Chhattisgarh Swami Vivekanand Technical University, Bhilai

Diploma in Mechanical Engineering **Semester-VI**

A) Course Code : 2037671(037)

B) Course Title : Industrial Engineering and Production Management

C) Pre-requisite Course Code and Title :

D) Rationale :

Prosperity of nation in general depends on the productivity of industries and quality of production. Technical managers, Engineers, plant operators, machine operators, supervisors and workers working in industries have to compulsorily meet set standards of production in terms of quality, quantity and productivity so as to compete domestic and international market. This is possible for them only when they employ and exploit the principles of industrial engineering. Industrial engineering always aims to achieve higher productivity and better standards of quality through its constant endeavor in design, improvements and installation of integrated systems of human resource, machines and methods. The knowledge of industrial management is required of all diploma holders who wish to choose industry/field as this career. This course is designed to develop understanding of various functions of management, role of workers and Engineers and providing knowledge about safety and labor, industrial laws and management in different areas.

E) Course Outcomes:

CO-1 Use relevant work study procedure to increase the productivity.

CO-2 Use relevant method and time study techniques in industry.

CO-3 Analyze the behavior of industrial systems.

CO-4 Select relevant material handling system and plant layout for industry.

CO-5 Use relevant charts for production planning and control in industry.

CO-6 Apply material management and project planning techniques

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037671(037)	Industrial Engineering and Production Management	2	-	1	3

Legend:L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work (SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037671(037)	Industrial Engineering and Production Management	70	20	30	-	-	120

Note : i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.

ii. Separate passing is must for End Semester Exam (Theory) and End Semester Exam (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Use relevant work study procedure to increase the productivity.

(Approx. Hrs: L+P+T=07)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Identify different types of industries from the given situation. SO1.2 Select production systems for a given situation with justification. SO1.3 Identify the factors affecting the given production system with justification SO1.4 Identify the objectives of work study for a given situation. SO1.5 Describe the procedure of given work study method		**Unit 1.0 Productivity and Work Study** 1.1 Introduction to Industry and Industrial Engineering. 1.2 Scope and role of industrial engineering, fields of application. 1.3 Production and productivity, Production systems and their impact on productivity, significance and benefits of higher productivity. 1.4 Long term and short term factors affecting productivity, Productivity cycle. 1.5 Objectives and application of work study, Basic procedure and techniques of work study, Human factors in work study.	• Role of manager, supervisor and workers. • Working conditions, environment of industry affecting work-study.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Identify the different industries nearby your city on basis small, medium and large scale with justification.
ii. Identify industries nearby your area on basis of high and low production capacity with justification.

b. Mini Project:

i. Collect the production capacity data of various industries (any 05) in your industrial area and prepare a report on the basis of given criteria.
ii. Collect information and analyze the about work study methods used in industry (any 05) and prepare a report.

c. Other Activities (Specify):

i. Visit to nearby industry to identify and compare different work study methods employed to increase productivity and suggest improvements.

CO-2 Use relevant method and time study techniques in industry.

(Approx. Hrs: L+P+T=07)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Select recording techniques of method study for the given situation. SO2.2 Explain different Operation process charts and flow process charts. SO2.3 Prepare Operation process chart, flow process chart, man-machine chart, Flow diagrams, String Diagrams, two hand process charts as per the given situation. SO2.4 Prepare Therbligs, cycle graph and chronocycle graph for the given problem SO2.5 Select work measurement technique for a given situation with justification. SO2.6 Calculate normal and standard time for a given work study problem.		**Unit 2.0 Method Study and Time Study** 2.1 Definition, objectives of method study 2.2 Basic procedures and Recording techniques of method study 2.3 Operation process chart, flow process chart, man-machine chart, Flow diagrams, String Diagrams, two hand process charts 2.4 Motion economy principles, Therbligs, cycle graph and chronocycle graph. Work Measurement. 2.5 Time Study: selection and timing the job, rating, allowances, Numerical on Normal and standard time calculation.	• Questioning techniques procedure to develop, install and maintain new methods. • Factors considered in selecting a job for time study • Job element and their need of identification

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Give examples of different types of recording techniques in method study.
ii. Draw flow process chart of a given industry.

Iii Identify the types of allowances given for any industrial work with reference to time study method.

b. Mini Project:

i. Prepare operation process chart of a industry (05) nearby your area and prepare a report on the basis of given criteria.

ii. Prepare a man machine chart for a given job and enumerate various man and machine activities involved.

c. Other Activities (Specify):

i. Seminar on method study and time study methods used in industry.

CO-3 Analyze the behavior of industrial systems.

(Approx. Hrs: L+P+T=07)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Describe Reliability and Maintainability and availability. SO3.2 Compare MTBF and MTTR. SO3.3 Compare Preventive maintenance and total productive maintenance. SO3.4 Calculate reliability, availability and maintainability in industry. SO3.5 Predict the behavior of industrial system. SO3.6 conduct RAM analysis of the system		**Unit 3.0 Reliability and Maintainability** 3.1 Need for Maintainability Maintenance and Reliability 3.2 Reliability, availability and maintainability terms and definitions 3.3 Reliability : The reliability function, mean time to failure, Hazard rate function, bath tub curve, conditional reliability 3.4 Reliability Model: constant failure rate model, Time dependent failures model, Weibull Distribution, normal distribution 3.5 Reliability system: Serial configuration, parallel configuration, Combined series –parallel configuration system. 3.6 Reliability Evaluation Tools: Failure Modes and Effect Analysis (FMEA), Network Reduction 3.7 Maintainability Analysis of downtime The Repair time distribution, Maintainability Function for Exponential Distribution, Ra yleigh Distribution, Weibull Distribution. 3.8 Maintainability Design Considerations, Fault Tree Analysis, Cause and Effect Diagram, Failure Modes Effect and Critically Analysis (FMECA)	• sampling, inspection • Effect of product reliability marketing

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		3.9 Preventive maintenance and replacement, total productive maintenance, Corrective Maintenance – concept and applications, examples	

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Describe the importance of reliability, availability and maintainability in manufacturing industries.
ii. Explain bath tub curve.
iii. Explain different reliability models.

b. Mini Project:

i. Perform comparative study of MTBF and MTTR applicable in maintenance industry.
ii. Prepare detail report on the preventive maintenance and productive maintenance employed in the nearby industry (03 no).

c. Other Activities (Specify):

i. Seminar on applications of Reliability, availability and maintainability in industry.
ii. Seminar on preventive reliability systems serial, parallel and combination series –parallel combination.
iii. Seminar on reliability evaluation tools.

CO-4 Select relevant material handling system and plant layout for industry.

(Approx. Hrs: L+P+T=07)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Select the relevant material handling system for particular application. SO4.2 Select the relevant plant layout for particular industrial application with justification.		**Unit 4.0. Material Handling and Plant Layout** 4.1 Importance and its effect on productivity, Requirements of good material handling system, Classification and selection of material handling equipment. 4.2 Principles of economic material handling Hoisting equipment - forklift truck, Cranes- mobile motor cranes, overhead cranes, travelling bridges crane. Derrick crane. Whirler crane Conveying equipment - Package conveyors, gravity roller conveyors, screw conveyors, flight or scraper conveyors, bucket conveyors, bucket elevators, belt conveyors, and pneumatic conveyors.	• Principle of maximum flexibility. • Principle of minimum handling • Self service and modified self service layout. • software for designing layouts

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		4.3 Requirements of good layout, effect of bad layout, Factors affecting plant layout, Types of layout, Advantages and limitations of each type of layout, Selection of layout, factors affecting the plant location.	

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. Prepare list of different material handling equipments in industry.
ii. Select and draw the best plant layout for rolling mill industry.

b. Mini Project:

i. Prepare a plant layout model for mini steel plant.
ii. Collect information about latest material handling equipments in your local industry.

c. Other Activities (Specify):

i. Seminar on Principles of economic material handling Hoisting equipment.

CO-5 Use relevant charts for production planning and control in industry.

(Approx. Hrs: L+P+T=10)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Describe production system, PPC. SO5.2 Describe the function of PPC in a given organization. SO5.3 Differentiate between loading and Scheduling on the basis of given criteria. SO5.4 Describe job, batch and Mass production. SO5.5 Describe quality and total quality. SO5.6 Interpret various control charts in statistical quality controls. SO5.7 Explain basic tools of S.Q.C. SO5.8 Explain construction of X and R chart.		**Unit 5.0 Production Planning and Control** 5.1 Production system, concept of planning, meaning of PPC, Classification and characteristics of each type, Function of and place of PPC in a organization, Production and consumption rate 5.2 Job, Batch and Mass production, Batch size, Buffer stock, Production cost components, Concept of production scheduling. Difference between Loading and Scheduling, 5.3 Gantt chart scheduling, advantages and preparation of GANTT chart. **Statistical Quality Control**	• Introduction to MRP and ERP, LOB (Line of Balance), JIT inventory, and Japanese concepts. • Crashing of network, updating and its applications • Karl Pearson's coefficient of correlation

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		charts 5.4 Definition of quality and total quality, Three stages of quality, quality control and SQC, 5.5 Difference between inspection and Quality control, Concept of variability natural variation, its importance to quality control, classification of quality characteristics, 5.6 Basic tools of S.Q.C. and their applications, Frequency distribution, measures of central tendency and dispersion, their need and calculations 5.7 Normal curve: Definition, characteristics, calculation of area under normal curve and its applications. 5.8 Statistical basic for control charts for variables, Construction of X and R charts- their interpretation, Use of X and R chart in establishment of process capability, Limitation of X and R charts, 5.9 Meaning, use and advantages of attributes, Calculation, Construction, interpretation and application of P, C charts, 5.10 Need of calculating the revised values of mean, and control limits and their calculation.	

SW-5 Suggested Sectional Work (SW):

d. Assignments:

i. Describe differences between inspection and quality control.
ii. Prepare list of control charts used for statistical quality control in any specific industry.

e. Mini Project:

i. Prepare p chart and c chart for a given industry specific problem.
ii. Prepare process capability chart for a given case study of industry.

f. Other Activities (Specify):

i. Seminar on of quality and total quality, three stages of quality, quality control and SQC

CO-6 Apply material management and project planning techniques.

(Approx. Hrs: L+P+T=10)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO6.1 Explain function of Material Management and purchase system. SO6.2 Explains different techniques of Inventory control. SO6.3 Select inventory control techniques for the given situation with justification SO6.4 Calculates Economic order quantity and safety stock. SO6.5 Describe rules for drawing network diagram. SO6.6 Identify Different techniques of PERT and CPM. SO6.7 Describe procedure of Network analysis.		**Unit 6.0 Material management and project planning** 6.1 Nature, Purpose and objectives of basic functions of management, Authority and Responsibility, social responsibility of manager, ethics and management. 6.2 Function of Material Management purchase system, Inventory, need and advantages of Inventory control, Different techniques of Inventory control -A.B.C. analysis, FIFO,LIFO, Just In Time, Perpetual Inventory Management. 6.3 Correlation, stock turn over, order quantity, Lead time purchase cycle, 6.4 Economic order Quantity, simple numerical problems, Safety stock 6.5 Stores Management- Definition and importance, Storing Procedure and store records. **Project Planning** 6.6 Network –meaning and objectives, Network	• Centralization and decentralization in industrial management. • Supply chain management. • Variance in network analysis. • Errors in drawing network diagram. • Bottlenecking- meaning, effect and ways to reduce

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		formation, representation of activities and event on network, rules for drawing network diagram, Fulkerson's rule 6.7 Different techniques- PERT and CPM, Dependency of activities, Dummy activities, 6.8 Different Time estimates- Optimistic, Pessimistic and Most likely Time, ET, LT, EST, LST, LCT, ECT, Floats and Slacks and Network analysis on tabular form, Man power loading and calculation on load smoothing.	

