# *Department of Mechanical Engineering*

# COURSE PLAN 2021-22

# VI Semester

## *INSTITUTE VISION*

"To be a preferred institution in Engineering Education by achieving excellence in teaching and research and to remain as a source of pride for its commitment to holistic development of individual and society"

## *INSTITUTE MISSION*

"To continuously strive for the overall development of students, educating them in a state-of-the-art-infrastructure, by retaining the best practices, people and inspire them to imbibe real time problem solving skills, leadership qualities, human values and societal commitments, so that they emerge as competent professionals"

## DEPARTMENT OF MECHANICAL ENGINEERING

## *VISION*

"To be the centre of excellence in providing education in the field of Mechanical Engineering to produce technically competent and socially responsible engineering graduates"

## *MISSION*

"Educating students to prepare them for professional competencies in the broader areas of the Mechanical Engineering field by inculcating analytical skills, research abilities and encouraging culture of continuous learning for solving real time problems using modern tools"

## Program Educational Objectives (PEOs)

**The Graduates will be able to**

***PEO1:*** Acquire core competence in Applied Science, Mathematics and Mechanical Engineering fundamentals to excel in professional career and higher study

***PEO2:*** Design, demonstrate and analyze the mechanical systems which are useful to society.

***PEO3:*** Maintain professional & ethical values, employability skills, multidisciplinary approach & an ability to realize engineering issues to broader social context by engaging in lifelong learning.

## Program Specific Outcomes (PSOs)

***PSO1:*** Able to apply the basic principles of Mechanical Engineering in various practical fields to solve societal problems by engaging themselves in many state/national level projects.

***PSO2:*** Able to analyze and design basic mechanical system using relevant tools and techniques.

***PSO3:*** Able to resolve contemporary issues of industries through industry institute interaction and alumni social networks

## Program Outcomes (POs)

***PO1:*** **Engineering knowledge-** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

***PO2:*** **Problem analysis-** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

***PO3:*****Design/development of solutions-** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

***PO4:*****Conduct investigations of complex problems-** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

***PO5:*****Modern tool usage-** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

***PO6:*****The engineer and society-** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

***PO7:*****Environment and sustainability-** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

***PO8:*****Ethics-** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

***PO9:*****Individual and team work-** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

***PO10:*****Communication-** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

***PO11:*** **Project management and finance-** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

***PO12:*****Life-long learning-** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## CONTENTS

# Departmental Resources

Department of Mechanical Engineering was established in the year 1996 and is housed in a total area of **2584.5 Sq. Meters**.

**Faculty Position**

| Sl. No. | Category | No. in position | Average experience |
|---|---|---|---|
| 1 | Teaching faculty | 09 | 19 |
| 2 | Technical staff | 05 | 17 |
| 3 | Helper / Peons | 03 | 13 |

**Major Laboratories**

| S.N. | Name of the laboratory | Area in Sq. Meters | Amount Invested (Rs.) |
|---|---|---|---|
| 1 | Basic Workshop Laboratory | 170 | 428093 |
| 2 | Fluid Mechanics Machinery Laboratory | 172 | 775916.75 |
| 3 | Energy Conversion Engg. Laboratory | 173 | 1275603.2 |
| 4 | Machine shop Laboratory | 170 | 1372566.5 |
| 5 | Foundry & Forging Laboratory | 179 | 321057.11 |
| 6 | Design Laboratory | 73 | 365861.0 |
| 7 | Heat & Mass Transfer Laboratory | 148 | 524576.0 |
| 8 | Metallography & Material Testing Laboratory | 149 | 1102945.2 |
| 9 | Mechanical Measurements & Metrology Laboratory | 95 | 557593.75 |
| 10 | CIM & Automation/CAMA Laboratory | 66 | 3720793.1 |
| 11 | Computer Aided Machine Drawing Laboratory | 66 | 2014136.5 |
| 12 | Computer Aided Engg Drawing Laboratory | 66 | 1438121.3 |
| 13 | Department/Other | -- | 2031766.2 |
| | **Total** | **1527** | 638297 |
| | | | **16567326.61** |

## Teaching Faculty Details

| S.N. | Faculty Name | Designation | Qualification | Area of specialization | Teaching Exp (in years) | Contact Nos. |
|---|---|---|---|---|---|---|
| 1 | Dr. S. C. Kamate | Principal | Ph. D | Thermal(Cogeneration) | 31 | 9480849331 |
| 2 | Dr. S. N. Topannavar | Assoc. Prof. | Ph. D | Thermal Power Engg. | 23 | 9482440235 |
| 3 | Dr. K. M. Akkoli | Assoc. Prof. | Ph. D | Thermal Power Engg. | 18 | 9739114856 |
| 4 | Dr. M.M.Shivashimpi | Asst. Prof | Ph. D | Thermal Power Engg. | 15 | 9742197173 |
| 5 | Prof. D. N. Inamdar | Asst. Prof | M Tech.(Ph. D) | Tool Engg | 19 | 9591208980 |
| 6 | Prof. M.S.Futane | Asst. Prof | M Tech. | Computer Integrated Manufacturing | 16 | 9164105035 |
| 7 | Prof. S. A. Goudadi | Asst. Prof | M Tech. | Design Engineering | 14 | 9448876682 |
| 8 | Prof. M.A.Hipparagi | Asst. Prof | M Tech.(Ph.D) | Production Technology | 13 | 7411507405 |
| 9 | Prof. M. I. Tanodi | Asst. Prof | M Tech. (Ph.D) | Machine design | 10 | 9611998812 |
| 10 | Prof. G M Zulapi | Asst. Prof | M Tech. | Product Design & Manufacturing | 14 | 9480213587 |

## CALENDAR OF EVENTS FOR THE ACADEMIC YEAR 2021-22 OF II SEMESTER (EVEN)

| Date | Events |
|---|---|
| 06-06-2022 | Commencement of II Semester Classes |
| 14-06-2022 | World Blood Donor Day |
| 16-06-2022 to 18-06-2022 | HSIT-FEST |
| 21-06-2022 | International Yoga Day |
| 02-07-2022 | Submission of Assignment-1 |
| 01-07-2022 to 03-07-2022 | First Internal Assessment for II Semester |
| 04-07-2022 | Feedback-I on Teaching-Learning |
| [illegible]07-2022 | Display of 1st I.A. Marks and submission of Feedback-I to office |
| 21-07-2022 | Project Exhibition |
| 22-07-2022 to 23-07-2022 | First Lab Internal Assessment for II Semester |
| 29-07-2022 | Graduation Day |
| 31-07-2022 to 02-08-2022 | Second Internal Assessment for II Semester |
| 03-08-2022 | Feedback-II on Teaching-Learning |
| 08-08-2022 | Display of 2nd I.A. Marks and submission of Feedback-II to office |
| 13-08-2022 | Submission of Assignment-2 |
| 13-08-2022 | TECHNOVISION -2K22 |
| 25-08-2022 to [illegible]08-2022 | Third Internal Assessment for II Semester |
| 29-08-2022 to 30-08-2022 | Second Lab Internal Assessment for II Semester |
| 31-08-2022 | Last working day of II Semester |
| 02-09-2022 | Display of Final IA Marks |
| 02-09-2022 to 09-09-2022 | Practical/Viva Examination of II Semester |
| 12-09-2022 to 30-09-2022 | Theory Examination of II Semester |
| 01-10-2022 to 20-10-2022 | Intra/Inter Internship |

June-2022

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | | |

July-2022

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

August-2022

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | 31 | | | |

9-Last Day of Moharam, 15-Independence Day
31-Varasiddhi Vinayaka Vrata

September-2022

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | |

Dr. B. V. Madiggond
**Dean (Acad)**

Dr. S. C. Kamate
**Principal**

*Note:* 1. *Academic Calendar **may be modified** based on guidelines/directions issued in the future by competent authority.*

2. *The syllabus should be completed in offline classes to cover **80%** of the syllabus and **20%** of the syllabus can be covered in virtual (online) mode. **Attendance** of the students for offline and online classes is mandatory and records should be maintained and submitted to whenever informed.*

# VTU Scheme of Teaching and Examination

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI**
**Scheme of Teaching and Examination 2018 – 19** 5
**Outcome Based Education(OBE) and Choice Based Credit System (CBCS)**
**(Effective from the academic year 2018 – 19)**

**VI SEMESTER**

| Sl. No | Course and Course code | | Course Title | Teaching Department | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory Lecture | Tutorial | Practical/ Drawing | Duration in hours | CIE Marks | SEE Marks | Total Marks | |
| | | | | | L | T | P | | | | | |
| 1 | PCC | 18ME61 | Finite Element Methods | | 3 | 2 | – | 03 | 40 | 60 | 100 | 4 |
| 2 | PCC | 18ME62 | Design of Machine Elements II | | 3 | 2 | – | 03 | 40 | 60 | 100 | 4 |
| 3 | PCC | 18ME63 | Heat Transfer | | 3 | 2 | – | 03 | 40 | 60 | 100 | 4 |
| 4 | PEC | 18ME64X | Professional Elective -1 | | 3 | – | – | 03 | 40 | 60 | 100 | 3 |
| 5 | OEC | 18ME65X | Open Elective -A | | 3 | – | – | 03 | 40 | 60 | 100 | 3 |
| 6 | PCC | 18MEL66 | Computer Aided Modelling and Analysis Lab | | – | 2 | 2 | 03 | 40 | 60 | 100 | 2 |
| 7 | PCC | 18MEL67 | Heat Transfer Lab | | – | 2 | 2 | 03 | 40 | 60 | 100 | 2 |
| 8 | MP | 18MEMP68 | Mini-project | | – | – | 2 | 03 | 40 | 60 | 100 | 2 |
| 9 | Internship | – | Internship | To be carried out during the vacation/s of VI and VII semesters and /or VII and VIII semesters. | | | | | | | | |
| | | | | **TOTAL** | **15** | **10** | **6** | **24** | **320** | **480** | **800** | **24** |

**Note: PCC: Professional core, PEC: Professional Elective, OE: Open Elective, MP: Mini-project.**

**Professional Elective -1**

| Course code under 18XX64X | Course Title | Course code under 18XX64X | Course Title |
|---|---|---|---|
| 18ME641 | Non-Traditional Machining | 18ME644 | Advanced Vibrations |
| 18ME642 | Refrigeration and Air conditioning | 18ME645 | Composite Materials Technology |
| 18ME643 | Theory of Elasticity | | |

**Open Elective -A**

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (Please refer to the list of open electives under 18XX65X).
Selection of an open elective shall not be allowed if.

- The candidate has studied the same course during the previous semesters of theprogramme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professionalelectives.
- A similar course, under any category, is prescribed in the higher semesters of theprogramme.

Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

| Subject Title | FINITE ELEMENT ANALYSIS | | |
|---|---|---|---|
| Subject Code | 18ME61 | CIE Marks | 40 |
| Number of Lecture Hrs / Week | 03L+02T | SEE Marks | 60 |
| Total Number of Lecture Hrs | 50( 10 Hours per Module) | Exam Hours | 03 |
| CREDITS – 04 | | | |

| FACULTY DETAILS: | | |
|---|---|---|
| **Name:** Mr. S A Goudadi | **Designation:** Asst. Professor | **Experience:**14 |
| **No. of times course taught:**02 | **Specialization:** Design Engineering | |

## 1.0 Prerequisite Subjects:

| Sl. No | Branch | Semester | Subject |
|---|---|---|---|
| 01 | Mechanical Engineering | I/II/III/IV | Engg. Mathematics |
| 02 | Mechanical Engineering | III | Mechanics of Mechanics |
| 03 | Mechanical Engineering | VI | Design of Machine Elements-II |
| 04 | Mechanical Engineering | VI | Heat and Mass Transfer |

## 2.0 Course Objectives

- To learn basic principles of finite element analysis procedure.
- To learn the theory and characteristics of finite elements that represent engineering structures.
- To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

## 3.0 Course Outcomes

After successfully completion of this course, the student will be able to

| CO | Course Outcome | Cognitive Level | POs |
|---|---|---|---|
| CO1 | Understand the concepts behind formulation methods in FEM and Choose interpolation polynomial equation for simplex elements | L1,L2 | PO1,PO2,PO3,PO6,PO8,PO11,PO12 |
| CO2 | Develop element characteristic equation and solve the global equation of FEA elements such as bars and trusses. | L2,L3 | PO1,PO2,PO3,PO6,PO8,PO11,PO12 |
| CO3 | Develop element characteristic equation and solve the global equation of FEA for beams and circular shafts | L2,L3 | PO1,PO2,PO3,PO6,PO8,PO11,PO12 |
| CO4 | Develop element characteristic equation and solve the global equation of FEA for 1D heat transfer and fluid flow | L2,L3 | PO1,PO2,PO3,PO6,PO8,PO11,PO12 |
| CO5 | Develop element characteristic equation and solve the global equation of FEA for axi symmetric and dynamic problems | L2,L3 | PO1,PO2,PO3,PO6,PO8,PO11,PO12 |
| **Total Hours of instruction** | | **50** | |

## 4.0 Course Content

**Module I**

**Introduction to Finite Element Method :** General steps of the finite element method. Engineering applications of finite element method. Advantages of the Finite Element Method.
**Boundary conditions:** homogeneous and no homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretisation process,
**Types of elements:** 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.
**Interpolation models:** Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

**Module II**

**Introduction to the stiffness (Displacement) method:**
Introduction, Derivation of stiffness matrix, Derivation of stiffness matrix for a spring element, Assembly the total stiffness matrix by superposition. One-Dimensional Elements-Analysis of Bars and Trusses,
Linear interpolation polynomials in terms of local coordinate's for 1D, 2D elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 8), 2D isoparametric element, Lagrange interpolation functions,
**Numerical integration:** Gaussian quadrature one point, two point formulae, 2D integrals. Force terms: Body force, traction force and point loads,
**Numerical Problems:** Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.

**Module III**

**Beams and Shafts:** Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.
**Torsion of Shafts:** Finite element formulation of shafts, determination of stress and twists in circular shafts.

**Module IV**

**Heat Transfer:** Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, 1D finite element formulation using variational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.
**Fluid Flow:** Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.

**Module V**

**Axi-symmetric Solid Elements**: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.
**Dynamic Considerations:** Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element. Evaluation of eigen values and eigen vectors, applications to bars, stepped bars and beams.

## 5.0 Relevance to future subjects

| Sl No | Semester | Subject | Topics |
|---|---|---|---|
| 01 | VII | Mechanical Vibrations | Modal Analysis and Harmonic Analysis |

| | | | |
|---|---|---|---|
| 02 | VIII | Project work | Part Modeling and Analysis |

## 6.0 Relevance to Real World

| SL.No | Real World Mapping |
|---|---|
| 01 | Examples of bars, beams and Trusses |
| 02 | Examples of 1D bars for heat transfer |

## 7.0 Gap Analysis and Mitigation

| Sl. No | Delivery Type | Details |
|---|---|---|
| 01 | NPTEL | Analysis Application |

## 8.0 Books Used and Recommended to Students

**Text Books**

1. Logan, D. L., A first course in the finite element method,6th Edition, Cengage Learning,2016.
2. Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013.

