simplysupported I beams	1
4.4	Buckling of Thin-Walled Open Sections: Introduction	1
4.5	Torsional buckling - Torsional flexural buckling	1
4.6	Equilibrium and energy approaches	1
5	**Stability of Plates and Shells(11)**	
5.1	Stability of Plates -Governing Differential equation - Equilibrium, energy concepts	2
5.2	Buckling of rectangularplates of various end conditions	3
5.3	Finite differencemethod - post-buckling strength	2
6.1	Donnel's Equation – SymmetricalBuckling of Cylinder under uniform axial Compression	2
6.2	Cylinder under uniform external lateral pressure	1
6.3	Cylinder subjected to torsion.	1

Reference Books

1. Chajes, A., " Principles of Structural Stability Theory", Prentice Hall, 1974.
2. Iyengar, N.G.R., "Elastic Stability of Structural Elements", Macmillan India Ltd.,Newdelhi,2007.
3. Ziegler H, "Principles of structural stability", Blarsdell, Wallham, Mass, 1963.
4. Thompson J M, G W Hunt, "General stability of elastic stability", Wiley,New York.
5. Timoshenko, Gere, "Theory of elastic stability", Mc Graw Hill, New York.
6. Don O Brush, B O Almorth, "Buckling of Bars, plates and shells", Mc Graw Hill,1975
7. Cox H L, "The buckling of plates and shells", Macmillam, New York, 1963.
8. AshwiniKukar, "Stability of Structures ", Allied Publishers LTD, New Delhi, 1998.
9. Murali L. Gambir," Stability Analysis and Design of Strucures", Springer-Verlog, Berlin, 2004

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE039	THEORY OF PLATES AND SHELLS	PROGRAMME ELECTIVE 3	3	0	0	3

Preamble: The course aims to provide a basic understating of the behaviour of the plates and shells with different geometry under various types of loads. The student is expected to identify the various thin-walled structures in the form of plates and shellssuitable foruse in different structural systems.

Course Outcomes: After the completion of the course on Theory of Plates and Shellsthe student will be able to

CO 1	Explain the classification of plates, assumptions in the theory of thin plates and bending of long rectangular plates to a cylindrical surface
CO 2	Describe symmetrical bending of circular plates and use the concept to analyse annular plates
CO 3	Derive the differential equations for small deflections of laterally loaded plates for different boundary conditions and solve using Navier and Levy's method
CO 4	Understand the theory of folded plates
CO 5	Explain the theory, load carrying mechanism, state of stress and classification of shells
CO 6	Compute the stresses in cylindrical shell under dead and snow loads

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			1				
CO 2	2		1				
CO 3	2		1				
CO 4			1				
CO 5	1		1				
CO 6	1		1				

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	38
Apply	12
Analyse	
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. Therewill be two parts; Part A and Part B. Part A will contain 5 numerical/short answerquestions with 1 question from each module, having 5 marks for each question(such questions shall be useful in the testing of knowledge, skills, comprehension,application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of thestudents in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitativeevaluation), with minimum one question from each module of which studentshould answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20%over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_______________

Name:__________________________ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SECOND SEMESTER M.TECH. DEGREE EXAMINATION,

MONTH & YEAR

Course Code: XXXX

THEORY OF PLATES AND SHELLS

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ALL questions; each question carries 5 marks)

1. Show that for the small deflection of a plate subjected to pure bending, the directions of zero slope and max slope are perpendicular to each other.
2. A solid circular plate of radius 0.3 m with its outer edge completely restrained is subjected to a pressure load of 10 MPa. If the allowable stress in the plate is limited to 100 MPa, determine (i) The thickness of the plate, (ii) The maximum deflection, (iii) The stress at the centre of the plate. Take E = 200 GPa, ν = 0.3.
3. How would you compare Navier solution and Levy's solution as used for simply supported rectangular plates?
4. How shells are classified based on Gaussian curvature?
5. Show that there is a compression along the meridians of a spherical shell of radius a subjected to the action of its own weight of magnitude q per unit area.

PART B

(Answer any FIVE questions; each question carries 7 marks)

6. Derive the differential equation for the cylindrical bending of long rectangular plates.
7. Derive the differential equation for symmetrical bending of laterally loaded circular plates and obtain the expression for maximum deflection for circular plate with clamped edges.
8. Find the deflection of a circular plate (radius a) with a hole (radius b) at the centre and subjected to moments M1 and M2 at the inner and outer edges respectively.

9. Obtain the differential equation for the small deflections of a laterally loaded plate.
10. A rectangular plate ($\boldsymbol{a} \times \boldsymbol{b} \times \boldsymbol{h}$), simply supported on all four edges is subjected to sinusoidal load ($\boldsymbol{q_0 \sin\frac{\pi x}{a} \sin\frac{\pi y}{b}}$) distributed over the surface of the plate. Find expressions for deflection ($\boldsymbol{w}$), bending moments ($\boldsymbol{M_x}$, $\boldsymbol{M_y}$)
11. Explain the load carrying mechanism of shells.
12. Develop the expressions for the displacements in symmetrically loaded shells having the form of a surface of revolution.

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Syllabus

Module 1

Introduction- Classification of plates -Assumptions in the theory of thin plates-Bending of long rectangular plates to a cylindrical surface. Pure bending of plates-Slope and curvature - Relations between bending moments and curvature-Particular cases of pure bending.

Module 2

Symmetrical bending of circular plates-Differentialequation. Uniformly loaded circular plates with simplysupported and fixed boundary conditions-Annular plate withuniform moments and shear forces along the boundaries.

Module 3

Small deflections of laterally loaded plates-Differentialequation-Boundary conditions-Navier solution and Levy'ssolution for simply supported rectangular plates.

Module 4

Theory-Load carrying action of folded plates.

Classical shell theory- Load carrying mechanism of shells - Types of state of stress for thin shells-Classification of Shells.