SW-6 Suggested Sectional Work (SW):

a. Assignments:

i. Explain functions of material management.
ii. Explain different techniques of inventory control.
iii. Prepare a network diagram for a given network problem.
iv. Prepare a chart for different time estimates used in network analysis
v. Describe the concept of production scheduling.
vi. Draw CPM and PERT diagrams based on given conditions and data.

b. Mini Project:

i. Prepare case study of store record keeping of any industry.
ii. Prepare a chart showing different techniques for PERT and CPM.
iii. Determine different time estimates in network analysis for a given network problem.
iv. Prepare a detail report on type of production in nearby industry.
v. Calculate floats on CPM and PERT given conditions and data.

c. Other Activities (Specify):

i. Seminar on social responsibility of manager, ethics and management.
ii. Seminar on inventory management.
iii. Seminar on Project Planning using Network Techniques.
iv. Seminar on Gantt chart scheduling method.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Productivity and Work Study	2	3	5	10
II	Method Study and Time Study	2	3	5	10
III	Reliability and Maintainability	2	4	6	12
IV	Material Handling and Plant Layout	2	4	6	12
V	Production Planning and Control	2	4	7	13
VI	Material management and Project planning	2	4	7	13
	Total	**12**	**22**	**36**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*): Not Applicable

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
10. Brainstorming

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher
1.	Industrial Engineering and Production Management.	Telsang Martand	S Chand and company, New Delhi ISBN 10: 8121924626 ISBN 13: 9788121924627
2.	Industrial Engineering and Production Management	Banga and Sharma	Khanna Publishers, New Delhi ISBN: 978-81-933284-6-0
3.	Industrial Engineering and Management	Khanna. O.P.	Dhanpat Rai and sons, New Delhi ISBN 818992835X, 9788189928353
4.	Industrial Engineering and Management	Kumar. B.	Khanna Publishers, New Delhi ISBN 9788174092649

(b) Open source software and website address:

i. www.vssut.ac.in › lecture-notes › url=mechanical-engineering
ii. https://www.omicsonline.org › open-access › productivity-improvement-b
iii. https://www.academia.edu › Productivity_Improvement_by_Work_Study_
iv. https://www.ijsr.net/archive/v6i2/ART20171266.pdf
v. https://nptel.ac.in/courses/112107142/2
vi. https://nptel.ac.in/courses/112107142/2

vii. https://nptel.ac.in/courses/112107142/28
viii. http://fmcet.in/MECH/ME2037_uw.pdf
ix. https://lecturenotes.in/subject/481/plant-layout-material-handling-plmh
x. https://www.scribd.com/document/145194093/Plant-Layout-notes
xi. http://shodhganga.inflibnet.ac.in/bitstream/10603/33368/6/06_chapter%201.pdf
xii. https://lecturenotes.in/subject/803/statistical-quality-control-sqc
xiii. http://www.ddegjust.ac.in/2017/Uploads/11/POM-325.pdf
xiv. http://nraomtr.blogspot.com/2013/01/purchasing-and-materials- management.html
xv. https://nptel.ac.in/courses/112107238/26
xvi. https://easyengineering.net/production-planning-and-control-jayakumar/
xvii. https://nptel.ac.in/courses/112107142/29
xviii. https://www.sciencedirect.com/topics/economics-econometrics-and-finance/project-network-techniques

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

M) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Use relevant work study procedure to increase the productivity.	3	2	-	1	2	1	1	-	1	1	1	-	3
CO-2 Use relevant method and time study techniques in industry.	3	3	-	2	1	1	1	-	1	1	1	-	3
CO-3 Analyze the behavior of industrial systems**.**	3	3	-	1	2	2	1	-	1	2	1	-	3
CO-4 Select relevant material handling system and plant layout for industry.	3	3	-	2	2	2	1	2	1	2	1	-	3
CO-5 Use relevant charts for production planning and control in industry.	3	3	-	2	2	2	1	2	2	2	2	-	3
CO-6 Apply material management and project planning techniques	3	3	-	2	1	2	2	-	1	2	2	-	3

Legend:1 – Low, 2 – Medium, 3 – High

N) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,4,5,6, 7,9,10 PSO-1,3	CO-1 Use relevant work study procedure to increase the productivity.	SO1.1 - SO1.5		Unit 1.0 Productivity and Work Study 1.1 , 1.2 1.3 1.4 ,1.5	As mentioned in relevant page numbers
PO-1,2,4,5,6, 7,9,10 PSO-1,3	CO-2 Use relevant method and time study techniques in industry.	SO2.1 - SO2.6		Unit 2.0 Method Study and Time Study 2.1, 2.2 ,2.3 ,2.4,2.5	
PO-1,2,4,5,6, 7,9,10 PSO-1,3	CO-3 Analyze the behavior of industrial systems.	SO3.1 - SO3.6		Unit 3.0 Reliability and Maintainability 3.1, 3.2, 3.3 , 3.4, 3.5, 3.6,3.7,3.8,3.9	
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-4 Select relevant material handling system and plant layout for industry.	SO4.1 - SO4.2		Unit 4.0 Material Handling and Plant Layout 4.1 4.2 ,4.3	
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-5 Use relevant charts for production planning and control in industry.	SO5.1 - SO5.8		Unit 5.0 Production Planning and Control 5.1, 5.2 ,5.3,5.4,5.5,5.6,5.7,5.8,5.9, 5.10	
PO-1,2,4,5,6, 7,9,10 PSO-1,3	CO-6 Apply material management and project planning techniques	SO6.1 - SO6.7		Unit 6.0 Material management and Project planning 6.1,6.2,6.3,6.4,6.5,6.6,6.7,6.8	

A) Course Code : 2037672(037)
B) Course Title : Power Plant Engineering
C) Pre-requisite Course Code and Title :
D) Rationale :

The world is driven by electricity and the resource available is limited hence the output and efficiency of the system has to be optimized to fully utilize the resources. A mechanical engineer has to frequently deal with the devices like turbines, compressor, condenser and other power generation units whose knowledge will help the students to understand their working performance under different situations. This Syllabus is designed to give the knowledge about steam, diesel, gas, hydro and nuclear power plant and their controls and economics.

E) Course Outcomes:

CO-1 Use the concept of thermodynamics in different cycle for power plants.

CO-2 Use steam boilers, prime mover and condensing unit as per requirement.

CO-3 Analyze thermodynamic cycles of gas turbine power plant and Diesel engine power plant.

CO-4 Analyze the site for setting of nuclear power plant.

CO-5 Analyze the site for Hydro Electric Power Plant.

CO-6 Analyze the power station control and power plant economics.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037672 (037)	Power Plant Engineering	2	-	1	3

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Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
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1	Mechanical Engineering	2037672 (037)	Power Plant Engineering	70	20	30	-	-	120

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ii. Separate passing is must for End Semester Exam (Theory) and End Semester Exam (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Use the concept of thermodynamics in different cycle for power plants.

(Approx. Hrs: L+P+T=08)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Explain the general layout of power station. SO1.2 Explain the different power generation methods, its economics and global energy situation. SO1.3 Select the site for power plant with justification SO1.4 Apply the concept of thermodynamics in Rankine cycles. SO1.5 Explain the different methods used to improve the thermal efficiency of Rankine cycle. SO1.6 Describe the given type of power stations.		**Unit 1.0 Steam Power Plant** **1.1 Power plant** : General layout of modern thermal power plant, Site selection, Presents status of power generation in India, Elements of power plant, function of each element, steam condition and dryness fraction. **1.2 Rankine cycle:** Representation on PV, TS, HS plane, efficiency of Rankine cycle, Revision & improvement of thermal efficiency of Rankine cycle by lowering exhaust pressure, increasing boiler pressure and superheating of steam. Numerical problems. **1.3 Reheat cycle**- representation on T-S and H-S Planes, flow diagram and advantages. **1.4 Simple regenerating cycle** **1.5** Flow diagram, representation on T-S and H-S plants, bleeding and feed power heating and pumping, advantages of regenerative cycle. **1.6 1.5 Power station-** Types of power station such as central power station, industrial power station, captive power station, advantages, and classification of power station on the basis of prime-movers.	• Combine cycle power plant. • Presents status of power generation in India,

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Compare the reheat cycle and regenerative cycle on the basis of heat input, power generation and efficiency.
ii. Signify the importance of Captive power station used in industry.
iii. Explain why the steam is condensed before pumping in close cycle Rankine power plant.

b. Mini Project:

i. Visit nearby power plant and collect information of types of power station and types of prime mover used and overall efficiency of plant.
ii. Visit nearby power plant and enlist the safety procedure and precaution adopted to enhance the safety in power plant.
iii. Develop a working model of any water treatment system.

CO-2 Use steam boilers, prime mover and condensing unit as per requirement.

(Approx. Hrs: L+P+T=08)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Classify different types of steam generators used in power station. SO2.2 Prepare heat balance sheet for given boiler SO2.3 Write the functions of given Boiler accessories in steam generators. SO2.4 Compare different low pressure boilers. SO2.5 Compare different high pressure boilers. SO2.6 Explain the construction, principle and special features of given boiler. SO2.7 Explain the function of Condenser. SO2.8 Select boiler, prime mover and condensing unit as need with justification		**Unit 2.0 Elements of power plant** 2.1 Steam Generators: Classification according to working pressure. **(a)**Low pressure boilers- Cocharn,Lancashire and locomotive boilers **(b)**High pressure boilers in modern steam power plants such as Velox, Benson, La-mont, Leoffler, supercritical boilers. 2.2 **(a)**Boiler mountings- Safety valves, water level indicator, pressure gauge, blow off cock etc. **(b)** Accessories – super heater, economizer, pre heater and draft equipment. Superheat control methods, Pulverized fuel and necessity, storing systems etc. 2.3 Steam Prime mover- Steam nozzle-types, Velocity of steam at outlet, Weight of discharge, Area of cross section at throat and outlet, Critical pressure	• Pulverized coal fire boiler • Fluidized bed boilers

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		ratio, Nozzle efficiency, Concept of prime mover, Steam turbine – working principle , method of compounding and governing, losses in steam turbines. 2.4 Condensing Unit - Functions of Steam condenser and its type's jet and surface, Limitations and advantages of steam condenser, Elements of condensing unit, cooling towers.	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Write the importance of boiler accessories in steam generators.
ii. Compare boiler accessories and boiler mountings.
iii. Write the advantages of Compounding in steam turbine.

b. Mini Project:

i. Visit nearby power plan and collect the data of types of boiler used and its operating pressure, temperature and boiler capacity.
ii. Make a Power point presentation in steam prime mover.

CO-3 Analyze thermodynamic cycles of gas turbine power plant and Diesel engine power plant.

(Approx. Hrs: L+P+T=08)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Calculate the thermal efficiency of gas turbine power plant. SO3.2 Explain open cycle and closed cycle power plant. SO3.3 Explain the given component of diesel engine power plant SO3.4 Explain different Diesel power plant systems.		**Unit 3.0 Gas & Diesel Power Plants** 3.1 **Gas Turbine Power Plants-** Brayton cycle, classification of Brayton or Joule Cycle, Open and Close cycle, representation of cycle on P.V. and T.S. diagram. 3.2 Thermal efficiency in terms of terminal temperature and pressure, effect of pressure ratio on thermal efficiency, Advantages and disadvantages of	• Optimization of Brayton cycle

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.5 Explain the working of given type of steam turbines		open and close cycle gas turbines, Important components of gas turbine power plant, 3.3 Methods of improving thermal efficiency, Essential auxiliaries and controls of a gas turbine power plants, Fuels for gas turbines. **3.4 Diesel Engine Power Plants-** Diesel power plant layout, Functions & components of diesel power plant , Diesel power plant systems such as -Cooling and lubrication system, fuel injection system, solid injection system – common rail system, individual pump system, distribution system, data recording.	

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Solve at least five numerical problems on Brayton cycle.
ii. Describe the fuel injection system used in diesel engine power plant.

b. Mini Project:

i. Write the technical specification of diesel generator available in institute and also write different component of it.
ii. Make a power point presentation comparing gas turbine power plant and diesel engine power plant.

CO-4 Analyze the site for setting of nuclear power plant.

(Approx. Hrs: L+P+T=10)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Differentiate between nuclear fusion and fission. SO4.2 Explain the working, construction of nuclear power station.		**Unit 4.0 Nuclear Power Station** 4.1 Evolution of nuclear energy from atoms by fission and fusion. Chain reactions, fission materials, types of reactors, gas cooled, boiling water liquid, metal cooled and fast reactor, 4.2 Arrangements of various	• Nuclear Fuel

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.3 Explain given type of reactor. SO4.4 Select site for the nuclear power plant with justification. SO4.5 Explain regulatory approaches adopted, to ensure the safety of NPP. SO4.6 Select safety procedure to protect from nuclear radiation with justification.		elements in a nuclear power station, steam cycles and boilers coolant heat exchangers, Reactor control, Reactor shielding and safety methods. 4.3 Setting of Nuclear plants: Site evaluation Stages, Site Rejection Criteria, Earthquake, Geological criteria, Meteorological considerations, Flooding, Tsunami, Shoreline erosion, chemical explosion, Radiological impact study, Radioactivity pathways to humans, environmental Impact study. 4.4 Hazards in nuclear power station – units of radiations, safe and dangerous dozes of radiations, safety precautions in nuclear power station, Nuclear power plants in India.	