**Reference Books**

1. J.N.Reddy, "**Finite Element Method"-** McGraw -Hill International Edition.Bathe K. J. Finite Elements Procedures, PHI.
2. Bathe K. J "**Finite Elements Procedures** "PHI
3. Cook R. D., et al. "**Concepts and Application of Finite Elements Analysis"-** 4th Edition, Wiley & Sons, 2003.

**Additional Study material & e-Books**

1. VTU, E- learning
2. NPTEL of FEM and FEA
3. FEM by ARK Swamy.

## 9.0 Relevant Websites (Reputed Universities and Others) for Notes /Animation /Videos Recommended

**Website and Internet Contents References**

1) https://en.wikipedia.org/wiki/Finite_element_method
2) nptel.ac.in/courses/112104116
3) http://autofem.com/en/examples.html

## 10.0 Magazines/Journals Used and Recommended to Students

| Sl.No | Magazines/Journals | website |
|---|---|---|
| 1 | International Journal of Computational Methods | *www.worldscientific.com* |
| 2 | International Journal of Solids and Structures | http://www.sciencedirect.com/science/journal/00207683 |

## 11.0 Examination Note

**Internal Assessment: 40 Marks**

Theoretical aspects as well as relevant sketches should be drawn neatly for questions asked in Internal Assessments

**Scheme of Evaluation for Internal Assessment**

Internal Assessment test in the same pattern as that of the main examination (Average of 3 Tests):40marks.

**SCHEME OF EXAMINATION:**

- Course to be evaluated for 100 marks, irrespective of its Credits.
- One question from each module

**INSTRUCTION FOR** FINITE ELEMENT METHOD **(**18ME61**) EXAMINATION**

- The total duration is 3 hours.

- Draw free hand sketch if required neatly.

## 12.0 Course Delivery Plan

| Module No. | Lecture No. | Content of Lecture | % of Portion |
|---|---|---|---|
| 1 | 1. | **Introduction to Finite Element Method:** General description of the finite element method. Engineering applications of finite element method. | 20 |
| | 2. | Boundary conditions: homogeneous and Non homogeneous for structural, heat transfer and fluid flow problems. | |
| | 3. | Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation | |
| | 4. | Convergence criteria, Discretization process, Types of elements: 1D, 2D and3D, Node numbering, | |
| | 5. | Location of nodes. Strain displacement relations, | |
| | 6. | Stress strain relations, Plain stress and Plain strain conditions, temperature effects | |
| | 7. | **Interpolation models:** Simplex, complex and multiplex elements, | |
| | 8. | Linear interpolation | |
| | 9. | Polynomials in terms of global coordinates | |
| | 10. | 1D, 2D, 3D Simplex Elements. | |
| 2 | 11. | **Introduction to the stiffness (Displacement) method:** Linear interpolation polynomials in terms of local coordinate's for 1D | 20 |
| | 12. | 2D elements, Higher order interpolation functions for | |
| | 13. | 1D quadratic and cubic elements in natural coordinates, Constant strain triangle | |
| | 14. | Four-Nodded Tetrahedral Element (TET 4) , Eight-Nodded Hexahedral Element (HEXA 8), | |
| | 15. | 2DIso parametric element, Lagrange interpolation functions, | |
| | 16. | Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals | |
| | 17. | Force terms: Body force, traction force and point loads, | |
| | 18. | **Numerical Problems:** Solution for displacement, stress and strain in 1D straight bars, | |
| | 19. | stepped bars and tapered bars using elimination approach and penalty approach , | |
| | 20. | Analysis of trusses | |
| 3 | 21. | **Beams and Shafts:** Boundary conditions, Load vector, Hermite shape functions, | 20 |
| | 22. | Beam stiffness matrix based on Euler-Bernoulli beam theory, | |
| | 23. | Examples on cantilever beams, propped cantilever | |
| | 24. | propped cantilever beams, | |
| | 25. | Numerical problems on simply supported, fixed straight and | |
| | 26. | stepped beams using direct stiffness method with concentrated and | |
| | 27. | uniformly distributed | |
| | 28. | **Torsion of Shafts:** Finite element formulation of shafts, | |
| | 29. | Determination of stress and | 20 |
| | 30. | twists in circular shafts. | |
| 4 | 31. | **Heat Transfer:** Basic equations of heat transfer: | |
| | 32. | Energy balance equation, | |
| | 33. | Rate equation: conduction, convection, radiation, | |

| | | | |
|---|---|---|---|
| | 34. | 1D finite element formulation using variational method | |
| | 35. | Problems with temperature gradient and | |
| | 36. | Heat fluxes | |
| | 37. | heat transfer in composite sections, | |
| | 38. | straight fins. | |
| | 39. | Numerical examples | |
| | 40. | Numerical examples | |
| 5 | 41. | **Axi-symmetric Solid Elements**: Derivation of stiffness matrix of axisymmetric bodies with triangular elements | 20 |
| | 42. | Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads. | |
| | 43. | Angular velocity, | |
| | 44. | Pressure Vessels | |
| | 45. | **Dynamic Considerations:** Formulation for point mass and distributed masses | |
| | 46. | Consistent element mass matrix of one dimensional bar element, | |
| | 47. | truss element, axisymmetric triangular element, beam element | |
| | 48. | Lumped mass matrix of bar element, Truss element, evaluation of eigen values and eigen vectors | |
| | 49. | Application to bars, stepped bars and | |
| | 50. | beams | |

## 13.0 Assignments, Pop Quiz, Mini Project, Seminars

| Sl. No. | Title | Outcome expected: students able to | Allied study | Week No. | Individual / Group activity | Reference: book/website /Paper |
|---|---|---|---|---|---|---|
| 1 | Assignment 1: Questions on Introduction to FEM | Understand the concepts behind formulation methods in FEM and Choose interpolation polynomial equation for simplex elements | Module I | 2 | Individual Activity. | Text Books |
| 2 | Assignment 2: Questions on Analysis of bars, trusses | Develop element characteristic equation and solve the global equation of FEA elements such as bars and trusses. | Module II | 4 | Individual Activity. | Text Books |
| 3 | Assignment 3: Questions on Beams and Shafts | Develop element characteristic equation and solve the global equation of FEA for beams and circular shafts | Module III | 6 | Individual Activity.. | Text Books |
| 4 | Assignment 4: Questions on heat transfer and fluid flow | Develop element characteristic equation and solve the global equation of FEA for 1D heat transfer and fluid flow | Module IV | 8 | Individual Activity. | Text Books |
| 5 | Assignment 5: Questions on Axi-symmetric Solid Elements, Dynamic Considerations | Develop element characteristic equation and solve the global equation of FEA for axi symmetric and dynamic problems | Module V | 10 | Individual Activity. | Text Books |

## 15.0 QUESTION BANK

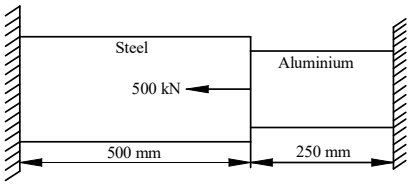
**Module – 1**

1. Write the equilibrium equations in elasticity subjected to body force
2. Write the equilibrium equations in elasticity subjected to traction force
3. Write the stress strain relations for plane stresses and plane strains
4. Write the General description of Finite Element Method
5. Write the Engineering applications of finite element methods
6. Explain different types of elements
7. Explain size of the elements, location of nodes, node numbering scheme

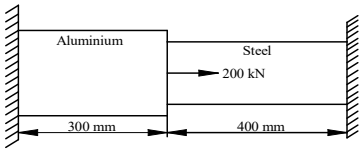
8. Write the Polynomial form of interpolation functions-of linear, quadratic and cubic, Simplex, Complex, Multiplex elements.
9. Explain the Selection of the order of the interpolation polynomial,
10. What is meant by Convergence requirements,
11. What is 2D Pascal triangle
12. Derive an expression for Euler's Lagrange's equations of bar
13. Derive an expression for Euler's Lagrange's equations of beam
14. Derive an expression for Principal of a minimum potential energy,
15. What is meant by principle of virtual work?
16. Explain Rayleigh-Ritz.
17. Derive an expression for Stiffness matrix of bar element by direct method.

**Module – 2**

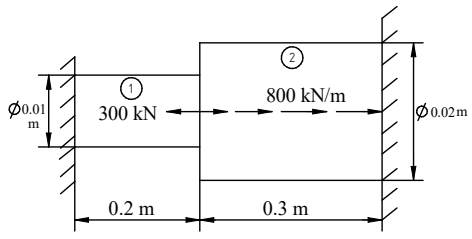
1. Write the Linear interpolation polynomials in terms of global coordinates of bar. triangular (2D simplex) elements
2. What is CST element?
3. What is B matrices, Jacobin, Jacobin of 2D triangular element, quad lateral Jacobin of 2D triangular element, quad lateral Consistent load vector
4. What is Higher Order and Isoparametric Elements.
5. Explain the Lagrangian interpolation, Higher order one dimensional elements- quadratic Cubic element their shape functions.
6. Write the Shape functions of 1D quadratic element in natural coordinates
7. Write the shape functions of 1D cubic element shape
8. Write plane trusses by direct stiffness,
9. Explain Solution for displacements reactions.
10. Find the reactions and stresses by using elimination approach
11. Explain penalty approach
12. Using the penalty approach, determine the nodal displacements, stresses and reaction solutions of the axially loaded bar shown in the following Fig. Take $E_{steel}$ = 200 GPa, $E_{Al}$ = 70 GPa, $A_{steel}$ = 16 mm$^2$, $A_{Al}$ = 24 mm$^2$.



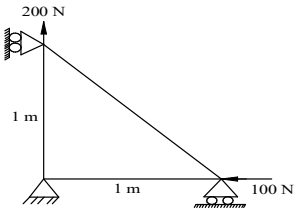

13. Determine the nodal displacements, stresses induced in a stepped bar shown in the following Fig. subjected to thermal loads. Take $E_{steel}$ = 200 GPa, $E_{Al}$ = 72 GPa, $A_{steel}$ = 1000 mm$^2$, $A_{Al}$ = 500 mm$^2$, $\alpha_{steel}$ = 11.7×10-6 / $^0$C, $\alpha_{Al}$ = 23×10-6 / $^0$C, $\Delta T = 60^0$.



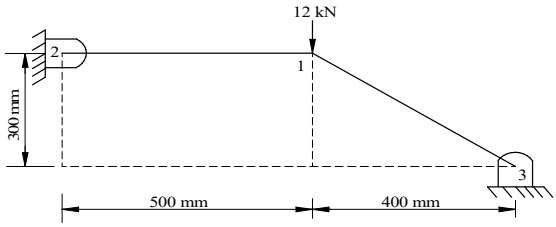

14. Obtain the displacement at node 2 and stresses in the circular solid stepped bar as shown in figure. Take E1 = 70 GPa, E2 = 200 GPa for the element 1 and 2 respectively.



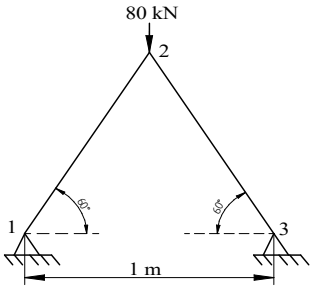

15. Write the properties of shape functions, Truss element.
16. Determine the nodal displacement in the truss segments subjected to concentrated load as shown in Figure. Take E = 70 GPa, A = 0.01 m$^2$.




17. Obtain the displacement at node 1, and stresses induced in each member of the truss shown in figure. Take E = 70 GPa and A = 200 mm$^2$.

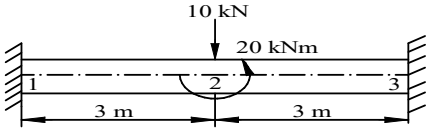



18. For the two member truss shown in figure, determine nodal displacements and stresses in each member. Take E = 70 GPa and A = 100 mm$^2$.

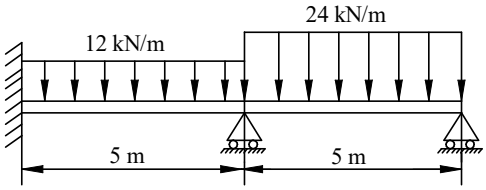



**Module – 3**

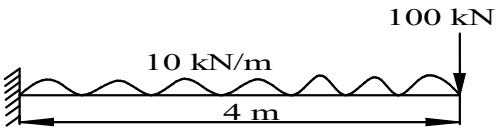
1. Write the Shape function of beam element.
2. Write the Hermite shape function of beam element
3. For the beam shown in the figure, determine the displacement at the centre node. Take E = 210 GPa, b = 0.2 m and h = 0.4 m.




4. Analyse the beam shown in figure, by finite element method and determine the end reactions. Also determine the deflections at mid span of every element. Take E = 2x10$^5$ N/mm$^2$ and I = 5x10$^6$ mm$^4$.




5. Determine the maximum deflection and internal loads in the uniform cross-section of the cantilever beam as shown in the Fig.3. If the beam is treated as a single finite element. Take E = 70 x 10$^9$ N/m$^2$, I = 4 x 10$^{-4}$ m$^4$.




6. Explain Finite element formulation of shafts

**Module -4**

1. Problems related to beam, heat transfer 1D problems, and convection.
2. Discuss the finite element formulation of circular fin with conduction-convection boundary condition.

3. For the brick wall shown in Fig. 2, the inner surface temperature is $28^0$C and the outer surface is exposed to cold air at $-15^0$C. Determine the temperature distribution in steady state, within the wall, by considering 2 elements. What is the heat flux through the wall?

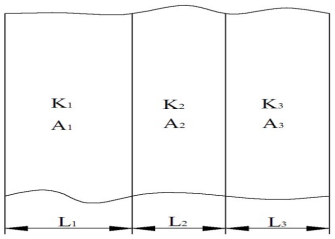



Fig.1

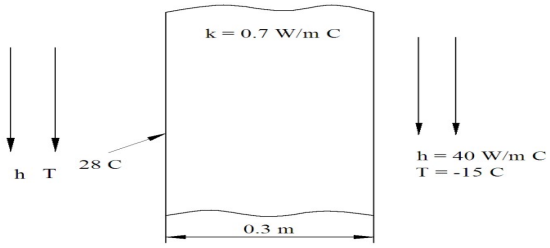
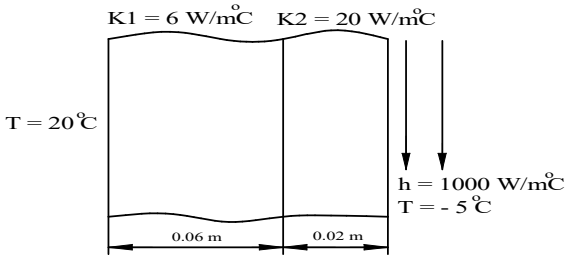



Fig.2

4. Determine the temperature distribution through the composite wall as shown in figure when convection heat loss occurs on the right surface. Assume a unit cross-sectional area.