Module 5

Shells in the form of a surface of revolution, displacements. Membrane theory of cylindrical shells. General theory of cylindrical shells-A circular cylindrical shell loaded symmetrically with respect to its axis- stresses in cylindrical shell under dead and snow loads.

Course Plan

No	Topic	No. of Lectures
1	**Pure Bending of Plates (10)**	
1.1	Introduction- Classification of plates -Assumptions in the theory of thin plates. Bending of long rectangular plates to a cylindrical surface – Differential equation.	2
1.2	Pure bending of plates-Slope and curvature.	2
1.3	Relations between bending moments and curvature-Particular cases of pure bending.	6
2	**Circular Plates (6)**	
2.1	Symmetrical bending of circular plates-Differentialequation.	1
2.2	Uniformly loaded circular plates with simplysupported and fixed boundary conditions	2
2.3	Annular plate withuniform moments and shear forces along the boundaries.	3
3	**Laterally loaded Plates (10)**	
3.1	Small deflections of laterally loaded plates-Differential equation - Boundary conditions.	4
3.2	Simply supported rectangular plates under sinusoidal load.	2
3.3	Navier solution and Levy's solution for simply supported rectangular plates.	4
4	**Folded Plates and shells (6)**	
4.1	Theory-Load carrying action of folded plates.	2
4.2	Classical shell theory- Load carrying mechanism of shells.	2
4.3	Types of state of stress for thin shells-Classification of shells.	2
5	**Theory of Shells (8)**	
5.1	Displacements in symmetrically loaded shells having the form of a surface of revolution.	2
5.2	Membrane theory of cylindrical shells.	2
5.3	General theory of cylindrical shells-A circular cylindrical shell loaded symmetrically with respect to its axis- stresses in cylindrical shell under dead and snow loads.	4

Reference Books

1. Timoshenko S.P. and Krieger S. W., Theory of Plates and Shells, Tata McGraw Hill, 1959
2. Chandrashekhara K., Theory of Shells, Universities(India)Press Ltd., 2001
3. Ramaswamy G. S., Design and Construction of Concrete Shell Roofs, CBS Publishers, 2005
4. Bairagi N. K., Plate Analysis, Khanna Publishers, 1986

5. Kelkar V. S. and Sewell R.T., Fundamentals of the Analysis and Design of Shell Structures, Prentice Hall Inc., 1987
6. T.K.Varadan& K. Bhaskar, Análysis of plates – Theory and problems, Narosha Publishing Co., 1999.
7. Reddy J N., Theory and Analysis of Plates and Shells, Taylor and Francis, 2006

SEMESTER II

PROGRAM ELECTIVE IV

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TCE042	ADVANCED COMPOSITE STRUCTURES	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: The course aims to provide a basic understating of the concepts and design of both concrete and steel composite structures. The student is expected to analyse and design various types composite structures, after the completion of this course The students are also able to apply the knowledge in real civil engineering problems and to design new and advanced composite structures.

Course Outcomes: After the completion of the course on Design of Bridges, the student will be able to

CO 1	Understand the behaviour of composite structures and its components.
CO 2	Familiarise the various types of composite structural elements.
CO 3	Describe shear connectors and profile sheeting
CO 4	Analyse the various composite structural elements.
CO 5	Design the various composite structural elements.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1		2	3	2	1	
CO 2	1		2	3	2	1	
CO 3	1	2	3	2	2	2	
CO 4	3	2	3	3	3	2	
CO 5	3	2	3	3	3	2	

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	10
Understand	10
Apply	25
Analyse	15
Evaluate	..
Create	..

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40 + 20 = 60 %.

Model Question Paper

PART A

(Answer ALL questions; each question carries 5 marks)

1. What is the difference between RCC and steel-concrete composite construction?
2. What are the characteristics of shear connectors?
3. Write short note on selection of effective breadth of composite beam?
4. What are the structural benefits of using composite floors with profiled steel decking?
5. Comment on the mechanism of load resistance in composite columns

PART B

(Answer any FIVE questions; each question carries 7 marks)

6. Explain with sketches no interaction and full interaction cases in a composite beam.
7. What are shear connectors? Explain different types of shear connectors.
8. Design a simple supported composite beam with 10 m span spaced at 3.2 m c/c. Thickness of the slab is 150 mm. The floor has to carry an imposed load of 3.5kN/m2, a construction load of 1 kN/m2 and floor finish load of 1kN/m2. Assume that the floor is not propped during construction. Use M30 grade concrete.
9. Describe the structural elements of a composite floor system.
10. Obtain the plastic resistance of a steel section made of ISHB350 encased in M30 concrete. The height of the column is 3.4 m and is pinned at both the supports. The dimension of the column is 450 mm × 450 mm. The cover to the flanges is 50 mm. Reinforcement steel is provided as 0.4 % of gross concrete
11. Check the adequacy of the composite beam at composite stage having a span 12 m, spacing of the beams= 3 m, thickness of slab = 120 mm. Floor is carrying an imposed load of 3.0 kN/m^2, partition load of 1.5 kN/m^2 and floor finish of 0.5 kN/m^2.
12. What are the Analysis for internal forces and moments of composite slabs? Describe the effective width of composite slab for concentrated point and line loads.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Composite structures (8)**	
1.1	Introduction to Composite construction	2
1.2	General behaviour of composite beams and columns	3
1.3	Elastic behaviour of composite beams No interaction case, Full interaction case	3
2	**Shear connectors (7)**	
2.1	Types of shear connectors	1
2.2	Mechanism of dowel action	1
2.3	Characteristics of shear connectors	3
2.4	Load bearing mechanism of shear connectors	1
2.5	Strength of connectors	1
3	**Composite beam (8)**	
3.1	Ultimate load behaviour of composite beam	2
3.2	Provision for service opening in composite beams	1
3.3	Serviceability limit states, Basic design considerations	2
3.4	Design of composite beams	3
4	**Composite floors (8)**	
4.1	Composite profiled slabs and profiled decking	2
4.2	Bending resistance of composite slab	2
4.3	Shear resistance of composite slab	2
4.4	Analysis for internal forces and moments	1
4.5	Serviceability criteria, Design steps of profiled decking	1
5	**Composite columns (9)**	
5.1	Material properties and partial safety factors of composite construction	1
5.2	Combined compression and uni-axial bending	2
5.3	Combined compression and bi-axial bending	2
5.4	Composite column design	4