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. Explain different types of nuclear power station.
ii. Write the importance of moderator in nuclear power station.

b. Mini Project:

i. Develop working model of nuclear power plant
ii. Virtual Study of Tarapur nuclear power station by identifying the element of power station, History and economics, Fuel used, Safety procedure adopted.
iii. Virtual Study of Rajasthan Atomic Power Station by Identifying the element of power station, History and economics, Fuel used, Safety procedure adopted

c. Other Activities (Specify):

i. Make a power point presentation in safety features used in nuclear power station.
ii. Case study in future scope of nuclear power plant in India.

CO-5 Analyze the site for Hydro Electric Power Plant.

(Approx. Hrs: L+P+T=06)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Identify different component of hydro electric plant. SO5.2 Select suitable water turbine for a given site. SO5.3 Explain power generation through hydro electric plant using water turbine SO5.4 Describe the construction and working of water turbines. SO5.5 Compare the hydro, steam and diesel power plant. SO5.6 Select prime mover for a given problem. SO5.7 Describe the different method of governing. SO5.8 Explain Maintenance procedure of hydropower plants		**Unit 5.0 Hydro Electric Power Plants** 5.1 Potential power with reference to rainfall and catchments area, Water storage, element of hydro electric power stations. 5.2 Characteristics of hydraulic turbines, Comparison of the factors governing the cost of hydro, steam and diesel power stations. 5.3 Selection of prime mover, speed and pressure regulation, methods of governing, starting and stopping of water turbines, operation of hydro turbines. Maintenance of hydropower plants	• Future of hydro electric plant in India.

SW-5 Suggested Sectional Work (SW):

a. Assignments:

i. Visit the nearby hydro power station and collect the specification of turbine being used.
ii. List the criteria of classification of water turbine.
iii. List the Mini, Micro, and Medium capacity Hydel plants located in Chhattisgarh and Mention their Key features.

b. Mini Project:

i. Prepare a model of Hydel power station which you have visited.
ii. Prepare a report on hydro electric plant by
- Identifying the element of power station
- History and economics
- Cost of power generation and capacity of plant.

CO-6 Analyze the power station control and power plant economics.

(Approx. Hrs: L+P+T=8)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO6.1 Explain the effect of load variation on power plant system. SO6.2 Identify the different element of control system. SO6.3 Explain the importance of Load curve in power economics. SO6.4 Explain the procedure of energy auditing.		**Unit 6.0 Steam Power station Control and Economics** 6.1 Effect of load variation on shaft speed, steam admission, valve opening, steam flow rate, steam pressure and combustion control system. 6.2 Necessity of controlling factors in load variation, Control system (area system, centralized control system) Basic elements of control system, controls and instruments located in modern control station. **Power plant economics-** 6.3 Concept of occurrence of fluctuating loads, Load curve and its significance, Definition and terminology of connected load, maximum demand, demand factor, average load, load factor, diversity factor, plant capacity factor, plant use factor, effect of variable load and remedies.	

SW-6 Suggested Sectional Work (SW):

a. Assignments:

i. Write the necessities of controlling factor in load variation.
ii. List the different controlling instrument used in power station.
iii. Write the significance of load curve.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Steam Power Plant	2	5	5	12
II	Elements of power plant	2	5	5	12
III	Gas & Diesel Power Plants	2	5	5	12
IV	Nuclear Power Station	2	5	5	12
V	Hydro Electric Power Plants	2	5	5	12
VI	Steam Power station Control and Economics	2	3	5	10
	Total	**12**	**28**	**30**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*): Not Applicable

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Demonstration
10. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)

L) Suggested Learning Resources:

(a) Books :

S. No.	Title	Author	Publisher	ISBN NO.
1	Power Plant Engineering	Nag P.K.	Mcgraw hill	1259082849, 9781259082849
2	A Textbook of Power Plant Engineering	Rajput R. K.	Laxami publication	9788131802557
3	Power Plant Engineering	Domkundwar, Arora	Dhanpat Rai & Co..	6700000000406
4	A Textbook of Power Plant Engineering	Sharma. P.C.	Katson publ.	978-93-5014-384-1
5.	Power plant Engineering (Shakti Sanyantra Abhiyantriki Vikas)	S.S.L. Patel	Deepak Prakashan, Gwalior	ISBN- 81-7776-134-X Year-2015

(b) Open source software and website address:

i. https://nptel.ac.in/courses/108105058/8
ii. https://nptel.ac.in/courses/108105058/9
iii. https://nptel.ac.in/courses/108105058/10
iv. https://nptel.ac.in/courses/108105058/12
v. https://nptel.ac.in/courses/108105058/13
vi. https://www.youtube.com/results?search_query=animated+video+on+boiler
vii. https://www.youtube.com/results?search_query=animated+video+on+turbine
viii. https://www.youtube.com/results?search_query=animated+video+on+cooling+tower
ix. https://www.youtube.com/results?search_query=animated+video+of+hydro+power+plant+
x. https://www.youtube.com/results?search_query=animated+video+of+diesel+electric+power+plant

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

M) List of Major Laboratory Equipment and Tools: Not applicable

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Use the concept of thermodynamics in different cycle for power plants.	3	3	3	-	-	-	1	2	2	1	-	2	3
CO-2 Use steam boilers, prime mover and condensing unit as per requirement.	3	3	3	3	-	-	-	2	2	2	-	3	2
CO-3 Analyze thermodynamic cycles of gas turbine power plant and Diesel engine power plant.	3	3	1	-	1	-	-	1	-	2	1	-	3
CO-4 Analyze the site for setting of nuclear power plant.	3	3	3	1	1	1	-	2	1	2	2	-	3
CO-5 Analyze the site for Hydro Electric Power Plant.	3	3	3	1	1	1	-	2	1	2	2	-	3
CO-6 Analyze the power station control and power plant economics.	3	2-	1	-	-	-	-	1	-	2	2	-	3

Legend:1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3, 7,8,9,10 PSO-2,3	CO-1 Use the concept of thermodynamics in different cycle for power plants.	SO1.1 - SO 1.6		Unit 1.0 Steam Power Plant 1.1 , 1.2 1.3 1.4 ,1.5, 1.6	As mentioned in relevant page numbers
PO-1,2,3,4, 8,9,10 PSO-2,3	CO-2 Use steam boilers, prime mover and condensing unit as per requirement.	SO2.1 - SO2.7		Unit 2.0 Elements of power plant 2.1, 2.2 ,2.3 ,2.4,	
PO-1,2,3,5, 8,10 PSO-1,3	CO-3 Analyze thermodynamic cycles of gas turbine power plant and Diesel engine power plant.	SO3.1 - SO3.5		Unit 3.0 Gas & Diesel Power Plants 3.1,3.2,3.3,3.4	
PO-1,2,3,4,5,6, 8,9,10 PSO-1,3	CO-4 Analyze the site for setting of nuclear power plant.	SO4.1 - SO4.6		Unit 4.0 Nuclear Power Station 4.1, 4.2, 4.3, 4.4	
PO-1,2,3,4,5,6, 8,9,10 PSO-1,3	CO-5 Analyze the site for Hydro Electric Power Plant.	SO5.1 - SO5.8		Unit 5.0 Hydro Electric Plants 5.1, 5.2, 5.3	
PO-1,2,3, 8,10 PSO-1,3	CO-6 Analyze the power station control and power plant economics.	SO6.1 - SO6.4		Unit 6.0 Steam Power station Control and Economics 6.1, 6.2, 6.3,	

A) Course Code : 2037674(037)

B) Course Title : Computer Aided Modeling & Manufacturing

C) Pre-requisite Course Code and Title :

D) Rationale :

Manufacturing of this century belongs to computerized equipment & machine tools to manufacture a variety of components with high quality, high precision & low cost at a faster rate. Commuter Aided Designing, Computer Aided Manufacturing & Flexible Manufacturing Systems-all are the part of Computer Integrated manufacturing which help to achieve the desired goals in manufacturing. After studying the course, the students will be able to apply these integrated techniques which help a manufacturer to achieve his goal with in stipulated time.

E) Course Outcomes:

CO-1 Identify various elements of Computer aided Design and Manufacturing.

CO-2 Use Computer aided Design Software to model components and assemblies.

CO-3 Use Computer aided Design Software to create production drawings of machine components and assemblies.

CO-4 Develop components using CNC turning machine.

CO-5 Develop components using CNC milling machine.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037674 (037)	Computer Aided Modeling & Manufacturing	1	-	1	2
2	Mechanical Engineering	2037661 (037)	Computer Aided Modeling & Manufacturing (Lab)	-	4	-	2

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037674 (037)	Computer Aided Modeling & Manufacturing	70	20	30	-	-	120
2	Mechanical Engineering	2037661 (037)	Computer Aided Modeling & Manufacturing (Lab)	-	-	-	50	30	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam (Theory) and End Semester Exam (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Identify various elements of Computer aided Design and Manufacturing.

(Approx. Hrs: L+P+T=14)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Explain CAD-CAM process. SO1.2 Justify the need of CAD and CAM. SO1.3 Identify various CAD/CAM software and hardware. SO1.4 Compare commercially available graphics packages used for modeling of mechanical components. SO1.5 Differentiate between NC, CNC and DNC. SO1.6 Identify parameters governing selection of CNC machines.	LE1.1 Launch and exit an CAD software LE1.2 Start, stop and manipulate, CNC lathe and Milling machines	**Unit 1.0 Essentials of CAD/CAM** 1.1 CAD definition, concept and need. 1.2 CAD process and Functional areas of CAD. 1.3 CAD Workstation-types, functions and configuration. 1.4 CAD Software: types, features, strengths and limitations 1.5 CAM - concept and definition. 1.6 NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) - concept, features and differences. 1.7 CNC machines: Advantages, limitations and selection criteria.	• Input devices like voice, gesture, 3D scanner.

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Identify various CAD/CAM software and hardware.
ii. Compare commercially available graphics packages used for modeling of mechanical components.
iii. Differentiate between NC, CNC and DNC.

b. Other Activities (Specify):

1. Collect quotation from different vendors and prepare final specification for a CAD workstation.(group work with group size of five students each)
2. Collect photographs of all the cutting tools generally used in today's industries with CBN, PCBN, TC inserts (group work with group size of five students each)
3. Prepare list of controllers that are generally being used in CNC machines.

CO-2 Use Computer aided Design Software to model components and assemblies.

(Approx. Hrs: L+P+T=17)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Describe the procedure to create given 3D model (part) using the given commands. SO2.2 Describe the procedure to use 3D modify commands to edit the given 3D Model. SO2.3 Describe the procedure to create assembly of the given 3D solid models. SO2.4 Describe the procedure to modify the given assembly. SO2.5 Describe the procedure to use explode command for the given assembly.	LE2.1 Develop solid models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post using any parametric CAD software. LE2.2 Develop solid model of any complex industrial component using any parametric CAD software. LE2.3 Develop anyone assembly using solid models from LE2.1and any parametric CAD software.	**Unit 2.0 Computer aided Solid Modeling and Assembly** 2.1 Working in 3D environment - 2.2 Creating 3D Solid Models of simple and complex machine parts using Extrude, Revolve, Sweep, variable section sweep, Draft, loft, Blend or similar 3D commands. 2.3 Part Editing tool: Trim, Extend, Erase, Mirror, Chamfer, Round, Copy, Move, Draft, Boolean operations, patterns, etc. 2.4 Parametric and non parametric modeling-concept, differences and illustration. 2.5 Preparation of assemblies using assembly commands. Introduction to Top down and Bottom up approach of assembly 2.6 Exploded view: Explode the assembly.	• Surface Modeling tools

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Differentiate Parametric and Non parametric modeling approaches with example.
ii. List sketch based commands available in any parametric CAD software.
iii. List feature based commands available in any parametric CAD software.
iv. Explain the procedure of modeling a Ball bearing and Helical Gear using any parametric CAD software.
v. Explain the procedure of modeling open coil helical spring using any parametric CAD software.

b. Mini Project:

i. Each student will identify a small assembly from the institute workshop/laboratory. Measure the dimensions of each part and prepare sketches. Using sketches prepared 3D model of parts and assembly. (e.g. Bench vice, Machine vice, Tool post, Couplings, Joints, Ball/Roller

Bearings, Gears, Mouse, Motor casing etc.) Specify the material and try to find out mass of the complete assembly.

ii. Develop 3D model and complete assembly of 'computer mouse' you are using, specify the material and try to find out mass of the complete assembly.

c. Other Activities (Specify):

i. Down load already prepared solid models and modify them.

CO-3 Use Computer aided Design Software to create production drawings of components and assemblies.