## Module -5

1. What is axisymmetric element? Where do you use?
2. Derive stiffness matrix of axisymmetric triangular element.
3. Derive the stiffness matrix, consistent mass matrix and lumped matrix for 1D bar element

| Prepared by | | |
|---|---|---|
| Prof. S. A. Goudadi | HOD | Principal |

| Subject Title | NON TRADITIONAL MACHINING | | |
|---|---|---|---|
| Subject Code | 18ME641 | IA Marks | 40 |
| Number of Lecture Hrs / Week | 03 | SEE | 60 |
| Total Number of Lecture Hrs | 40 | Exam Hours | 03 |
| | | CREDITS – 03 | |

| FACULTY DETAILS: | | |
|---|---|---|
| **Name:** G.M.Zulapi | **Designation:** Asst. Professor | **Experience:**14 |
| **No. of times course taught:**05 | **Specialization:** Product Design and Manufacturing | |

## 1.0 Prerequisite Subjects:

| Sl. No | Branch | Semester | Subject |
|---|---|---|---|
| 01 | Mechanical Engineering | III / IV | MTO |

## 2.0 Course Objectives

1. To learn various concepts related to modern machiningprocesses and their applications.
2. To appreciate the differences between conventional and non-conventional machining processes.
3. To acquire a functional understanding of non-traditional manufacturing equipment.
4. To know about various process parameters and their influence on performance with their applications.
5. To impart knowledge on various types of energy involved in non-traditional machining processes.

## 3.0 Course Outcomes

On completion of the course, the students will be able to;

1. Understand the comparison between traditional and non-traditional machining process also recognize the need for Non-traditional machining process.
2. Understand the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM, AJM and WJM.
3. Identify the need of Chemical and electro-chemical machining process along with the constructional features, process parameters, process characteristics, applications, advantages and limitations.
4. Understand the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM & PAM.
5. Understand the LBM equipment, LBM parameters and characteristics. EBM equipment and mechanism of metal removal, applications, advantages and limitations LBM & EBM.

## 4.0 Course Content

**MODULE – 1**

**INTRODUCTION**

Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Nontraditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes. **08 hours**

**MODULE 2**

**Ultrasonic Machining (USM):** Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM.

**Abrasive Jet Machining (AJM):** Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD).Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.

**Water Jet Machining (WJM):** Equipment & process, Operation, applications, advantages and limitations of WJM.

**08 hours**

**MODULE 3**

**ELECTROCHEMICAL MACHINING (ECM)**

Introduction, Principle of electro chemical machining: ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish.

Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

**CHEMICAL MACHINING (CHM)**

Elements of the process: Resists (maskants), Etchants. Types of chemical machining process chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process. **10 hours**

**MODULE 4**

**ELECTRICAL DISCHARGE MACHINING (EDM)**

Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium- its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

**PLASMA ARC MACHINING (PAM)**

Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations. **08 hours**

**MODULE 5**

**LASER BEAM MACHINING (LBM)**

Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

**ELECTRON BEAM MACHINING (EBM)**

Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations. **08 hours**

## 5.0 Relevance to future subjects

| Sl No | Semester | Subject | Topics |
|---|---|---|---|
| 01 | VIII | Project work | Machining of different materials |

## 6.0 Relevance to Real World

| SL.No | Real World Mapping |
|---|---|
| 01 | Unconventional machining |
| 02 | Machining of high strength to low weight ratio materials. |
| 03 | Machining of difficult to machine materials. |

## 7.0 Gap Analysis and Mitigation

| Sl. No | Delivery Type | Details |
|---|---|---|
| 01 | Tutorial | Topic: Machining of difficult to machine materials |

## 8.0 Books Used and Recommended to Students

| **Text Books** |
|---|
| '1. Modern machining process, Pandey and Shan, Tata McGraw Hill 2000 2. New Technology, Bhattacharya 2000 |
| **Reference Books** |
| 1. Production Technology, HMT Tata McGraw Hill. 2001.<br>2. Modern Machining Process, Aditya. 2002<br>3. Non-Conventional Machining, P.K.Mishra, The Institution of Engineers (India) Test book series, Narosa Publishing House – 2005. 4.<br>4. Metals Handbook: Machining Volume 16, Joseph R. Davis (Editor), American Society of Metals (ASM) |
| **Additional Study material & e-Books** |
| 1. "Workshop Technology vol II" .Hazra Choudary |

## 9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

| Website and Internet Contents References |
|---|
| 4) https://www.scribd.com/doc/210082935/**non-conventional** |
| 5) https://ec.europa.eu/.../sites/.../cross-cutting-kets-roadmap-innovation-fields-manufact*uring*. |
| 6) https://www.smec.ac.in/**sites**/default/files/courses/mech/4-1/UCMP |
| 7) *https://en.wikipedia.org/wiki/Advanced_**manufacturing*** |

## 10.0 Magazines/Journals Used and Recommended to Students

| Sl.No | Magazines/Journals | website |
|---|---|---|
| 1 | Journal of Manufacturing system | http://www.sciencedirect.com/science/journal/02786125 |
| 2 | Production and Manufacturing research | http://www.tandfonline.com/doi/full/10.1080/21693277.2014.938276 |
| 3 | Journal machining and grinding engineers | http://www.in-situ.co.uk/in-situ-journal-machining?gclid=CM-o-pqYgtECFROVaAodwbkN2w |
| 4 | International journal of material forming and machining processes | http://www.igi-global.com/journal/international-journal-materials-forming-machining/69666 |

## 11.0 Examination Note

**Internal Assessment: 40 Marks**
Theoretical aspects as well as relevant sketches should be drawn neatly.
**Scheme of Evaluation for Internal Assessment**
Internal Assessment test in the same pattern as that of the main examination
**Semester End Examination: 60 Marks**
Two question to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.

**INSTRUCTION FOR NON TRADITIONAL MACHINING EXAMINATION**

1. Draw the neat sketches for relevant theory. The total duration is 3 hours.
2. Draw the flow charts required for some machining processes.

## 12.0 Course Delivery Plan

| Module | Lecture No. | Content of Lecturer | % of Portion |
|---|---|---|---|
| **Module 1:** | 1 | Introduction to Non-traditional machining | 19.04 |
| | 2 | Need for Non-traditional machining process | |
| | 3 | Comparison between traditional and non-traditional machining | |
| | 4 | General classification of Nontraditional machining processes, | |
| | 5 | Classification based on nature of energy employed in machining | |
| | 6 | Selection of non-traditional machining processes | |
| | 7 | Specific advantages, limitations | |
| | 8 | Applications of non-traditional machining processes | |
| **Module 2:** | 9 | **Ultrasonic Machining (USM):** Introduction, Equipment and material process, | 19.04 |
| | 10 | Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. | |
| | 11 | Process characteristics: Material removal rate, tool wear, accuracy, surface finish, | |
| | 12 | Applications, advantages & limitations of USM.<br>**Abrasive Jet Machining (AJM):** Introduction | |
| | 13 | Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). | |
| | 14 | Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM. | |
| | 15 | **Water Jet Machining (WJM):** Equipment & process, Operation | |

| | | | |
|---|---|---|---|
| | 16 | Applications, advantages and limitations of WJM. | |
| **Module 3:** | 17 | **ELECTROCHEMICAL MACHINING (ECM)** Introduction | 23.8 |
| | 18 | Principle of electro chemical machining: ECM equipment, elements of ECM operation, | |
| | 19 | Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. | |
| | 20 | Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. | |
| | 21 | ECM Tooling: ECM tooling technique & example Tool & insulation materials. Applications | |
| | 22 | ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH. | |
| | 23 | **CHEMICAL MACHINING (CHM)** Elements of the process: Resists (maskants), Etchants. | |
| | 24 | Types of chemical machining process chemical blanking process, chemical milling process. | |
| | 25 | Process characteristics of CHM: material removal rate, accuracy, surface finish | |
| | 26 | Advantages, limitations and applications of chemical machining process. | |
| **Module 4:** | 27 | **ELECTRICAL DISCHARGE MACHINING (EDM) :** Introduction | 19.04 |
| | 28 | Mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), | |
| | 29 | Dielectric medium-its functions & desirable properties, electrode feed control system. | |
| | 30 | Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM | |
| | 31 | Process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, | |
| | 32 | Electrical discharge grinding, Traveling wire EDM.<br>**PLASMA ARC MACHINING (PAM) :** Introduction, non-thermal generation of plasm | |
| | 33 | Equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions | |
| | 34 | Applications, advantages and limitations | |
| **Module 5:** | 35 | **LASER BEAM MACHINING (LBM)** | 19.04 |
| | 36 | Introduction, generation of LASER | |
| | 37 | Equipment and mechanism of metal removal | |
| | 38 | LBM parameters and characteristics | |
| | 39 | Applications, Advantages & limitations | |
| | 40 | **ELECTRON BEAM MACHINING (EBM)**<br>Introduction, | |
| | 41 | Principle, equipment and mechanism of metal removal | |
| | 42 | Applications, advantages and limitations. | |

## 13.0 Assignments, Pop Quiz, Mini Project, Seminars

| Sl.No. | Title | Outcome expected | Allied study | Week No. | Individual / Group activity | Reference: book /website /Paper |
|---|---|---|---|---|---|---|
| 1 | Assignment 1: | Students study the Topics and write the Answers. Get practice to solve university questions. | Module 1 of the syllabus | 2 | Individual Activity. | Books 1 and 3 of the text book list |
| 2 | Assignment 2: | Students study the Topics and write the Answers. Get practice to solve university questions. | Module 2 of the syllabus | 4 | Individual Activity. | Books 1 and 3 of the text book list |
| 3 | Assignment 3: | Students study the Topics and write the Answers. Get practice to solve university questions. | Module 3 of the syllabus | 6 | Individual Activity. | Books 1 and 3 of the text book list |
| 4 | Assignment 4: | Students study the Topics and write the Answers. Get practice to solve university questions. | Module 4 of the syllabus | 8 | Individual Activity. | Books 1 and 3 of the text book list |
| 5 | Assignment 5: | Students study the Topics and write the Answers. Get practice to solve university questions. | Module 5 of the syllabus | 10 | Individual Activity. | Books 1 and 3 of the text book list |

## 14.0 QUESTION BANK

**Module 1**

1. Explain the need for Non-Traditional Machining processes.
2. Differentiate between Traditional and Non-Traditional machining processes.
3. Write the various classification of Non-Traditional machining processes based on nature of energy employedin machining.
4. List and explain the various factors to be considered for selection of Non-Traditional machining processes.
5. Write the various advantages, limitations and applications of Non-Traditional machining processes.

**Module 2**

1. Explain with sketch the working principle of ultrasonic machining process.
2. Explain how various process parameters influence on machining performance in ultrasonic machining process. . Mention its advantages, disadvantages and Applications.
3. Explain the methods to increase ultrasonic machining rates.
4. Write a note on abrasive slurry used in AJM indicating types of abrasive and their properties, sizes used and liquid media with functions and characteristics.
5. With neat sketch explain AJM. Mention its advantages, disadvantages and Applications
6. Explain influence of various parameters on the metal removal rate in abrasive jet machining process.
7. Explain the desired properties of abrasive materials used in abrasive jet machining
8. Which are the abrasive materials used in abrasive jet machining?
9. Explain with neat sketch WJM.
10. Explain how various process parameters influence on machining performance in water jet machining process.
11. Mention the advantages, disadvantages and Applications of WJM.

**Module 3**

1. Explain with neat sketch ECM along with its advantages, disadvantages and Applications.
2. Explain with neat sketch ECG and ECH along with their advantages, disadvantages and Applications.
3. Explain the various process parameters and characteristics of ECM.
4. Explain the different types of Etchants and Maskants used in CHM.
5. Explain with neat sketch the different steps involved in chemical blanking.
6. Explain with neat sketch the different steps involved in chemical milling.
7. List the advantages, disadvantages and Applications of CHM.

**Module 4**

1. Explain with neat sketch EDM along with its advantages, disadvantages and Applications.
2. Explain witch neat sketches various types of generators and flushing in EDM.
3. Explain with neat sketch EDG and Travelling wire EDM.
4. Explain various process parameters and characteristics with respect to EDM.
5. Explain with neat sketch mechanism of metal removal in EDM process.
6. Explain with neat sketch PAM with its advantages, disadvantages and Applications.

**Module 5**

1. Explain With neat sketch LBM. Along with its advantages, disadvantages and Applications.
2. Explain various process parameters and characteristics with respect to LBM.
3. Explain With neat sketch Explain With neat sketch EBM. Along with its advantages, disadvantages and Applications.
4. Explain various process parameters and characteristics with respect to EBM.
5. Explain with neat sketch generation of LASER and the principle of LBM.