Reference Books

1. Johnson R.P, Composite Structures of Steel and Concrete, Vol.1Beams, Slabs, Columns and Frames in Buildings, Oxford Blackwell Scientific Publications, London.
2. INSDAG teaching resource for structural steel design, Vol 2, INSDAG, IspatNiketan, Calcutta.
3. Deric J. Oehlers, and Mark A. Bradford, Composite Steel and Concrete Structural Members Fundamental Behaviour, The University of Adelaide, Australia and University of New South Wales, Australia, Pergamon

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE043	DESIGN OF EARTHQUAKE RESISTANT STRUCTURES	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: The course provides the basic principles of earthquake resistant design of structures. Students are introduced to the engineering aspects of earthquakes, their characterisation and effects. The course covers seismic design force computation, design and detailing as per Indian Standards. An introduction to seismic evaluation and retrofitting is also included.

Course Outcomes: After the completion of the course on Design of Earthquake Resistant Structures the student will be able to

CO 1	Describe various engineering aspects of earthquakes, earthquake effects and earthquake resistant design.
CO 2	Apply IS code provisions for the analysis, design and detailing of earthquake resistant structures.
CO 3	Develop earthquake response spectrum.
CO 4	Perform response spectrum analysis of multi-storied frames.
CO 5	Analyse and design shear walls.
CO 6	Describe different strategies for seismic evaluation and seismic retrofitting.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			1				
CO 2	1		2				
CO 3	2		2				
CO 4	1		2				
CO 5	1		2				
CO 6			1				

(1- Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	
Understand	25
Apply	14
Analyse	21
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. Therewill be two parts; Part A and Part B. Part A will contain 5 numerical/short answerquestions with 1 question from each module, having 5 marks for each question(such questions shall be useful in the testing of knowledge, skills, comprehension,application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of thestudents in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitativeevaluation), with minimum one question from each module of which studentshould answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20%over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_______________

Name:__________________________ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SECOND SEMESTER M.TECH. DEGREE EXAMINATION,

MONTH & YEAR

Course Code: XXXX

DESIGN OF EARTHQUAKE RESISTANT STRUCTURES

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Distinguish between *magnitude* and *intensity* of earthquake.
2. Explain the philosophy of earthquake resistant design.
3. Can the exact value of maximum seismic response of a multi-degree of freedom be determined using response spectrum analysis? Explain.
4. Explain the significance of ductility in earthquake resistant design.
5. What do you mean by retrofitting of structures? Explain the retrofitting methods used for RC columns.

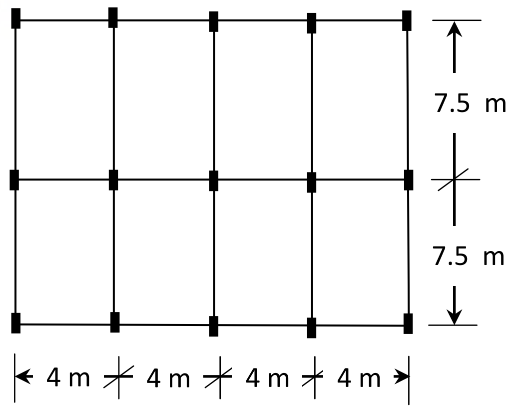
PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Figure shows the plan of a four storied RC framed structure to be constructed in Bangalore. Height of each story is 3.0 m. Calculate the seismic forces at various floor levels.

Data given:

Column section : 23×60 cm.
Beam section : 23×55 cm.
Slab Thickness : 13 cm.
Thickness of brick wall around: 23 cm.
Live load on floors : 4 kN/m²
Live load on roof : 1.5 kN/m²
Unit weight of concrete : 25 kN/m³
Unit weight of brick wall : 20 kN/m³



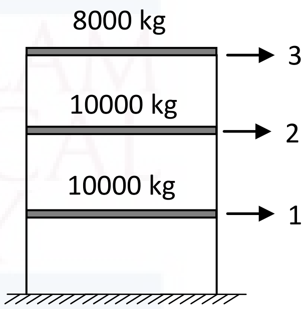
Frame type : SMRF
Type of soil : Soft soil

Missing data may be suitably assumed.

7. Explain the factors which ensure proper seismic behaviour of a building.

8. The natural frequencies (in rad/s) of the three storied shear building shown below are 6.57, 16.91 and 24.67. The mass normalized modal matrix is

$$\begin{bmatrix} 0.0034 & 0.0066 & 0.0067 \\ 0.0061 & 0.0038 & -0.0069 \\ 0.0080 & -0.0072 & 0.0031 \end{bmatrix}.$$

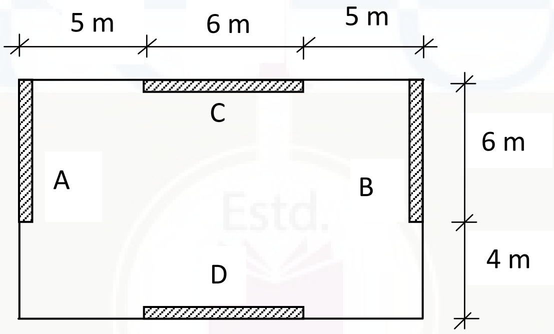


The damping may be assumed as 5% for all modes. Using response spectrum method calculate the base shear.

Assume that the building is to be constructed in Zone V and the foundation soil is Type I (hard soil). The frame may be assumed as SMRF. Take importance factor as 1.5. Use SRSS rule to combine the modal responses.