(Approx. Hrs: L+P+T=17)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Describe the procedure to generate 2D drawings of the given part models and assembly. SO3.2 Describe the procedure to plot production drawing as per the given dimensions. SO3.3 Describe the procedure to create exploded view of the given assembly.	LE3.1 Print orthographic views (regular and sectioned)of the solid models developed LE2.1 LE3.2 Print orthographic views (regular and sectioned)of the solid models developed LE2.2 LE3.3 Print orthographic views (regular and sectioned)of the assembly developed LE2.3 LE3.4 Print production drawing of the solid models developed LE2.1 LE3.5 Print production drawing of the assembly developed LE2.3 with Bill of Materials.	**Unit 3.0 Computer aided Drafting and Plotting** 3.1 Generate orthographic projections. All types of views – front view, top view, side view, sectional views, isometric views, auxiliary views. 3.2 Dimensioning Commands – Apply dimensions, dimensional and geometrical tolerances. 3.3 Preparation of Assembly drawing using assembly features. 3.4 Exploded view – Explode the assembly. 3.5 Working in Drafting Mode. 3.6 Bill of material – Prepare part list table and name plate. 3.7 Page set up, Plot command.	• Explode views

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. List the page setup and plot commands available in any parametric CAD software.

ii. List the different types of views that can be drawn in any parametric CAD software.

iii. Explain the procedure of drawing detailed view of any feature of a component.

b. Mini Project:

i. Each student will collect one or two production drawings for complex components from the nearby industry/workshop and prepare the model and 2D drawing from it.

ii. Each batch will identify a small assembly from the institute workshop/laboratory. Measure the dimensions of each part and prepare sketches. Using sketches prepare 3D model of parts

and assembly. Plot the assembly and detail drawings. (e.g. Bench vice, Machine vice, Tool post, Couplings, Joints, Bearings etc.)

c. Other Activities (Specify):

1. Collect videos of Modeling, assemblies and drawing of 5 complex parts and try to model them.

CO-4 Prepare components using CNC turning machine.

(Approx. Hrs: L+P+T=24)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Explain the working and constructional details of the given CNC turning machine. SO4.2 Describe functions of main elements of the given CNC turning machine. SO4.3 Explain CNC axes and nomenclature of the given CNC turning machine. SO4.4 Describe application of the given qualified tool and tool holders used on the given CNC turning machines with justification. SO4.5 Prepare components using applicable codes like G and M etc. on the given CNC turning machine.	LE4.1 Operate CNC turning machine and try to change different parameters and controls to see their effect during machining. LE4.2 Prepare CNC part programme using G and M codes with ISO format for Simple turning of part. LE4.3 Prepare part on CNC turning machine using part program developed in LE4.2 LE4.4 Prepare CNC part programme using G and M codes with ISO format for turning of complex part. LE4.5 Prepare complex part on CNC turning machine using part program developed in LE4.4.	**Unit 4.0 CNC Turning** 4.1 CNC machines: Types, classification, working and constructional features. 4.2 Elements of CNC machines - Types, sketch, working and importance of: Slide ways; Re-circulating ball screw; Feedback devices (transducers, encoders); Automatic tool changer (ATC); Automatic pallet changer (APC); CNC axes and motion nomenclature. 4.3 CNC tooling : Tool presetting-concept and importance; Qualified tools-definition need and advantages; Tool holders-types and applications. 4.4 CNC Turning centres: Types; Features; Axes nomenclature; Specification; Work holding devices -types, working and applications; Tool holding and changing devices - types, working and applications; 4.5 CNC part programming: programming format and structure of part programme. 4.6 ISO G and M codes for turning -meaning and applications of important codes. 4.7 Simple part programming for turning using ISO	• Loops and cycles in CNC turning

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation).	

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. Explain the working and constructional details of Head Stock, Tail stock Quill and CNC control panel of a typical CNC tuning machine.
ii. Describe functions of Display unit and Servo Control unit of the given CNC turning machine.
iii. Explain CNC axes and nomenclature of the given CNC turning machine.
iv. Prepare part program using applicable codes like G and M etc. for any taper turning component according to Fanuc/Seimens/Fagor/ (any one) controller.

b. Mini Project:

i. Collect/download at least four different CNC turning tooling manufacturer's catalogues and prepare a chart for type of tool inserts and optimized machining parameters required to turn components of Mild steel, Stainless steel, Aluminium, Brass.
ii. Prepare a list of industrial components which are produced through CNC turning.

c. Other Activities (Specify):

1. Collect videos of manufacturing of different components which involve CNC turning operation. Watch them and practice them.
2. Collect/download at least four different CNC turning machine manufacturer's catalogues and at least one catalogue each of cutting tool, work holding device and tool holder related to CNC tuning machine.

CO-5 Prepare components using CNC milling machine.

(Approx. Hrs: L+P+T=24)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Explain the working and constructional details of the given CNC milling machine. SO5.2 Describe functions of main elements of the given CNC milling machine. SO5.3 Explain CNC axes and nomenclature of the given CNC milling machine. SO5.4 Describe application of the given qualified tool and tool holders used on the given CNC milling machines with justification. SO5.5 Prepare	LE5.1 Operate CNC milling machine and try to change different parameters and controls to see their effect during machining. LE5.2 Prepare CNC part programme using G and M codes with ISO format for Simple contour milling of part. LE5.3 Prepare part on CNC milling machine using part program developed in LE5.2 LE5.4 Prepare CNC part programme using	**Unit 5.0 CNC Milling** 5.1 CNC milling centres: Types; Features; Axes nomenclature; Specification; Work holding devices -types, working and applications; Tool holding and changing devices - types, working and applications; 5.2 CNC part programming: programming format and structure of part programme. 5.3 ISO G and M codes for milling -meaning and applications of important codes.	• CNC Gear manufacturing

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
components using applicable codes like G and M etc. on the given CNC milling machine.	G and M codes with ISO format for milling a complex part. LE5.5 Prepare complex part on CNC milling machine using part program developed in LE5.4	5.4 Simple part programming for milling using ISO format. 5.5 Importance, types, applications and format for: Canned cycles; Macro; Do loops; Subroutine; 5.6 CNC milling part programming using canned cycles, Do loops and Subroutine. 5.7 Need and importance of various compensations: Tool length compensation; Pitch error compensation; Tool radius compensation; Tool offset. 5.8 Simple part programming using various compensations	

SW-5 Suggested Sectional Work (SW):

a. Assignments:

i. Explain the working and constructional details of Head Stock, Tail stock Quill and CNC control panel of a typical CNC milling machine.
ii. Describe functions of Display unit and Servo Control unit of the given CNC milling machine.
iii. Explain the meaning and utility of 4^{th} axis in a CNC milling machine.
iv. Prepare part program using applicable codes like G and M etc. for any taper turning component according to Fanuc/Seimens/Fagor/ (any one) controller.
v. Prepare a list of CNC milling machine accessories.

b. Mini Project:

i. Collect/download at least four different CNC turning tooling manufacturer's catalogues and prepare a chart for type of tool inserts and optimized machining parameters required to turn components of Mild steel, Stainless steel, Aluminium, Brass.
ii. Prepare a list of industrial components which are produced through CNC turning.

c. Other Activities (Specify):

1. Collect videos of manufacturing of different components which involve CNC turning operation. Watch them and practice them.
2. Collect/download at least four different CNC turning machine manufacturer's catalogues and at least one catalogue each of cutting tool, work holding device and tool holder related to CNC tuning machine.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Essentials of CAD/CAM	2	4	8	14
II	Computer aided Solid Modeling and Assembly	2	4	8	14
III	Computer aided Drafting and Plotting	2	4	8	14
IV	CNC Turning	2	4	8	14
V	CNC Milling	2	4	8	14
	Total	**10**	**20**	**40**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Title	Assessment of Laboratory Work (Marks)			50 Marks are allocated for performance under ESA based on following performance parameters:
		Performance		Viva-Voce	
		PRA	PDA		
LE1.1	Launch and exit an CAD software	25	20	05	• Developing/ using Institute Template • Selecting relevant set up parameters • Creating given drawing/model using relevant Commands. • Dimensioning the given drawing/model and writing text using blocks and layers effectively. • Answer to sample questions • Submission of digital drawing file/plot in time
LE1.2	Start, stop and manipulate, CNC lathe and Milling machines	25	20	05	
LE2.1	Develop solid models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post using any parametric CAD software.	25	20	05	
LE2.2	Develop solid model of any complex industrial component using any parametric CAD software.	25	20	05	
LE2.3	Develop anyone assembly using solid models from LE2.1and any parametric CAD software.	25	20	05	
LE3.1	Print orthographic views (regular and sectioned)of the solid models developed LE2.1	25	20	05	
LE3.2	Print orthographic views (regular and sectioned)of the solid models developed LE2.2	25	20	05	
LE3.3	Print orthographic views (regular and sectioned)of the assembly developed LE2.3	25	20	05	
LE3.4	Print production drawing of the solid models developed LE2.1	25	20	05	
LE3.5	Print production drawing of the assembly developed LE2.3 with Bill of Materials.	25	20	05	

LE4.1	Operate CNC turning machine and try to change different parameters and controls to see their effect during machining.	25	20	05	• Preparation of experimental set up • Setting and operation • Safety measures • Observations and Recording • Interpretation of result and conclusion • Answer to sample questions • Submission of report/sheets in time
LE4.2	Prepare CNC part programme using G and M codes with ISO format for Simple turning of part.	25	20	05	
LE4.3	Prepare part on CNC turning machine using part program developed in LE4.2	25	20	05	
LE4.4	Prepare CNC part programme using G and M codes with ISO format for turning of complex part.	25	20	05	
LE4.5	Prepare complex part on CNC turning machine using part program developed in LE4.4	25	20	05	
LE5.1	Operate CNC milling machine and try to change different parameters and controls to see their effect during machining.	25	20	05	
LE5.2	Prepare CNC part programme using G and M codes with ISO format for Simple contour milling of part.	25	20	05	
LE5.3	Prepare part on CNC milling machine using part program developed in LE5.2	25	20	05	
LE5.4	Prepare CNC part programme using G and M codes with ISO format for milling a complex part.	25	20	05	
LE5.5	Prepare complex part on CNC milling machine using part program developed in LE5.4	25	20	05	

* Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **50** Marks as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration
11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)

12. Brainstorming
13. Others

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	CNC Machines	Pabla B.S., Adithan M.	New Age International, New Delhi,	2014
2.	Computer Numerical Control-Turning and Machining centres	Quesada Robert	Prentice Hall India, New Delhi	2014
3.	CAD/CAM	Sareen Kuldeep	S. Chand, New Delhi	2012
4.	Introduction to NC/CNC Machines	Vishal S.	S.K. Kataria and Sons, New Delhi	2012
5.	Computer Aided Manufacturing	Rao P N, Tiwari N K, Kundra T	Tata McGraw Hill, New Delhi	2014
6.	CAD/CAM: computer aided design and manufacturing	Groover Mikell P, Zimmered W Emory	Prentice Hall, New Delhi	2011
7.	CNC Machines.	Pabla B.S., Adithan M.	New Age International, New Delhi	2014

(b) Open source software and website address:

Introduction to Computer Aided Drafting/Design (CAD) and Computer Aided Manufacturing (CAM)

1. http://www.nptel.ac.in
2. https://www.inc.com/encyclopedia/computer-aided-design-cad-and-computer-aided-cam.html
3. https://www.autodesk.in/solutions/cad-cam
4. http://www.youtube.com/watch?v=M3eX2PKM1RI
5. http://www.youtube.com/watch?v=EHQ4QIDqENI&list=PLBkqkLQO 2nAt5MNLo eUhvkFS9M0p8y_1
6. http://www.youtube.com/watch?v=hJFLcvtiNQI
7. http://www.youtube.com/watch?v=BIM1AyxfYkw
8. http://www.mtabindia.com
9. http://www.swansoftcncsimulator.com

Surface / Solid Modeling Using CAD/CAM

10. https://all3dp.com/2/surface-modeling-cad-simply-explained/
11. http://www.dm.unibo.it/~casciola/html/research_ssm.html
12. https://www.youtube.com/watch?v=WY0YuCkJWdw
13. https://www.youtube.com/watch?v=OIYrkF_FId8
14. https://www.youtube.com/watch?v=zoMW_usjaJo
15. https://www.youtube.com/watch?v=fx6kt9djIpc
16. https://www.youtube.com/watcAh?v=8wdOIHxICxw
17. https://www.youtube.com/watch?v=srnm--IKtI4
18. https://www.youtube.com/watch?v=rtjDfZXscrI