## 15.0 University Result

| Examination | FCD | FC | PC | % Passing |
|---|---|---|---|---|
| 2020-21 | 48 | 04 | 00 | 100 |

| Examination | S+ | S | A | B | C | D | E | % Passing |
|---|---|---|---|---|---|---|---|---|
| 2019-20 | 02 | 36 | 37 | 43 | 11 | 01 | 0 | 100 |

| Prepared by | Checked by | | |
|---|---|---|---|
| |  |  |  |
| Prof. G.M.Zulapi | Prof. M A Hipparagi | HOD | Principal |
| Faculty | Module coordinator | | |

| Subject Title | DESIGN OF MACHINE ELEMNTS II | | |
|---|---|---|---|
| Subject Code | 18ME62 | CIE Marks | 40 |
| Number of Lecture Hrs / Week | 03L+02T(3:2:0) | SEE Marks | 60 |
| Total Number of Lecture Hrs | 50 | Exam Hours | 03 |
| CREDITS – 04 | | | |

| FACULTY DETAILS: | | |
|---|---|---|
| **Name:**Prof.D.N.Inamdar | **Designation:** Asst. Professor | **Experience:**17 |
| **No. of times course taught:**07 | **Specialization:** Tool engineering | |

## 1.0 Prerequisite Subjects:

| Sl. No | Branch | Semester | Subject |
|---|---|---|---|
| 01 | Applied Science | I to IV | Engineering Mathematics |
| 02 | Mechanical Engineering | I/II | CAED |
| 03 | Mechanical Engineering | III | CAMD ,Mechanics Of Materials , Kinematics OF Machine |
| 04 | Mechanical Engineering | V | Design of Machine Elements I |

## 2.0 Course Objectives

| | |
|---|---|
| **CO1** | To understand various elements involved in a mechanical system. |
| **CO2** | To analyze various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards. |
| **CO3** | To select transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue. |
| **CO4** | To design completely a mechanical system integrating machine elements. |
| **CO5** | To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes. |

## 3.0 Course Outcomes

The student, after successful completion of the course, will be able to

| Course Code | Course Outcome | POs& PSOs |
|---|---|---|
| C320.1 | Apply design principles for the design of mechanical systems involving springs, belts, pulleys, andwire ropes. | PO1,PO2,PO3,PO5,PO6,PO8,PO11,PO12 PSO1-PSO3 |
| C320.2 | Design different types of gears and simple gear boxes for relevant applications. | PO1,PO2,PO3,PO5,PO6,PO8,PO11,PO12 PSO1-PSO3 |
| C320.3 | Understand the design principles of brakes and clutches. | PO1,PO2,PO3,PO5,PO6,PO8,PO11,PO12 PSO1-PSO3 |
| C320.4 | Apply design concepts of hydrodynamic bearings for different applications and select Anti friction bearings for different applications using the manufacturers, catalogue. | PO1,PO2,PO3,PO5,PO6,PO8,PO11,PO12 PSO1-PSO3 |
| **Total Hours of instruction** | | **50** |

## 4.0 Course Content

| Modules | Teaching Hours | Revised Bloom's Taxonomy |
|---|---|---|

| | | (RBT) Level |
|---|---|---|
| **MODULE 1** | | |
| **Springs:** Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; springs under fluctuating loads.<br>**Leaf Springs:** Stresses in leaf springs, equalized stresses, and nipping of leaf springs. Introduction to torsion and Belleville springs.<br>**Belts:** Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition. Selection of flat and V belts- length & cross section from manufacturers' catalogues. Construction and application of timing belts.<br>**Wire ropes:** Construction of wire ropes, stresses in wire ropes, and selection of wire ropes. | 08 Hours | **L1, L2, L3, L4** |
| **MODULE 2** | | |
| **Gear drives:** Classification of gears, materials for gears, standard systems of gear tooth, lubrication of gears, and gear tooth failure modes.<br>**Spur Gears:** Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear.<br>**Helical Gears:** Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear. | 12 Hours | **L2, L3** |
| **MODULE 3** | | |
| **Bevel Gears:** Definitions, formative number of teeth, design based on strength, dynamic load and wear.<br>**Worm Gears:** Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives. | 10 Hours | **L2, L3. L4** |
| **MODULE 4** | | |
| **Design of Clutches:** Necessity of a clutch in automobile, types of clutch, friction materials and its properties. Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories.<br>**Design of Brakes:** Different types of brakes, Concept of self-energizing and self-locking of brakes. Practical examples, Design of band brakes, block brakes and internal expanding brakes. | 10 Hours | **L2, L3** |
| **MODULE 5** | | |
| **Lubrication and Bearings:** Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. Numerical examples on hydrodynamic journal and thrust bearing design. | 10 Hours | **L2, L3, L4** |

## 5.0 Relevance to future subjects

| Sl No | Semester | Subject | Topics |
|---|---|---|---|
| 01 | VII | Design Lab | Lubrication Experiment |
| 02 | VIII | Project work | Design and Drawings, Part Modeling |

## 6.0 Relevance to Real World

| SL.No | Real World Mapping |
|---|---|
| 01 | Industrial drawings and design of various components |
| 02 | Design of Automobile, Boilers, Heat exchangers and other industrial components |
| 03 | Development of a software applications |

## 7.0 Gap Analysis and Mitigation

| Sl. No | Delivery Type | Details |
|---|---|---|
| 01 | Tutorial | Topic: Spur Gear & Helical Gear |

## 8.0 Books Used and Recommended to Students

**Text Books**

1) Richard G. Budynas, and J. Keith Nisbett, **"**Shigley's Mechanical Engineering Design**",** McGraw-Hill Education, 10th Edition, 2015.
2) Juvinall R.C, and Marshek K.M, "Fundamentals of Machine Component Design", John Wiley & Sons, Third Edition, Wiley student edition, 2007.
3) V. B. Bhandari, *"*Design of Machine Elements", 4th Ed., Tata Mcgraw Hill, 2016.

**Reference Books**

1) Robert L. Norton "Machine Design- an integrated approach", Pearson Education, 2nd edition.
2) Spotts M.F., Shoup T.E "Design and Machine Elements", Pearson Education, 8th edition, 2006.
3) Orthwein W, "Machine Component Design", Jaico Publishing Co, 2003.
4) Hall, Holowenko, Laughlin (Schaum's Outline Series), "Machine design" adapted by S.K.Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.
5) G. M. Maithra and L.V.Prasad, "Hand book of Mechanical Design", Tata McGraw Hill, 2nd edition,2004.

**Additional Study material & e-Books**

1) Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.
2) Design Data Hand Book, K.Mahadevan and Balaveera Reddy, CBS publication.
3) Design Data Hand Book, H.G.Patil, I.K.International Publisher, 2010
4) PSG Design Data Hand Book, PSG College of technology, Coimbatore.

## 9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

**Website and Internet Contents References**

1. https://en.wikipedia.org/wiki/**Machine_element**
2. **www.nptel.ac.in**
3. https://cosmolearning.org
4. www.vtu.ac.in
5. http://nevonprojects.com/mini-projects-for-mechanical-engineering/

## 10.0 Magazines/Journals Used and Recommended to Students

| S.No | Magazines/Journals | website |
|---|---|---|
| 1 | Journal of Machine Design | http://www.mdesign.ftn.uns.ac.rs/ |
| 2 | International Journal of Solids and Structures | http://www.sciencedirect.com/science/journal/00207683 |
| 3 | Journal of Advanced Mechanical Design, Systems, and Manufacturing | https://www.jstage.jst.go.jp/article/jamdsm/4/5/4_5_795/_pdf |
| 4 | International Journal of Design Engineering | http://www.inderscience.com/jhome.php?jcode=IJDE |

## 11.0 Examination Note

**Scheme of Examination:**

**Question paper pattern:**

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Assignment:**

Course work includes a Design project. Design project should enable the students to design a mechanical system (like single stage reduction gear box with spur gears, single stage worm reduction gear box, V-belt and pulley drive system, machine tool spindle with bearing mounting, C-clamp, screw jack, etc.) A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modeling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report. Design project should be given due credit in internal assessment.

## 12.0 Course Delivery Plan

| Module No. | Lecture No. | Content of Lecture | % of Portion |
|---|---|---|---|
| 1 | 1 | **Springs:** Types of springs, stresses in helical coil springs of circular and non- circular cross-sections, | 16% |
| | 2 | Tension and compression springs, springs under fluctuating loads, Energy stored in springs, | |
| | 3 | Leaf springs, Stresses in Leaf springs | |
| | 4 | Equalized stressesand nipping of leaf springs. | |
| | 5 | Introduction to Torsion, Belleville springs. | |
| | 6 | **Belts**: Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, Initial tension, effect of centrifugal tension, maximum power condition. | |
| | 7 | Selection of flat and V belts- length & cross section from manufacturers' catalogues. Construction and application of timing belts. | |
| | 8 | **Wire ropes**: Construction of wire ropes, stresses in wire ropes, and selection of wire ropes.(Only theoretical treatment) | |
| 2 | 9 | **Gear drives**: Classification of gears, materials for gears, standard systems of gear tooth. | 20% |
| | 10 | Gear tooth failure modes and lubrication of gears. | |
| | 11 | **Spur Gears**: Definitions, stresses in gear tooth: Lewis equation and form factor. | |
| | 12 | Design of spur Gear for strength, dynamic load and wear with an illustrative example | |
| | 13 | Discussion of recent VTU question Paper problems. | |
| | 14 | **Helical Gears:** Definitions, transverse and normal module, formative number of teeth | |
| | 15 | Design of helical gear based on strength, dynamic load and wear with an illustrative example | |
| | 16 | Discussion of recent VTU question Paper problems. | |
| 3 | 17 | **Bevel Gears:** Definitions, formative number of teeth. | 24% |
| | 18 | Design of bevel gear based on strength, dynamic load with an illustrative example | |
| | 19 | Design based on wear loads and efficiency of worm gear drives with an illustrative example | |
| | 20 | Discussion of recent VTU question Paper problems. | |
| | 21 | Discussion on Assignment of design project on mechanical systems | |
| | 22 | **Worm Gears**: Definitions, types of worm and worm gears, and materials for worm and worm wheel. | |
| | 23 | Design based on strength, dynamic loads and efficiency of worm gear drives with an illustrative example | |
| | 24 | Design based on wear loads and efficiency of worm gear drives with an illustrative example | |
| | 25 | Discussion of recent VTU question Paper problems. | |
| | 26 | Discussion of recent VTU question Paper problems. | |
| 4 | 27 | **Design of Clutches**: Types of clutches and their applications, single plate and multi-plate clutches. | 20% |
| | 28 | Numerical examples on single plate clutches | |

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| | 29 | Numerical examples on multi-plate clutches | |
| | 30 | **Design of Brakes**: Types of Brakes,Block and Band brakes | |
| | 31 | Numerical examples on Block brakes | |
| | 32 | Numerical examples on Band brakes | |
| | 33 | self-locking of brakes and Heat generation in brakes | |
| 5 | 34 | **Lubrication and Bearings**: Lubricants and their properties, bearing materials and properties | 20% |
| | 35 | Mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. | |
| | 36 | Numerical examples on hydrodynamic journal design | |
| | 37 | Numerical examples on thrust bearing design | |
| | 38 | **Anti-friction bearings**: Types of rolling contact bearings and their applications, | |
| | 39 | Static and dynamic load carrying capacities, equivalent bearing load, load life relationship | |
| | 40 | Selection of deep grove ball bearings from the manufacturers' catalogue | |
| | 41 | Selection of bearings subjected to cyclic loads and speeds; probability of survival. | |
| | 42 | Discussion of recent VTU question Paper problems. | |
| | 43 | Discussion on Assignment of design project on mechanical systems | |

## 13.0 Assignments, Pop Quiz, Mini Project, Seminars

| S.No. | Title | Outcome expected | Allied study | Week No. | Individual / Group activity | Reference: book/website /Paper |
|---|---|---|---|---|---|---|
| 1 | Assignment 1to 5: University Questions from Text Books mentioned in VTU Syllabus and from previous question papers | Students study the Topics and write the Answers. Get practice to solve university questions. | Modules 1,2,3,4,5 of the syllabus | After every 2 weeks | Individual Activity. with due credit in internal assessment. | Refer all the above mentioned text books& reference books |
| 2 | Group Assignment on Design project to enable the students to design a mechanical system Like<br>• single stage reduction gear box with spur gears, single stage worm<br>• Reduction gear box,<br>• V-belt and pulley drive system<br>• Machine tool spindle with bearing mounting,<br>• C-clamp,<br>• screw jack,<br>• single plate clutch, etc | Student should able to<br>• design different Mechanical systems involving springs, belts and pulleys, different types of gears and simple gear boxes for different applications, & C-clamp, screw jack, single plate clutch, etc<br>• Design calculations must be hand written and should be included in the report. | Modules 1,2,3,4,5 of the syllabus for design Calculations &ModelingCAD Software's like, Solid edge,Catia,Solidworks AutoCAD & Pro-E Etc. | After completion of respective Modules | Group Activity& Design project with due credit (5 marks) in internal assessment. | Refer all the above mentioned text books & reference books and Use any of the below mentioned Modeling CAD Software's like, Solidedge,Catia,Solidworks AutoCAD & Pro-E Etc, http://nevonprojects.com/mini-projects-for-mechanical-engineering/ |

## 14.0 QUESTION BANK

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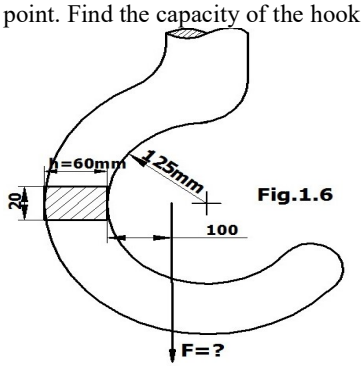
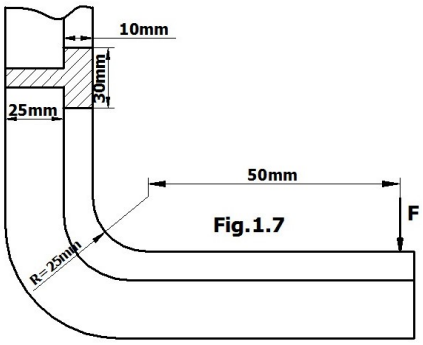
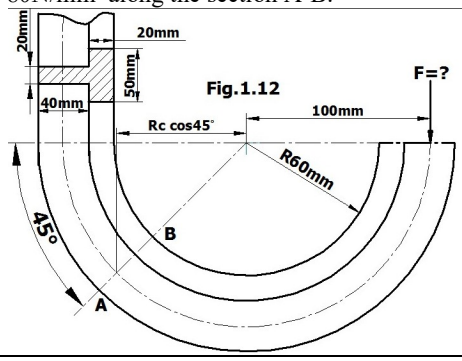
| **Module 1: Curved Beams:** | |
| 6 | The section of a crane hook is rectangular in shape whose width is 30mm and depth is 60mm. The center of curvature is the section is at a distance is 125mm from the inside section and the load line is 100mm from the same point. Find the capacity of the hook if the allowable stress in tension is 75N/mm$^2$ (refer Fig.1.6)   |
| 7 | Determine the force F such that the maximum tensile stress in the clamp is not to exceed 140N/mm$^{2.}$ (Refer Fig.1.7)   |
| 11 | Determine the capacity of a frame of a punch press shown in Fig. 1.12. The material from which the frame is made has an allowable stress of stress of 80N/mm$^2$ along the section A-B.   |
| **Module 1:Design of Belts, Wire Rope and chains Drives:** | |
| 1 | Show that in flat belt drives the ratio of belt tensions is given by $T_1/T_2=e^{\mu\theta}$, Where $T_1$ and $T_2$ are belt tensions, μ is the coefficient of friction and θ is the angle of lap. |
| 2 | Derive an expression for the ratio of tension in V-belt drive. |
| 3 | A belt is required to transmit 18.5 KW from a pulley of 1.2m diameter running at 250rpm to another pulley which runs at 500rpm. The distance between the centers of pulleys is 2.7m. The following data refer to an open belt drive μ=0.25. Safe working stress for leather is 1.75N/mm2. Thickness of belt =10mm. Determine the width and length of belt taking centrifugal tension into account. Also find the initial tension in the belt and absolute power that can be transmitted by this belt and the speed at which this can be transmitted. |
| 4 | A flat belt is required to transmit 10KW from a pulley of 600mm effective diameter running at 300rpm. The angle |