9. Explain how the ductility of RC members can be increased.

10. Plan of a single storey building having two shear walls in each direction is shown. The shear walls are 6 m long and 200 mm thick. Design shear force on the building is 120 kN in either direction. Determine the design lateral force in shear wall A using the torsion provisions of the IS code.



11. A slender shear wall of length 6 m and thickness 200 mm carries an axial load of 2700 kN. The wall is reinforced with 10# bars at 250 mm c/c in two layers. If M25 concrete and Fe415 steel are used, estimate the moment of resistance of the wall.

12. What is seismic evaluation? When is it required? Explain the different steps in seismic evaluation.

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Syllabus

Module 1

Introduction to earthquakes and earthquake engineering, Mechanism of earthquake, seismic waves, effects of earthquakes. Measurement of earthquakes, magnitude and intensity, seismographs. Strong motion characteristics, response spectrum, Fourier spectrum. Characteristics of response spectrum, Design spectrum, construction of tripartite response spectrum.

Module 2

Effect of architectural features and structural irregularities. Damages of structures during past earthquakes, principles of earthquake resistant construction.

Philosophy of earthquake resistant design. Code provisions as per IS:1893 and IS:4326.

Module 3

Design seismic force calculation in multi storied frames. Dynamic analysis, Introduction to response spectrum analysis – theoretical aspects, Modal combination rules.

Design seismic force calculation in multi storied frames using response spectrum method.

Module 4

Ductility – Significance, Ductility factors. Ductile detailing considerations as per IS:13920. Design and detailing of structural members. Reinforcement detailing in joints.

Module 5

Torsion – code provisions, Shear walls – design force calculation, Design of shear wall, Design and detailing for earthquake resistance – Discussion of code provisions in IS 13920.

Repair and rehabilitation. Seismic evaluation and vulnerability assessment – Methods, Disaster mitigation, Response reduction techniques, Base isolation.

Course Plan

No	Topic	No. of Lectures
1	**Earthquakes and Response Spectrum (9)**	
1.1	Earthquakes, Mechanism, Elastic rebound theory. Seismic waves, Effects of earthquakes	3
1.2	Size of earthquake – magnitude & intensity, moment magnitude Measurement of earthquakes – seismographs	2
1.3	Strong motion characteristics, response spectrum, Fourier spectrum	2

1.4	Characteristics of response spectrum, design spectrum, construction of tripartite response spectrum	2
2	**Earthquake Effects and Philosophy of Earthquake Resistant Construction (7)**	
2.1	Structural irregularities, Effect of architectural features, Damages during past earthquakes.	2
2.2	Seismo-resistant building architecture	1
2.3	Philosophy of earthquake resistant construction. Principle of earthquake resistant construction	2
2.4	Introduction of IS codes (1893 & 4326), Code provision	2
3	**Design Seismic Force Computation (8)**	
3.1	Seismic force computation using IS code provisions	2
3.2	Response spectrum analysis – theoretical aspects, Modal combination rules	2
3.3	Seismic force computation using Response spectrum method	2
3.4	Modal combination using ABS, SRSS & CQC rules	2
4	**Ductility Aspects and Ductile Detailing (7)**	
4.1	Ductility – significance in earthquake resistant design, Ductility factors.	2
4.2	Ductile detailing considerations as per IS:13920	2
4.3	Design & detailing of structural members & joints	3
5	**Torsion and Shear Walls (9)**	
5.1	Torsion – code provisions Design eccentricity computation	1
5.2	Shear walls – design force calculation. Design of shear wall.	3
5.3	Seismic evaluation – methods	2
5.4	Repair and rehabilitation – methods	2
5.5	Response reduction techniques, Base isolation	1

Reference Books

1. PankajAgarwal and Manish Shrikhande, Earthquake Resistant Design of Structures, Prentice- Hall of India, New Delhi.
2. Anil K Chopra, Dynamics of Structures, Prentice- Hall of India, New Delhi.
3. S. K. Duggal-Earthquake Resistant Design of Structures-Oxford University Press-2007
4. T.K. Datta, Seismic Analysis of Structures, John Wiley & Sons (Asia) Pte Ltd.
5. IS: 1893-2016, Indian Standard criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi
6. IS: 4326-2013, Indian Standard code for practice for Earthquake Resistant Design and Construction of Buildings, Bureau of Indian Standards, New Delhi.
7. IS: 13920-2006, Indian Standard Ductile Detailing of RCC Structures subjected to seismic forces Code of practice, Bureau of Indian Standards, New Delhi

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE044	THEORY OF PLASTICITY	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand stress, strain, deformations, the relation between stress and strain, and plastic deformation in solids.
CO 2	Understand plastic stress-strain relations and associated flow rules.
CO 3	Perform stress analysis in beams and bars including Material nonlinearity.
CO 4	Analyze the yielding of a material according to different yield theories for a given state of stress.
CO 5	Interpret the importance of the plastic deformation of metals in engineering problems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	-	-	–	-	-	-	-
CO 2	-	-	-	3	-	-	-
CO 3	-	-	-	3	-	-	-
CO 4	-	-	-	3	2	-	-
CO 5	3	2	-	3	-	-	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	10
Analyse	20
Evaluate	10
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation: 40 marks Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:
The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.
.

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand stress, strain, deformations, the relation between stress and strain, and plastic deformation in solids.

1. Explain spherical and deviatoric stress tensors.

2. Explain various factors affecting plastic deformation.

3. Derive the equilibrium equation in two dimensions considering the body forces.

4. Write a note on octahedral stresses.

5. Explain effective and representative strain.

6. Derive an expression for cubical dilatation stress.

7. Explain true stress and true strain.

Course Outcome 2 (CO2):Understand plastic stress-strain relations and associated flow rules.

1. Explain various theories of plastic flow

2. Explain the different stress strain diagram employed to describe elasto-plastic behaviour of materials.

3. Derive an expression for cubical dilation strain.

4. Enumerate different types of materials encountered in practice from plastic flow point of view. Also sketch the corresponding mechanical models.