Viewing Objects in 3D Space

19. https://coursesweb.net/flash/objects-3d-space
20. https://www.toppr.com/guides/maths/boxes-and-sketches/visualisation-of-3d-objects-in-2d/
21. https://courses.cs.washington.edu/courses/cse576/book/ch12.pdf

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Manufacturers' Catalog
5. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	CAD Workstations	With Latest configuration, Ethernet card, graphics acceleration card	LE1.1 LE2.1-2.3 LE3.1-3.5 LE4.2, LE4.4 LE5.2, LE5.4 LE6.1
2	Creo/Unigraphics/CATIA/Solid Edge/Inventor software (Any one).	Latest network educational version	LE1.1 LE2.1-2.3 LE3.1-3.5 LE6.1
3	Laser printer	A3 size with Latest configuration,	LE3.1-3.5
4	CNC Turning 250	With standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type minimum diameter 25 mm, Length 120 mm with ATC. (Suggested)	LE4.2, LE4.4
5	CNC Milling 250	With standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type-X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, with ATC.(Suggested)	LE5.2, LE5.4

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Identify various elements of Computer aided Design and Manufacturing.	2	3	3	2	1	1	2	2	1	3	3	1	1
CO-2 Use Computer aided Design Software to model components and assemblies	2	3	3	2	1	1	1	2	1	3	3	1	1
CO-3 Use Computer aided Design Software to create production drawings of machine components and assemblies.	2	3	3	2	2	1	2	2	2	3	3	1	1
CO-4 Develop components using CNC turning machine.	2	3	3	2	2	1	2	2	2	3	3	3	3
CO-5 Develop components using CNC milling machine.	2	3	3	2	2	1	2	2	2	3	3	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-1 Identify various elements of Computer aided Design and Manufacturing.	SO1.1-SO1.6	LE1.1 LE1.2	Unit 1.0 Essentials of CAD/CAM 1.1-1.7	As mentioned in relevant page numbers
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-2 Use Computer aided Design Software to model components and assemblies	SO2.1 SO2.2 SO2.3 SO2.4	LE. 2.1 LE. 2.2 LE. 2.3	Unit 2.0 Computer aided Solid Modeling and Assembly 2.1-2.6	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-3 Use Computer aided Design Software to create production drawings of machine components and assemblies.	SO3.1 SO3.2 SO3.3	LE3.1-LE3.5	Unit3.0 Computer aided Drafting and Plotting 3.1-3.7	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-4 Develop components using CNC turning machine.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	LE4.1 LE4.2 LE4.3 LE4.4 LE4.5	Unit-4.0 CNC Turning 4.1-4.7	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-5 Develop components using CNC milling machine.	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	LE5.1 LE5.2 LE5.3 LE5.4 LE5.5	Unit-5.0 CNC Milling 5.1-5.8	

A) Course Code : 2000673(037)

B) Course Title : Entrepreneurship Development and Management

C) Pre- requisite Course Code and Title :

D) Rationale :

Our fast growing economy provides ample opportunities for diploma engineers to succeed in entrepreneurship. Diploma engineers can be their own masters and job provider to others by starting their service industry/assembly/marketing/consultancy/manufacturing enterprises. As entrepreneurship requires distinct set of skills which may not be developed while undergoing technical subjects? Hence a separate course has been introduced for developing such skills set amongst diploma students. This course aims at developing competencies in the diploma engineer for becoming an intrapreneur or a successful entrepreneur. After successfully completing this course students who develop qualities of successful entrepreneur can set up their own manufacturing industry/service industry/business/startup or be self employed and those who prefer job can become intrapreneur and share profits with their company.

E) Course Outcomes

CO-1 Demonstrate traits of a successful intrapreneur/entrepreneur

CO-2 Analyze the level of achievement motivation by preparing one's own portfolio.

CO-3 Innovate products and services using creativity techniques.

CO-4 Manage critical resources from support institutions.

CO-5 Prepare sustainable small business plans.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2000673 (037)	Entrepreneurship Development and Management	2	-	1	3

Lead:

Classroom Instruction (Includes different instructional strategies i.e.Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2000673 (037)	Entrepreneurship Development and Management	70	20	30	-	-	120

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.

ii. Separate passing is must for End Semester Exam (Theory) and End Semester Exam (Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Demonstrate traits of a successful intrapreneur/entrepreneur.

(Approx. Hrs: L+P+T=16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Select intrapreneurship or entrepreneurship as a career based on the qualities possessed by an individual. SO1.2 Identify various avenues of entrepreneurship for diploma engineers. SO1.3 Demonstrate qualities of successful intrapreneur /entrepreneur. SO1.4 Explain various steps in establishment of enterprise. SO1.5 Select an area of business opportunity as per your interest.		**Unit 1.0 Characteristics of entrepreneurs** 1.1 Concept of entrepreneur and intrapreneur 1.2 Benefits of becoming an intrapreneur/ entrepreneur. 1.3 Scope of entrepreneurship in local and global market. 1.4 Planning for establishment of an enterprise. 1.5 Traits of successful intrapreneur/ entrepreneur and passion, initiative, independent decision making, team work, assertiveness, persuasion, persistence, information seeking, commitment to work contract etc. SW analysis. Team work simulation. 1.6 Trait of successful entrepreneur: calculated risk taking. Risk taking simulation exercise. 1.7 Business opportunity Guidance	• History of entrepreneurship. • Definition of entrepreneurship • Social entrepreneurship

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Identify existing needs of the institute/college and convert them into business opportunity.
ii. Enumerate characteristics of assigned first generation successful entrepreneurs, intrapreneurs, managers by preparing a presentation.
iii. Analyze the reasons for success and failure of the assigned entrepreneurs by preparing ppt on the basis of news, articles, reviews, video etc.

b. Mini project:

i. Interviewing few local entrepreneurs and prepare a collage on “Traits of successful entrepreneurs”.

ii. Identify traits to be developed in you for becoming a successful entrepreneur based on your strength and weakness analysis and submit an action plan to develop the same.
iii. Organize "best from waste" competition.

c. Other Activities:

i. Identify your hobbies and interests and convert them into business idea.
ii. Organize seminar on history of entrepreneurship, Definition and selected case studies of social entrepreneurship.

CO-2 Analyze the level of achievement motivation by preparing one's own portfolio.

(Approx. Hrs: L+P+T= 16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Explain the concept of achievement motivation. SO2.2 Assess level of need for Achievement in the individual through different tools. SO2.3 Prepare an action plan for enhancing need for achievement.		**Unit 2.0 Motivation Management** 2.1 Motives, motivation and motivational cycle. 2.2 Concept of Need for Achievement. 2.3 Need for Achievement assessment through various tools. • Ring toss game • Boat making exercise • Building block exercise • TAT stories • Who am I? 2.4 Interpretation and action plan for self development.	• Kakinada experiment Techno-preneurship.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Prepare a portfolio based on achievement motivation exercise and tasks.

b. Mini project:

i. Prepare a report on need for achievement exercises.
ii. Develop achievement motivation field exercises.

c. Other Activities:

i. Prepare a plan for development of achievement motivation and execute it.
ii. Develop case studies on Techno-preneurship.
iii. Prepare a report on Kakinada experiment.

CO-3 Innovate products using creativity techniques.

(Approx. Hrs: L+P+T= 16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Elucidate the use of creativity techniques for entrepreneurs. SO3.2 Improve a chosen product using brainstorming technique. SO3.3 Differentiate between creativity and innovation. SO3.4 Apply concept of product life cycle for conceiving a project. SO3.5 Design a product using new product development process.		**Unit 3.0 Management of Creativity & Innovation** 3.1 Creativity: Divergent thinking, creativity techniques. 3.2 Innovation, types and applications 3.3 Product life cycle, New product development process. Product development and innovation through creativity and innovation.	• Check list of questions. • Six thinking hats. • Case study of innovative first generation entrepreneur. • Schemes and incentives for innovation. • Innovative solutions for social problems.

SW-3 Suggested Sessional Work (SW):

a. Assignments:

i. Use the assigned creativity technique for improvement of product characteristic.

ii. Use the assigned creativity technique for improvement of service process characteristic.

b. Mini project:

i. Apply innovative practices in different process of an enterprise.

c. Other Activities:

i. Prepare a prototype of a creative solution to industrial/ social problem.

ii. Organise seminar on Schemes and incentives for innovation, Innovative solutions for social problems and Kakinada experiment.

CO-4 Manage critical resources from support institutions.

(Approx. Hrs: L+P+T= 16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Select appropriate form of business organization for enterprise SO4.2 Identify entrepreneurship support institutions for technical/		**Unit 4.0 Critical Resources** 4.1 Forms of business organization: Proprietorship, Partnership, Cooperative, Private, Public Ltd Company, Section 8 company, LLP 4.2 Institutional Support for entrepreneurship: MSMESI, CED, DTIC,	• Establishment procedure of Proprietorship, LLP, Cooperative, Section 8 company, LLP Factory Act, Labour Laws, GST.

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
marketing and finance. SO4.3 Explain salient features of entrepreneurship promotion schemes of centre and state. SO4.4 Prepare a marketing mix plan for identified industry. SO4.5 Develop a materials management plan. SO4.6 Develop a human resource plan.		CITCON, CSIDC, LUN, NSIC, KVIC, NABARD, Banks, SIDBI 4.3 Entrepreneurship promotion schemes of centre and state. 4.4 Marketing Mix, Market survey for project identification 4.5 Inventory control, vendor development, material movement, store management. 4.6 Manpower plan, hiring process, compensation, performance appraisal.	

SW-4 Suggested Sessional Work (SW):

a. Assignments:

i. Examine suitability of different forms of business organization for the given project and prepare a presentation for the same.
ii. Conduct a market survey and prepare a report along with marketing mix plan for the given project.
iii. Prepare materials management strategy for a business or manufacturing unit and submit a report.
iv. Prepare a man power plan chart and job specifications for identified positions.

b. Mini project:

i. Explore facilities extended by support institutions to entrepreneurs for marketing of the given situation.
ii. Investigate facilities extended by support institutions to entrepreneurs for technical support of the given situation.
iii. Identify facilities extended by support institutions to entrepreneurs for financial support of the given situation

c. Other Activities:

i. Visit the assigned agencies engaged in institutional support for entrepreneurship and make a report.
ii. For your selected project decide a unique name of the enterprise, logo, signboard, letterhead and pamphlet.
iii. Organize a seminar on establishment procedure of proprietorship, LLP, cooperative, section 8 company, factory act, labour laws and GST.

CO-5 Prepare sustainable small business plans.

(Approx. Hrs: L+P+T= 16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Prepare business plan/techno economic feasibility report. SO5.2 Calculate and comment on breakeven point for given project. SO5.3 Explain financing of startups.		**Unit 5.0 Sustainable business plan** 5.1 Format of business plan/techno-economic feasibility report. 5.2 Demand and annual production target based on market survey. 5.3 Outline production/service process. 5.4 Land, building and machinery requirement. 5.5 Power, utilities and raw material requirement. 5.6 Fixed capital, Working capital, Subsidy and Cost of Project. 5.7 Means of finance, calculation of interest. 5.8 Profitability analysis, Break-even point.	• Techno-economic feasibility report of MSME. • Startup process. • Angel Investors. • Venture capitalist. • Incubators.