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| | of contact is spread over 7/16 of circumference. Determine the width of belt whose thickness is 10mm. The allowable stress for the belt is 2.25N/mm$^2$. Coefficient of friction between the pulley and belt is 0.3. |
| 5 | Design a belt drive to transmit 25KW from a motor shaft rotating at 1500rpm to a compressor running at 500rpm. The motor pulley is 96mm effective diameter and the centre distance between the shafts is 1.5m. |
| 6 | A belt of 100mm wide and 10mm thick is transmitting power at 1000m/min. The nit driving tension is 2 times the slack side tension. Allowable stress in the belt material is 2MPa. Specific weight of the belt material is 10KN/m$^3$. Determine the power that can be transmitted by the belt. Also determine the absolute power that can be transmitted by the belt and the velocity at which that power can be transmitted. |
| 7 | Select a V-belt drive to transmit 10KW of power from a pulley of 200mm diameter mounted on an electric motor running at 720rpm to another pulley mounted on compressor running at 200rpm. The service is heavy duty varying from 10 hours to 14 hours per day and centre distance between centers of pulley is 600mm. |
| 8 | A compressor is driven by a motor of 2.5KW running at 1200rpm to a 400rpm compressor. Select a suitable V-belt. |
| 9 | A V-belt is to transmit 20KW from a 250mm pitch diameter sheave operating at 1500rpm to a 900mm diameter flat pulley. The centre distance between input and output shafts is 1m. The groove angle is 40° and coefficient of friction is 0.2 for both pulleys and sheaves combination. The cross-section of the belt is 38mm wide at the top and 19mm wide at the bottom by 25mm deep. Each belt weighs 11KN/m$^3$ and allowable tension per belt is 1000N. How many belts are required? |
| 10 | Select a wire rope to lift a load of 10KN through a height of 600m from a mine. The weight of bucket is 2.5KN. The load should attain a maximum speed of 50m/min in 2 seconds. |
| 11 | Select a wire rope for a vertical mine hoisting to lift 12000KN of ore in 8 hour shift from a depth of 720m. Assume two compartments skip with the hoisting skips in balance. The maximum velocity of the rope is 750m/min with an acceleration and deceleration period of 12seconds. The rest period for load and unload is 10seconds. The hoisting skip weights approximately 50% of the load capacity. |
| 12 | Select a roller chain drive to transmit power of 10KW from a shaft rotating at 750rpm to another shaft to be run at 450rpm. The distance between the shaft centers could be taken as 35 pitches. |
| 13 | Select a chain drive to actuate a compressor from 10KW electric motor at 670rpm, the compressor rpm being 350. Minimum, centre distance should be approximately 560mm. The chain tension may be adjusted by shifting the motor on rails. Compressor is to work for 10 hours per day. |
| 14 | Select a chain drive to actuate the compressor from 15KW electric motor at 600rpm, while the compressor rpm being 120. |
| 15 | A roller chain is to transmit 66.24KW from a 17 tooth sprocket to a 34 tooth sprocket at a pinion speed of 300rpm. The loads are moderate shock. The equipment is to run 18hour per day. Specify the length and size of the chain required for a center distance of about 25 pitches. |
| **Module 1: Springs(continued)** | |
| 1 | Design helical compression spring to support an axial load of 3000N. The deflection under load is limited to 60mm. the spring index is 6. The spring is made of Chrome-Vanadium steel and factor of safety is equal to 2. |
| 2 | A helical valve spring is to be designed for an operating load of approximately 90 to 135N. The deflection of the spring for the load range is 7.5 mm. Assume a spring index of 10 and factor of safety =2. Design the spring. |
| 3 | Design a valve spring for an automobile engine, when the valve is closed, the spring produces a force of 45N and when it opens, produces a force of 55N. The spring must fit over the valve bush which has an outside diameter of 20mm and must go inside a space of 35mm. The lift of the valve is 6mm. The spring index is 12. The allowable stress may be taken as 0.33 GPa. Modulus of rigidity 80GPa. |
| 4 | Round wire cylindrical compression spring has an outside diameter of 75mm. It is made of 12.5mm diameter steel wire. The spring support an axial load of 5000N, determine i) Maximum shear stress, ii) Total deflection, if the spring has 8coils with squared- ground end and is made of SAE9260, iii) Find also the pitch of coil and iv)The natural frequency of vibration of the spring if one end is at rest. |
| 5 | The spring loaded safety valve for a boiler is required to blow off at a pressure of 1.3MPa. The diameter of the valve is 65mm and maximum lift of the valve is 17.5mm. Design a suitable compression spring for the valve, assuming spring index to be 6 and providing initial compression of 30mm. Take $\tau$=0.45GPa and G=84GPa. |
| 6 | The valve spring of a gasoline engine is 40mm long when the valve is open and 48mm long when the valve is closed. The spring loads are 250N when the valve is closed and 400N when the valve is open. The inside diameter of the spring is not to be less than 25mm and factor of safety is 2. Design the spring. |
| 7 | A spring controlled lever is shown in Fig. 3.5a. The spring is to be inserted with an initial compression to produce a force equal to 125N between the right end of lever and the stop. When the maximum force at A reaches a valve of 200N the end of the lever moves downward by 25mm. Assume the spring index as 8 find i) spring rate, ii) size of wire, iii) Outside diameter of spring , iv) Number of active coils, v) Free length and vi) Pitch. |
| 8 | A closed helical spring is to have a stiffness of 1N/mm, maximum load of 40N and maximum shear stress of 130 N/mm$^2$. The solid length is 45mm. find the diameter of wire and number of coils required. Take G=80GPa. |
| 9 | Design a spring used in a recoil system so as to absorb 120Nm of energy with a maximum force of 3000N. Assume |

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| | spring index 8 and factor of safety is 2. |
| 10 | A railway wagon weighing 50KN and moving with a speed of 8 Km/hr has to be stopped by four buffer springs in which the maximum compression allowed is 220mm. find the number of turns or coils in each spring of mean diameter 150mm. The diameter of spring wire is 25mm. Take G=84GPa. Also find the shear stress. |
| 11 | A loaded narrow gauge car weighs 18KN and moving at a velocity of 80m/min is brought to rest by a buffer consists of two helical springs. In bringing the car to rest the spring undergoes a compression of 200mm. The allowable shear stress is 0.3 GPa sand the spring index is 8. Design a suitable spring. Take G=84GPa. |
| 12 | A load of 2000N is dropped axially on a closed helical spring from a height of 250mm. The spring has 20effective turns, and it is made of 25mm diameter wire. Find the maximum shear stress produced in the spring and the amount of compression produced. Take c=8 and G=84GPa. |
| 13 | Design a spring for an elevator shaft at the bottom of which 8 identical springs are set in parallel to absorb the shock of the elevator in case of failure. The weight of elevator is 60KN and the counter weight of elevator is 20KN. The elevator has a free fall of 1.5m from rest. The spring is made of 25mm diameter rod. Determine the maximum stress in each spring, if the spring index is 6. Each spring has 15 active turns. Take G= 84GPa. |
| 14 | A single plate friction clutch transmits 20KW at 1000rpm. There is 2 pair of friction surfaces having a mean radius of 150mm. The axial pressure is provided by six springs. If the springs are compressed by 5mm during declutching, design the spring. Take c=6, $\tau$=0.42GPa, G=80GPa and $\mu$=0.3. |
| 15 | Design the spring for the Hartnell type spring loaded governor for the following particulars. Mass of each ball=2.97kg, length of vertical or ball arm is 150mm, length of sleeve or horizontal arm is 112.5mm. The governor is begin to lift at a speed of 240rpm and the maximum speed is 7.5% higher than that .The maximum radius of rotation is 150mm and minimum radius of rotation is 100mm. The allowable stress on the spring material is 0.42HPa and modulus of rigidity is 84GPa. Take c=8. |
| 16 | Spring loaded governor with dimensions shown in Fig. 3.7a needs a spring force of 190N to permit proper speed of balls of 125mm radius. Assuming limiting position to be shown that in Fig.3.7b with balls at 175mm radius corresponding the spring force is 650N. Take G=84GPa, $\tau$=0.35GPa and c=8. Determine i) Rate of spring ii) Wire diameter and coil diameter and iii) number of coils. |
| 17 | Design a concentric spring for an air craft engine valve to exert a maximum force of 5000N under a deflection of 40mm. Both the springs have same free length, solid length and are subjected to equal maximum shear stress of 0.85GPa spring index for both springs is 6. Assume G=80GPa and diametral clearance to be equal to difference between wire diameters. |
| 18 | A rectangular section helical spring is mounted to a buffer to sustain a maximum load of 30KN. The deflection under load is limited to 100mm. The spring is made of chrome-vanadium steel with a reliability of 1.5. The longer side of the rectangle is 2 times the shorter side and the spring is wound with longer side parallel to the axis. The spring index is 10. Design the spring and draw a conventional sketch. |
| 19 | A railway car weighing 18KN and moving at a speed of 72m/min is brought to rest by a buffer consisting of 2 helical compression spring of square cross-section. In bringing the car to rest the spring under goes a deflection of 0.25m. The allowable shear stress for the steel wire is 0.3 GPa. Spring index=6. Design the spring and draw a conventional sketch. Take G=84GPa. |
| 20 | Determine the width and thickness of a flat spring carrying a central load of 5000N. The deflection is limited to 100mm. The spring is supported at both ends at a distance of 800mm. The allowable stress is 30N/mm2 and modulus of elastcity221GPa. The spring is of constant thickness and varying width. |
| 21 | Determine the width and thickness of 6leaves cantilever spring 300mm long to carry a load of 1550N with a deflection of 30mm. The maximum stress in the spring should not exceed 0.330GPa. Take E=204GPa. |
| 22 | A locomotive spring has an overall length of 1100mm and sustains a load of 75KN at its centre. The spring has 3 full length leaves and 15 graduated leaves with a central band of 100mm. all the leaves are to be stressed at 0.4GPa when fully loaded. The ratio of total spring depth to width is 2. Determine,<br>i) Width and thickness of leaves.<br>ii) Initial space that must be provided between full length and graduated leaves before the band is applied and<br>iii) What load is exerted on the band after the spring is assembled? |
| 23 | A Truck spring has 12 numbers of leaves 2 of which are full length leaves. The spring supports are 1.05m apart and the central band is 85mm wide. The central load is to be 5400N with a permissible stress of 0.28GPa. The ratio of total depth to width of spring is 3 and modulus of elasticity =210GPa. Determine i) Thickness and width of steel spring ii) maximum deflection. |
| 24 | Design a leaf spring for the following specifications for a truck. Total load=120KN. Number of springs=4. , material for the spring is chrome-vanadium steel. Permissible stress is 0.55GPa. Span of spring= 1100mm. Width of central band= 100mm and allowable deflection=80mm. Number of full length leaves are 2 and graduated leaves 6. |
| 25 | A multi-leaf spring with camber is fitted to the chassis of an automobile over a span of 1.2m to absorb shocks due to a maximum load of 20KN. The spring material can sustain a maximum stress of 0.4GPa. All the leaves of the spring were to receive the same stress. The spring is required at least 2 full length leaves out of 8leaves. The leaves are assembled with bolts over a span of 150mm width at the middle. Design the spring for a maximum deflection of f50mm. |

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| 26 | A truck spring has 10leaves of graduated length. The spring supports 1060mm apart and central band is 80mm. The central load is to be 5400N with a permissible stress as 0.28GPa. The spring should have a ratio of total depth to width is about 2.5. Determine the width and thickness of spring plate and deflection when loaded. To what radius should the leaves be bent initially for the spring to be flat under the given load? Take=210Gpa. |
| 27 | A helical torsion spring of mean diameter 50mm is made of a round wire of 5mm diameter. If a torque of 5Nm is applied on this spring, find the bending stress, maximum stress and deflection of the spring in degrees. Modulus of elasticity=200Gpa and number of effective turns 10. |
| 28 | Design a helical spring for spring loaded safety valve for the following data: operating pressure=1MPa; Maximum pressure when the valve blows off=1.075MPa. Maximum lift of valve when pressure is 1.075MPa=6mm. diameter of valve seat=100mm. Maximum allowable shear stress=0.4GPa. Rigidity modulus=86GPa. Spring index=5.5. Assume this to be a Rams bottom safety valve. |
| 29 | Derive the equation for energy stored in a helical spring. |
| 30 | With usual notations, derive the equations for deflection and bending stresses induced in full length leaves and graduated leaves of a laminated spring. What are the requirements of spring materials? What are the important spring materials? |
| 31 | Derive an expression for the shear stress induced in a helical compression spring, with usual notations. |
| 32 | Explain equalizing the stresses in leaf spring. |
| 33 | Define spring index, mean coil diameter and helix angle. |
| 34 | When do you recommend non-circular wire spring? Why this cross-section of the wire is not generally used? |
| 35 | What do you understand by surge in helical springs? How it can be eliminated. |
| **Module 2: Spur &Helical Gears:** | |
| 1 | Derive an expression for beam strength of spur gear tooth standard notations. |
| 2 | Explain what is meant by Lewis form factor. |
| 3 | What is interference in gears? Explain briefly. |
| 4 | With sketch explain formative or virtual number of teeth applicable to helical gear: also derive an expression for virtual number of teeth in terms of helix angle and the actual number of teeth. |
| 5 | State the assumptions made in Lewis equation. |
| 6 | A pair of mating spur gears has 20° full depth of module 5mm. The pitch diameter of smaller gear is 100mm. If transmission ratio is 4:1. Calculate i) Number of teeth for each gear ii) Addendum iii) Dedendum iv) Whole depth v) clearance vi) outside diameter vii) Tooth thickness viii)working depth ix) circular pitch x) center distance xi) base circle diameters xii) Dedendum or root circle diameters. |
| 7 | A spur gear pinion 100mm diameter has a torque of 200Nm applied to it. The spur gear mesh with it is 250mm in diameter. The pressure angle is 20°. Determine i) Tangential force $F_t$ ii) radial or separating force $F_r$ ii) Torque on the gear. Also show the forces acting on the wheels separately. |
| 8 | A forged steel pinion (SAE1040) rotating at 400rpm drives a high grade cast iron gear. The transmission ratio is 4:1. The pinion has 15 standards 20° full depth involute teeth of 4mm module. The face width of both gears is 40mm. How much power can be transmitted from the stand point of strength? |
| 9 | Two spur gears are to be used for a rock crusher drive and are to be minimum size. The gears are to be designed for the following requirements: Power to be transmitted is 18KW, speed of pinion 1200rev/min: Velocity ratio 3.5 to 1, tooth profile 20° stub involute. Determine module and face width for strength requirements only. |
| 10 | A pair of carefully cut spur gears with 20° full depth involute profile is used to transmit 12KW at 1200 revolutions per minute of pinion. The gear has to rotate at 300revlutions per minute. The material used for both pinion and gear is medium carbon steel whose allowable stress may be taken as 230MPa. Determine the module and face width of the spur pinion and gear. Suggest suitable hardness. Take 24 teeth on pinion. Modulus of elasticity may be taken as 210GPa. |
| 11 | Design a pair of spur gears to transmit 20KW from a shaft rotating at 1000rpm to a parallel shaft which is to rotate at 310rpm. Assume number of teeth on pinion 31 and 20° full depth tooth for. The material for pinion is C45 steel untreated and for gear cast steel 0.20%C untreated. |
| 12 | Design a bronze spur gear 81.4MN/$m^2$ and mild steel pinion 101MN/$mm^2$ to transmit 5KW at 1800rpm. The velocity ratio is 3.5:1. Pressure angle 141/2°. Not less than teeth are to be used on either gear. Determine the module and face width. Also suggest suitable surface hardness for the weaker member based on dynamic and wear considerations. |
| 13 | In an automobile gear box, the second speed gear shaft is to be driven from main shaft with velocity ration 1.5:1. Main shaft transmits 12KW at 3000rpm. The shaft center distance=80mm pinion material is cast steel heat treated and gear material is cast steel untreated. Profile of the gear is 20° stub involute. Determine i) Module ii) Face width iii) Number of teeth on pinion and gear. |
| 14 | A pair of carefully cut (class-II) spur gear transmits 20KW at 230rpm of the gear. Reduction ratio is 5:1. The pinion is made of cast steel heat treated with allowable stress 197MN/$m^2$. Gear is made of cast iron with allowable |

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| | stress 56MN/m2. Determine module, face width and number of teeth on pinion and gear. Also suggests suitable surface hardness for the gear pair. Pitch line velocity of pinion is not to exceed 7.5m/sec. |
| 15 | Design a pair of spur gears to transmit a power of 18KW from a shaft sunning at 1000rpm to a parallel shaft to be run at 250rpm maintaining a distance of 160mm between the shaft centers. Suggest suitable surface hardness for the gear pair. |
| 16 | Design a spur gear drive to transmit 12KW from 1500rpm motor to a compressor run at 50rpm. |
| 17 | A pair of mating helical gears have 20° pressure angle in the normal plane. The normal module is 5mm and the module in the diametral plane is 5.7735mm. The pitch diameter of the smaller gear is 115.47mm. If the transmission ratio is 4:1 calculate i)Helix angle ii) normal pitch iii) Transverse pitch iv) Number of teeth for each gear v) Addendum vi) Dedendum vii) Whole depth viii) Clearance ix)Tooth thickness x) Working depth xi) Outside diameters xii) Center distance xiii) Root or dedendum circle diameters xiv)Base circle diameters. |
| 18 | A pair of parallel helical gears is shown in Fig 4.14. A 5KW power at 720rpm is supplied to pinion through its shaft. The normal module is 5mm and the normal pressure angle is 20°. The pinion has right hand helix, while the gear has left hand helix. The helix angle is 30°. The arrow indicates the direction of rotation when seen from the right hand side. Determine the components of the tooth force and draw a free body diagram showing the forces acting on the pinion and the gear. |
| 19 | Design a pair of helical gears to transmit power of 15KW at 3200rpm with speed reduction 4:1 pinion is made of cast steel 0.4% C untreated. Gear made of high grade CI. Helix angle is limited to 26°and not less than 20 teeth are to be used on either gear. Suggest suitable surface hardness for the gear pair. |
| 20 | A pair of carefully cut (class-II) helical gears for a turbine has a transmission ratio of 10:1 the teeth are 20° stub involute in the normal plane. Pinion has 25 teeth and rotates at 5000rpm. Material for pinion and gear is 0.4% carbon steel untreated. Determine the module in normal plane, diametral plane and face width of the gears. Suggest suitable hardness. Modulus of elasticity may be taken as 210GPa. Helix angle =30°. Power transmitted = 90KW. |
| 21 | Design a pair of helical gears to transmit a power of 20KW from a shaft running at 1500rpm to a parallel shaft to be run at 450rpm. Suggest suitable surface hardness for the gear pair. |
| 22 | A pair of steel helical gears is to transmit 15KW at 5000rev/min of the pinion. Both the gears are made of the same material, hardened steel with allowable bending stress of 120MPa. The gears have to operate at a centre distance of 200mm. the speed reduction ratio is 4:1. The teeth are 20° full depth involute profile on the normal plane. Helix angle is 45°. The gears are manufactured to class III accuracy (precision class). Face width can be taken as 16 times the normal module, if the wear strength has to be more than the dynamic load.<br>Determine the following :i) Normal plane ii) Transverse module iii) Pressure angle in the transverse plane iv) Number of teeth on pinion and gear v) Face width vi) Required surface endurance limit.( note: Lewis bending strength is based on normal module) |
| **Module 3 :Bevel &Worm Gears** | |
| 1 | Explain briefly the formative number of teeth of bevel gears. |
| 2 | Explain “self locking effect” in case of worm gear drive. |
| 3 | Explain spiral bevel gear and hypoid gears? |
| 4 | Sketch and describe a meshing worm gear and worm wheel. What are their advantages? |
| 5 | A pair of bevel gears transmitting 7.5KW at 300rpm of pinion. The pressure angle is 20°. The pitch diameters of pinion and gear at their large ends are 150mm and 200mm respectively. The face width of the gears is 40mm. determine the components of the resultant gear tooth force and draw a free body diagram of forces acting on the pinion and the gear. |
| 6 | Design a pair of bevel gears to connect two shafts at 60°. The gears are alloy steel of case hardened and precision cut with form cutters. The gear ratio is 5:1. The power transmitted is 30KW at 900rpm of the pinion. The teeth are 20° full depth. The pinion has 24 teeth. Suggest suitable surface hardness for the gear pair. |
| 7 | Design a pair of bevel gears to transmit a power of 25KW from a shaft rotating at 1200rpm to a perpendicular shaft to be rotated at 400rpm. |
| 8 | A pair of bevel gears to transmitting 12KW at 300rpm of the gear and 1470rpm of the pinion. The angle between the shaft axes is 90°. The pinion has 20teeth and the material for gears is cast steel ($\sigma_o$=183.33N/mm2, BHN320). Take service factor as 1.25 and check the gears for wear and dynamic load. Suggest suitable surface hardness for the gear pair. |
| 9 | A pair of straight bevel gears transmits 15KW at 1250rpm of 120nmm diameter pinion. The speed reduction is 3.5. Use 141/2° full depth teeth system. The pinion is made of alloy steel of case hardened and (SAE2320) gear is cast steel 0.20%C heat treated. Determine module, face width and number of teeth on pinion and gear. Suggest suitable hardness if the wear strength has to be more than the dynamic load. |

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| 10 | A pair of bevel gear wheels with 20° pressure angle consists of 20 teeth pinion meshing with 30 teeth gear. The module is 4mm while the face width is 20mm. The surface hardness of both pinion and gear is 400 BHN. The pinion rotates at 500rpm and receives power from an electric motor. The starting torque of the motor is 150% of the rated torque. Determine the safe power that can be transmitted considering the dynamic load, wear strength and endurance strength. The allowable bending stress may be taken as 240MPa. |
| 11 | Complete the design and determine the input capacity of a worm gear speed reducer unit which consists of a hardened steel worm and a phosphor bronze gear having 20°stub involute teeth. The centre distance is to be 200mm and transmission ratio is 10 and the worm speed is 2000rpm. |
| 12 | Design a worm gear drive to transmit a power of 2KW at 1000rpm. The speed ratio is 20 and the centre distance is 200mm. |
| 13 | Design a worm gear drive to transmit a power of 40KW at 500rpm of worm. The speed is 25. Material for the gear is phosphor bronze and that of worm is hardened steel. Determine the efficiency of the drive also. |
| 14 | Two teeth right hand worm transmits 2KW at 1500rpm to a 36 teeth wheel. The module of the wheel is 5mm and the pitch diameter of the worm is 60mm. The normal pressure angle is 14.2°. The coefficient of friction is found to be 0.06. i) Find the centre distance, the lead and lead angle, ii) determine the forces and iii) determine the efficiency of the drive. |
| 15 | Design a pair of right-angled bevel gears to transmit a power of 15KW from a shaft running at a speed of 750rpm to a perpendicular shaft to be run at 250rpm. Suggest suitable surface hardness for the gear pair. |
| 16 | Design a pair of bevel gears to transmit a power of 25KW from a shaft rotating at 1200rpm to a perpendicular shaft to be rotated at 400rpm. |
| 17 | Determine the cone pitch angles, pitch diameters for the following bevel gear pairs:<br>i) For shaft angle 77° (Acute angle bevel gearing),<br>ii) For shaft angle 147° (Obtuse angle bevel gearing).<br>The module is 5mm and the number of teeth on the pinion and the gear are 14 and 42 respectively. Draw the sketches of gearing. |
| **Module 4: Clutches and Brakes:** | |
| 1 | Explain briefly the uniform pressure theory and uniform wear theory as applicable to friction clutches and brakes. |
| 2 | Name the different type of clutches. Describe with the help of a neat sketch the working principles of any one friction clutch. |
| 3 | Classify the brakes and name different types of mechanical brakes. |
| 4 | Derive a relation to compute the torque developed on block brake. |
| 5 | A car engine develops maximum power of 15KW at 1000rpm. The clutch used is single plate type of both sides effective having external diameter 1.25 times internal diameter μ=0.3. Mean axial pressure is not to exceed 0.085N/mm2. Determine the dimensions of the friction surface and the force necessary to engage the plates. Assume uniform pressure condition. |
| 6 | Design a single plate clutch consists of two pairs of contacting surfaces for a torque capacity of 200Nm. Due to space limitation the outside diameter of the clutch is to be 250mm. |
| 5 | Determine the power transmitted by a single pair plate clutch assuming uniform pressure distribution. The friction surfaces have an outside diameter of 350mm and a diameter of 280mm. The coefficient of friction is 0.25 and the maximum allowable pressure is 0.85MPa. |
| 6 | Design a single plate clutch used in automobile transmission for the following specifications: power to be transmitted=20KW, speed 1500rpm to 2500rpm (max). Friction surface molded asbestos on steel. |
| 7 | In a multiple disc clutch the radial width of the friction material is to be 0.2 of maximum radius. The coefficient of friction is 0.25. The clutch is to transmit 60KW at 3000rpm. Its maximum diameter is 250mm and the axial force is limited to 600N. Determine i) Number of driving and driven discs, ii) Mean unit pressure on each contact surface. Assume uniform wear. |
| 8 | A 25KW at 3000rpm is to be transmitted by a multi-plate friction clutch. The plates have friction surfaces of steel and phosphor bronze alternatively and run in oil. Design the clutch for 25% over load. |
| 9 | A multiple plate clutch has steel on bronze is to transmit 8KW at 1440rev/min. The inner diameter of the contact is 80mm and the outer diameter of contact is 140mm. The clutch operates in oil with expected coefficient of friction of 0.1; the average allowable pressure is 0.35MPA. Assume uniform wear theory and determine the following. I) Number of steel and bronze plates ii) Axial force required iii) Actual maximum pressure. |
| 10 | Design the main dimensions of a cone clutches to transmit 40KW at 1000rpm. Assume suitable material for friction lining. |
| 11 | A cone clutch has a semi-cone angle of 12° to transmit 10KW at 750rpm. The width of the face is one fourth of the mean diameter of friction lining. If the normal intensity of pressure between the contacting surface is not to exceed |

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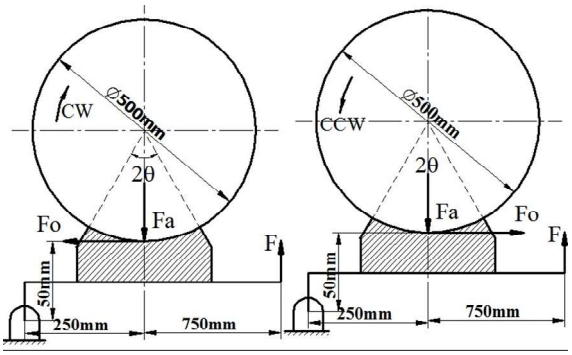
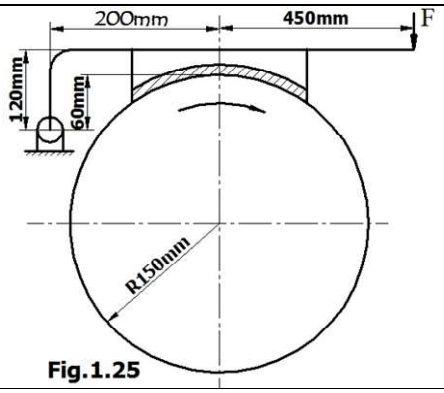
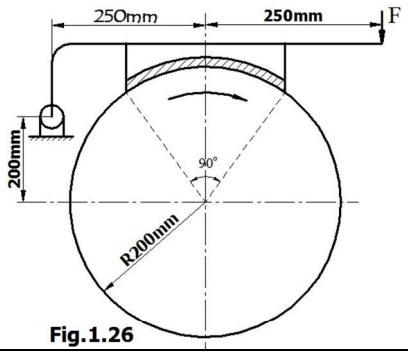
| | 0.85 bar, assuming uniform wear theory and taking μ=0.2. Calculate dimensions of clutch. Also find the axial force while running that is, at the beginning of engagement. |
| 12 | A friction cone clutch has to transmit a torque of 200Nm at 1440rev/min. The larger diameter of the cone is 350mm; the cone pitch angle is 6.25°. The face width is 65mm. The coefficient of friction is 0.2. Determine, i) The axial force required to transmit the torque, ii) The average normal pressure on the contact surfaces when the maximum torque is transmitted. |
| 13 | An engine developing 30KW at 1250rpm is fitted with a cone clutch. The cone has a face angle of 12.5°. The mean diameter is 400mm; μ=0.3 and the normal pressure is not to exceed 0.08N/mm2. Design the clutch. |
| 14 | Design a cone clutch to transmit a power of 40KW at a rated speed of 750rpm. Also determine i) Axial force necessary to transmit torque. ii) Axial force necessary to engage the cone clutch. |
| 15 | The block brake shown in Fig 1.22 is to balance a torque of 500Nm on a drum shaft at 1000rpm. Assuming the coefficient of friction between the brake shoe and drum is to be 0.25. determine i) Tangential force on the shoe ii) normal force on the shoe iii) Force F applied to the brake for clockwise and counter clockwise rotation. iv) The dimension 'c' required to make the brake self-locking assuming the other dimensions remains the same. v) Heat generated.   |
| 16 | A single block brake with a torque capacity of 15Nm is shown in Fig.1.25. The coefficient of friction is 0.3 and the maximum pressure on the brake lining is 1N/mm$^2$. the width of block is equal to its length calculate,<br>i) Actuating force,<br>ii) Dimensions of the block<br>iii) Resultant hinge-pin reaction and<br>iv) Rate of heat generated, if the brake drum rotates at 50rpm.   Fig.1.25 |
| 17 | Fig.1.26 a shows a single block brake. The brake drum diameter is 400mm and rotates at a speed of 15rpm. The friction material permits a maximum pressure of 0.5MPa and μ=0.25. Face width of the block is 50mm. If the brake is applied for 10sec at full capacity to bring the shaft to stop determine,<br>i) Effort<br>ii) Maximum torque<br>iii) Heat generated.   Fig.1.26 |
| 18 | A single band brake shown in Fig.Q.6 (B) is to be designed to stop the rotation of a shaft transmitting a power of 45 KW at a rated speed of 500 rpm. Selecting suitable materials determine,<br>i) Dimensions of rectangular cross section of band.<br>ii) Dimensions of rectangular cross section brake lever. (Assume $h_1 = 2b_1$).<br>iii) Diameter of fulcrum pin.<br>Assume $I_p = 1.5\ d_p$, bearing stress $\sigma_b = 10$MPa. |