5. Explain St. Venants theory of plastic flow in detail. What are the limitations of this theory?

6. Write a short note on Luder's line.

Course Outcome 3(CO3): Perform stress analysis in beams and bars including Material nonlinearity.

1. A rectangular beam having linear stress strain behaviour is 80 mm wide and 120 mm deep. it is 3 m long simply supported at the ends and carries a uniformly distributed load over the entire span. The load is increased so that the outer 30 mm depth of the beam yields plastically. If the yield stress for the beam is 240MPa, plot the residual stress distribution in the beam

2. A hollow circular shaft of inner radius 30 mm and outer radius 60 mm is subjected to a twisting moment so that the outer 10 mm deep shell yields plastically. the yield stress in shear for the shaft material is 160 mega pascal and it is made of a non-linear material whose shear stress strain curve given by $j = 300g^{0}$. If the twisting moment is now released determine the residual stress distribution in the shaft. Assume G =80 GPa for the shaft material

3.A circular shaft of inner radius 40 mm and outer radius 100 mm is subjected to a twisting couple so that the outer 20 mm deep shell yields plastically. Determine the twisting couple applied to the shaft. Yield stress in shear for the shaft material is 145 N/mm^2. also determine the couple for full yielding

Course Outcome 4 (CO4): Analyze the yielding of a material according to different yield theories for a given state of stress.

1. What do you mean by yield criteria? Explain any two yield criteria are commonly used.

2. Derive the equation for theory of plastic torsion of circular bar subjected to torsion for following cases.

i) Incipient yielding

ii) Elasto plastic yielding

iii) Fully yielding.

3. Explain experimental verification of yield criteria using Quinny and Taylor's experiments.

Course Outcome 5 (CO5): Interpret the importance of the plastic deformation of metals in engineering problems.

1. Explain various factors affecting plastic deformation.

2. Write short notes on the following

i) Recovery, recrystallization and grain growth.

ii) Flow figures of luder's line.

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

M.TECH DEGREE EXAMINATION

THEORY OF PLASTICITY

Time 2.5 hrs | Maximum: 60marks

PART A (***Answer all questions; each question carries 5 marks)***

1. The state of stress at a point in a stressed body is given below:

$$\sigma_{ij} = \begin{bmatrix} 50 & 50 & -40 \\ 50 & -30 & 30 \\ -40 & 30 & -100 \end{bmatrix} \text{MPa}$$

   Calculate stress invariants, principal stresses, spherical and deviatoric stress tensor

2. A material is to be loaded to a stress state

$$[\sigma_{ij}] = \begin{bmatrix} 50 & -30 & 0 \\ -30 & 90 & 0 \\ 0 & 0 & 0 \end{bmatrix} \text{MPa}$$

   What should be the minimum uniaxial yield stress of the material so that it does not fail, according to the Trescacriterian?

3. Explain st.venants theory of plastic flow?

4. A hollow circular shaft of inner radius 30 mm and outer radius 60 mm is subjected to a twisting moment so that the outer 10 mm deep shell yields plastically. the yield stress in shear for the shaft material is 160 mega pascal and it is made of a non-linear material whose shear stress strain curve given by j = 300g^0. If the twisting moment is now released determine the residual stress distribution in the shaft. Assume G =80 GPa for the shaft material.

5. What are assumptions of slip line theory?

PART B (***Answer any five questions; each question carries 7 marks)***

6. Derive the equation of generalized Hook's Law

7. Derive the equilibrium equation in two dimensions considering the body forces.

8. What do you mean by yield criteria? Explain any two yield criteria are commonly used?

9. A rectangular beam having linear stress strain behaviour is 80 mm wide and 120 mm deep. it is 3 m long simply supported at the ends and carries a uniformly distributed load over the entire span. The load is increased so that the outer 30 mm depth of the beam yields plastically. If the yield stress for the beam is 240MPa, plot the residual stress distribution in the beam

10. Explain experimental verification of yield criteria using Quinny and Taylor's experiments.

11. Derive the equation for theory of plastic torsion of circular bar subjected to torsion for following cases.

    i) Incipient yielding

    ii) Elasto plastic yielding

13. A circular shaft of inner radius 40 mm and outer radius 100 mm is subjected to a twisting couple so that the outer 20 mm deep shell yields plastically. Determine the twisting couple applied to the shaft. Yield stress in shear for the shaft material is 145 N/mm^2. also determine the couple for full yielding

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Brief review of fundamentals of elasticity**: Concept of stress, stress invariants.	2hr
1.1	Principal Stresses, octahedral normal and shear stresses, spherical and deviatoric stress,	2hr
1.2	Stress transformation; concept of strain, engineering and natural strains, octahedral strain, deviator and spherical strain tensors,	1hr
1.3	strain rate and strain rate tensor, cubical dilation, generalized Hooke's law, numerical problems	1hr
2	**Plastic Deformation of Metals**: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation	1hr
2.1	Strain hardening, recovery, re crystallization and grain growth, flow figures or Luder's cubes	1hr
2.2	Yield Criteria: Introduction, yield or plasticity conditions, Von Mises and Tresca criterion,	1hr
2.3	Geometrical representation, yield surface, yield locus (two-dimensional stress space), experimental evidence for yield	1hr
3	**Stress-Strain Relations:** Idealised stress-strain diagrams for different material models	1hr
3.1	Empirical equations, Levy-Von Mises equation, Prandtl - Reuss and Saint Venant theory	2hr
3.2	Experimental verification of Saint Venant's theory of plastic	1hr

	flow.	
3.3	Concept of plastic potential, maximum work hypothesis, mechanical work for deforming a plastic substance.	2hr
4	**Bending of Beams**: Stages of plastic yielding, analysis of stresses,	3hr
4.1	Linear and nonlinear stress strain curve, problems. Torsion of Bars: Introduction, plastic torsion of a circular bar,	3hr
4.2	Elastic perfectly plastic material, elastic work hardening of the material.	1hr
4.3	Numerical problems.	2hr
5	**Slip Line Field Theory**: Introduction, basic equations for incompressible two-dimensional flows,	2hr
5.1	Continuity equations, stresses in conditions of plain strain,	2hr
5.2	convention for slip lines, the geometry of slip line field,	1hr
5.3	Properties of the slip lines, construction of slip line nets.	2hr