SW-5 Suggested Sessional Work (SW):

a. Assignments:

i. Describe the procedure of registration and availing of facilities from the assigned support institution.

ii. Prepare a process plan for the selected project.

b. Mini project:

i. Prepare a marketing plan for the assigned project.

ii. Prepare a financial plan for the assigned project.

iii. Prepare a technical feasibility plan for the assigned project.

iv. Prepare a techno-economical feasibility report of the assigned project.

c. Other Activities:

i. Analyse a case study on startups focusing on financing from angel investor and venture capitalist.

ii. Organize seminar on Startup process, Angel investors, Venture Capitalist and Incubators

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Title	Marks Distribution			Total Marks
		R	U	A	
I	Characteristics of entrepreneurs	2	4	8	14
II	Motivation Management	2	2	6	10
III	Management of Creativity and Innovation	2	4	8	14
IV	Critical Resource	2	4	10	16
V	Sustainable Business Plan	2	4	10	16
Total		**10**	**18**	**42**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*): Not Applicable

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Field Trips
6. Portfolio Based Learning
7. Demonstration
8. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
9. Brainstorming

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	Entrepreneurial Development	Desai Vasant	Himalaya Publishing House	Mumbai/2017 ISBN 978 93 5097 383 7
2	Starting your own business, step by step Blue print for the First – time Entrepreneur	Harper Stephen C.	Mc Craw-Hill	2003 ISBN13: 9780071410120
3.	The Business Planning GUIDE	H.Bangs David	Upstart Publishing Company in Chicago	978-0793154098
4	Entrepreneurship Development in India	Gupta Dr.C.B. Shriniwasa NP	Sultan Chand & Sons	9788180548185
5	Entrepreneurship Development	Khanka Dr.S.S.	S.Chand New Delhi	ISBN 81 219 1801 4
6	Entrepreneurship Development and small Business Enterprises	Charantimath M.	Pearson Edu.Soc. INDIA	2013/ISBN 13 978 8131 762264
7.	Entrepreneurship Development	Sharma Sangita	PHI, DELHI	ISBN 978 81 203 5270 4

(b) Open source software and website address:

1. Free e books: https://www.free-ebooks.net/book-list/entrepreneurship
2. Startups:https://inc42.com/startups/?utm_source=top-menu&utm_medium=website&utm_campaign=menu
3. Indian Tech Startup funding report: https://pages.inc42.com/annual-indian-tech-startup-funding-report-2017/?utm_source=top-menu&utm_medium=website&utm_campaign=menu
4. Project profile: https://my.msme.gov.in/MyMsmeMob/MsmeProjectProfile/Home.htm
5. Project profile: http://www.dcmsme.gov.in/publications/pmryprof/pjseries.html
6. Project profile http://www.dcmsme.gov.in/reports/ProjectProfile.htm

M) List of Major Laboratory Equipment and Tools: Not Applicable

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)	
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2
CO-1 Demonstrate traits of a successful intrapreneur/entrepreneur.	-	3	-	-	2	2	2	2	2	2	-	-
CO-2 Analyse the level of achievement motivation by preparing one's own portfolio.	-	3	-	-	2	2	2	2	2	2	-	-
CO-3 Innovate products using creativity techniques.	-	3	-	-	2	2	2	2	2	2	-	-
CO-4 Manage critical resources from support institutions.	-	3	-	-	2	2	2	2	2	2	-	-
CO-5 Prepare sustainable small business plans.	-	3	-	-	2	2	2	2	2	2	-	-

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No. & Title	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-2,5,6,7,8, 9,10	CO-1 Demonstrate traits of a successful intrapreneur/entrepreneur.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5		Unit 1.0 Characteristics of entrepreneurs 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7	As mentioned in relevant page numbers
PO-2,5,6,7,8, 9,10	CO-2 Analyse the level of achievement motivation by preparing one's own portfolio.	SO2.1 SO2.2 SO2.3		Unit 2.0 Motivation Management 2.1, 2.2, 2.3, 2.4	
PO-2,5,6,7,8, 9,10	CO-3 Innovate products using creativity techniques.	SO.3.1 SO3.2 SO3.3 SO3.4 SO3.5		Unit 3.0 Management of Creativity and Innovation 3.1, 3.2, 3.3	
PO-2,5,6,7,8, 9,10	CO-4 Manage critical resources from support institutions.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5 SO4.6		Unit 4.0 Critical Resources 4.1, 4.2, 4.3, 4.4,4.5,4.6	
PO-2,5,6,7,8, 9,10	CO-5 Prepare sustainable small business plans.	SO5.1 SO5.2 SO5.3		Unit 5.0 Sustainable Business Plan 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8	

A) Course Code : 2037675(037)
B) Course Title : Industrial Maintenance and Safety
C) Pre-requisite Course Code and Title :
D) Rationale :

Maintenance of the machines and equipment is of paramount importance in any Industry. Regular maintenance of the machines always leads to the timely production schedules and less problems due to breakdowns in the industries. The diploma pass outs works in wide spectrum in any industry like the production, quality control planning etc. He should have the knowledge of the maintenance of the plant machinery. The course is intended to inculcate basic concept of the plant maintenance and safety aspects**.**

E) Course Outcomes:

CO-1 Use relevant maintenance method to maintain the equipments.

CO-2 Prepare preventive and periodic maintenance schedule.

CO-3 Use relevant lubrication and lubrication method as per the situation.

CO-4 Diagnoses faults in the inoperative machine.

CO-5 Use recovery reconditioning and retrofitting as per the situation.

CO-6 Apply Industrial safety and Safety Acts.

F) Scheme of Studies:

S. No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037675 (037)	Industrial Maintenance and Safety	2	-	1	3

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037675 (037)	Industrial Maintenance and Safety	70	20	30	-	-	120

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial

includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Use relevant maintenance method to maintain the equipments.

(Approx. Hrs: L+P+T=06)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Explain the need of maintenance in industry. SO1.2 Describe different functions of maintenance department SO1.3 Explain different types of maintenance. SO1.4 Select tools and equipment used for the given maintenance with justification SO1.5 Relate maintenance cost with replacement economy. SO1.6 Calculate service life of equipment		**Unit 1.0 Fundamentals of industrial maintenance** 1.1 Definition and aim of maintenance engineering. 1.2 Primary and secondary functions and responsibility of maintenance department. 1.3 Types of maintenance – Preventive, Periodic, Predictive, Condition based monitoring 1.4 Types and applications of tools and equipments used for maintenance. 1.5 Maintenance cost & its relation with replacement economy. 1.6 Service life of equipment.	• Condition monitoring

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Explain the problems resulting from absence of maintenance activities in an industry.
ii. Identify various types of maintenance tools used and list their functions.

b. Mini Project:

i. Visit nearby industries and prepare a report on maintenance activities/procedures used in them.
ii. Collect information and prepare a list about service life of equipment in nearby industry.

CO-2 Prepare preventive and periodic maintenance schedule.

(Approx. Hrs: L=P+T=09)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Differentiate between periodic maintenance and preventive maintenance. SO2.2 Prepare		**Unit 2.0 Preventive and Periodic Maintenance** 2.1 Periodic maintenance – concept and need. 2.2 Degreasing, cleaning and repairing.	• Short-term Scheduling of Planned Maintenance Work

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
maintenance and replacement schedule for the given machine. SO2.3 Use standard data for maintenance and replacement of parts. SO2.4 Explain maintenance and replacement schedule SO2.5 Write procedure for preventive and periodic maintenance for given machine tools.		2.3 Preventive maintenance - concept, need, steps and advantages. 2.4 Maintenance and replacement schedules, Standard data for maintenance and replacement of parts 2.5 Steps/procedure for periodic and preventive maintenance of: i machine tools ii. Pumps. iii. Air compressors. iv. Diesel generating (DG) sets. 2.6 Repair cycle-concept and importance.	• Long-range Maintenance planning.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. List the comparative benefits of periodic and preventive maintenance.

ii. Visit nearby industry and collect data regarding replacement of parts of a particular machine.

b. Mini Project:

i. Identify mechanical based any one equipment in nearby industry which require maintenance, observe the maintenance tasks and prepare a report.

c. Other Activities (Specify):

i. Prepare a preventive maintenance schedule of any workshop equipment of your institute.

CO-3 Use relevant lubrication and lubrication method as per the situation.

(Approx. Hrs: L+P+T=07)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1. Identify different types of wear. SO3.2. Write cause and effects of different kind of wears. SO3.3. Explain the Wear Mechanism. SO3.4. Explain causes, effects and reduction methods of wear.		**Unit 3.0 Wear and Corrosion** 3.1 Basic fundamentals of friction and Wear 3.2 Wear Mechanism. 3.3 Wear- types, causes and their effects. 3.4 Wear reduction methods 3.5 Function, types and applications of Lubricants 3.6 General sketch, working and applications of Lubrication methods. • Screw down grease cup.	• Environmental Important Regulations**.**

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.5. Select appropriate lubricants and lubrication method. SO3.6. Identify different types of corrosion, their causes and method of prevention.		• Pressure grease gun. • Splash lubrication. • Gravity lubrication. • Wick feed lubrication. • Side feed lubrication. • Ring lubrication 3.7 Definition, principle and factors affecting the corrosion. 3.8 Types of corrosion. 3.9 Corrosion prevention methods.	

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Analyze a wear problem in a given machine and identify the kind of wear and its reduction technique.
ii. Explain the effect of impurities on corrosion.
iii. Explain the cathodic protection method with a neat sketch.

b. Mini Project:

i. Prepare a report on types of lubrication used in internal combustion engines to reduce wear.

c. Other Activities (Specify):

i. Present a seminar on various corrosion prevention techniques used in nearby industry.

CO-4 Diagnoses faults in the inoperative machine.

(Approx. Hrs: L+P+T=10)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Write the sequence of fault finding activities. SO4.2 Develop decision trees to diagnose faults in the given equipment SO4.3 Identify the types of faults. SO4.4 Explain the causes of faults in the given machine.		**Unit 4.0 Fault tracing** 4.1 Fault tracing-concept and importance. 4.2 Decision tree-concept, need and applications. 4.3 Sequence of fault finding activities, show as decision tree. 4.4 Draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment like: • Pump • Air compressor.	• Fault finding methods.

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		• Internal Combustion engine. • Boiler. • Electrical motors. 4.5 Types of faults in machine tools and their general causes.	

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. Explain fault tracing concepts and its importance for industrial safety.

ii. Develop decision tree for location of fault for any two: Internal combustion (IC) engine. Boiler. Pump. Machine tool and air compressor.

b. Mini Project:

i. Perform any suitable fault-finding methods in nearby maintenance industry.

c. Other Activities

i. Seminar on various types of fault in machine tool and their general cause in industry.

CO-5 Use recovery reconditioning and retrofitting as per the situation.

(Approx. Hrs: L+P+T=08)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Select method of recovery for the given situation with justification. SO5.2 Explain different methods of recovery. SO5.3 Write the procedure of reconditioning for the given situation SO5.4 Write the procedure of retrofitting for the given situation.		**Unit 5.0 Recovery, Reconditioning and Retrofitting** 5.1. Definition of recovery, reconditioning and retrofitting. 5.2. Methods of recovery and their applications. 5.3. Selection criteria of recovery methods. 5.4. Reconditioning - process, features and advantages. 5.5. Retrofitting - concept, need and applications.	• Reconditioning methods • Types of retrofitting

SW-5 Suggested Sectional Work (SW):

d. Assignments:

i. Write the procedure of retrofitting for the given equipment.

ii. Describe the features of reconditioning.

iii. Describe various method of recovery.

e. Mini Project:

i. Visit to the nearby industry and prepare a report on the retrofitting method used by the industry for min 05 equipment on the basis of given criteria.
ii. Visit to the nearby industry and prepare a report on the recovery and reconditioning method used by the industry for min 05 equipment on the basis of given criteria.

CO-6 Apply Industrial safety and Safety Acts.

(Approx. Hrs: L+P+T=08)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO6.1 Explain the plant for locations and hazards. SO6.2 Prepare Accident and Investigations report. SO6.3 Explain Industrial psychology in accident prevention and Safety trials. SO6.4 Explain various factory Acts. SO6.5 Explain Industrial hygiene and Occupational safety SO6.6 Describe engineering methods of controlling hazards. SO6.7 Identify the code and regulations for worker safety and health.		**Unit 6.0 Industrial Safety and Safety Acts** 6.1 Need, Aim, Objective and Four E's of Industrial Safety. 6.2 Mechanical and electrical hazards-types, causes and preventive steps/procedure 6.3 Personal protective equipments, Survey the plant for locations and hazards 6.4 Education and training in safety, Prevention causes and cost of accident, Industrial psychology in accident prevention and Safety trials 6.5 Accident -causes, types, results and control, Accident reporting and Investigations. 6.6 Features of Factory Act, Introduction of Explosive Act, Boiler Act and ESI Act, Workman's compensation Act 6.7 Industrial hygiene and Occupational safety, Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health Safety and the physical environment 6.8 Engineering methods of controlling chemical hazards, safety and the physical environment 6.9 Control of industrial noise and protection	• Safety by design. • Behavior Based Safety (BBS) • Safety Appraisal & Control Techniques. • Occupational Health and Safety Audits.

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		against it, Code and regulations for worker safety and health.	

SW-6 Suggested Sectional Work (SW):

a. Assignments:

i. List any Ten Safety Rules followed in a nearby company.
ii. List out the Health Provisions under Factories Act / Rule.
iii. List out the Hazards at IT / Electronic Industries.
iv. List out the Hazards at Engineering Industries.
v. List out the Hazards at Textile Industries

b. Mini Project:

i. Preparation of Model Occupational Health & Safety Policy.
ii. Development of a SOP for any one machine.
iii. Prepare PPE Matrix for working at Construction site-activity wise

c. Other Activities (Specify):

i. Identify the Duties of Occupier under Factories Act / Rule.
ii. Case Law on Dock Safety Act, 1986.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Fundamentals of Industrial maintenance	2	3	4	9
II	Preventive and Periodic Maintenance	2	4	6	12
III	Wear and Corrosion	3	4	6	13
IV	Fault Tracing	3	4	6	13
V	Recovery reconditioning and retrofitting	2	4	6	12
VI	Industrial safety and safety acts	2	3	6	11
	Total	**14**	**22**	**34**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*): Not Applicable

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Industrial visits
4. Industrial Training
5. Field Trips
6. Demonstration
7. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)

L) Suggested Learning Resources:

(a) Books :

S. No.	Title	Author	Publisher name and place	ISBN No.	Edition & Year
1	Industrial Maintenance Management	Srivastava, S.K.	S. Chand and Co.	ISBN-10: 8121916631 ISBN-13: 978-8121916639	Third edition 2002
2	Installation, Servicing and Maintenance	Bhattacharya, S.N.	S. Chand and Co.	ISBN-10: 8121908310 ISBN-13: 978-8121908313	2013
3	Occupational Safety Management and Engineering	Willie Hammer	Prentice Hall	ISBN-10: 0136293794 ISBN-13: 978-0136293798	4th Edition 1988
4	Maintenance Planning	White, E.N.	Ashgate Publishing Limited	ISBN-10: 0566021447 ISBN-13: 978-0566021442	Revised edition 1979
5	Industrial Maintenance	Michael E.Brumbach,J Jeffrey A. Clade	Cengage Learning	ISBN-10: 1133131190, ISBN-13:978-1133131199	2nd Edition 2013
6	Industrial Maintenance: Techniques, Stories, and Cases	José Baptista	CRC Press	ISBN-10: 0367341158 ISBN-13: 978-0367341152	1st Edition September 2019
7	Maintenance Engineering Hand book	Higgins, L.R.	Springer	ISBN-10: 1848824718 ISBN-13: 978-1848824713	August 2009
8	Machinery Condition Monitoring: Principles and Practices	Amiya Ranjan Mohanty	CRC Press	ISBN-10: 1466593040 ISBN-13: 978-1466593046	1st Edition December 2014
9	Industrial Safety and Health Management	Ray Asfahl, C., David W. Rieske	Pearson	ISBN-10: 0134630564 ISBN-13: 978-0134630564	7th edition January 2018
10	A Textbook of Reliability and Maintenance Engineering	Alakesh Manna	Dreamtech Press	ISBN-10: 9389698707 ISBN-13: 978-9389698701	February 2020
11	Maintenance Engineering Handbook	Higgins & Morrow	McGraw Hill	ISBN-10: 0070287554 ISBN-13: 978-0070287556	3rd Revised edition April 1977
12	Audels Pumps Hydraulics Air Compressors; A Practical Guide	Audels.	Theo Audel & Co	ASIN: B0024CQIG	January 1949
13	Foundation Engineering Handbook	Winterkorn and Fang	Galgotia Booksource (2010)	ISBN-10: 8193296060 ISBN-13: 978-8193296066	January 2010

S. No.	Title	Author	Publisher name and place	ISBN No.	Edition & Year

(b) Open source software and website address:

List of Software/Learning Websites.

Unit 1- Fundamentals of Industrial maintenance

i. https://nptel.ac.in/courses/110/105/110105094/
ii. https://www.academia.edu/7775550/BASIC_CONCEPTS_IN_INDUSTRIAL_SAFETY_MANAGEMENT
iii. https://shodhganga.inflibnet.ac.in/bitstream/10603/850/8/08_chapter%201.pdf
iv. https://sjce.ac.in/wp-content/uploads/2018/01/SCHEME-AND-SYLLABUS-M.TECH_.MMT-2017-18.pdf
v. https://www.inspirenignite.com/jntuh/jntuh-b-tech-2016-2017-r16-detailed-syllabus-maintenance-safety-engineering/

Unit 2- Preventive and Periodic Maintenance

i. https://www.osha.gov/Publications/complinks/OSHG-HazWaste/3-4.pdf
ii. https://www.slideshare.net/nagoorvali8/unit1-me-6012
iii. https://www.prometheusgroup.com/posts/6-maintenance-planning-principles-for-success-in-planning-scheduling
iv. https://www.scribd.com/doc/230715060/01-Principles-and-Practices-of-Maintenance-Planning
v. http://pit.ac.in/pitnotes/uploads/ME%206012_I.pdf
vi. http://www.brainkart.com/article/Basic-Principles-of-maintenance-planning_5187/
vii. https://www.fieldeagle.com/inspection-software-blog/6-maintenance-planning-principles-for-your-preventative-maintenance-program/

Unit 3- Maintenance policies and preventive maintenance

i. https://www.reliableplant.com/Read/30980/maintenance-safety
ii. https://www.sciencedirect.com/science/article/pii/S1474667015300975
iii. https://www.researchgate.net/publication/288119064_Optimal_maintenance_policies_with_preventive_maintenance
iv. https://www.hindawi.com/journals/isrn/2011/407457/
v. https://en.wikipedia.org/wiki/Maintenance_(technical)
vi. https://www.tandfonline.com/doi/abs/10.1080/00207548908942670?journalCode=tprs20

Unit 5- Recovery reconditioning and retrofitting

i. https://rigquip.com/services/condition-monitoring/?gclid=CjwKCAjwqJ_1BRBZEiwAv73uwFIIVGTE56arUwrDRFzOWeLyl-xjIJCpDx418uIoX0uAi4tXqVCjiBoCtesQAvD_BwE
ii. https://www.bakerhughesds.com/bently-nevada/online-condition-monitoring?_bt=418514858833&_bk=condition%20monitoring&_bm=e&_bn=g&_bg=94161508945&utm_source=google&utm_medium=cpc&utm_campaign=Search%7CAPAC%7CCondition%20Monitoring&utm_term=condition%20monitoring&utm_content=&gclid=CjwKCAjwqJ_1BRBZEiwAv73uwPQCjUO98ue3A3WfC84oydad6RTh9vS1P8LUHvL54is6tM_tqg-tfxoCSfsQAvD_BwE

iii. https://adash.com/?gclid=CjwKCAjwqJ_1BRBZEiwAv73uwOKTU2cZd2gzWbdX3BJtQyYYjkBs0oD1qpa7vxe9SCdTQS7mGSF2CBoCjNgQAvD_BwE
iv. https://en.wikipedia.org/wiki/Condition_monitoring
v. https://www.twi-global.com/what-we-do/services-and-support/asset-management/condition-and-structural-health-monitoring/condition-monitoring
vi. https://www.sciencedirect.com/topics/engineering/condition-monitoring
vii. https://www.sciencedirect.com/topics/engineering/condition-monitoring-system
viii. https://www.semioticlabs.com/resources/what-is-condition-monitoring
ix. https://www.mromagazine.com/features/complete-list-of-condition-monitoring-techniques/
x. https://www.lifetime-reliability.com/cms/free-articles/maintenance-management/condition-monitoring-as-a-reliability-improvement-strategy/
xi. https://www.seebo.com/condition-monitoring/

Unit 6 - Industrial Safety and Safety Acts

i. https://www.draeger.com/en-us_us/Chemical-Industry/Industrial-Maintenance
ii. https://www.slideshare.net/georgesebastian714/industrial-safety-mg-university-notes
iii. https://www.slideshare.net/ShaikhIrshad/project-report-on-health-safety
iv. https://www.hsa.ie/eng/Topics/Managing_Health_and_Safety/Safety_and_Health_Management_Systems/
v. https://tifac.org.in/index.php/8-publication/182-industrial-safety-and-hazard-management-in-general-engineering-fabrication-units
vi. https://www.osha.gov/shpguidelines/hazard-prevention.html
vii. https://greenwgroup.co.in/unsafe-acts-conditions/
viii. https://books.google.co.in/books?id=5wcSqqkJ3AcC&pg=PA80&dq=Accident+preventions,+protective+equipments+and+the+Acts&hl=mr&sa=X&ved=0ahUKEwiL2ebW9IvpAhV94XMBHU0CCNUQ6AEIPjAC#v=onepage&q=Accident%20preventions%2C%20protective%20equipments%20and%20the%20Acts&f=false
ix. https://www.ccohs.ca/oshanswers/prevention/ppe/designin.html
x. https://www.shponline.co.uk/ppe-personal-protective-equipment/
xi. https://labour.gov.in/industrial-safety-health
xii. https://www.hsa.ie/eng/Legislation/List_of_Legislation/
xiii. https://www.hsa.ie/eng/Legislation/Acts/
xiv. https://taxguru.in/corporate-law/safety-acts-indian-international-perspective.html
xv. https://en.wikipedia.org/wiki/Factories_Act,_1948_(India)
xvi. https://pria-academy.org/pdf/OHS/unit6/OHS_Unit-6_Course%20Content_OHS%20Legislation%20in%20India.pdf

(c) Others:

1. Learning Packages
2. Lab Manuals
3. Manufacturers' Manual
4. SOPs

M) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Use relevant maintenance method to maintain the equipments.	3	3	-	3	2	2	2	3	2	3	2	-	3
CO-2 Prepare preventive and periodic maintenance schedule.	3	3	-	3	2	3	2	3	2	3	2	-	3
CO-3 Use relevant lubrication and lubrication method as per the situation	3	3	-	3	2	2	2	3	2	3	2	-	3
CO-4 Diagnoses faults in the inoperative machine	3	3	-	3	2	2	2	3	2	3	2	-	3
CO-5 Use recovery reconditioning and retrofitting as per the situation	3	3	-	3	2	3	2	3	2	3	2	-	3
CO-6 Apply Industrial safety and Safety Acts	3	3	-	3	2	2	2	3	2	3	2	-	3

Legend: 1 – Low, 2 – Medium, 3 – High

N) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-1 Use relevant maintenance method to maintain the equipments.	SO1.1 - SO1.6	NA	Unit-1.0 Fundamentals of Industrial maintenance 1.1,1.2, 1.3, 1.4, 1.5, 1.6	As mentioned in relevant page number
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-2 Prepare preventive and periodic maintenance schedule.	SO2.1 - SO2.5	NA	Unit-2.0 Preventive and Periodic Maintenance 2.1,2.2, 2.3, 2.4, 2.5, 2.6	
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-3 Use relevant lubrication and lubrication method as per the situation	SO3.1 - SO3.6	NA	Unit-3.0 Wear and Corrosion 3.1,3.2, 3.3, 3.4, 3.5, 3.6, 3.7,3.83.9	
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-4 Diagnoses faults in the inoperative machine	SO4.1 - SO4.4	NA	Unit-4.0 Fault Tracing 4.1, 4.2, 4.3, 4.4, 4.5	
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-5 Use recovery reconditioning and retrofitting as per the situation	SO5.1 - SO5.4	NA	Unit-5.0 Recovery reconditioning and retrofitting 5.1,5.2, 5.3, 5.4, 5.5	
PO-1,2,4,5,6, 7,8,9,10 PSO-1,3	CO-6 Apply Industrial safety and Safety Acts	SO6.1 - SO6.7	NA	Unit-6.0 Industrial safety and safety acts 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9	

A) Course Code : 2037681(037)
B) Course Title : Jigs, Fixtures and Press Tool Design
C) Pre-requisite Course Code and Title :
D) Rationale :

The quality and efficiency of any machining operation basically depends upon quality of tools and fixtures used. Tools in turn depend upon the proper shape, size and material of the tools. Productivity and quality of machining operations may further be enhanced by proper and quick mounting of tools and jobs on machines using suitable Jigs and Fixtures. Therefore, this course attempts to develop abilities in students to select a tool of proper size and shape for required machining operation. The design of basic cutting tools, jigs and fixtures are also dealt with in this course.

E) Course Outcomes:

CO-1 Select proper cutting tool insert and tool holders for different machining operations.

CO-2 Select locating and clamping devices for components.

CO-3 Select Jig and Fixture for components and machining operations.

CO-4 Use Press tools and Press tools operations.

CO-5 Select proper Die for forming simple components.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037681(037)	Jigs, Fixtures and Press Tool Design	2	-	1	3
2	Mechanical Engineering	2037691(037)	Jigs, Fixtures and Press Tool Design (Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037681 (037)	Jigs, Fixtures and Press Tool Design	70	20	30	-	-	120
2	Mechanical Engineering	2037691 (037)	Jigs, Fixtures and Press Tool Design (Lab)	-	-	-	30	50	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.

ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Select proper cutting tool insert and tool holders for different machining operations.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Classify different cutting processes. SO1.2 Draw cutting tool geometry of single cutting point tool using given ASA or ORS system. SO1.3 Enlist different properties and composition of the given tool material(s). SO1.4 Interpret ISO designation of the given tool inserts. SO1.5 Select tool holders and inserts for the given component and machining operation with justification. SO1.6 Explain the given tool sharpening method(s).	LE1.1 Demonstrate different types of tools, use and their designation systems. LE1.2 Draw the cutting tool with nomenclature taken for re-sharpening. LE1.3 Demonstrate different tool holders and their use with specific applications. LE1.4 Re-sharpen any one Single Point Cutting Tool as per given specification.	**Unit 1.0 Single point cutting tools and inserts** 1.1 Types of metal cutting process – orthogonal cutting 1.2 Cutting tool Geometry-Single point cutting tool. 1.3 Principles in tool engineering. 1.4 Cutting tool materials - types, composition, properties and applications. 1.5 Carbide inserts -types, ISO -designation and Applications. Other inserts like CBN and PCBN. 1.6 Tool holders for turning, milling machines and CNC machines. 1.7 ISO designations of Tool holders. 1.8 Tool sharpening method for single point cutting tool.	• Tool inserts for milling and drilling operations

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Classify different cutting processes with examples and sketches.

ii. Draw cutting tool geometry of a single cutting point turning tool using given ASA or ORS system.

iii. Enlist different properties and composition of the given tool material(s).

iv. Interpret ISO designation of the given tool inserts.

v. Select tool holders and inserts for the given component and machining operation with justification.
vi. Explain the given tool sharpening method(s).

b. Mini Project:

1. Prepare a list of single point tools with actual photographs which are used to perform different machining operations.
2. Prepare a technical report on specifications, selection of operational parameters and details about tool/work holders used with different cutting tools.
3. Prepare a technical report on specifications, selection of operational parameters and details various tool inserts used to perform different machining operations.
4. Collect various Carbide inserts as per ISO specification.

c. Other Activities (Specify):

1. Watch various videos on you tube or any particular website related to selection of tools and tool inserts used to produce a component.
2. Undertake a market survey of local dealers for tools, equipments; machineries and raw material and prepare a report.
3. Preparation of Wax/Rubber model of various dies/single point cutting tools.

CO-2 Select locating and clamping devices for components.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Explain principle of location with reference to the given work piece. SO2.2 Calculate the Degrees of freedom in the given situation. SO2.3 Select different types of Locators for the given situation with justification. SO2.4 Select different types of Clamping devices for the given situation with justification.	LE2.1 Demonstrate different clamping devices and their use available in the workshop. LE2.2 Demonstrate different locators and their use available in the workshop	**Unit 2.0 Locating and Clamping devices** 2.1 Concept, definition locating and clamping. 2.2 Use of locating and clamping principles on shop floor. 2.3 Degree of freedom concept and importance. 2.4 Locator- Types construction, working and applications. 2.5 Clamping devices - Types construction, working and applications 2.6 Fool proofing and ejecting techniques.	• Swinging clamps, Toggle clamps.

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Explain principle of location with reference to the given work piece.
ii. Calculate the Degrees of freedom in the given situation.
iii. Select different types of Locators for the given situation with justification.
iv. Select different types of Clamping devices for the given situation with justification.
v. Explain how work pieces are located by pre machined (drilled, bored or pierced) holes.
vi. Explain with examples:

- Mechanical Actuation Clamps
- Pneumatic and Hydraulic Clamps
- Vacuum Clamping
- Magnetic Clamping
- Electrostatic Clamping
- Non Mechanical Clamping
- Special Clamping Operations

b. Mini Project:

i. Prepare a list of industrial locating and clamping devices.
ii. Identify and restrict degree of freedom of a given component for designing a clamping/locating device for a given machining operation.
iii. Prepare a report on the usage of Vee block and used for self locating solid and hollow cylindrical jobs.
iv. Collect photographs of, Screw clamps, Strap clamps, Pivoted clamps, hinged clamps, Swinging clamps, Quick action clamps, Power clamps, Non-conventional clamps.

c. Other Activities (Specify):

i. Develop/download Flash/Animations to explain various concepts of clamping and locating devices.
ii. Watch various videos on you tube or any particular website related to locating and clamping devices used to produce a component.
iii. Prepare a chart showing different clamping and locating devices.

CO-3 Select Jig and Fixture for components and machining operations.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Differentiate between given jigs and fixtures. SO3.2 Select Jigs and fixtures for the given component with justification. SO3.3 Explain the design procedure for the given Jig and fixture.	LE3.1 Design a Jig and Fixture for machining of a given simple component. LE3.2 Draw assembly and detail drawing of the designed Jig. LE3.3 Draw assembly and detail drawing of the designed Fixture.	**Unit 3.0 Jigs and Fixtures** 3.1 Concept, definition of jigs and fixtures. 3.2 Difference between jigs and fixtures. 3.3 Jigs- Types construction, working and applications. 3.4 Fixtures - Types construction, working and Applications. 3.5 Design considerations and procedure for Jigs and Fixtures.	• Automated jigs and fixtures

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Differentiate between given jigs and fixtures.
ii. Select Jigs and fixtures for the given component with justification.
iii. Explain the design procedure for the given Jig and fixture.
iv. List basic principles or rules to be followed while designing or planning for supporting.
v. Explain with examples:

- Turning fixtures
- Milling fixtures
- Fixture for grinding
- Fixture for broaching
- Fixture for boring/drilling
- Tapping fixture
- Fixture for welding
- Assembling fixture

b. Mini Project:

i. Prepare a list of industrial jigs and fixtures with their areas of application.
ii. Prepare a list of different drilling jigs with photographs.
iii. Prepare a technical report on welding fixtures, machining fixtures and drilling fixtures.
iv. Prepare a PPT on fixtures used to produce connecting rod.

c. Other Activities (Specify):

1. Watch various videos on you tube or any particular website related to various industrial Jigs and Fixtures used to produce components.

CO-4 Use Press tools and Press tools operations.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Select suitable press tool operation for the given simple press tool component with justification. SO4.2 Calculate press tonnage and centre of pressure for the given press tool component. SO4.3 Prepare scrap strip layout for the given press tool component. SO4.4 Design progressive cutting die for the given simple press tool component.	LE4.1 Design a progressive cutting die for a simple component. LE4.2 Draw assembly and detail drawing of the designed progressive cutting die. LE4.3 Prepare Strip layout of simple component. LE4.4 Demonstrate different parts and uses of Press.	**Unit 4.0 Press tool Design** 4.1 Press working processes-types, sketches and Applications. 4.2 Press tools: types, working, components and their Functions. 4.3 Concept, meaning, definitions and calculations of press tonnage and shut height of press tool. Shear action in die cutting operation. 4.4 Centre of pressure: Concept, meaning, definition, Methods of finding and importance. 4.5 Die clearance: Concept, meaning, definition, Reasons, effects and methods of application. 4.6 Cutting force: Methods to calculate and methods of reducing. 4.7 Shear angle- concept, need and method to give shear angle on punch and die.	• Hydraulic sheet metal forming press

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		4.8 Scrap strip layout: - Concept, importance, method to prepare, and determining percentage stock utilization. 4.9 Types, working, and applications of stock stop, pilots, strippers and knockouts. 4.10 Cutting dies-types and applications. 4.11 Design of progressive cutting die: i. Sketch the component. ii. Prepare scrap strip layout. iii. Calculate tonnage. iv. Determine centre of pressure. v. Determine dimensions of punches die block and die shoe. vi. Prepare sketch of stripper plate. vii. General assembly sketch of punches arrangement, die block, die shoe and stripper plate.	

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. Select suitable press tool operation for the given simple press tool component with justification.
ii. Calculate press tonnage and centre of pressure for the given press tool component.
iii. Prepare scrap strip layout for the given press tool component.
iv. Design progressive cutting die for the given simple press tool component.
v. Explain with schematic diagram:
- Shearing press
- Seaming press
- Straightening press
- Punching press
- Extruding press
- Caining press
- Forging press
- Rolling press
- Bending press.

b. Mini Project:

i. Collect photographs and videos of different types and application of press and press tools.

ii. Prepare a technical report on the types of press:

- According to the Power Source
- According to the Type and Design of Frame
- According to the Position of Frame
- According to the Actions
- According to Mechanism Used to Transmit Power to Ram
- According to Number of Drive Gears
- According to Number of Crankshaft in a Press
- Method of transmission of power from Motor to Crankshaft
- According to the Purpose of Use

c. Other Activities (Specify):

1. Prepare a chart showing photo of various press and press tools.

CO-5 Select proper Die for forming simple components.

(Approx. Hrs L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Calculate bend radius, bend allowance and spring back for the given simple part. SO5.2 Draw labeled sketch of the given die(s). SO5.3 Select die(s) for the given part with justification.	LE5.1 Design a bending die for given component. LE5.2 Draw bending die indicating all parts and dimensions. LE5.3 Estimate blank size for Deep Drawing a simple component.	**Unit 5.0 Bending, Drawing and Forming Dies** 5.1 Bending dies - i. Types. ii. Parts and functions of bending die. iii. Definition, calculations and factors affecting bend radii, bend allowance and spring back. iv. Method to compute bending pressure. v. Types, sketch, working and applications of bending dies. 5.2 Drawing dies-types and method to determine blank size for drawing operation. 5.3 Types, sketch, working and applications of drawing dies (embossing, curling, bulging, coining, swaging and hole flanging). 5.4 Forming dies-terminology, types,	• Stainless steel sheet metal working (Utensils)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		sketch, working and application	

SW-5 Suggested Sectional Work (SW):

a. Assignments:

i. Calculate bend radius, bend allowance and spring back for the given simple part.
ii. Draw labeled sketch of the given die(s).
iii. Select die(s) for the given part with justification.
iv. Explain working and applications of the given drawing die. (embossing, curling, bulging, coining, swaging and hole flanging).
v. Explain working and applications of the given forming die.

b. Mini Project:

i. Prepare a chart showing various dies and operations that can be performed using Bending, Drawing and Forming Dies.
ii. Prepare a list of industrial components which are produced through Bending, Drawing and Forming Dies.

c. Other Activities (Specify):

1. Watch various videos on you tube or any particular website related to Bending, Drawing and Forming Die operations.
2. Give a presentation on Bending, Drawing and Forming Die operations and applications using animations.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Single point cutting tools and inserts	4	6	4	14
II	Locating and Clamping devices	4	4	6	14
III	Jigs and Fixtures	4	4	8	16
IV	Press tool Design	4	4	6	14
V	Bending, Drawing and Forming Dies	4	4	4	12
	Total	**20**	**22**	**28**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Title	Assessment of Laboratory Work (Marks)			30 Marks are allocated for performance under ESE based on following performance parameters:
		Performance		Viva-Voce	
		PRA	PDA		
LE1.1	Demonstrate different types of tools, use and their designation systems.	15	10	5	• Preparation of machine set up
LE1.2	Draw the cutting tool with nomenclature taken for re-sharpening.	15	10	5	

LE1.3	Demonstrate different tool holders and their use with specific applications.	15	10	5	• Setting and operation • Safety measures • Observations and Recording • Interpretation of result and conclusion • Answer to sample questions • Submission of report/sheets in time
LE1.4	Re-sharpen any one Single Point Cutting Tool as per given specification.	15	10	5	
LE2.1	Demonstrate different clamping devices and their use available in the workshop.	15	10	5	
LE2.2	Demonstrate different locators and their use available in the workshop	15	10	5	
LE3.1	Design a Jig and Fixture for machining of a given simple component.	15	10	5	
LE3.2	Draw assembly and detail drawing of the designed Jig.	15	10	5	
LE3.3	Draw assembly and detail drawing of the designed Fixture.	15	10	5	
LE4.1	Design a progressive cutting die for a simple component.	15	10	5	
LE4.2	Draw assembly and detail drawing of the designed progressive cutting die.	15	10	5	
LE4.3	Prepare Strip layout of simple component.	15	10	5	
LE4.4	Demonstrate different parts and uses of Press	15	10	5	
LE5.1	Design a bending die for given component.	15	10	5	
LE5.2	Draw bending die indicating all parts and dimensions.	15	10	5	
LE5.3	Estimate blank size for Deep Drawing a simple component.	15	10	5	

* Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend:PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30** Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration
11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
12. Brainstorming
13. Others

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	Tool Design	Cyrll Donaldson	Mcgraw Hill Education	(2000), ISBN: 9780070153929, 0070153922
2.	Tool Engineering, Jigs and Fixture	Albert Atkins	McGraw-Hill	(2009),ISBN: ISBN/ASIN: 1151454966
3.	Fundamentals of Tool Engineering Design	S. K. Basu	Oxford Ibh	(1979),ISBN: 9788120400160
4.	Tool Engineering and Design	G. H. Nagpal	Khanna Publication	(2003),ISBN: 817409203X
5.	Machine tool and Tool Design	P. C. