BASIC SHIP KNOWLEDGE AND WATCH KEEPING		Semester	3
Course Code	**BMR301**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- To provide basic knowledge of ship layout and terms related to ships
- To provide knowledge of various types of vessels and the cargo they carry
- To provide understanding on manning, Certificate of Competence
- To provide basic knowledge on ship operation and watch keeping in the engine room
- To provide knowledge on handling emergencies and survival equipment's

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction to ship layout

Sections and parts of a ship: Longitudinal view of a ship, Mid ship section. Ships parts-Hull, Deck, Bottom, double bottom, collision bulkhead, aft bulkhead-E/R- cargo Holds-ForeCastle deck-poop deck- deck houses–Accommodation, main engine-intermediate shaft-propeller shaft, stern tube seals : aft seal and fwd seal – propeller – stern Cooling Tank- aft peak tank, and rudder stock-rudder- Double bottom tanks cofferdam- fore peak tank , Chain locker

Deck arrangements – Air vents, sounding pipes , Ventilators , bunker manifold, masts, CO_2 room and paint store and cargo holds.

Accommodation arrangements – Bridge , Galley , Mess rooms , Cargo control room, stores

Engine room - Main engine, Generator diesel engine and auxiliaries, cold chambers- meat room, vegetable room and dry provision room.

Deck machinery - Mooring winches, Windlass, Anchor chain

Module-2

Types of ships and its operations:

Unit Cargo – Container vessel, RORO, Refrigerated ships, cattle ship and heavy cargo ship

Bulk Cargo –Bulk carrier, ore carrier, Coal carrier and Grain carrier

Liquid cargo- Crude carrier - product tanker , Chemical tanker, LPG Tanker and LNG tanker

Offshore vessels – Drillships, Anchor handling Tugs, Platform supply vessels , Accommodation vessels

Dredgers, Port vessels - Tugs and Pilot vessels.

Operation of ocean going vessels –difference between coastal ships and foreign going ships, difference between short and unrestricted international voyages, .

Arrival and departure procedures for ships with familiarization of various notices and action to be taken in case of emergencies.

Module-3

Manning of ships, Certificate of competence

Manning - Deck, Engine and catering depts., officers and crew. Safe manning of a vessel. Certificate of competence, Requirements of COC- Class IV, Class II and Class I as per DG shipping, Introduction to DG and MMD and their roles- Flag state and port state control / inspection , Reasons for detention of vessels

Introduction to IMO, STCW and its role – (only Chapter III), pre sea courses, Post sea courses, specialized vessels courses.

Module-4

Operation of vessels and Watch keeping

Vessel in port for loading / unloading or both. Draft marks, trim, heel, Loading limit, load line marks on the ships side. Anchorage, Pilot age and berthing of vessels

Definition of watch, watch keeping principles, Watch arrangements, - Sea watch, Port watch and anchor watch. Duties of Engineer officer in sea watch and in port.

Requirements of watch keeping, Fitness for duty, Rest hours, Alcohol limit, -COC, Engine room Log book and movement book, difference of ships log book and engine log book.

Preparation for main diesel engine for a sea voyage. Bow and stern Thrusters Various systems that are required for operation of the main engine.

Dry docks – purpose of dry docking of the vessel , Floating dry dock.

Module-5

Shipboard Emergencies

Fire -Fire Triangle , Types of Fire , Fire in Engine room, Portable extinguishers and types, Fixed fire fighting systems , Fire main system including emergency fire pump system , Hoses and Hydrants . Cargo hold fire, Paint store fire, accommodation fire, Galley exhaust fire and deep fat fryer fire . Towing arrangement in ships.

Grounding – To check tank soundings, precautions, Towing of a vessel after grounding. Collision

Flooding of engine room – emergency bilge suction

Power failure – Emergency Generator.

Introduction to SOLAS and SOLAS lifeboats, life rafts

Man overboard

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

CO1: Define parts of a ship, types of vessels and watch keeping routines (L1)

CO2: Classify ship structures, vessel types, ranks; voyages and emergencies (L2)

CO3: Explain deck and engine room arrangements, ship operations, manning, COC and emergencies (L2)

CO4: Identify ship layouts, vessel types; requirements of competence and apply principles of seamanship to specific emergency scenarios. (L3)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. J. K. Dhar, Basic Marine Engineering, 11th Edition,2019, G-Maritime Publications , ISBN:GMPISBN01.
2. David House, Seamanship Techniques: Shipboard and Marine Operations ,5th Edition ,2018, Routledge, ISBN-13 978-1138676114
3. Paul A Russell, Leslie Jackson, Thomas D. Morton, Reeds Vol. 8: General Engineering Knowledge,6th Edition,2018, Bloomsbury, ISBN9781472952714

Reference Books:

1. SOLAS Consolidated Edition 2020, International Maritime Organization; 7th ed.,2020 ,ISBN-13 : 978-9280116908
2. MARPOL Consolidated Edi□on 2018 (Vol A & B), Bhandarkar Publications; 2016th edi□on, 2018, ASIN : B071DFXF3H

Web links and Video Lectures (e-Resources):

- https://www.imo.org/en/KnowledgeCentre/ConferencesMeetings/Pages/SOLAS.aspx
- https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx
- https://www.youtube.com/watch?v=Q7Espb0afMw
- https://www.dieselduck.info/index.html
- https://www.youtube.com/channel/UClH53bXYykb-erNZ_kVBtOQ

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Organise Industrial visits to ports
- Case study on SOLAS and MARPOL
- Ship models to be made in groups to study various ship structures
- Presentations on various shipping accidents and their case studies.

MANUFACTURING PROCESSES (IPCC)		Semester	3
Course Code	**BMR302**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

- To acquaint with the basic knowledge on fundamentals of casting processes.
- To impart knowledge of various joining processes used in manufacturing.
- To know the various subtractive machining processes in industries.
- To understand different advanced machining processes.
- To study various metal forming processes.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.
These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.
6. Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

MODULE-1

CASTING PROCESS

Sand casting: pattern and core making- materials, allowances, types, moulding process - sand properties, melting furnaces – pit furnace and electric furnaces. Melting and founding of cast iron, degasification, design of casting and risering, pouring and feeding of casting,

Special casting processes: Shell, investment, die casting – pressure and gravity types – squeeze casting - defects in casting - Plastic moulding – injection and blow moulding.

MODULE-2

WELDING PROCESS

Definition, Principles, classification, application, advantages & limitations of welding.

Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW) and Atomic Hydrogen Welding (AHW).

Special type of welding: Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. Friction welding, Explosive welding, Thermit welding, Laser welding and Electron beam welding.

Gas welding: Principle, oxy-Acetylene welding, oxyhydrogen welding, air-acetylene welding, Gas cutting,
Defects and Inspection of welded joints.

MODULE-3

MACHINING PROCESSES

Lathe: *Review of- working principle, classification, specification, different operations on a lathe.* Lathe accessories and tool holders, machining time and power required for cutting. Capstan lathe and Turret lathe, Introduction to CNC lathe, parts and functions.

Drilling and boring - classification, specification and constructional features of drilling and boring machines, machining time calculation

Milling - classification, principle, parts & specification of milling machines, milling process-cutters, indexing

Shaping, Planing and Slotting machines- constructional features and machining operations

MODULE-4
METAL FORMING PROCESS **Hot and cold working processes** – Rolling, forging, drawing and extrusion processes, bending, hot spinning, shearing, tube and wire drawing, cold forming, shot peening. **Sheet metal working** – Blanking, piercing, punching, trimming, Bending – types of dies – progressive, compound and combination dies. High-energy rate forming processes. **Additive Manufacturing**: Introduction to 3D-printing and rapid prototyping
MODULE-5
ADVANCED MACHINING PROCESSES Abrasive Jet Machining, Water Jet Machining, Ultrasonic Machining, Electrical Discharge Machining, Electrochemical Machining, Laser Beam Machining, Plasma Arc Machining, Electron Beam Machining. **FINISHING PROCESS** **Surface finishing processes**: Grinding, Lapping, honing and super finishing process –overview of machines used, grinding wheels and specification, selection of grinding wheels, ship hull finishing.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	Study the effect of the clay and moisture content on sand mould properties
2	Preparation of sand specimens and conduction of the following tests: Compression, Shear, and Tensile tests on Universal Sand Testing Machine.
3	Determine the permeability number of green sand, core sand, and raw sand.
4	Determine AFS fineness number and distribution coefficient of the given sand sample.
5	Make a model of ship components using sand moulding and Aluminium casting
6	Prepare a model of any ship components using arc welding including L-Joint, T-Joint, Butt joint, V-Joint, and Lap joints.
7	Prepare a model of any ship component by using forging involving upsetting, drawing, and bending operations
8	Make a set of ship components by using a Lathe machine (including turning, facing, threading, parting, tapering, and knurling), Shaping, milling, and drilling machine and grinding process.
9	**Demonstration:** Operation on anyone advanced machining process
10	**Demonstration:** Experimentation of simple programming of CNC machine operations.
11	**Demonstration:** Experiment on using Drill Jig & turning and grinding fixtures.

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

CO1: Understand the concepts of metal casting, forming, welding and metal cutting.(L2)

CO2: Assess, compare and select appropriate manufacturing Processes. (L2)

CO3: Apply principles of casting, forming, welding, and metal cutting to specific applications. (L3)

CO4: Adapt the principles of manufacturing Processes to develop the mechanical components.(L3)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is

35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books:

1. P N Rao, Manufacturing Technology, Vol. 1 – Foundry, Forming, and Welding, 5th Edition, 2019, McGraw Hill Education (India) Private Limited, ISBN-13: 978-93-5316-050-0.
2. P N Rao, Manufacturing Technology, Vol. 2 Metal Cutting and Machine Tools, 4th Edition,2019, McGraw Hill Education(India) Pvt. Limited,ISBN-13: 978-93-5316-052-4.
3. Hajra Choudhary, S. K. and Hajra Choudhary, A. K., "Elements of Workshop Technology", Vol I (10^{th} edition) , Media Promoters & Publishers, Bombay 2007
4. Hajra Choudhary, S. K. and Hajra Choudhary, A. K., "Elements of Manufacturing Technology" Vol II (15^{th} edition), Media Promoters & Publishers, Bombay 2010

Additional References:

1. Chapman W.A.J., "Workshop Technology", Vol. II, Arnold Publishers,1972
2. H.M.T., "Production Technology", Tata McGraw-Hill, New Delhi, 2000.
3. Serope Kalpakjian , Steven,R. Schmid, "Manufacturing Engineering and Technology,"4^{th} Ed. Pearson, 2011
4. Roy A Lindberg, "Process and Materials of Manufacturing", Pearson Edu 4th Ed. 2006
5. Mikell P. Groover, (2019), Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Wiley Publications.

Web links and Video Lectures (e-Resources):

1. Manufacturing Processes II, IIT Kharagpur, Prof. A.B. Chattopadhyay, Prof. A.K. Chattopadhyay, Prof. S. Paul , http://nptel.ac.in/courses/112105127
2. V. K. Jain, Advanced Machining Processes, NPTEL Course Department of Mechanical Engineering, IIT Kanpur, Link: http://nptel.ac.in/courses/112104028/.
3. Principles of foundry technology, 4th edition, P L Jain, Tata McGraw Hill, 2006. (https://books.google.co.in/books?id=NOotk64Grx0C&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false)
4. Advanced Welding Processes technology and process control, John Norrish, Wood Head Publishing, 2006.
5. Chattopadhyay, Manufacturing Processes II, NPTEL Course of Department of Mechanical Engineering, IIT Kharagpur, https://nptel.ac.in/courses/112/105/112105126/
6. U. S. Dixit, Mechanics of Machining, NPTEL Course Department of Mechanical Engineering Guwahati, Link: http://nptel.ac.in/courses/112103248/.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning:

1. Case study/visit on Metal Casting: Design pattern/core for a given component drawing and develop a sand mould with optimum gating and riser system for ferrous and non-ferrous materials. Melting and casting, inspection for macroscopic casting defects.
2. Case study/visit on Welding: TIG and MIG welding processes – design weld joints – welding practice –weld quality inspection.
3. Case study/visit on Metal Forming: Press working operation – hydraulic and mechanical press -load calculation: blanking, bending and drawing operations – sheet metal layout design.
4. Visit any one machining centre or machining industry /Case study on process parameter influence on any one advanced machining process and hybrid machining process.

Semester - III

MATERIAL SCIENCE (IPCC)		Semester	3
Course Code	**BMR303**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

- To understand the structure and be haviour of engineering materials.
- To explore the mechanical properties of metals and their alloys
- To impart knowledge of formation of alloys
- To impart knowledge of selections of different materials for various applications.
- To understand modifications of material properties by heat treatment processes.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.
6. Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

Module-1

Structure of Materials

Introduction: Classification of materials, crystalline and non-crystalline solids, atomic bonding

Geometrical Crystallography: Symmetry elements, the operation of rotation.

Crystal Structure: Crystal Lattice, Unit Cell, space lattice, Planes and directions in a lattice, Planar Atomic Density, packing of atoms and Atomic packing factor, simple numericals. *Imperfections in Solids:* Types of imperfections, Point defects: vacancies, interstitials, line defects, 2-D and 3D-defects, Concept of free volume in amorphous solids.
Module-2
Mechanical Behaviour: Stress-strain diagrams showing ductile and brittle behaviour of materials, Engineering stress and true strains, Linear and non- linear elastic behaviour and properties, Mechanical properties in plastic range: Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness, Hardness-testing methods. Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals, simple numericals. **Failure of Materials: Fracture** – Definition of fracture, ductile & brittle fracture, fracture mechanism **Fatigue**: Definition of fatigue, Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, S-N diagram, fatigue testing. **Creep**: Definition of creep, mechanism of creep, creep curve, factors affecting creep.
Module-3
Solidification: Mechanism of solidification, Homogeneous and Heterogeneous nucleation, Crystal growth, cast metal structures, Solidification of Steels and Cast irons. Gibbs phase rule, Effect of non-equilibrium cooling. **Concept of formation of alloys**: Types of alloys, solid solutions, factors affecting solid solubility (Hume-Rothery rules) ,Binary phase diagrams: Eutectic and Eutectoid systems, Lever rule, Intermediate phases, Numericals on Lever rule. **Iron-Carbon (Cementite) diagram**: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels.
Module-4
Ferrous and non-ferrous materials Properties, Composition and uses of Grey cast iron, malleable iron, SG iron and steel Copper alloy-brass and bronzes. Aluminum alloys-Al-Cu, Al-Si,Al-Zn alloys. Titanium alloys, Properties and applications of materials used in machinery on board ships **Properties and parameters considered in the fabrication and repair of systems and components** – Materials under load, vibration, self-secured joints, permanent joints, adhesives and bonding, pipe work. **Environmental Degradation of Materials**: Different forms of environmental degradation, forms of corrosion- Galvanic, Intergranular, pitting, stress related corrosion. Corrosion control- Materials selection, protective coating.
Module-5
Heat Treatment: Time-Temperature Transformation (TTT) curves, Continuous Cooling Transformation (CCT) curves, Heat treatment: Annealing- Types of annealing, Normalizing, Hardening, Tempering, Concept of Hardenability, Factors affecting hardenability, Martempering, Austempering. **Surface hardening methods**: Carburizing, Cyaniding, Nitriding, Flame hardening and Induction hardening, Age hardening of aluminium-copper alloys.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.No.	Experiments
1	Specimen preparation for macro and micro structural examinations and study the macrostructure and microstructure of a sample metal/ alloys
2	Study the heat treatment processes (Hardening and tempering) of steel/Aluminium specimens.
3	To determine the hardness values of Mild Steel/ Aluminium by Rockwell hardness/Vickers Hardness.
4	To determine the hardness values of Copper/ Brass by Brinell's Hardness testing machine.
5	To determine the tensile strength, modulus of elasticity, yield stress, % of elongation and % of reduction in area of Cast Iron, Mild Steel/Brass/ Aluminium and to observe the necking.
6	Shear, compression and Bending tests of steel, aluminum and cast iron specimens using Universal Testing Machine

7	To determine the Impact strength of the mild steel using Izod test and Charpy test.
8	Torsion Test on steel bar.
9	To study the defects of Cast and Welded components using Non-destructive tests like: a) Ultrasonic flaw detection b) Magnetic crack detection c) Dye penetration testing.
10	Study the chemical corrosion and its protection.(**Demonstration**)
11	Computer Aided Selection of Materials: Application of GRANTA Edupack for material selection: Case studies based on material properties. (**Demonstration**)

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:
CO1: Understand behaviour of various materials with respect to crystal structure, mechanical behaviour, phase transformation and corrosion (L2)
CO2: Identify suitable materials for specific engineering application (L3)
CO3: Investigate mechanical properties and microstructures of different materials (L4)
CO4: Analyze materials crystal structure, mechanical behaviour, phase transformation and corrosion, composition and their phase transformation (L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books:

1. William D Callister, Material Science and Engineering, , 6th Edition, 1997, John Wiley and Sons, ISBN 9812-53-052-5
2. Raghavan, V. Materials Science and Engineering: A First course, 6th edition, PHI Learning, 2015.
3. Smith, W.F., Hashemi, J. & Prakash, R. "Materials Science and Engineering". Tata McGraw Hill Education Pvt. Ltd., 2014.

Additional References:

1. O. P Khanna, A text book of Material Science and Metallurgy, Dhanpat Rai Publishers, 2010
2. Ashby, M.F., Materials Selection in Mechanical Design, 4th Edition, Butterworth- Heinemann, 2010
3. Avner, S.H., Introduction to Physical Metallurgy, 2nd Edition, McGraw Hill Education, 2017

Web links and Video Lectures (e-Resources):

1. Bhattacharya,B., *Materials Selection and Design,* NPTEL Course Material, Department of Mechanical Engineering, Indian Institute of Technology Kanpur, http://nptel.ac.in/courses/112104122/
2. Prasad, R., Introduction to Materials Science and Engineering, NPTEL Course Material, Department of Materials Science and Engineering, Indian Institute of Technology Delhi,
3. http://nptel.ac.in/courses/113102080/
4. Subramaniam, A., Structure of Materials, NPTEL Course Material, Department of Material Science and Engineering, Indian Institute of Technology Kanpur,https://nptel.ac.in/courses/113104014/
5. Schuh, C., 3.40J Physical Metallurgy. Fall 2009. Massachusetts Institute of Technology: MIT Open Course Ware, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
6. Ghosh, R.N., Principles of Physical Metallurgy, IIT Kharagpur, http://nptel.ac.in/syllabus/113105024/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning:

1. Case study/visit on Metal Casting: Design pattern/core for a given component drawing and develop a sand mould with optimum gating and riser system for ferrous and non-ferrous materials. Melting and casting, inspection for macroscopic casting defects.
2. Case study/visit on Welding: TIG and MIG welding processes – design weld joints – welding practice –weld quality inspection.
3. Case study/visit on Metal Forming: Press working operation – hydraulic and mechanical press -load calculation: blanking, bending and drawing operations – sheet metal layout design.
4. Visit any one machining center or machining industry /Case study on process parameter influence on any one advanced machining process and hybrid machining process.

THERMODYNAMICS		Semester	3
Course Code	**BMR304**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Understand various forms of energy - heat transfer and work
- State and apply the basic laws of thermodynamics viz: zeroth law, first law and second law.
- Interpret the behaviour of pure substances and its application in practical problems.
- Study the behaviour of Ideal and real gases and evaluate their thermodynamic properties
- Analyse the air standard, gas and vapour power cycles used in prime movers.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction and Review of fundamental concepts (**Only for Self-study & CIE**)*: Thermodynamic definition and scope, Microscopic and Macroscopic approaches, Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium*

Zeroth law of thermodynamics. Temperature; scales, thermometry, Importance of temperature measuring instruments. Design of Thermometers.

Work and Heat: Thermodynamic definition of work; examples, sign convention, Displacement work, Heat; definition, units and sign convention, Expressions for displacement work and heat in various processes through p-v diagrams. Shaft work, Electrical work.

Module-2

First Law of Thermodynamics: Statement of the first law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, Steady Flow Energy Equation (SFEE) and engineering applications.

Second Law of Thermodynamics and Entropy: Limitations of first law of thermodynamics. Devices converting heat to work; (a) In a thermodynamic cycle, (b) In a mechanical cycle. Thermal reservoir, direct heat engine; schematic representation and efficiency, Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Refrigerators, and heat pumps, COP, Clausius statement of Second law of Thermodynamics, Equivalence of statements, Carnot cycle, Carnot theorem.

Module-3

Entropy: Clausius inequality, Statement-proof, Entropy- definition, a property, change of entropy, Reversibility, causes of irreversibility, entropy as a quantitative test for irreversibility, entropy as a coordinate.

Pure Substances: P-T and P-V diagrams, triple point and critical points, sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapour, saturated vapour and superheated vapour states of pure substance with water as example. Enthalpy of change of phase (Latent heat), Dryness fraction (quality) representation of various processes on T-S & H-S diagrams, measurement of quality.

Module-4

Combustion thermodynamics: Theoretical (Stoichiometric) air for combustion of fuels, excess air, actual combustion. Exhaust gas analysis. A/F ratio, energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion, adiabatic flame temperature, combustion efficiency.

Vapour Power Cycles: Carnot vapour power cycle, simple Rankine cycle, actual vapour power cycles, ideal and practical regenerative Rankine cycles, open and closed feed water heaters, Reheat Rankine cycle and characteristics of an Ideal working fluid in vapour power cycles.

Module-5

Gas power cycles

Ericson Cycle, Stirling Cycle, Air standard cycles-Otto cycle, Diesel cycle and Dual cycle, computation of thermal efficiency and mean effective pressure, comparison of Otto, Diesel & Dual cycles.

Gas turbine Cycles: Introduction and classification of gas turbine, gas turbine (Brayton) cycle; description and thermal analysis, Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles, Jet Propulsion.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

CO1: Describe the fundamental concepts and principles of engineering thermodynamics. (L2)

CO2: Understand the thermodynamic relations for different engineering applications. (L2)

CO3: Apply the governing laws of thermodynamics for different engineering applications. (L3)

CO4: Analyse the various thermodynamic processes, cycles and results. (L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. Basic and Applied Thermodynamics, P K Nag, 2nd Ed., Tata McGraw Hill Publications, 2017.
2. A textbook of Engineering Thermodynamics, R K Rajput, Fifth edition, Laxmi Publications, 2019.
3. Fundamentals of Thermodynamics, Claus Borgnakke and Richard E Sonntag, 8th edition, Wiley India Edition, 2020
4. Thermodynamics, An Engineering Approach, Yunus A Cenegal, Michael A Boles, and Mehmet Kanoglu, 9th Edition, Tata McGraw Hill publications, 2019

Reference Books

1. Engineering Thermodynamics, J B Jones and G A Hawkins, John Wiley and sons, 1986.

2. An Introduction to Thermodynamics, Y V C Rao, Wiley Eastern, 2003

Applications of Thermodynamics, Dr V Kadambi and Dr T R Seetharam, Wiley Publications, 2018.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/112104113, (NPTEL-NOC: Basic Thermodynamics, IIT Kanpur)
- https://www.youtube.com/watch?v=9GMBpZZtjXM, (Lecture Series on Basic Thermodynamics, IIT Kharagpur
- https://www.youtube.com/watch?v=9GMBpZZtjXM&list=PLD8E646BAB3366BC8
- https://www.youtube.com/watch?v=jkdMtmXo664&list=PL3zvA_WajfGAwLuULH-L0AG9fKDgplYne
- https://www.youtube.com/watch?v=1lk7XLOxtzs&list=PLkn3QISf55zy2Nlqr5F09oO2qcIwNNfrZ&index=3
- https://www.youtube.com/watch?v=Dy2UeVCSRYs&list=PL2_EyjPqHc10CTN7cHiM5xB2qD7BHUry7

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Organise Industrial visits to Thermal power plants and submission of report
- Case study report and power point presentation on steam power plant.
- List of thermal energy devices at homes, hostels and college premises and applicable laws

ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ
("ವಿ ಟಿ ಯು ಅಧಿನಿಯಮ ೧೯೯೪" ರ ಅಡಿಯಲ್ಲಿ ಕರ್ನಾಟಕ ಸರ್ಕಾರದಿಂದ ಸ್ಥಾಪಿತವಾದ ರಾಜ್ಯ ವಿಶ್ವವಿದ್ಯಾಲಯ)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

(State University of Government of Karnataka Established as per the VTU Act, 1994)"Jnana Sangama" Belagavi-590018, Karnataka, India)

Prof. B. E. Rangaswamy, Ph.D.
REGISTRAR

Phone: (0831) 2498100
Fax: (0831) 2405467

REF: VTU/BGM/BOS/New UG-PG Prog/2023-24/4618 DATE: 5 DEC 2023

CIRCULAR

Subject: The syllabus of BMEL305-Introduction to Modelling and Design for Manufacturing is revised...

Reference: The email from Chairperson BoS Mechanical Engineering, VTU Belagavi dated 27.11.2023

The Hon'ble Vice Chancellors' approval dated 04.12.2023

The faculty development program has been conducted on the course/subject BMEL305: Introduction to Modelling and Design for Manufacturing between the 6th and 8th of November 2023 at 6 different places in Karnataka to cover the faculty of all zones of VTU Belagavi (ref. VTU/BGM/BOS/FDP/2023-24/3728, Dated October 31, 2023).

Based on the feedback received from the faculty, the syllabus of the course/subject **BMEL305: Introduction to Modelling and Design for Manufacturing** has been revised and submitted to the university for circulation to all concerned by the Board of Studies in Mechanical Engineering, VTU Belagavi.

A revised syllabus copy has been enclosed in this circular for stakeholder reference. The revised syllabus of the course will take effect in the academic year 2023-24 for Mechanical Engineering and its allied branches.

All the principals of the engineering colleges are hereby informed to bring the content of the circular to the notice of all concerned.

Sd/-
Registrar

To,
All the Principals of Affiliated /Constituent Engineering Colleges, under the University.
The Chairperson / Program Coordinator, University Department at Kalaburagai, Belagavi, Bengaluru and Mysuru

Copy to:

1. The Hon'ble Vice-Chancellor through the secretary to VC VTU Belagavi for information
2. The Registrar (Evaluation) VTU Belagavi for information and needful

3. The Director, ITI SMU, VTU Belagavi for information and request to make arrangements for uploading this circular on the VTU web portal in the section of Circular/Notification @ https:// vtu.ac.in/ en/ category/ administration/
4. The Chairperson/s Board of Studies in Mechanical Engineering and its allied branches
5. The Special Officer, QPDS Examination Section VTU Belagavi for needful.
6. Office Copy

05/12/23

REGISTRAR

05/12/23

Introduction to Modelling and Design for Manufacturing		Semester	3
Course Code	**BMEL305**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	**0:0:2:0**	SEE Marks	50
Total Hours of Pedagogy	**14 Sessions**	Total Marks	100
Credits	**01**	Exam Hours	3
Examination nature (SEE)	**Practical**		

Course objectives:

- Develop a comprehensive understanding of mechanical assemblies and design for manufacturing principles.
- Learn and apply best practices to create designs that are robust, adaptable, and cost-effective.
- Master the art of maintaining control over designs throughout the entire lifecycle, from initial sketch to final production.
- Gain hands-on experience in practical exercises and projects to reinforce theoretical concepts.
- Acquire effective communication and collaboration skills for multidisciplinary teamwork in design and production processes.

Teaching-Learning Process (General Instructions)

These are sample strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Project-Based Learning: Engage students in hands-on projects that simulate real-world design scenarios, enabling practical application of concepts and fostering deeper understanding.
- Interactive Workshops: Conduct collaborative workshops where students work together to solve design challenges, encouraging active participation and knowledge sharing.
- Design Reviews with Feedback: Regularly review student designs, providing constructive feedback to guide iterative improvement and promote attention to detail.
- Industry Insights: Invite guest speakers from the industry to share experiences and insights, helping students connect theoretical knowledge to real-world applications.
- Multidisciplinary Teams: Form diverse teams for group projects, allowing students to leverage different skill sets and perspectives to develop comprehensive designs.

Module-1 — 02 Sessions

Introduction to Computer Aided Sketching Review of graphic interface of the software. Review of 2D Sketching, Parametric Solid Modelling, Assembly creation and product rendering. Limits, Fits and Tolerances: Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, Types of fits with symbols and applications, Geometrical tolerances on drawings, Standards followed in industry. (**Above topics to be studied as a review)**

Geometrical Dimensioning and Tolerances (GD&T): Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, machining symbols, types of fits with symbols and applications, geometrical tolerances on drawings. Standards followed in industry. **(Only for CIE)**

The basics of sketching and modelling: Explore Fusion 360 User Interface, Navigation and display settings, create new projects and designs, creating basic 2D sketches, Creating & Modifying a solid 3D body with Sections. **(For SEE)**

Module-2 — 02 Sessions

Create draft during a feature, create draft as a feature, Add ribs and plastic supports, Create holes and threads. Thread Forms: Terminologies, ISO Metric, BSW, Square & Acme. Seller threads, American Standard Thread. Use a coil feature, Mirrors and patterns. Fasteners: 3D & Section views - Hexagonal headed bolt and nut with washer, Square headed bolt and nut with washer. **Keys**: Parallel Key, Taper Key & Feather Key.

Module-3 — 04 Sessions

The different ways to create components, Use scripts to create gears, Component color swatch and color cycling, Use McMaster-Carr parts in a design. Assembly of Joints and Coupling using 3D environment.

Joints: Like Cotter joint (socket and spigot), knuckle joint (pin joint). **Couplings:** Like flanged coupling, universal coupling.

27-11-2023.

Module-4	06 Sessions

Assembly Drawings: (Part drawings shall be given) Drawing Basics-Detailing Drawings. Explode a 3D model for a drawing, Create a drawing sheet and views, Add geometry and dimensions to a drawing, Add GD & T text, BOM, tables and symbols, Place an exploded view, Edit a title block, Export to different file formats.

1. **LIFTING DEVICE (Screw Jack)**
2. **BEARINGS (Plumber Block)**
3. **MACHINE TOOL COMPONENT (Machine Vice or Tailstock)**
4. **VALVES (Ram's Bottom Safety Valve)**
5. **IC ENGINE COMPONENTS (Piston or Connecting Rod)**

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

1. Create and modify a form-based design.
2. Use design tools for moulded parts.
3. Demonstrate proficiency in the setup and creation of a design.
4. Simulate the assembly of machine components in 3D environment.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation (CIE):

- CIE marks for the practical course is 50 Marks.
- CIE shall be evaluated for max marks 100. Marks obtained shall be accounted for CIE final marks, reducing it by 50%.
- CIE component should comprise of
  - Continuous evaluation of Drawing work of students as and when the Modules are covered.
  - At least one closed book Test covering all the modules on the basis of below detailed weightage.
  - *Weightage for Test and Continuous evaluation shall be suitably decided by respective course coordinators.*

Module	Max. Marks weightage	Evaluation Weightage in marks	
		Computer display & printout	Preparatory sketching
Module-1	15	10	05
Module-2	15	10	05
Module-3	30	20	10
Module-4	40	30	10
Total	**100**	**70**	**30**

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

- The duration of SEE is 03 hours. Questions shall be set worth of 3 hours
- SEE shall be conducted jointly by the two examiners (one internal and one external) appointed by the University.
- SEE shall be conducted and evaluated for maximum of 100 marks as shown in the table below. Marks obtained shall be accounted for SEE final marks, reducing it to 50 marks.
- Question paper shall be set jointly by both examiners and made available for each batch as per schedule.
- Evaluation shall be carried jointly by both the examiners.
- Scheme of Evaluation: To be defined by the examiners jointly and the same shall be submitted to the university along with question paper.

- One full question shall be set from each Modules as per the below tabled weightage details. ***However, the student may be awarded full marks, if he/she completes solution on computer display without sketch***

Module	Max. Marks weightage	Evaluation Weightage in marks	
		Computer display & printout	Preparatory sketching
Module-1 **or** Module-2	20	15	05
Module-3	30	20	10
Module-4	50	40	10
Total	**100**	**75**	**25**

Suggested Learning Resources:

Books

Text Books:

1. K L Narayana, P Kannaiah, K Venkata Reddy, "Machine Drawing", New Age International, 3rd Edition. ISBN-13: 978-81-224-2518-5, 2006
2. N D Bhatt , "Machine Drawing", Charotar Publishing House Pvt. Ltd.,50th Edition, ISBN-13: 978-9385039232, 2014
3. Machine drawing by K R Gopalakrishna, Subhash Publication

Web links and Video Lectures (e-Resources):

- Learn Fusion 360 in 90 Minutes
  https://www.autodesk.com/certification/learn/course/learn-fusion-360-in-90-minutes

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

NON-TRADITIONAL MACHINING		Semester	3
Course Code	**BMR306A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

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

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Introduction to Non-traditional machining

Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining elements of the processes, mechanics of metal removal process, parameters, economic considerations, Specific advantages, limitations and applications of non-traditional machining processes. recent development.

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.

Module-2

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.

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.

Module-3

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.

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.

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.

Laser Beam Machining (LBM):

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

Module-5

Electron Beam Machining (EBM):

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

Hybrid Machining Process: Importance of hybrid machining process; Process principle, process parameters, and application of: - Electrochemical Discharge Machining (ECDM), Ultrasonic Assisted Electric Discharge Machining (UAEDM), Electrochemical Discharge Grinding (EDG), Powder Assisted Electric Discharge Machining (PAEDM).

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

CO1: Describe non-traditional and hybrid machining process and compare it with Traditional machining process. [L1]

CO2: Explain the constructional features, performance parameters, process characteristics, applications, advantages, and limitations of different non traditional and hybrid machines [L2]

CO3: Apply an understanding of non-traditional and hybrid machining processes to address specific machining needs.[L3]

CO4: Analyze use of different non traditional and hybrid machining processes for different engineering applications. [L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

The Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

TEXT BOOKS:

1. Modern Machining Process by P.C Pandey and H S Shah, McGraw Hill Education India Pvt. Ltd. 2000
2. Wellar, E.J. "Non-Traditional Machining Processes", Society of Manufacturing Engineers Publications, 2nd Edition, Michigan, 1984.
3. Non Traditional Manufacturing Processes, by Gary F Benedict, Taylor & Francis

REFERENCE BOOKS:

1. Production technology, HMT, McGraw Hill Education India Pvt. Ltd. 2001
2. New Technology, Dr. Amitabha Bhattacharyya, The Institute of Engineers (India), 2000
3. Modern Machining process, Aditya, 2002.
4. Non-Conventional Machining, P.K.Mishra, The Institution of Engineers (India) Test book series, Narosa Publishing House – 2005.
5. Metals Handbook: Machining Volume 16, Joseph R. Davis (Editor), American Society of Metals (ASM)
6. Gary F. Benedict, —Nontraditional manufacturing processes‖, Marcel Dekker, Inc. 1987.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/112105127
- https://en.wikipedia.org/wiki/Small_and_medium-sized_enterprises
- https://www.americanmicroinc.com/resources/beginner-guide-cnc-programming/
-

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Give students a design challenge, such as designing a non-traditional machining process to produce a specific part.
- Take students on a field trip to a manufacturing facility that uses non-traditional machining.

INTRODUCTION TO ROBOTICS		Semester	3
Course Code	**BMR306B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Gain knowledge of Robotics and automation.
- Understand the working methodology of robotics and automation.
- Write the program for robot for various applications

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Industrial Automation: Definition, Types of automation, List basic Devices in Automated Systems, Distinguish Different Controllers Employed In Automated Systems. Identify Safety in Industrial Automation

Basic Concepts: Definition and origin of robotics – different types of robotics – various generations of robots – degrees of freedom – Asimov's laws of robotics

Module-2

Fundamentals of Robotics: robot anatomy, work volume, robot drive systems, control systems, precision of movement, end effectors, Introduction to Manipulator kinematics, Robot Dynamics.
Basic control systems and components: Basic control systems concepts and models, Controllers, control system analysis

Module-3

Robot End Effector: Types of End effectors, Mechanical Grippers, Other types of Grippers, Tools and End effector, The Robot/End effector interface Consideration in Gripper selecting and Design.
Sensors in Robotics: Transducers and sensors, sensors in robotics, tactile sensors, proximity and range sensors, uses of sensors in robotics.

Module-4

Robot Programming: Methods of robot programming, lead -through programming methods, a robot program as a path in space, motion interpolation, wait, signal and delay commands, branching, capabilities and limitations of lead-through methods.

Module-5

Material handling and Identification Technologies: Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.

Course outcome (Course Skill Set)
At the end of the course, the student will be able to :

CO 1: Understand various types of Robotics, automation, robotics motion, sensors and control, machine vision, robotic programming and roles of robots in industry. [L2]
CO 2: Classify the different material handling , identification technologies and programming used in automation [L2]
CO 3: Apply knowledge of robotics and automation, motion and control, machine vision and programming, application of robots in industry. [L3]
CO 4: Analyze different types of robotics and automation, motion and control, machine vision and programming.[L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. Mikell P. Groover, Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, "Industrial Robotics: Technology, Programming and Applications", 2 nd Edition, Tata McGraw Hill, 2012.
2. Roland Siegwart, Illah R. Nourbakhsh, an d Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 2 nd Edition, PHI, 2011

Web links and Video Lectures (e-Resources):

- NPTEL course on Industrial Robotics: https://onlinecourses.nptel.ac.in/noc23_me143/preview
- **Videos on Industrial Automation :** The Robot Revolution: The New Age of Manufacturing | Moving Upstream

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Students should build and program a simple robot.
- Students may design and build a robot for a specific task, such as navigating a maze or completing an obstacle course.

NANOMATERIALS AND APPLICATION		Semester	3
Course Code	**BMR306C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Performance characteristics of fuel cell power plants and its components.
- Performance and design characteristics and operating issues for various fuel cells.
- Design philosophy and challenges to make this power plant economically feasible.
- Design and analysis emphasis will be on thermodynamics and electrochemistry.
- Working in a fuel cell industry R&D organization.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

NANOMATERIALS

Introduction, Classification: 0D, 1D, 2D, 3D nanomaterials and nano-composites, their mechanical, electrical, optical, magnetic properties; Nanomaterials versus bulk materials.

Module-2

THERMODYNAMICS & KINETICS OF NANOSTRUCTURED MATERIALS

Size and interface/interphase effects, interfacial thermodynamics, phase diagrams, diffusivity, grain growth, and thermal stability of nanomaterials.

Module-3

PROCESSING

Bottom-up and top-down approaches for the synthesis of nanomaterials, mechanical alloying, chemical routes, severe plastic deformation, and electrical wire explosion technique.

Module-4

STRUCTURAL CHARACTERISTICS

Principles of emerging nanoscale X-ray techniques such as small angle X-ray scattering and Xray absorption fine structure (XAFS), electron and neutron diffraction techniques and their application to nanomaterials; SPM, Nanoindentation, Grain size, phase formation, texture, stress analysis

Module-5

APPLICATIONS

Applications of nanoparticles, quantum dots, nanotubes, nanowires, nanocoatings; applications in electronic, electrical and medical industries

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

CO 1: Recall nanomaterial classifications and properties, differentiating from bulk materials. Understand interfacial thermodynamics' significance.[L1]

CO 2: Compare the synthesis principles for creating nanomaterials, demonstrate and explain structural analysis using advanced techniques, and summarize key findings.

CO 3: Apply bottom-up and top-down approaches in nanomaterial synthesis. Comprehend the roles of mechanical alloying and chemical routes.[L3]

CO 4: Analyze nanomaterial properties using emerging techniques. Apply nanoparticle, nanotube, and nanowire applications in diverse industries.[L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

TEXT BOOKS :

1. Bhusan, Bharat (Ed), "Springer Handbook of Nanotechnology", 2nd edition, 2007.
2. Carl C. Koch (ed.), NANOSTRUCTURED MATERIALS, Processing, Properties and Potential Applications, NOYES PUBLICATIONS, Norwich, New York, U.S.A.

REFERENCE BOOKS :

1. Poole C.P, and Owens F.J., Introduction to Nanotechnology, John Wiley 2003
2. Nalwa H.S., Encyclopedia of Nanoscience and Nanotechnology, American Scientific Publishers 2004
3. Zehetbauer M.J. and Zhu Y.T., Bulk Nanostructured Materials, Wiley 2008
4. Wang Z.L., Characterization of Nanophase Materials, Wiley 2000
5. Gutkin Y., Ovid'ko I.A. and Gutkin M., Plastic Deformation in Nanocrystalline Materials, Springer 2004

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/113104102
- https://www.coursera.org/learn/nanotechnology1

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Give students a design challenge, such as designing a nanomaterial-based device for a specific application.
- Have students research a specific type of nanomaterial and present their findings to the class.

Fuel Cell Technology		Semester	3
Course Code	**BMR306D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Performance characteristics of fuel cell power plant and its components.
- Performance and design characteristics and operating issues for various fuel cells.
- Design philosophy and challenges to make this power plant economically feasible.
- Design and analysis emphasis will be on the thermodynamics and electrochemistry.
- Working in a fuel cell industry R&D organization.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

INTRODUCTION AND OVERVIEW OF FUEL CELLS TECHNOLOGY

Fuel cells: History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell, Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, microbial fuel cells, relative merits and demerits.

Module-2
FUEL CELL THERMODYNAMICS. Gibbs free energy; reversible and irreversible loss - Nernst Equation; effect of temperature and pressure concentration on Nernst potential – Concept of Electrode potential and Electrochemical Potential**.**
Module-3
HYDROGEN FUEL AND FUEL CELL Properties of hydrogen as fuel, Hydrogen pathways introduction-current uses, general introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and hydrogen production plants. low and high temperature fuel cells - Effect of Green House Gas (GHC) emission - Basic fuel cell operations -Fuel cell and Hydrogen economy - Basic electrochemistry for all fuel cells
Module-4
APPLICATIONS OF FUEL CELLS Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space, economic and environmental analysis on usage of hydrogen and fuel cell. Future trends in fuel cells, portable fuel cells, laptops, mobiles, submarines
Module-5
HYDROGEN PRODUCTION AND STORAGE. Thermal-Steam reformation, thermochemical water splitting, gasification-pyrolysis, nuclear thermal catalytic and partial oxidation methods. Electrochemical-Electrolysis, photo electro chemical, Biological-Anaerobic digestion, fermentation micro-organism, PM based electrolyser- Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, carbon based materials for hydrogen storage.
Course outcome (Course Skill Set) **At the end of the course, the student will be able to :** **CO 1:** Identify, formulate, and solve problems related to fuel cell technology keeping in mind economic viability. **CO 2:** Apply know-how of thermodynamics, electrochemistry, heat transfer, and fluid mechanics principles to design and analysis of this emerging technology. **CO 3:** Use the techniques, skills, and modern engineering tools necessary for design and analysis of innovative fuel cell systems. **CO 4:** Develop enough skills to design systems or components of fuel cells.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

TEXT BOOKS :

1. Fuel Cell Systems Explained by James Larminie and Andrew Dicks, Second Edition, John Wiley, New York, 2003, ISBN 0-470- 84857-X.
2. A.J. Appleby and F.R. Foulkes, Fuel Cell Handbook, Von Norstrand Reinhold, New York, 1989.
3. A.J. Bard, and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd ed., Wiley, New York, 2001.
4. L.J. Blomen, Fuel Cell Systems, Plenum Publishing Corporation, New York, NY, 1994.

REFERENCE BOOKS :

1. A. Bauen and D. Hart, Assessment of the environmental benefits of transport and stationary fuel cells, Journal of Power Sources, Vol. 86, pp. 482-494, 2000.
2. M. Cassir and C. Belhomme, Technological applications of molten salts: the case of the molten carbonate fuel cell, Plasma & Ions, Vol. 1, pp. 3-15, 1999.
3. S. Gottesfeld, Polymer electrolyte fuel cells, Advances in Electrochemical Science and Engineering, Vol. 5, Eds. R. C. Alkire, et al., Wiley-VCH, pp. 195-301, 1997.
4. Hammou, Solid oxide fuel cells, Advances in Electrochemical Science and Engineering, Vol. 2, Eds. H. Gerischer and C.W. Tobias, et al., Wiley-VCH, pp. 88-139, 1992.
5. K. Hemmes, G. Lindbergh, J. R. Selman, D. A. Shores, and I. Uchida, Carbonate Fuel Cell Technology, PV 99-20, Honolulu, Hawaii, Fall 1999, Published by The Electrochemical Society, Inc., 10 South Main Street, Pennington, NJ, 08534; Tel: 609-7371902; website: www.electrochem.org

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/103/102/103102015/
- https://www.udemy.com/course/hydrogen-powered-fuel-cell-electric-vehicle/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Have students research a specific type of fuel cell and present their findings to the class.
- Give students a design challenge, such as designing a fuel cell-powered vehicle or portable power supply.

Spreadsheet for Engineers		Semester	3
Course Code	**BMR358A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0-0-2-0	SEE Marks	50
Total Hours of Pedagogy	15 sessions	Total Marks	100
Credits	01	Exam Hours	3
Examination nature (SEE)	Theory/Practical/Viva-Voce /Term-work/Others		

Course objectives:

- .To create different plots and charts
- To compute different functions, conditional functions and make regression analysis
- To carry out iterative solutions for roots, multiple roots, optimization and non-linear regression analysis
- To carryout matrix operations
- To Understand VBA and UDF
- To understand VBA subroutines and Macros
- To carry out numerical integration and solving differential equations using different methods

Sl.NO	Experiments
1	Charting: Create an XY scatter graph, XY chart with two Y-Axes, add error bars to your plot, create a combination chart
2	Functions: Computing Sum, Average, Count, Max and Min, Computing Weighted Average, Trigonometric Functions, Exponential Functions, Using The CONVERT Function to Convert Units
3	Conditional Functions: Logical Expressions, Boolean Functions, IF Function, Creating a Quadratic Equation Solver, Table VLOOKUP Function, AND, OR and XOR functions.
4	Regression Analysis: Trendline, Slope and Intercept, Interpolation and Forecast, The LINEST Function, Multilinear Regression, Polynomial Fit Functions, Residuals Plot, Slope and Tangent, Analysis ToolPack.
5	Iterative Solutions Using Excel: Using Goal Seek in Excel, Using The Solver To Find Roots, Finding Multiple Roots, Optimization Using The Solver, Minimization Analysis, NonLinear Regression Analysis.
6	Matrix Operations Using Excel: Adding Two Matrices, Multiplying a Matrix by a Scalar, Multiplying Two Matrices, Transposing a Matrix, Inverting a Matrix and Solving System of Linear Equations.
7	VBA User-Defined Functions (UDF): The Visual Basic Editor (VBE), The IF Structure, The Select Case Structure, The For Next Structure, The Do Loop Structure, Declaring Variables and Data Types, An Array Function The Excel Object Model, For Each Next Structure.
8	VBA Subroutines or Macros: Recording a Macro, Coding a Macro Finding Roots by Bisection, Using Arrays, Adding a Control and Creating User Forms.
	Demonstration Experiments (For CIE)
9	Numerical Integration Using Excel: The Rectangle Rule, The Trapezoid Rule, The Simpson's Rule, Creating a User-Defined Function Using the Simpson's Rule.
10	Differential Equations: Euler's Method, Modified Euler's Method, The Runge Kutta Method, Solving a Second Order Differential Equation

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Describe different plots and charts in spread (L1)
- Classify different functions, conditional functions and make regression analysis(L2)
- Apply iterative solutions for roots, multiple roots, optimization and non-linear regression analysis(L3)
- Analyse matrix operations, VBA and UDF, VBA subroutines , Macros and numerical integration (L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- Excel Resources - 600+ Self Study Guides, Articles & Tools (wallstreetmojo.com)
- https://www.ictlounge.com/html/year_7/esafety_part7.htm
- McFedries PaulMicrosoft Excel 2019 Formulas And Functions Microsoft Press, U.S, 2019 Edition

Microcontrollers		Semester	3
Course Code	BMR358B	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Total Hours of Pedagogy	15 sessions	Total Marks	100
Credits	01	Exam Hours	3
Examination nature (SEE)	Theory/Practical/Viva-Voce /Term-work/Others		

Course objectives:

- Understand the basics of microcontroller and its applications.
- Have in-depth knowledge of 8051 assembly language programming.
- Understand controlling the devices using C programming.
- The concepts of I/O interfacing for developing real time embedded systems.

Sl.NO	Experiments
1	Studying the Architecture of 8051 microcontroller.
2	Studying basic instruction set.
3	Write an ALP to Data Transfer: Block Move, Exchange, Sorting, Finding largest element in an array.
4	Write an ALP for an Arithmetic Instructions like - Addition/subtraction, multiplication and division, square, Cube – (16 bits Arithmetic operations – bitaddressable).
5	Write an ALP for Boolean & Logical Instructions (Bitmanipulations).
6	Write an ALP for Counters.
	Demonstration Experiments (For CIE)
9	Demonstrate a simple toggle switch to 8051 and write an ALP to generate an interrupt which switches on an LED
10	To demonstrate interface a Stepper Motor to 8051 to rotate the motor.
11	Write a C program to (i) transmit and (ii) to receive a set of characters serially by interfacing 8051 to a terminal

Course outcomes (Course Skill Set):

CO1:Define the fundamental principles and concepts underlying the design and operation of digital communication systems.[L1]

CO2: Explain and demonstrate the use of 8051 Assembly language programs to manipulate input data, classifying and comparing different instructions. (L2)

CO2: Utilize Assembly language programs to interface and control various input and output devices with the 8051 microcontroller, demonstrating effective problem-solving skills. (L3)

CO3: Analyze and classify the interfacing of serial devices with the 8051 microcontroller. Utilize C programming to execute serial data transfers, demonstrating a deep understanding of the process. (L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

Text Books:

1. "The 8051 Microcontroller and Embedded Systems – using assembly and C", Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, 2006 / Pearson, 2006.
2. "The 8051 Microcontroller", Kenneth J. Ayala, 3rd Edition, Thomson/Cengage Learning.

Reference Books:

1 "The 8051 Microcontroller Based Embedded Systems", Manish K Patel, McGraw Hill, 2014, ISBN: 978-93-329-0125-4.
2. "Microcontrollers: Architecture, Programming, Interfacing and System Design", Raj Kamal, Pearson Education, 200

Chartering		Semester	3
Course Code	**BMR358C**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	1:0:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Understands the basics of cargoes and trade routes
- Explore the basics of freight Markets
- Understand the charter contracts

Teaching-Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it

Module-1

CARGOES AND TRADE ROUTES: ship types required for different cargoes and trade routes,nature, characteristics, hazards and stowage requirements of the four main dry commodities, namely Coal, Ore, Grain and Fertilizers. Angle of repose, ventilation and prevention of stowage hazards.

Module-2

FREIGHT MARKETS: Role of the different market practitioners; Charterers, Shipowners, Operators;dry cargo chartering market and the relative importance of the major market centres,role of the Broker and its relationship to the principals as an agent;INCOTERMS.

Module-3

CONTRACTS: Basic format and purpose and content of those main clauses common to all Charter Party forms; use of standard forms of voyage and time charter parties.;Voylay Rules 1993 and FONASBA Time Charter Interpretation Code 2000; responsibilities and liabilities of owners, charterers and brokers which arise under the charter party.

Module-4

CHARTERING MARKET PRACTICE: Procedure of negotiations including cargo circulars, indications, and firm offers; customary abbreviations used during negotiation; process of offer, rejection and new offer (counter offer, accept/except) and acceptance; legal, tactical and ethical requirements of the market and the avoidance of conflicts between them.

Module-5

LAYTIME: importance of the clarity of notice of readiness clauses and be able to draft a concise clause; tendering valid NOR and common problems relating to acceptance; nature of the information contained in the Statement of Facts and how the Laytime Statement is prepared; application of "Voylay Rules" with particular reference to Berth-v-Port charters and Weather Working Days.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

1. CO 1: list the basics chartering terms [L1]
2. CO 2: Describe applications of charter document[L2]
3. CO 3: Illustrate the use of a charter document [L3]
4. CO4: Apply the rules of charter parties for dry cargo vessels, writing of contracts, negotiating a charter, lay time calculation[L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

- SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question paper is MCQ (multiple choice questions).
- The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Textbooks

1. Pagonis T., Pentheroudakis N., 2019, 'Chartering Manual by Practitioners', 1st Edition by Practitioner' Book Avenue, LLP, 27, Old Gloucester street, London WC1N 3AX, United Kingdom
2. Institute of Chartered Shipbrokers (2017). Dry Cargo Chartering, London: Witherbys

Reference Books:

1. Collins, N. (2000). The essential guide to chartering and the dry freight market. Clarkson Research Studies.

Web links and Video Lectures (e-Resources):

- .http://www.imo.org/en/Pages/Default.aspx https://lloydslist.maritimeintelligence.informa.com/
- https://splash247.com/ https://www.bimco.org/ https://www.essdocs.com/
- https://www.hellenicshippingnews.com/ https://www.ics.org.uk/ https://www.ics-shipping.org/
- https://www.intertanko.com/https://www.marineinsight.com/ https://www.maritime-executive.com/
- https://www.maritimeinfo.org/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Case studies on chartering negotiations.
- Presentations on changes in charter parties historically.

Tools in Scientific Computing		Semester	3
Course Code	BMR358D	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Total Hours of Pedagogy	15 hrs	Total Marks	100
Credits	01	Exam Hours	3
Examination nature (SEE)	Theory/Practical/Viva-Voce /Term-work/Others		

Course objectives:

1. To learn the fundamentals of problem-solving using MATLAB/MATHCAD and go plot graphs using Origin software
2. To introduce programming for curve fitting and solving both linear and nonlinear equations.
3. To understand the concept of approximate methods and recognize their significance in computing.

Sl.NO	Experiments
1	Develop a program to find the eigenvalues and eigenvectors of a square matrix
2	Develop a user-friendly program for the Newton-Raphson method for solving simultaneous nonlinear equations
3	Develop a user-friendly program to find solution of simultaneous linear equations using matrix methods
4	Develop a program to find the equation that best fits for the given set of points using any of the curve fitting techniques
5	Develop a program to compute the area under the given curve described by the function using numerical techniques
6	Develop a user-friendly program for the thick or thin cylinders subjected to internal and external loads, determine the stresses developed within the cylinder and plot the variation of stresses
7	Develop a program to find the principal stresses and their associated directions for a given state of stress described by the components of stress in three dimensions (σxx, σyy, σzz, σxy, σxz, σyz),
8	Develop a user-friendly program for plotting the Mohr's circle for the given 2D stress state and determine the principal stresses and directions of principle stress
	Demonstration Experiments (For CIE)
9	Develop a program to find the multiplication and inverse of a square matrix
10	Develop a program to find and plot the response of spring-mass-dashpot system subjected to harmonic excitation.
11	Develop a program to find the roots of a quadratic equation using numerical method
12	Develop a program to find the solution of differential equation using approximate methods

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Understand the fundamentals of programming in scientific computations.
2. Develop programming for curve fitting and solving both linear and nonlinear equations.
3. Apply the concept of approximate methods and recognize their significance in computing.
4. Apply MATLAB/MATHCAD/FORTRAN/PYTHON tools, etc., for solving engineering problems

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

1. Applied Numerical Methods with MATLAB for Engineers and Scientists, Steven C. Chapra, Edition 3, McGraw-Hill, 2012
2. Numerical methods for engineers, Steven C. Chapra, Raymond P. Canale, 5th fifth edition, 2006, McGraw-Hill Higher Education, Boston, 2006
3. MATLAB and Its Applications in Engineering, Raj Kumar Bansal, et.al 2009, Pearson Education,

MECHANICS OF MATERIALS		Semester	4
Course Code	**BMR401**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2-2-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- To know behaviour & properties of engineering materials.
- To know the different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.
- To understand the stresses developed in bars, compound bars, beams, shafts, and cylinders.
- To analyze the concepts of calculation of shear force and bending moment for beams with different load conditions and supports.
- To explore the concepts of Buckling of columns.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Stresses and Strains: Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them.

Module-2

Bi-axial Stress system: Introduction, plane stress, stresses on inclined sections, principal stresses and maximum shear stresses, graphical method - Mohr's circle for plane stress.

Thick and Thin cylinders: Stresses in thin cylinders, Lame's equation for thick cylinders subjected to internal and external pressures, Changes in dimensions of cylinder (diameter, length and volume), simple numerical.

Module-3

Bending moment and Shear forces in beams: Definition of beam – Types of beams – Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, uniformly distributed loads, uniformly varying loads and combination of these loads – Point of contra flexure.

Module-4

Theory of simple bending – Assumptions – Derivation of bending equation - Neutral axis – Determination of bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I, T and Channel sections – Design of simple beam sections, Shear Stresses: Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, and T sections.

Module-5

Torsion of circular shafts: Introduction, pure torsion, assumptions, derivation of torsional equations, polar modulus, torsional rigidity / stiffness of shafts, power transmitted by solid and hollow circular shafts.

Theory of columns – Long column and short column - Euler's formula – Rankine's formula.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :
CO1: Understand the concept of stress and strain in structural problems (L2)
CO2: Apply the concept of different elastic functions, stress and strain to solve structural problems (L3)
CO3: Analyse the influence of various geometric and loading parameters in axial, bending, shear and torsion (L4)
CO4: Analyse concept of solid mechanics in designing structural members. (L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. Mechanics of Materials, S.I. Units, Ferdinand Beer & Russell Johnstan, 7th Ed, TATA McGrawHill-2014
2. Strength of Materials by R.K. Bansal ,Laxmi Publications 2010.
3. Mechanics of Materials, J M Gere, B J Goodno, Cengage Eighth edition 2013
4. Strength of Materials, R K Rajput S. Chand and Company Pvt. Ltd 2014
5. Mechanics of Materials, R C Hibbeler, Pearson Latest edition

Web links and Video Lectures (e-Resources):

https://www.digimat.in/nptel/courses/video/112107147/L02.html
https://www.cpp.edu/meonline/strength-of-materials.shtml
https://nptel.ac.in/courses/105105108
https://www.springer.com/journal/11223
http://www.astm.org/DIGITAL_LIBRARY/JOURNALS/TESTEVAL/PAGE S/JTE12637J.htm
http://www.freeengineeringbooks.com/Civil/Strength-of-MaterialBooks.php

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Use Mdsolids (https://web.mst.edu/mdsolids/) or any open source software for active teaching and learning.
- Use of Simulation Softwares to model and analyse beams, columns, cylinders etc.

Marine Electrical Technology (IPCC)		Semester	4
Course Code	**BMR402**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Theoretical and practical knowledge of the Electrical systems on Board ships.
- Study the electrical power distribution systems on board ships.
- Understanding of Motors and starters and their protection.
- Theoretical and practical understanding of lighting and battery systems.
- Understanding of the troubleshooting aspects of marine electrical systems.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and
2. Video demonstrations or Simulations.
3. Chalk and Talk method
4. Adopt flipped classroom teaching methods.
5. Adopt collaborative (Group Learning) learning in the class.
6. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.
7. Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

MODULE-1

SHIPS' ELECTRICAL SYSTEMS - GENERATORS

Ships' Electrical System introduction - DC and AC. AC Generator (s), Rotating alternating current GeneratorConstruction and Cooling - Excitation Methods. Automatic Voltage Regulation - Generators in Parallel –synchronization. Generator Protection, Electromagnetic Compatibility, Emergency Generators and its location, SOLAS requirement for Emergency Generators.

MODULE-2

ELECTRICAL POWER DISTRIBUTION

Power Distribution Systems – 380V, 440 V & 240 V systems - Insulated and Earthed Neutral Systems - Switch boards and combination of switch and control gear - Circuit breakers and magnet switches . MSB Protection - Significance of Earth Faults - Transformers - Instrument Transformers - Shore Supply Connection -Non essential trips -Cables, types and requirement, Cable tracks (laying of cables), sealing when penetrates bulkheads Basic design criteria –load balanceshort circuit calculation- Block, System, Line And Circuit Diagrams, Dangerous Zones – Zone 0, Zone 1 and Zone 2- Power Management systems , Dead man alarm system of engine room.

MODULE-3

MOTORS AND STARTERS

Introduction - Motor Construction – IP Protection /ratings – Induction Motor Operation - Control Equipment - Direct onLine Starting - Reduced Voltage Starting - Speed Control - Motor Protection – Single Phase Motors – Maintenance. Flame proof Enclosures (for light fittings and motors, etc on tankers) - Intrinsically Safety circuits - Increased Safety – Non-Sparking - Pressurized Enclosure - Special Protection - Certification and Identification(Markings).

MODULE-4

ELECTRICAL SERVICES

Introduction - Ships' Lighting - Incandescent Lamps - Discharge Lamps - Voltage Effects on Lighting - Navigation and Signal Lights - Emergency Lighting - Maintenance of Lighting - Types of Batteries Battery Supplies. UPS ,Emergency generators and emergency Power for cargo ships, Internal Communication system -Talk back system, Sound powered telephone system- Automatic telephone installations, External communication system – ship shore communication system , Global Maritime Distress safety system

MODULE-5
SAFETY AND MAINTENANCE OF ELECTRICAL SYSTEMS General Electrical maintenance - Fault Finding, Generator maintenance , Overhauling of Motors when insulation is zero, Circuit Calculations – Electrical Diagrams - Electrical Safety - Electric Shock - Insulation Resistance - Circuit Testing - Insulation Testing - Continuity Testing – Multimeter - Diode Tests - Current Clamp meters - Live-line Testers – Maintenance of batteries and precautions to be taken for battery room

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	Load Characteristics of DC shunt and compound generator 1) Short shunt – cumulative and differential 2) Long shunt - cumulative and differential
2	Load test on a DC Motor- determination of speed – torque and HP – efficiency Characteristics
3	Swineburne's Test
4	Hopkinson's test
5	Field test on series motors
6	Retardation test – electrical braking method
7	Speed control of DC motor by armature voltage control and flux control
8	Ward leonard method of speed control of DC motor
9	Voltage regulation of an alternator by EMF and MMF Method
10	DEMO: Exercises in reading and drawing of electrical circuits with reference to ship electrical systems
11	DEMO: Exercises in Testing and troubleshooting of electric motors.
12	DEMO: Exercises in the use of Multimeter, Megger, Clamp meter, etc and their calibration.
13	DEMO: Exercises in Power Wiring and earthing.

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

- CO1:Describe Ships electrical systems, power distribution systems, motor construction, protection, lighting and battery services (L1)
- CO2:Explain AC and DC generator systems, protection and circuit breakers, fire protection on electrical systems,working of communication systems, various testing equipment (L2)
- CO3: Examine and compare electrical generation systems, distribution systems, motor protection, lighting , battery systems, safety and insulation. (L3)
- CO4: Evaluate the performance of electrical machines and systems(L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the

credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books:

1. Elstan.A. Fernandez., "Marine Electrical Technology", 4th Edition, "Sterling Book House", Mumbai, 2004.
2. Edmund GR Kraallavers , "Advanced Elecrto-technology For Marine Engineers", 2nd Ed. Reeds Vol 07, Adlard Coles Nautical, London, 2010
3. H. D. McGeorge, "Marine Electrical Equipment and Practice, 2nd Edition, Elsevier Science, 2014

Additional References:

1. Surinder Pal Bali," Electrical Technology Machines and Measurements", Vol II, 1st Ed. Pearson, 2013
2. Surinder Pal Bali," Electrical Technology Machines and Measurements", Vol.I, 1st Ed. Pearson, 2013

Web links and Video Lectures (e-Resources):

1: https://ems-iitr.vlabs.ac.in/List%20of%20experiments.html (Electrical Machines virtual Lab)
2:https://nptel.ac.in/courses/108105155 (NPTEL-NOC: Electrical Machines - I, IIT Kharagpur)
3: https://www.youtube.com/watch?v=5Z-pHEJuL-U (VideoTel Lecture)

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1: Conduct interactive sessions on reading of ship electrical diagrams.
2: Conduct Case studies on fires due to failure of electrical systems.
3: Group discussions on SOLAS Regulations Chapter II-1.

Semester - IV

FLUID MECHANICS & MACHINERY (IPCC)		Sem	IV
Course Code	BMR403	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:2*:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

* One additional hour may be considered wherever required

Course objectives:

- Acquire a basic understanding of properties of fluids and the measurement of pressure and fluid kinematics.
- Acquire a basic understanding of fundamentals fluid dynamics, and Benoulli's equation and flow meters.
- Acquire the basic concepts of flow through pipes and flow over bodies
- Understand the basic concepts of energy conversion in turbomachines.
- Analyse power producing and power absorbing turbomachines.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.
6. Conduct Laboratory Demonstrations and Practical Experiments to enhance experiential skills.

MODULE-1 **8 HOURS**

Introduction*: Definition and properties, types of fluids, pressure at a point in static fluid, variation of pressure, Pascals Law, (To be reviewed in class but not for examination)*

Pressure- Absolute, gauge, vacuum, pressure measurement by manometers and gauges, hydrostatic pressure on plane submerged bodies. Buoyance and metacentre, Stability of submerged bodies

Fluid Kinematics: types of fluid flow, streamlines, pathlines and streaklines, continuity equation, stream function & potential function.

Teaching-Learning Process	1. Power-point Presentation 2. Video demonstration or Simulations 3. Chalk and Talk.

MODULE-2 **8 HOURS**

Fluid Dynamics: Introduction, Forces acting on fluid in motion, Linear momentum equation, Impact of jets,, Euler's equation of motion along a streamline

Bernoulli's equation – assumptions and limitations. Introduction to Navier Stokes equation, Venturi meters, orifice meters, rectangular and triangular notches, pitot tubes, Rotameter.

Teaching-Learning Process	1. Power-point Presentation 2. Video demonstration or Simulations 3. Chalk and Talk.

MODULE-3 **8 HOURS**

Laminar and turbulent flow: Dimensionless numbers, Flow through circular pipe, Poiseuille equation, Flow between parallel plates, Power absorbed in viscous flow in bearings, loss of head due to friction in viscous flow

Turbulence: characteristics of turbulent flow, laminar turbulent transition, major and minor losses, Development of boundary layer, Lift and Drag.

Teaching-Learning Process	1. Power-point Presentation 2. Video demonstration or Simulations 3. Chalk and Talk.

MODULE-4	8 HOURS
Introduction to Turbo machines: Classification of Turbomachines, Basic constructional details, Euler's equations for a Turbo machine, Impulse & Reaction machine, Axial flow and radial flow machines, utilization factor, degree of reaction & efficiencies of Turbo machines **Hydraulic Turbines**: Classification of hydraulic turbines, Principle of working, velocity triangles - Pelton wheel - Francis turbine- Kaplan turbine, design parameters and numerical problems, Draft tubes	
Teaching-Learning Process	1. Power-point Presentation 2. Video demonstration or Simulations 3. Chalk and Talk.
MODULE 5	**8 HOURS**
Centrifugal and Axial flow Pumps: Main Parts of centrifugal pump, basic terms and definitions, velocity triangles, work done, minimum speed for starting centrifugal pump, Classifications- Performance characteristics of centrifugal pumps, Cavitation in pumps and NPSH, multistage pumps. Axial flow Pumps – characteristics – constructional detail.	
Teaching-Learning Process	1. Power-point Presentation 2. Video demonstration or Simulations 3. Chalk and Talk.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.No.	Experiments
1	Determine the viscosity of oil using Red wood viscometer and Say-bolt viscometer.
2	Measurement of pressure using different Manometers for high and low pressure measurements (manometers using different manometric fluids).
3	Working principle of different flow meters and their calibration (orifice plate, Venturi meter, turbine, Rota meter, electromagnetic flow meter)
4	Working principle of different flow meters for open channel and their calibration
5	Determination of head loss in pipes and pipe fittings having different diameters, different materials and different roughness
6	Effect of change in cross section and application of the Bernoulli equation
7	Impact of jet on flat and curved plates
8	Performance test on Pelton turbine and draw main and operating characteristics.
9	Performance test on Francis turbine and draw main and operating characteristics.
10	Performance test on Kaplan turbine and draw main and operating characteristics.
11	Performance test on single / multi-stage centrifugal pump.
12	Reynolds apparatus to measure critical Reynolds number for pipe flows (Demonstration)
13	Determination of drag and lift co-efficient of standard objects using wind tunnel (Demonstration)

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

CO1: Describe the fundamental concepts and principles of fluid mechanics and machinery. (L1)
CO2: Understand the fluid dynamics relations for different engineering applications. (L2)
CO3: Apply the governing laws of fluid mechanics for different engineering applications. (L3)
CO4: Analyse the various fluid flow processes and turbomachines. (L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

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- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.

Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the

- theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component

Suggested Learning Resources:

Books:

1. Fox, R. W., Pitchard,P. J.,and McDonald, A. T., (2010), Introduction to Fluid Mechanics, 7thEdition, John Wiley & Sons Inc.
2. Cimbala, J.M., Cengel, Y. A. (2010),Fluid Mechanics: Fundamentals and Applications, McGraw-Hill
3. Frank M White., (2016), Fluid Mechanics, 8thEdition , McGraw-Hill
4. V. Kadambi and Manohar Prasad (2008), An Introduction to Energy Conversion, Volume III, Turbo machinery, New Age International Publishers, reprint

Additional References:

A text book of Fluid Mechanics and Hydraulic Machines, Dr. R K Bansal, Laxmi publishers

Fundamentals of Fluid Mechanics, Munson, Young, Okiishi & Hebsch, John Wiley Publicationss, 7th Edition

Web links and Video Lectures (e-Resources):

1. Fluid Mechanics, IIT Kanpur,Prof. Gautam Biswas, Prof. Suman Chakraborty, https://nptel.ac.in/courses/112104118
2. Fluid Mechanics, IIT Guwahati, Dr. Subhashisa Dutta, https://nptel.ac.in/courses/105103192
3. Fluid Machines, IIT Kharagpur, Prof. Suman Chakraborty, https://nptel.ac.in/courses/112105206
4. Fluid Machines, IIT Kharagpur, Prof. Sankar Kumar Som, https://onlinecourses.nptel.ac.in/noc19_me55

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning:

1. Visit to thermal hydel power plant and make a report
2. Make presentations on latest research work in the field of fluid mechanics and machines
3. Visit to ports and make a study report on hydraulic systems used on board ships

Mechanical Measurements & Metrology laboratory		Semester	4
Course Code	**BMR404**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	3
Examination nature (SEE)	Theory/Practical/Viva-Voce /Term-work/Others		

Course objectives:

- To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
- To illustrate the use of various measuring tools & measuring techniques.
- To understand calibration techniques of various measuring devices.