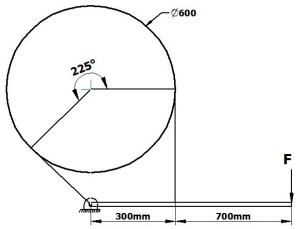


Fig.Q.6(B)

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| **Module 5:Lubrication and Bearings:** | |
| 1 | What is Somerfield Number? What is its application in designing hydrodynamic journal bearing? Explain at least four dimensionless parameters, which depend upon the Somerfield Number as plotted by Raimondi and Boyd. |
| 2 | Derive Petroff's equation for coefficient of friction for Hydrodynamic bearing. |
| 3 | List the difference forms lubrication and bearing materials. |
| 4 | Explain the significance of the bearing characteristics number in the design of sliding contact bearing. |
| 5 | Explain the mechanisms of Hydrodynamic lubrication in journal bearing. |
| 6 | What are the limitations in Petroff's law? |
| 7 | What do you understand by, i) minimum oil film thickness and ii) coefficient friction in bearing. |
| 8 | Write a short note on; i) bearing modulus ii) bearing characteristics number. |
| 9 | Explain the following, i) Hydrostatic lubrication ii) Boundary lubrication iii) Thick film lubrication iv) journal bearing v) thrust bearing. |
| 10 | A 75mm long journal bearing of diameter 75mm supports a load of 10KN. The speed of the journal is 1200rpm. The absolute viscosity of the oil is $10x10^{-3}$Pas and diametral clearance ratio is 0.001. Determine the coefficient of friction by using i) Petroff's equation ii) McKee's equation and iii) Raimondi and Boyd curve. |
| 11 | Determine the power loss for a Petroff's bearing 100mm in diameter and 150mm long. The radial clearance is 0.05mm. Speed of the journal is 1000rpm. The lubrication oil is SAE 10 and bearing operating temperature is 60°C. |
| 12 | The viscosity of oil is 110saybokt second at 50°C and the specific gravity is 0.8894 at 15.5°C. Determine the absolute viscosity at the bearing operating temperature of 80°C. |
| 13 | A 75mm long full journal bearing of diameter 75mm supports a radial load of 12KN at the shaft speed of 1800rev/min. Assume ratio of diameter to the diametral clearance as 1000. The viscosity of oil is 0.01 Pas at the operating temperature. Determine the following i) Sommerfeld Number ii) The coefficient friction based on Mckee's equation and iv) Amount of heat generated. |
| 14 | A lightly loaded journal bearing has a load of 1KN. The oil used is SAE60 and mean effective temperature of operation is 40°C. The journal has a diameter of 50mm and the bearing has a diameter of 50.5mm. The speed of journal is 15000rpm. The L/D ratio is limited to 1.2. Determine the coefficient of friction and power loss in friction. |
| 15 | SAE20 oil is used to lubricate a hydrodynamic journal bearing of diameter 75mm and length 75mm, oil enters 40°C. The journal rotates at 1200rpm. The diametral clearance is 75µm (0.075mm). Assume operating temperature of the oil as 53°C and determine i) Magnitude and location of the minimum film thickness ii) Power loss iii) Oil flow through the bearing and iv) Side leakage. |
| 16 | The oiliness curve for a 75mmx150mm long bearing happens to be a straight line passing through points $\eta n`/P=191x10^{-9}$and µ=0.002 and another point $\eta n`/P=956x10^{-9}$ and µ=0.0065. The load supported by the bearing is 6 KN and the speed of the journal 1200rpm. Calculate the friction loss in KW at the bearing, if the oil film has a temperature of 80°C and the viscosity of the lubricant is 8.7cP at the operating temperature. Assume ψ=0.001. |
| 17 | A turbine shaft 60mm in diameter rotates at a speed of 10000rpm. The load on each bearing is estimated at 2KN and the length of bearing is 80mm. Taking radial clearance as 0.05mm and ASE-20 oil for lubrication determine the coefficient of friction, power loss, minimum film thickness and the oil flow rate. The temperature of the bearing is not to exceed 50°C. |

## 16.0 University Result

| Examination | Total No. of Students Appeared | FCD | FC | SC | % Passing |
|---|---|---|---|---|---|
| July 2020-21 | 63 | - | - | - | 100 |
| July 2019-20 | 125 | 03 | 14 | 71 | 80.77 |

| Prepared & Checked by | | |
|---|---|---|
| Sd/- | | |
| Prof. D.N.Inamdar | HOD | Principal |

| Subject Title | PROGRAMMING IN JAVA | | |
|---|---|---|---|
| Subject Code | 18CS653 | IA Marks | 40 |
| Number of Lecture Hrs / Week | 03 | Exam Marks | 60 |
| Total Number of Lecture Hrs | 40 | Exam Hours | 03 |
| CREDITS – 04 | | | |

| FACULTY DETAILS: | | |
|---|---|---|
| **Name:** Prof. P. G. Patil | **Designation:** Asst. Professor | **Experience:** 09 Years |
| **No. of times course taught:**00 | **Specialization:** Computer Science and Engineering | |

## 1.0 Prerequisite Subjects:

| Sl. No | Branch | Semester | Subject |
|---|---|---|---|
| 01 | Computer Science and Engineering | I/II | CPS |

## 2.0 Course Objectives

**This course will enable students to**

1. Learn fundamental features of object-oriented language and JAVA.
2. Set up a Java JDK environment to create, debug and run simple Java programs.
3. Learn object-oriented concepts using programming examples.
4. Study the concepts of importing packages and exception handling mechanisms.
5. Discuss the String Handling examples with Object Oriented concepts.

## 3.0 Course Outcomes

**After studying this course, students will be able to**

| CO | Course Outcome | RBT Level | POs |
|---|---|---|---|
| C320.1 | Explain the object-oriented concepts and JAVA. | L1, L2 | 1,2,3,8,10, 12 |
| C320.2 | Develop computer programs to solve real world problems in Java. | L1, L2 | 1,2,3,8,10, 12 |
| C320.3 | Develop simple GUI interfaces for a computer program to interact with users. | L1, L2 | 1,2,3,8,10, 12 |
| **Total Hours of instruction** | | **50** | |

## 4.0 Course Content

### Module 1 (8 Hours)

**An Overview of Java:** Object-Oriented Programming, A First Simple Program, A Second Short Program, Two Control Statements, Using Blocks of Code, Lexical Issues, The Java Class Libraries, Data Types, Variables, and **Arrays:** Java Is a Strongly Typed Language, The Primitive Types, Integers, Floating-Point Types, Characters, Booleans, A Closer Look at Literals, Variables, Type Conversion and Casting, Automatic Type Promotion in Expressions, Arrays, A Few Words About Strings

### Module 2 (8 Hours)

**Operators:** Arithmetic Operators, The Bitwise Operators, Relational Operators, Boolean Logical Operators, The Assignment Operator, The ? Operator, Operator Precedence, Using Parentheses, **Control Statements:**Java‟s Selection Statements, Iteration Statements, Jump Statements.

### Module 3 (8 Hours)

**Introducing Classes:** Class Fundamentals, Declaring Objects, Assigning Object Reference Variables, Introducing Methods, Constructors, The this Keyword, Garbage Collection, The finalize( ) Method, A Stack Class, **A Closer Look at Methods and Classes:** Overloading Methods, Using Objects as Parameters, A Closer Look at Argument Passing, Returning Objects, Recursion, Introducing Access Control, Understanding static, Introducing final, Arrays Revisited,

**Inheritance:** Inheritance, Using super, Creating a Multilevel Hierarchy, When Constructors Are Called, Method Overriding, Dynamic Method Dispatch, Using Abstract Classes, Using final with Inheritance, The Object Class.

### Module 4 (8 Hours)

**Packages and Interfaces:** Packages, Access Protection, Importing Packages, Interfaces, **Exception Handling:** Exception-Handling Fundamentals, Exception Types, Uncaught Exceptions, Using try and catch, Multiple catch Clauses, Nested try Statements, throw, throws, finally, Java's Built-in Exceptions, Creating Your Own Exception Subclasses, Chained Exceptions, Using Exceptions.

### Module 5 (8 Hours)

**Enumerations, Type Wrappers, I/O, Applets, and Other Topics:** I/O Basics, Reading Console Input, Writing Console Output, The PrintWriter Class, Reading and Writing Files, Applet Fundamentals, The transient and volatile Modifiers, Using instanceof, strictfp, Native Methods, Using assert, Static Import, Invoking Overloaded Constructors Through this( ), **String Handling:** The String Constructors, String Length, Special String Operations, Character Extraction, String Comparison, Searching Strings, Modifying a String, Data Conversion Using valueOf( ), Changing the Case of Characters Within a String , Additional String Methods, StringBuffer, StringBuilder.

## 5.0 Relevance to future subjects

| Sl No | Semester | Subject | Topics |
|---|---|---|---|
| 01 | VIII | Project work | Java |

## 6.0 Relevance to Real World

| SL.No | Real World Mapping |
|---|---|
| 01 | Development of a software applications |

## 7.0 Gap Analysis and Mitigation

| Sl. No | Delivery Type | Details |
|---|---|---|
| 01 | Tutorial | |
| 02 | NPTEL | |

## 8.0 Books Used and Recommended to Students

| **Text Books** |
|---|
| 1. Herbert Schildt, Java The Complete Reference, 7th Edition, Tata McGraw Hill, 2007. (Chapters 2, 3, 4, 5, 6,7, 8, 9,10, 12,13,15) |
| **Reference Books** |
| 1. Cay S Horstmann, "Core Java - Vol. 1 Fundamentals", Pearson Education, 10th Edition, 2016.<br>2. Raoul-Gabriel Urma, Mario Fusco, Alan Mycroft, "Java 8 in Action", Dreamtech Press/Manning Press, 1st Edition, 2014. |
| **Additional Study material & e-Books** |
| 1. Programming in Javaby Balguruswamy |

## 9.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

| Website and Internet Contents References | |
|---|---|
| 1. | www.nptelvideos.com/**java**/**java**_video_lectures_tutorials.php |
| 2. | https://www.cse.**iit**b.ac.in/~nlp-ai/**java**lect_august2004.html |
| 3. | www.nptel.ac.in/courses/106105084/28 |

## 10.0 Magazines/Journals Used and Recommended to Students

| Sl. No | Magazines/Journals | website |
|---|---|---|
| 1 | Java Magazine - Oracle | www.oracle.com/technetwork/java/javamagazine/ |
| 2 | Java - IEEE Conferences, Publications, and Resources | https://www.computer.org/software-magazine/ |
| 3 | Java Developer's Journal - Steven Gould | https://jserd.springeropen.com/ |

## 11.0 Examination Note

**Internal Assessment: 30+10=40 Marks**
30 marks –from three internal assessment test
10 marks- from the assignments
**Scheme of Evaluation for Internal Assessment (30 Marks)**
a) Internal Assessment test in the same pattern as that of the main examination (Average of the three Tests): 30 marks.
b) Assignment marks for each module is 25. Average of 5 assignment marks will be taken and finally scale down to 10 marks.

**Question Paper Pattern (IA):**
1. Two main questions to be set from syllabus covered up to IA tests.
2. Students have to answer two full main questions and each question carries 15 marks, Total test marks are 30.

a. Q.No I or Q.No II = 15 Marks
b. Q.No III or Q.No IV = 15 Marks
c. **Total = 30 Marks**

**Question Paper Pattern and instructions (Main Exam):**
1. The question paper will have TEN questions.
2. There will be TWO questions from each module.
3. Each question will have questions covering all the topics under a module.
4. The students will have to answer FIVE full questions, selecting ONE full question from each module.

Max. Marks: 100 and each question carries 20 marks.
Exam Duration: 3 Hrs.
5. The total marks scored out of 100 marks will be scaled down to 60 marks.

## 12.0 Course Delivery Plan

| Module | Lecture No. | Content of Lecturer | % of Portion |
|---|---|---|---|
| MODULE 1 | 1 | Object-Oriented Programming, A First Simple Program, A Second Short Program, | 20% |
| | 2 | Two Control Statements, Using Blocks of Code, Lexical Issues, | |
| | 3 | The Java Class Libraries, Data Types, Variables | |
| | 4 | Arrays: Java Is a Strongly Typed Language, The Primitive Types, Integers | |
| | 5 | Floating-Point Types, Characters, Booleans, A Closer Look at Literals, | |
| | 6 | Variables, Type Conversion and Casting, Automatic Type Promotion in Expressions, | |
| | 7 | Arrays | |
| | 8 | A Few Words About Strings | |
| MODULE 2 | 9 | Operators: Arithmetic Operators | 20% |
| | 10 | The Bitwise Operators, | |
| | 11 | Relational Operators, Boolean Logical Operators | |
| | 12 | The Assignment Operator, The ? Operator | |
| | 13 | Operator Precedence, Using Parentheses | |
| | 14 | Control Statements: Java's Selection Statements | |
| | 15 | Iteration Statements | |
| | 16 | Jump Statements. | |
| MODULE 3 | 17 | Introducing Classes: Class Fundamentals, Declaring Objects, Assigning Object Reference Variables, | 20% |
| | 18 | Introducing Methods, Constructors, The this Keyword, | |
| | 19 | Garbage Collection, The finalize( ) Method, A Stack Class, | |
| | 20 | A Closer Look at Methods and Classes: Overloading Methods, Using Objects as Parameters, A Closer Look at Argument Passing, Returning Objects, | |
| | 21 | Recursion, Introducing Access Control, Understanding static, Introducing final | |
| | 22 | Arrays Revisited, Inheritance: Inheritance, Using super, Creating a Multilevel Hierarchy | |
| | 23 | When Constructors Are Called, Method Overriding, Dynamic Method Dispatch | |
| | 24 | Using Abstract Classes, Using final with Inheritance, The Object Class. | |
| MODULE 4 | 25 | Packages, Access Protection, Importing Packages, | 20% |
| | 26 | Interfaces, | |
| | 27 | Exception Handling: Exception-Handling Fundamentals, Exception Types, , | |
| | 28 | Uncaught Exceptions, Using try and catch, Multiple catch Clauses, | |
| | 29 | Nested try Statements, throw, throws, | |
| | 30 | finally, Java's Built-in Exceptions, | |
| | 31 | Creating Your Own Exception Subclasses | |
| | 32 | Chained Exceptions, Using Exceptions. | |
| MODULE 5 | 33 | I/O Basics, Reading Console Input, Writing Console Output, | 20% |
| | 34 | The PrintWriter Class, Reading and Writing Files, Applet Fundamentals, | |
| | 35 | The transient and volatile Modifiers, Using instanceof, strictfp, Native Methods | |
| | 36 | Using assert, Static Import, Invoking Overloaded Constructors Through this( ) | |
| | 37 | String Handling: The String Constructors, String Length, Special String Operations, | |
| | 38 | Character Extraction, String Comparison, Searching Strings | |
| | 39 | Modifying a String, Data Conversion Using valueOf( ), Changing the Case of Characters Within a String | |
| | 40 | Additional String Methods, StringBuffer, StringBuilder. | |

## 13.0 Assignments, Pop Quiz, Mini Project, Seminars

| Sl. No. | Title | Outcome expected | Allied study | Week No. | Individual / Group activity | Reference: book/website /Paper |
|---|---|---|---|---|---|---|
| 1 | Assignment 1: Some important University Questions on Module one. | Students study the Topics and write the Answers. Get practice to solve questions. | Module one of the syllabus | 3 | Individual Activity. Witten solutions expected. | Text book |
| 2 | Assignment 2: Some important University Questions on Module two | Students study the Topics and write the Answers. Get practice to solve questions. | Module two of the syllabus | 6 | Individual Activity. Witten solutions expected. | Text book |
| 3 | Assignment 3: Some important University Questions on module three. | Students study the Topics and write the Answers. Get practice to solve questions. | Module three of the syllabus | 9 | Individual Activity. Witten solutions expected. | Text book |
| 4 | Assignment 4: Some important University Questions and comprehensive questions on module four. | Students study the Topics and write the Answers. Get practice to solve questions. | Module four of the syllabus | 11 | Group Activity powerpoint presentation | Text book and reference books |
| 5 | Assignment 5: Some important University Questions and comprehensive questions on module five. | Students study the Topics and write the Answers. Get practice to solve questions. | Module five of the syllabus | 13 | Group Activity powerpoint presentation | Text book and reference books |

## 14.0 QUESTION BANK

### Module 1:

1. Explain the features of Java.
2. Elucidate how Java is a platform independent language, with neat sketches
3. List and explain Java buzzwords.
4. Explain the process of creating and running Java programs.
5. Explain the structure of a Java program and its keywords with an example.
6. Write & demonstrate a Java program to initialize & display different types of integers & floating type variables.
7. Explain different access specifiers in Java & their scope.
8. Define type casting. Explain with an example.
9. Explain type conversion, with an example.
10. What is type casting? Illustrate with an example. What is meant by automatic type promotion?
11. How are arrays defined in Java? Explain with an example.

### Module 2:

1. Discuss operators in Java.
2. What is a jump statement? Explain with examples.
3. Explain : i) >>> ii)short circuit logical operators iii) for each
4. With an example explain the working of >> and >>> (unsigned right shift)
5. Write a Java program to print the factorial of the number 'n' using the "for" loop.
6. Write a program to calculate the average among the elements {8, 6, 2, 7} using "for each" in Java. How is "for each" different from "for" loop?
7. Write a Java program to sum only the first five elements of the array {1,2,3,4,5,6,7,8,9,10} using "for each" version of the for loop.
8. Write a java program to sum only first five elements of the array using for each looping.
9. Explain the operation of the following operators with examples. i) % ii) >>> iii) &&
10. How to declare two dimensional arrays in java? Explain with a simple example.

11. Write a Java program to illustrate the use of multidimensional arrays.

## Module 3:

1. Define inheritance. List the different types of inheritance. (Jan-2018)
2. Discuss the following terms with an example: i) super ii) final (Jan-2019)
3. Define inheritance. Explain the multilevel hierarchy with an example program,
4. Write a Java program to define an interface called Area which contains method called Compute( ) and calculate the areas of rectangle (ℓ * b) and triangle (1/2 * b * h) using classes Rectangle and Triangle.
5. With an example program explain the method overriding?
6. Compare and contrast method overloading and method overriding with suitable examples.
7. When constructors are called in the class hierarchy?
8. Distinguish between method overloading and overriding in Java, with suitable examples.

## Module 4:

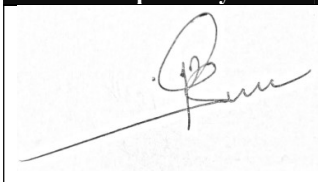
1. Explain the package and its types and import commands in Java with examples.
2. Describe the various levels of access protections available for packages and their implications.
3. Which is the alternative method to implement multiple inheritance in Java? Explain with an example.
4. Explain the role of interfaces while implementing multiple inheritance in Java.
5. Give the basic form of an exception handling block.
6. Define the role of Exception handling in software development.
7. What is an exception? Give an example for nested try statements.
8. Define exceptions. Explain the exception handling mechanism with an example.
9. Explain Java's built-in exceptions.
10. What is the importance of the clause finally?
11. Create a try block that is likely to generate three types of exception and incorporate necessary catch block to catch and handle them.
12. Write a Java program for illustrating the exception handling when a number is divided by zero and an array has a negative index value.

## Module 5:

1. Write a note about a PrintWriter Class.
2. With a neat diagram, explain the life cycle of Applet.
3. Write a note on Native Methods.
4. Write a note on Special String Operations.
5. Write a note on StringBuffer.
6. Write a note on StringBuilder.

## 15.0 University Result

| Examination | Total Students | PASS ( P ) | FAIL ( F ) | % Passing |
|---|---|---|---|---|
| | 41 | 40 | 01 | 97.5 % |
| | | | | |

| Prepared by | Checked by | | |
|---|---|---|---|
|  |  |  |  |
| Prof. P. G. Patil | Prof. M. G. Huddar | HOD | Principal |

| Subject Title | HEAT TRANSFER LAB | | |
|---|---|---|---|
| Subject Code | 18MEL67 | IA Marks | 40 |
| L-T-P | 0-2-2 | Exam Marks | 60 |
| Total No of Lecture + Practical Hrs | 40 | Exam Hours | 03 |
| | | | CREDITS – 02 |

| FACULTY DETAILS: | | |
|---|---|---|
| **Name:** Dr. K. M. Akkoli | **Designation:** Assistant Professor | **Experience :** 18 |
| **No. of times course taught:** 12 Times | **Specialization:** Thermal Power Engineering | |
| **Name :** Prof. M.M. Shivashimpi | **Designation:** Assistant Professor | **Experience :** 14 |
| **No. of times course taught:** 06 Times | **Specialization:** Thermal Power Engineering | |

## 1.0 Prerequisite Subjects:

| SL. No. | Branch | Semester | Subject |
|---|---|---|---|
| 01 | Mechanical Engineering | I | Engineering Physics |
| 02 | Mechanical Engineering | III | Basic Thermodynamics |
| 03 | Mechanical Engineering | IV | Fluid Mechanics |
| 04 | Mechanical Engineering | VI | Heat & Mass Transfer |

## 2.0 Course Objectives

1. The primary objective of this course is to provide the fundamental knowledge necessary to understand the behavior of thermal systems.
2. This course provides a detailed experimental analysis, including the application and heat transfer through solids, fluids, and vacuum.
3. Convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems are examined.

## 3.0 Course Outcomes

The student, after successful completion of the course, will be able to

| CO | Course Outcome | Cognitive Level | POs |
|---|---|---|---|
| C328.1 | Perform experiments to determine the thermal conductivity of a metal rod | L5 | PO1, PO2, PO9, PO12 |
| C328.2 | Conduct experiments to determine convective heat transfer coefficient for free and forced convection and correlate with theoretical values. | L5 | PO1, PO2, PO9, PO12 |
| C328.3 | Estimate the effectiveness and efficiency in pin-fin pin-fin | L5 | PO1, PO2, PO9, PO12 |
| C328.4 | Determine the emissivity of the given test plate and Prove Stefan Boltzmann law of radiation. | L4 | PO1, PO2, PO9, PO12 |
| C328.5 | Conduct and measure the overall heat transfer coefficient, effectiveness of parallel and counter flow heat exchangers. | L5 | PO1, PO2, PO9, PO12 |
| C328.6 | Estimate the heat transfer coefficient for film wise and drop wise condensation processes. | L5 | PO1, PO2, PO9, PO12 |
| C328.7 | Demonstrate the working of Refrigeration and Air-conditioning system. | L5 | PO1, PO2, PO9, PO12 |
| C328.8 | Calculate temperature distribution of study and transient heat conduction through plane wall, cylinder and fin using numerical approach. | L5 | PO1, PO2,PO5, PO9, PO12 |
| | **Total Hours of instruction** | **40** | |

## 4.0 Course Content

**PART – A**

1. Determination of Thermal Conductivity of a Metal Rod.
2. Determination of Overall Heat Transfer Coefficient of a Composite wall.

3. Determination of Effectiveness on a Metallic fin.
4. Determination of Heat Transfer Coefficient in a free Convection.
5. Determination of Heat Transfer Coefficient in a Forced Convention.
6. Determination of Emissivity of a Surface.

**PART – B**

1. Determination of Steffan Boltzmann Constant.
2. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
3. Experiments on Boiling of Liquid and Condensation of Vapour.
4. Performance Test on a Vapour Compression Refrigeration.
5. Performance Test on a Vapour Compression Air – Conditioner.
6. Experiment on Transient Conduction Heat Transfer.

**PART – C (Optional)**

1. Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package).
2. Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package).

## 5.0 Relevance to future subjects

| SL. No. | Semester | Subject | Topics / Relevance |
|---|---|---|---|
| 01 | III / IV & VI | BTD, ATD & HMT | Provides basics of Laws and understanding the theory |
| 02 | VIII | Project work | Innovations and modifications of projects related to Heat & Mass transfer |

## 6.0 Relevance to Real World

| SL. No. | Real World Mapping |
|---|---|
| 01 | Designing the heat exchangers, air conditioners, air compressors and furnaces for the industries |
| 02 | Study the properties of materials used in industries |
| 03 | Radiators |

## 7.0 Books Used and Recommended to Students

**Reading Books**

1. M. Necati Ozisik, Heat Transfer – A Basic Approach, McGraw Hill, New York, 2005.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley and Sons, New York, 2006.
3. Holman, J. P., Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.

**Additional Study Books**

1. Power plant Engineering by E Wakil.
2. Solar Energy By Sukhatme.
3. Heat and Mass Transfer By P K Nag.
4. Principles of heat transfer by Kreith Thomas Learning 2001.

## 8.0 Relevant Websites (Reputed Universities and Others) for Notes/Animation/Videos Recommended

**Website and Internet Contents References**

1.http://www.nptel.ac.in
2.https://en.wikipedia.org/wiki/Heat *transfer*
*3.nptel.ac.in/courses/112104116/*

## 9.0 Magazines/Journals Used and Recommended to Students

| Sl. No. | Magazines/Journals | website |
|---|---|---|
| 1 | International Journal of Heat transfer | https://www.journals.elsevier.com/international-journal-of-heat-and-mass-transfer/ |
| 2 | International Journal of Thermodynamics | http://dergipark.ulakbim.gov.tr/eoguijt/ |

## 10.0 Examination Note

**Scheme of Examination:**
ONE question from part -A: 40 Marks
ONE question from part -B: 40 Marks
Viva –Voice: 20 Marks
Total: 100 Marks

## 11.0 Course Delivery Plan

| Expt. No | Lecture / Practical No | Name of the Experiment | % Of Portion |
|---|---|---|---|
| | | **PART-A** | |
| 1 | 1 | Determination of Thermal Conductivity of a Metal Rod. | 47.61 |
| 2 | 2 | Determination of Overall Heat Transfer Coefficient of a Composite wall. | |
| 3 | 3 | Determination of Effectiveness on a Metallic fin. | |
| 4 | 4 | Determination of Heat Transfer Coefficient in a free Convection on a vertical tube. | |
| 5 | 5 | Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe. | |
| 6 | 6 | Determination of Emissivity of a Surface. | |
| 7 | 7 | Analysis of steady and transient heat conduction, temperature distribution of plane wall and cylinder using Numerical approach (ANSYS/CFD package). | |
| | | **PART-B** | 52.33 |
| 8 | 8 | Determination of Steffan Boltzmann Constant. | |
| 9 | 9 | Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers. | |
| 10 | 10 | Experiments on Boiling of Liquid and Condensation of Vapour. | |
| 11 | 11 | Performance Test on a Vapour Compression Refrigeration. | |
| 12 | 12 | Performance Test on a Vapour Compression Air – Conditioner. | |
| 13 | 13 | Experiment on Transient Conduction Heat Transfer. | |
| 14 | 14 | Determination of temperature distribution along a rectangular and circular fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package). | |

## 12.0 QUESTION BANK

1. Define and explain the different modes of heat transfer.
2. State laws concerned three modes of heat transfer.
3. Give the classification of heat exchangers based on flow and mode of heat exchanger.
4. Derive an expression for LMTD for a Parallel and Counter flow heat exchanger.
5. Derive an expression for Effectiveness for a Parallel and Counter flow heat exchanger.
6. List the assumptions made in the derivation of the Film Condensation theory.
7. Differentiate between drop-wise and film-wise condensation process.
8. Explain the following laws as applied to radiation: i) Stefan Boltzman law ii) Plank's Distribution law iii) Wein's Displacement law iv) Kirchoff's law.
9. Define the terms Critical thickness of insulation, Fin efficiency, Contact and thermal resistances.
10. Explain the following Dimensionless number and their physical significance:

(i) Reynolds number,
(ii) Prandtl number,
(iii) Nusselt number.

11. Define the terms Critical thickness of insulation, Fin efficiency, Contact and thermal resistances.

## 13.0 University Result

| Examination | FCD | FC | PC | % Passing |
|---|---|---|---|---|
| October 2021 | 50 | 02 | 00 | 100 |

| Prepared by | Checked by | | |
|---|---|---|---|
| | -Sd- | | |
| Dr. M. M. Shivashimpi | Dr. K. M. Akkoli | HOD | Principal |