Reference Books

1. Theory of Plasticity and Metal forming Process Sadhu Singh Khanna Publishers, Delhi.
2. Chakrabarty, J, Theory of Plasticity, McGraw Hill, New York.
3. Advanced Mechanics of solids L. S. Srinath Tata Mc. Graw Hill 2009
4. Johnson and Mellor, "Plasticity for Mechanical Engineers", Ban Nostrand.
5. R.Hill , "The Mathematic theory of Plasticity", Oxford Publication.
6. Basic Engineering Plasticity DWA Rees Elsevier 1st Edition
7. Engineering Plasticity W. Johnson and P. B. Mellor Van NoStrand Co. Ltd 2000
8. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag.
9. Kachanov, L.M., Fundamentals of the Theory of Plasticity, Mir Publishers, Moscow.
10. Martin, J.B., Plasticity: Fundamentals and General Results, MIT Press, London.
11. Plasticity: Fundamentals and applications, P. M. Dixit and U. S. Dixit

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE045	ENGINEERING FRACTURE MECHANICS	PROGRAMME ELECTIVE 4	3	0	0	3

Preamble: This course provides the fundamental aspects of Fracture Mechanics. The students will be exposed to the analysis of fracture of linear and non-linear materials and apply these concepts to structural components. The pre-requisite of this course is Continuum Mechanics, Mechanics of Solids(Desirable)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Fundamental understanding of fracture mechanics.
CO 2	Ability to analyze and diagnose fractures of linear elastic materials
CO 3	Analyze and diagnose fractures of non-linear materials
CO 4	Assessment of Critical crack growth
CO 5	Apply fracture and fatigue concepts for design of structural components.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2		2	2	2	2	
CO 2	3		3	3	3	3	
CO 3	3		3	3	3	3	
CO 4	3		3	3	3	3	
CO 5	3		3	3	3	3	
CO 6							

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	25
Evaluate	10
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40 + 20 = 60 %.

Model Question Paper

QP CODE: **RegNo:…………………**

Name:…………………

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SECOND SEMESTER M.TECH DEGREE EXAMINATION (MONTH & YEAR)

Course Code: 222ECE045

ENGINEERING FRACTURE MECHANICS

Max. Marks: 60 **Duration: 2.5 hours**

PART A

(Answer *ALL* questions)

1. Discuss the historic overview of fracture mechanics.
2. Define Griffith's theory.
3. Derive the stress intensity of through crack under internal pressure using principle of superposition.
4. Explain plastic zone and plot the plastic zone for plane stress condition
5. State Paris law and its limitations.

PART B

(Answer Any *FIVE* questions only)

6. Explain Airy's stress function and complex stress function.
7. Derive an equation for elliptical flaw in plate and its importance to fracture.
8. Write short note on (a) Leak before break and (b) Damage tolerance analysis.
9. Path independence of J-integral is not valid for elastic-plastic materials, why?
10. Explain any two Direct & indirect method to measure the fracture parameters.
11. Derive an expression for Irwin's plastic zone correction.
12. Describe the importance of R-curve in fracture analysis.

Syllabus

Module 1

Fundamentals of Fracture Mechanics– Introduction - Modes of failure, examples of structural failures due to fracture, fracture mechanics versus strength of materials

Mechanism of crack growth and fracture, fracture control, Review of elasticity, complex variables, complex Airy stress function

Module 2

Linear Elastic Fracture Mechanics -Elasticity based solutions for an infinite plate with circular hole and with elliptical hole

Stress in infinite plate with crack- Westergaard approach and Mushkelishvile approach, stress intensity factor(SIF), Griffith's theory, strain energy release rate, R-curve

Module 3

Design based on LEFM -Design philosophy, SIF due to complex loading, Application of principle of superposition, critical SIF, Leak before break, damage tolerance analysis

Module 4

Elasto-plastic fracture mechanics -J-integral, Crack tip opening displacement (CTOD), relation between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J,

Module 5

Finite element analysis of cracks in solids –Fracture parameters & determination, Mixed mode crack propagation criteria, Analytical models, Fatigue crack growth models to predict life,

Finite elements in fracture mechanics-isotropic singular elements, extraction of SIF using displacement correlation, Displacement extrapolation, Strain energy release rate

Course Plan

No	Topic	No. of Lectures 38
1	Introduction to fracture mechanics	**7**
1.1	Modes of failure, examples of structural failures due to fracture, fracture mechanics versus strength of materials,	2
1.2	Column stability versus fracture instability, mechanism of crack growth and fracture, fracture control	2
1.3	Review of elasticity, complex variables, complex Airy stress function	3
2	Linear Elastic Fracture Mechanics	**8**
2.1	Elasticity based solutions for an infinite plate with circular hole, Elasticity based solutions for an infinite plate with an elliptical hole,	3
2.2	Elasticity based solutions for an infinite plate with crack-Westergaard approach and Mushkelishvile approach, stress intensity factor(SIF),	3
2.3	Griffith's theory, strain energy release rate, R-curve	2
3	Design based on LEFM	**6**
3.1	Design philosophy, SIF due to complex loading	2
3.2	Application of principle of superposition, critical SIF	3
3.3	Leak before break, damage tolerance analysis	1
4	Elasto-plastic fracture mechanics	**8**
4.1	Plastic zone size and shape, effective crack length	2
4.2	J-integral – definition, experimental evaluation, numerical evaluation	3
4.3	Cracktip opening displacement (CTOD), relation between CTOD, K_I and G_I for small scale yielding, Equivalence between CTOD and J	3
5	Finite element analysis of cracks in solids	**9**
5.1	Direct & indirect methods to measure fracture parameters,	2
5.2	Mixed mode crack propagation criteria, Analytical models, empirical models, Fatigue crack growth models, life prediction	3
5.3	Finite elements in fracture mechanics-isotropic singular elements, extraction of SIF using displacement correlation, Displacement extrapolation, Strain energy release rate	4

Reference Books

1.T.L.Anderson, Fracture Mechanics, : Fundamentals and Applications, CRC Press, 3rd Edition

2.D.Broek, Elementary Engineering Fracture Mechanics, MartinusNijhoff publishers.

3.Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, New Delhi, India

4.Meinhardkuna, Finite Elements in Fracture Mechanics: Theory - Numerics - Applications

SEMESTER II

INTERDISCIPLINARY ELECTIVE

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE097	MECHANICS OF COMPOSITE MATERIALS	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: Fibre reinforced plastic composite materials are finding wide range of applications in the field of aerospace structures, automobile engineering, offshore structures, maritime structures, ships and civil engineering structures presently due to its outstanding material capabilities such as High strength, low weight, high corrosion resistance, high fatigue strength and faster assembly. The everyday applications of composites in the commercial markets and hence the job opportunities in this field are drastically increasing nowadays. This course will equip the students with the specialist knowledge and skills required by the leading employers in aerospace, marine, automobile, construction and renewable energy industries to design and develop next generation environmental-friendly and structural-efficient advanced lightweight composite materials and components.

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the Advanced Composite Structures course the student will be able to

CO 1	Identify the properties of fibre and matrix materials used in commercial composites, as well as some common manufacturing techniques.
CO 2	Explain linear elasticity with emphasis on the difference between layered composite materials and isotropic materials.
CO 3	Apply constitutive equations of composite materials and understand the mechanical behaviour at micro and macro levels.
CO 4	Predict the failure mode and strength of laminated composite structures.
CO 5	Apply the ideas developed in the analysis of composites towards using composites in various fields of engineering.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			3	3	2		
CO 2			3	3	2		
CO 3			3	3	2		
CO 4			3	3	2		
CO 5			3	3	2		

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	15
Understand	15
Apply	25
Analyse	5
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 70% of the syllabus.

End Semester Examination Pattern:
The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40 + 20 = 60 %.

Model Question paper

PART A

Answer **all** questions.

All Questions carry **equal** marks

1. How is the mechanical advantage of a composite measured?
2. Write the number of independent elastic constants for three dimensional anisotropic, orthotropic, transversely isotropic and isotropic materials.
3. What is Classical Lamination Theory? Explain its significance in composite analysis.
4. The weight fraction of glass in a glass epoxy composite is 0.8. If the specific gravity of glass and epoxy are 2.5 and 1.2 respectively, find (i) fibre and matrix volume fractions (ii) density of composite?
5. Explain briefly the progressive failure analysis in a composite laminate.

PART B

Answer any **FIVE** questions only

6. Briefly explain the Hooke's law for Anisotropic materials. Derive the stress-strain relation for a material with three planes of reflection and one 90◦ rotation symmetry
7. (a) Explain any two methods of manufacturing of composite in detail.
   (b) Derive the relations connecting the engineering constants and the elements of stiffness and compliance matrices for a specially orthotropic lamina.
8. (a) Calculate the longitudinal modulus and tensile strength of a unidirectional composite containing 60% by volume of carbon fibres (E_{1f} = 294 GPa and σ_{1fu} = 5.6 Gpa) in a toughened epoxy matrix (E_m = 3.6 GPa and σ_{mu} = 105 Gpa). Compare these values with the experimentally determined values of E_1 = 162 GPa and σ_{1u} = 2.94 GPa. What fraction of load is carried by fibres in the composite?
   (b) Explain how to calculate the effective modului of a composite lamina in terms of its constituent properties.
9. (a) Explain the free edge effects and interlaminar stresses in composite laminates
   (b) Explain how to determine the laminae stresses and strains from the analysis of a laminate?
10. Calculate the A, B , D matrices for a [0/90°] laminate each layer of which is of 0.125 mm thickness. The lamina properties are given by E_1 = 140 GPa, E_2 = 10 GPa, G_{12} = 5 GPa, υ_{12} = 0.3
11. (a) Explain the effect of interlaminar stresses in composite laminate in detail
    (b) Explain the importance of the sign of shear stress on strength of composites.

12. Find the maximum value of S>0 if a stress of σ_x = 2S, σ_y = -3S, and τ_{xy} = 4S is applied to a 60° Graphite/epoxy Lamina. Use Tsai-Hill Failure theory.
Given $(\sigma_1^t)_{ult} = 1500MPa,\ (\sigma_1^C)_{ult} = 1500MPa,\ (\sigma_2^t)_{ult} = 40MPa,\ \ (\sigma_2^C)_{ult} = 246MPa,$ $(\tau_{21})_{ult} = 68MPa$

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to Composite Materials (6)**	
1.1	Definition of composites, Objectives, constituents and Classification of composites.	2
1.2	Basic terminology used in fibre reinforced composite materials- Lamina, Laminates ,General Characteristics of reinforcement and classifications, Characteristics of matrix- Polymer matrix, Thermoplastics and thermosetting resins, Glass transition temperature , Prepregs	2
1.3	Structural applications of Composite Materials	1
1.4	Processing of Composites	1
2	**Macro mechanical behaviour of a composite lamina (9)**	
2.1	Review of Basic Equations of Mechanics and Materials, Hooke's law for different types of materials- Anisotropic, orthotropic, isotropic, monoclinic and Transversely isotropic materials.	2
2.2	Stress-Strain relations for a Two dimensional unidirectional and orthotropic lamina, lamina of arbitrary orientation, Transformations of stress and strain	3
2.3	Relationship of Compliance and stiffness matrix to elastic constants of a lamina	1
2.4	Strength and Failure theories of Continuous Fibre-reinforced orthotropic Lamina- Failure envelopes, Maximum stress/strain criteria, Tsai-Hill and Tsai-Wu criterion.	2
2.5	Hygrothermal stresses and strains in a lamina –unidirectional and angle lamina	1
3	**Micromechanical Behaviour of a Lamina (6)**	
3.1	Volume and Mass fractions, density and void content	1
3.2	Effective Moduli of a continuous fibre-reinforced lamina – Models based on mechanics of materials, theory of elasticity and experimental methods, Mechanics of materials approach to strength, Numerical Examples	2
3.3	Ultimate Strengths of unidirectional Lamina- longitudinal and transverse tensile and compressive strengths	2
3.4	Coefficients of moisture and thermal expansion	1
4	**Macro mechanical behaviour of Laminates (10)**	

4.1	Classical Lamination Theory-Laminae Stress-strain behaviour, In-plane forces, stress-strain variation in a laminate, resultant laminate stresses and strains,	3
4.2	Special cases of laminate stiffnesses-symmetric and antisymmetric laminates, cross ply and angle ply laminates, quasi-isotropic laminates	3
4.3	Inplane and flexural modulus of a laminate	1
4.4	Effects of stacking sequence-Laminate code	1
4.5	Free-Edge Interlaminar Effects, Hygro-thermal effects and warpage in a laminate	2
5	**Strength and Design of Laminates (9)**	
5.1	Determination of laminae stresses and strains, numerical examples	2
5.2	Laminate strength analysis procedure, Failure envelopes	3
5.3	Analysis of laminates after initial failures, Progressive failure Analysis. Numerical Examples	2
5.4	Composite mechanical design issues-Long-term environmental effects, impact resistance, fracture resistance, fatigue resistance	2

Text Books

1. Jones M. Roberts, Mechanics of Composite Materials, Taylor and Francis,1998
2. Reddy, J.N , Mechanics of Laminated Composite Plates: Theory and Analysis, CRC Press, 2003

Reference Books

1. Calcote, L. R., Analysis of Laminated Composite structures, Van Nostrand, 1969
2. Vinson, J. R. and Chou P, C., Composite materials and their use in Structures, Applied Science Publishers, Ltd. London, 1975
3. Agarwal, B.D. and Broutman, L. J., Analysis and performance of Fibre composites. 3rdEdn.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222ECE098	PROJECT EVALUATION AND MANAGEMENT	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: Objective of the course is to enable the students to understand the management aspects of project idea formulations, feasibility studies and report preparation, costing of project, project appraisal and project funding.

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

CO 1	To develop project ideas
CO 2	To do the feasibility analysis of projects
CO 3	To plan and arrive at Project Costs
CO 4	To carry out project appraisals
CO 5	To identify the various funding sources and select the apt source

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2		3	2		2	
CO 2	2		2				
CO 3	3	2		3			
CO 4	2		2	2	2		
CO 5	2		2	1			

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	20
Apply	10
Analyse	10
Evaluate	20
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

Model Question paper

Course Code & Name:

Project Evaluation and Management

Max. Marks: 60
Duration: 2.5 hours

PART A

(Answer all Questions: Each question carries 5 marks)

1. Discuss the need for project idea generation ?
2. Why feasibility studies are essential?
3. What do you understand by Present value of a single amount?
4. Explain the international practice of Project Appraisal.
5. Discuss the means of Project Financing.

PART B

(Answer any *five* questions: Each carries 7 marks)

6. Describe the various steps involved in Project Identification.
7. How will you assess the technical feasibility of a project?
8. Explain cash flow and what are the benefits of cash flow statement..
9. Discuss the various methods of Risk Analysis
10. Bluebell Enterprises had invested Rs.2,00,00,000 for the purpose of replacing some of its machinery components. This renovation is expected to result in incremental benefits of Rs.5000000 in 1st year, Rs.3000000 in 2nd year and Rs. 4000000 in 3rd year. Calculate the benefit-cost ratio of the replacement project if the applicable discounting rate is 5%..
11. Discuss the role of various institutions for project financing
12. Discuss the Private Sector Participation on Infrastructure Projects in India

Syllabus and Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	Project formulation	
1.1	Concepts of Project, Capital Investments	2
1.2	Purpose and need for Project Identification	2
1.3	Methodology for Project Identification	2
1.4	Steps in Project Identification	2
2	Project Feasibility	
2.1	Introduction to feasibility Studies, need for feasibility studies	2
2.2	Components of Feasibility Analysis - Market, Technical, Financial, Economic	4
2.3	Feasibility Reports and approvals	2
3	Project Costing	
3.1	Time Value of Money - Future value of single amount, Present value of single amount, Future value of an annuity, Present value of an annuity, Simple interest-Compound interest	3
3.2	Project Cash Flows	3
3.3	Cost of capital	2
4	Project Appraisal	
4.1	Investment Criteria- Discounting criteria-Net present value (NPV), Benefit cost ratio(BCR), internal rate of return(IRR)-Non-Discounting criteria - Pay Back Period, Accounting rate of return(ARR	4
4.2	Indian and International Practice of Appraisal	2
4.3	Methods of Analysis of Risk	2
5	Project Financing	
5.1	Project Financing – Means of Finance	2
5.2	Financial Institutions, schemes	3
5.3	Private sector participation in Infrastructure Development Projects - BOT, BOLT, BOOT	2
5.4	Technology Transfer and Foreign Collaboration	1

Reference Books

1. Project Planning Analysis selection financing Implementation and Review- Tata Mc Graw Hill Publication, 7th edition 2010, Prasana Chandra
2. United Nations Industrial Development Organization (UNIDO) Manual for the preparation of Industrial Feasibility Studies, (IDSI Reproduction), Bombay, 2007.

3 A Systems Approach to Planning, Scheduling, and Controlling Project Management Harold Kerzner (2013), Wiley India, New Delhi

4 Project planning scheduling & control, James P.Lawis, Meo Publishing Company 2001

5 Project planning analysis selection implementation & review Prasanna Chandra, ISBNO-07-462049-5 2002.