Sl.NO	Experiments
1	Study of instruments for Linear measurement and angular measurements: Slip gauges- Measurement of angle sine bar, Sine center, Angle gauges, Optical instruments for angular measurements.
2	Study of Autocollimator-Applications for measuring straightness and squareness.
3	Study of different Comparators and calibration of Dial indicator, Electrical comparators, LVDT, Pneumatic comparators
4	Study of Terminology of screw threads and Measurement of major diameter, Minor diameter, Pitch, Angle and Effective diameter of screw threads by 2- wire and 3-wire methods
5	Gear tooth measurement using Gear tooth Vernier and Parkinson Gear Tester
6	Various parameter measurement using computerized profile projector
7	Surface topology measurement using Surface Roughness Tester
8	Calibration of Pressure gauge, Thermocouple and Load cell
	Demonstration Experiments (For CIE)
9	Circularity measurement using Electronic and Mechanical comparator
10	Determination of modulus of elasticity and modulus of rigidity of a mild steel specimen using strain gauges
11	Demonstration of Measurement using Coordinate Measuring Machine (CMM) / Laser Scanner
12	Calibration of Micrometer and Vernier caliper using slip gauges

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- CO1: Define the Basic principles that govern the working of the measuring instruments[L1]
- CO2: Demonstrate proficiency in applying principles of Mechanical Measurements & Metrology in laboratory settings[L2]
- CO3: Utilize experimental techniques to demonstrate advanced proficiency in applying theoretical concepts to practical scenarios. [L3]
- CO4: Analyse and examine measurement precision and accuracy in the Mechanical Measurements & Metrology laboratory, drawing meaningful conclusions about their reliability.[L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners*, one internal examiner from the of the same institute and an external examiner from the other institute*, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- Engineering Metrology and Measurements, N.V.Raghavendra and L. Krishnamurthy, Oxford University Press
- Mechanical Measurements, Beckwith, Marangoni, Lienhard, Pearson Education. ISBN-13:978-9332518520
- Mechanical Measurements and Instrumentation, R K Rajput, S.K. Kataria & Sons publication, ISBN-13: 978- 9350142851
- Engineering Metrology by R K Jain, Khanna Publication, ISBN-13: 978-8174091536

Marine Environmental Protection		Semester	3
Course Code	**BMR405A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- To give the students a knowledge of Understand how IMO works and its function in international
- shipping
- Understand the regulatory process and the statutory regulations.
- How the working of the regulatory process and the statutory regulations of the bunkering process.
- To make the student aware of working knowledge of BWT, MARPOL and STCW regulations.
- To gain an understanding of emission surveying and its regulations.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

MARINE ENVIRONMENT

Marine environmental awareness. Marine ecology, seas and coastal areas. Ship's discharges to the sea and their environmental impact.

Module-2

BUNKERING

Precautions during bunkering, loading discharging oil cargo, tank cleaning, pumping out bilges, and knowledge of construction and operation of oil pollution prevention equipment in Engine room, and on various types of ships.

Module-3

BALLAST WATER MANAGEMENT

MARPOL 73/78-All Annexes, equipment requirements and their documentation, including necessary Record Books. Ballast Water Management Convention 2004. Anti-Fouling Convention 2001. Oil Pollution Act 1990.

Knowledge of Codes of Safety Working practices as published – Knowledge of type of information issued by D.G. Shipping with regard to safety at sea & safe working practices.

Module-4

MARPOL Annexes:

Responsibilities under the relevant requirements of the international Convention for the prevention of Pollution from Ships – Annex I, Annex II, Annex III, Annex IV, Annex V, Annex VI. Anti-Fouling Convention 2001. Oil Pollution Act 1990.

Module-5

EMISSIONS MEASURES

Environmental impact of accidental and operational discharges. Emissions to air from ships. Other pollutants. Proactive measures to control pollution and maintain the environment. Emergency situations-action to be taken to protect and safeguard the environment.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

CO1: Identify and define various types of convention, MARPOL Annexes , ballast water management (L1)

CO2:Classify the marine environmental pollution & its impact (L2)

CO3: Explain the operation of pollution prevention equipments and MARPOL requirements & documentation (L2)

CO4: Identify the OPA 90 & antifouling convention and apply environmental impact of accidental & operational discharges scenarios. (L3)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

1. Vikram Gokhale, N.Nanda,"Ship's Safety And Environmental Protection", N.G Series, 4th edition, 2011.
2. Nanda and Gokhale, "Basic Marine Engineering Knowledge" N.G Series, 4th edition, 2011
3. MARPOL Consolidated Edition 2011: Articles, Protocols, Annexes, Unified Interpretations of the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the 1978 and 1997 Protocols. United Kingdom, IMO, 2011.

Reference Books:

1. SOLAS Consolidated Edition 2020, International Maritime Organization; 7th ed.,2020,ISBN-13 : 978-9280116908
2. MARPOL Consolidated Edi□on 2018 (Vol A & B), Bhandarkar Publications; 2016th edi□on, 2018,ASIN :B071DFXF3H

Web links and Video Lectures (e-Resources):

- https://www.imo.org/en/OurWork/Environment/Pages/Default.aspx
- https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MEPC-default.aspx
- https://indiancoastguard.gov.in/content/246_3_MarineEnvironmentProtection.aspx

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Write a report on the efforts in India for environmentally sustainable growth.
- Do a case study on ports and its effect on the coastal environment.
- Do a poster presentation on IMO's efforts on sustainability.

Mechatronics		Semester	3
Course Code	**BMR405B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Selecting sensors to develop mechatronics systems.
- Explaining the architecture and timing diagram of microprocessor, and also interpret and
- develop programs.
- Designing appropriate interfacing circuits to connect I/O devices with microprocessor.
- Applying PLC as a controller in mechatronics system.
- Designing and develop the apt mechatronics system for an application.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

INTRODUCTION AND SENSORS

Introduction to Mechatronics – Systems – Need for Mechatronics – Emerging areas of Mechatronics – Classification of Mechatronics. Sensors and Transducers: Static and Dynamic Characteristics of Sensor, Potentiometers – LVDT – Capacitance Sensors – Strain Gauges Eddy Current Sensor – Hall Effect Sensor –Temperature Sensors – Light Sensors.

Module-2

8085 MICROPROCESSOR

Introduction – Pin Configuration - Architecture of 8085 – Addressing Modes – Instruction set, Timing diagram of 8085.

Module-3

PROGRAMMABLE PERIPHERAL INTERFACE

Introduction – Architecture of 8255, Keyboard Interfacing, LED display – Interfacing, ADC and DAC Interface, Temperature Control – Stepper Motor Control – Traffic Control Interface.

Module-4

PROGRAMMABLE LOGIC CONTROLLER

Introduction – Architecture – Input / Output Processing – Programming with Timers, Counters and Internal relays – Data Handling – Selection of PLC.

Module-5

ACTUATORS AND MECHATRONICS SYSTEM DESIGN :

Types of Stepper and Servo motors – Construction – Working Principle – Characteristics, Stages of Mechatronics Design Process – Comparison of Traditional and Mechatronics Design Concepts with Examples – Case studies of Mechatronics Systems – Pick and Place Robot – Engine Management system – Automatic Car Park Barrier.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

At the end of the course, the student will be able to :

CO1: Define the underlying principles in sensors to develop mechatronics systems.[L1]

CO2: Understand the architecture and timing diagram of microprocessor, and also interpret and develop programs.[L2]

CO3: Apply the knowledge of mechatronics to design appropriate interfacing circuits to connect I/O devices with microprocessor.[L3]

CO 4: Analyze the role of PLC as a controller within a mechatronics system, drawing conclusions about its impact on system functionality and performance.[L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

TEXTBOOKS:

1. **Bolton W., "Mechatronics", Pearson Education, 6th Edition, 2015.**
2. **Ramesh S Gaonkar, "Microprocessor Architecture, Programming, and Applications with the 8085", Penram International Publishing Private Limited, 6th Edition, 2013.**

REFERENCES:

1. **Bradley D.A., Dawson D., Buru N.C. and Loader A.J., "Mechatronics", Chapman and Hall, 1993.**
2. **Davis G. Alciatore and Michael B. Histand, "Introduction to Mechatronics and Measurement systems", McGraw Hill Education, 2011.**
3. **Devadas Shetty and Richard A. Kolk, "Mechatronics Systems Design", Cengage Learning, 2010.**
4. **Nitaigour Premchand Mahalik, "Mechatronics Principles, Concepts and Applications", McGraw Hill Education, 2015.**
5. **Smaili. A and Mrad. F, "Mechatronics Integrated Technologies for Intelligent Machines", Oxford University Press, 2007.**

Web links and Video Lectures (e-Resources):

- Smart materials intelligent system design NPTEL course

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Prepare a smart material sample
- Visit to industry

Smart Materials & Systems		Semester	3
Course Code	**BMR405C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- **To make the students understand about smart materials**
- **To make students to know about making of material smart**
- **To enable the students to appreciate the material properties**.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

Smart materials and structures:

System intelligence- components and classification of smart structures, common smart materials and associated stimulus-response, Application areas of smart systems

Module-2

Electrically Activated Materials:

Piezoelectricity, Piezoresistivity, Ferroelectricity, Piezoelectric materials- piezoelectric effect, Piezoceramics, Piezopolymers, Piezoelectric materials as sensors, Actuators and bimorphs, nanocarbon tubes.

Module-3

Thermally activated materials:

Shape memory materials; Shape memory alloys (SMAs), Classification - Transformation - Ni-Ti Alloys, Shape memory effect, Martensitic transformation, One way and two-way SME, binary and ternary alloy systems, Functional properties of SMAs, Shape memory ceramics - Shape memory polymers – Applications

Module-4

Smart polymers:

Thermally responsive polymers, Electroactive polymers microgels, Synthesis, Properties and Applications, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Drug delivery using smart polymers

Module-5

Chemically Activated Materials:

Chemical Gels - Self healing materials Optically Activated Materials - Optically activated polymers - Azobenzene - Liquid Crystal, Smart materials for space applications: Elastic memory composites, Smart corrosion protection coatings, Sensors, Actuators, Transducers

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

CO1: Define Smart Materials & Systems and demonstrate an understanding of their applications and properties in various engineering fields.[L1]

CO2: Classify, and compare the applications of Smart materials and structures, including Electrically Activated Materials, Thermally Activated Materials, Smart Polymers, and Chemically Activated Materials. (L2)

CO4: Apply a structured approach to evaluate materials by considering their unique properties. (L3)

CO3: Analyze materials to determine their suitability for specific applications. (L4)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), should have a mix of topics under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley 2007.
2. M. Addington, D.L. Schodek, Smart Materials and New Technologies in Architecture, Elsevier 2005.
3. Donald R. Askeland and Pradeep P. Fulay, Essentials of Materials Science and Engineering, 2009, Cengage Learning.

References

1. Gandi, M.V. and Thompson, B.S., "Smart Materials and Structures," Chapman & Hall, UK, 1992,
2. Culshaw, B., "Smart Structures and Materials," Artech House, Inc., Norwood, USA, 1996.
3. Dimitris C. Lagoudas, Shape Memory Alloys: Modelling and Engineering Applications, Springer, 2008.
4. T. Yoneyama & S. Mayazaki, Shape memory alloys for biomedical applications, CRCPress, 200
solidated Edi□on 2018 (Vol A & B), Bhandarkar Publications; 2016th edi□on, 2018,ASIN : B071DFXF3H

Web links and Video Lectures (e-Resources):

- Smart materials intelligent system design NPTEL course

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Prepare a smart material sample
- Visit to industry

Hydraulics and Pneumatics		Semester	4
Course Code	**BMR405D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- To knowledge on fluid power principles and working of hydraulic pumps
- To obtain the knowledge in hydraulic actuators and control components
- To understand the basics in hydraulic circuits and systems
- To obtain the knowledge in pneumatic and electro pneumatic systems
- To apply the concepts to solve the troubleshooting

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk
3. Adopt flipped classroom teaching methods.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analysing information.

Module-1

FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal's Law – Principles of flow - Friction loss – Work, Power and Torque Problems, Sources of Hydraulic power : Pumping Theory – Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary – Fixed and Variable displacement pumps

Module-2

HYDRAULIC ACTUATORS AND CONTROL COMPONENTS

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning –Hydraulic motors - Control Components : Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Servo and Proportional valves – Applications –Accessories : Reservoirs, Pressure Switches – Applications – Fluid Power ANSI Symbols

Module-3

HYDRAULIC CIRCUITS AND SYSTEMS

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Electro hydraulic circuits, Mechanical hydraulic servo systems.

Module-4

PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS :

Properties of air – Perfect Gas Laws – Compressor – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – Cascade method – Electro Pneumatic System – Elements – Ladder diagram – Problems,

Introduction to fluidics and pneumatic logic circuits

Module-5

TROUBLESHOOTING AND APPLICATIONS :

Installation, Selection, Maintenance, TroubleShooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

CO1: Define the fundamental principles of fluid power, encompassing hydraulic and pneumatic systems, including their advantages, applications, and key components.[L1]

CO2: Classify and analyze fluids, hydraulic pumps, actuators, control components, circuits, and pneumatic systems[L2]

CO3: Apply fluid power principles to design, analyze, and troubleshoot hydraulic and pneumatic systems for diverse industrial applications.[L3]

CO4: Analyze fluid power principles, components, and applications in hydraulic and pneumatic systems for diverse industrial use.[L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.
2. James A. Sullivan, "Fluid Power Theory and Applications", Fourth Edition, Prentice Hall, 1997.

REFERENCES

1. Shanmugasundaram.K, "Hydraulic and Pneumatic Controls". Chand & Co, 2006.
2. Majumdar, S.R., "Oil Hydraulics Systems – Principles and Maintenance", Tata McG Raw Hill, 2001.
3. Majumdar, S.R., "Pneumatic Systems – Principles and Maintenance", Tata McGRaw Hill, 2007.
4. Dudley, A. Pease and John J Pippenger, "Basic Fluid Power", Prentice Hall, 1987
5. Srinivasan. R, "Hydraulic and Pneumatic Controls", Vijay Nicole Imprints, 2008
6. Joshi.P, Pneumatic Control", Wiley India, 2008.
7. Jagadeesha T, "Pneumatics Concepts, Design and Applications ", Universities Press, 2015.

Web links and Video Lectures (e-Resources):

- .https://archive.nptel.ac.in/courses/112/106/112106300/
- https://archive.nptel.ac.in/courses/112/105/112105047/
- https://m.youtube.com/playlist?list=PLIMdd_mE4yZGWJ32cgnK2-bs44Gpj81xi

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Hands on Lab sessions in the Hydraulics and Pneumatics lab.

Advanced Programming in Python		Semester	4
Course Code	BMR456A	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0-0-2-0	SEE Marks	50
Total Hours of Pedagogy	15 sessions	Total Marks	100
Credits	01	Exam Hours	03
Examination nature (SEE)	Theory/**Practical**/Viva-Voce /Term-work/Others		

Course objectives:

- .To understand the problem solving approaches.
- To learn the basic programming constructs in Python.
- To practice various computing strategies for Python-based solutions to real world problems.
- To use Python data structures – lists, tuples, dictionaries.
- To do input/output with files in Python.

Sl.NO	Experiments
1	Demonstrate following functions/methods which operates on strings in Python with suitable examples: i) len( ) ii) strip( ) iii) rstrip( ) iv) lstrip( ) v) find( ) vi) rfind( ) vii) index( ) viii) rindex(),ix) count( ) x) replace( ) xi) split( ) xii) join( ) xiii) upper( ) xiv) lower( ) xv) swapcase( ) xvi) title( ) xvii) capitalize( ) xviii) startswith() xix) endswith()
2	Implementing programs using Functions. (Factorial, largest number in a list, area of shape).
3	NESTED LISTS: Write a program to read a 3 X 3 matrix and find the transpose, addition, subtraction, multiplication of two 3 X 3 matrices, check whether two given 3 X 3 matrices are identical or not.
4	Implementing programs using Strings. (Reverse, palindrome, character count, replacing characters). Real time applications using sets and Dictionaries
5	Scientific problems using Conditionals and Iterative loops. (Number series and different Patterns).
6	Numpy Library: Linear Algebra a) Write a python program to find rank, determinant, and trace of an array. b) Write a python program to find eigen values of matrices d) Write a python program to solve a linear matrix equation, or system of linear scalar equations.
7	Graphics: • Consider a turtle object. Write functions to draw triangle, rectangle, polygon, circle and sphere. Use object oriented approach. • Design a Python program using the Turtle graphics library to construct a turtle bar chart representing the grades obtained by N students read from a file categorizing them into distinction, first class, second class, third class and failed.
8	Create colour images using NumPy in Python.
	Demonstration Experiments (For CIE)
9	Write a python program to implement Pandas Series with labels.
10	Implementing real-time/technical applications using File handling. (copy from one file to another, word count, longest word).
11	Implementing real-time/technical applications using Exception handling. (divide by zero error, voter's age validity, student mark range validation).
12	Developing a game activity using Pygame like bouncing ball, car race etc.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- CO1: Define basic Python syntax, data structures, and functions for program development.[L1]
- CO2:Explain the principles of object-oriented programming (OOP) in Python and demonstrate their application in designing efficient and modular code. [L2]
- CO3: Apply advanced Python concepts like decorators, generators, and comprehensions in solving complex programming challenges. [L3]
- CO4: Analyze and optimize Python code for performance, identify potential bottlenecks, and implement appropriate solutions for efficient execution. [L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- G Venkatesh and Madhavan Mukund, "Computational Thinking: A Primer for Programmers and Data Scientists", 1st Edition, Notion Press, 2021.
- John V Guttag, "Introduction to Computation and Programming Using Python: With Applications to Computational Modeling and Understanding Data", Third Edition, MIT Press, 2021
- Paul Deitel and Harvey Deitel, "Python for Programmers", Pearson Education, 1st Edition, 2021.
- Eric Matthes, "Python Crash Course, A Hands – on Project Based Introduction to Programming", 2nd Edition, No Starch Press, 2019.
- Martin C. Brown, "Python: The Complete Reference", 4th Edition, Mc-Graw Hill, 2018.

PLC and SCADA		Semester	4
Course Code	**BMR456B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	1:0:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- To explain the history of Industrial automation.
- To describe the hardware components and field instruments.
- To describe PLC's and its architecture.
- To explain types of PLC models.
- To explain the ladder programming fundamentals

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it

Module-1

Introduction about industrial automation : Introduction about industrial automation, History of industrial automation, Need of automations in industries, Example for industrial automation, Automation control circuit and power circuit, Control system in Industry

Module-2

Field Instruments : Types and working of field devices, Automation using relays and field devices, Examples for relays and field devices ,Logical functions done by relays and field devices.

Module-3

Introduction about Programmable Logic Controller: History of PLC , Architecture of PLC, CPU IO Modules ,Power Supply and Communications, Input and Output Devices, Need of PLC for Industrial Automation.

Module-4

Types of PLC Models: Introduction about PLC Programming, Types of Programming Languages, Introduction about PLC Programming software.

Module-5

Ladder programming fundamentals: Ladder logic diagram , Structure of program, Procedure for creating ladder diagram, Logical function done by ladder program in software.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

1. CO1: Discuss history of PLC and describe the hardware components of PLC: I/O modules, CPU, memory devices, other support devices, operating modes and PLC programming.
2. CO2: Describe industrial automation, field devices, working of PLC's, Structure of a PLC program.
3. CO3: Analyze the need for automation, logical functions used in relays, types of programming languages, structure of the ladder program

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Textbook

1. Programmable Logic Controllers, Frank D Petruzella, McGraw Hill, 4th Edition, 2011.

Reference Books

1. Programmable Logic Controllers an Engineer's Guide, E A Parr, Newnes, 3rd Edition, 2013.

2. Introduction Programmable Logic Controllers, Gary Dunning, Cengage, 3rd Edition, 2006.

Web links and Video Lectures (e-Resources):

- .https://www.tiga.us/blog/what-is-the-difference-between-plc-and-scada
- https://nptel.ac.in/courses/108105088
- https://nptel.ac.in/courses/108106022

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Take a MOOC's course on industrial automation.
- Write very basic ladder programs on https://app.plcsimulator.online/

Maritime law		Semester	4
Course Code	**BMR456C**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	1:0:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01
Examination nature (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Understand admiralty law
- Learn about the history of admiralty law
- Understand Maritime Jurisdiction.
- Understand about ships as property

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.

Module-1

Admiralty Law:

Nature of Admiralty Law,–Common law of sea – Sources of maritime law and admiralty law.

Module-2

History of Admiralty Law:

History of admiralty law in England, other parts of the world and in India – History of admiralty jurisdiction of High Courts of India, immunity of Government ships.

Module-3

Admiralty and maritime jurisdiction:

Enforcement of maritime claims by actions in rem and in personam – juridical personality of the ship, Extra territorial jurisdiction – Changing concept of maritime frontiers. International waters; International fisheries -Sea as a common heritage of mankind

Module-4

The ship as property:

Ownership – registration – flag of convenience – ship construction rules – acquisition of ships – transfer of ships.

Module-5

Maritime Jurisdiction in India:

Jurisdiction in maritime ports; Access to maritime ports; Indian law – The maritime zones Act 1976; civil and criminal jurisdiction over ships; Ship owners liabilities for damage to ports – Limitation of ship owners liability.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

CO 1. Define fundamental maritime legal concepts and terminology. [L1]

CO 2. Describe the key principles and regulations governing maritime commerce and navigation. [L2]

CO 3. Apply maritime laws to resolve basic legal scenarios in shipping and maritime activities.[L3]

CO 4. Analyze complex maritime legal cases, considering international conventions, treaties, and precedent-setting judgments.[L4]

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

- SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question paper is MCQ (multiple choice questions).
- The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. Aleka Mandaraka – Sheppard – Modern Maritime Law (Second Edition)(2009)
2. D.C. Jackson, Enforcement of Maritime Claims, London: LLP (2005)
3. Southampton on Shipping Law, Informa (2008)
4. Halsbury's Laws of England, 4th Edn, London (1983)
5. Marsden, Collisions at Sea, London (1961)

Reference Books:

1. Chorly and Giles, Shipping Law, 6th Edn. London
2. Kochu Thommen, International Legislation on Shipping, U.N. New York

Web links and Video Lectures (e-Resources):

- https://en.wikipedia.org/wiki/Admiralty_law
- https://www.youtube.com/watch?v=0KDtbMhQfBI
- https://www.youtube.com/watch?v=Ont8bA-Yjk4
- https://lexforti.com/legal-news/maritime-laws-in-india/

- .

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Case study on the Suez Canal crisis and its litigation.
- Presentation of key maritime legislations in India

Fundamentals of Virtual Reality		Semester	4
Course Code	**BMR456D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	1:0:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01
Examination nature (SEE)	**Theory**/practical/Viva-Voce /Term-work/Others		

Course objectives:

- Describe how VR systems work and list the applications of VR.
- Understand the design and implementation of the hardware that enables VR systems to be built.
- Understand the system of human vision and its implication on perception and rendering.
- Explain the concepts of motion and tracking in VR systems.
- Describe the importance of interaction and audio in VR systems.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment of the various course outcomes.

1. Adopt different types of teaching methods to develop the outcomes through PowerPoint presentations and Video demonstrations or Simulations.
2. Chalk and Talk method for Problem Solving.
3. Adopt flipped classroom teaching method.
4. Adopt collaborative (Group Learning) learning in the class.
5. Adopt Problem Based Learning (PBL), which fosters students' analytical skills and develops thinking skills such as evaluating, generalizing, and analyzing information.

Module-1

Introduction to Virtual Reality : Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality.

Module-2

Representing the Virtual World : Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR

Module-3

The Geometry of Virtual Worlds &The Physiology of Human Vision: Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.

Module-4

Visual Perception & Rendering: Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information Visual Rendering -Ray Tracing and Shading Models, Rasterization, Correcting Optical Distortions, Improving Latency and Frame Rates

Module-5

Motion & Tracking: Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection

Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

- CO1: Define the basic concepts and terminology related to Virtual Reality (VR) technology and its applications. [L1]
- CO2: Illustrate the fundamental techniques and tools used in creating immersive virtual environments.[L2]
- CO3: Apply the foundational principles of human perception and interaction within virtual environments, and gauge their influence on user experience.
- CO4: Analyze and evaluate the design considerations and challenges in developing effective and engaging Virtual Reality experiences for specific use cases.[L4]

Assessment Details (both CIE and SEE)

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maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Examination (CIE)

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- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

- SEE paper shall be set for 50 questions, each of 01 mark. The pattern of the question paper is MCQ (multiple choice questions).
- The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

Suggested Learning Resources:

Books

1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
2. Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002.
3. Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig, William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.

Reference Books:

4. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.
5. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005.
6. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Meging Real and Virtual Worlds", 2005.
7. Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Interscience, India, 2003.

Web links and Video Lectures (e-Resources):

- http://lavalle.pl/vr/book.html
- https://nptel.ac.in/courses/106/106/106106138/
- https://www.coursera.org/learn/introduction-virtual-reality.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Have students research a specific topic in VR, such as the history of VR, the different types of VR headsets, or the latest advances in VR technology.
- Give students a design challenge, such as designing a VR experience for a specific purpose, such as training surgeons, teaching students about history, or helping people with phobias.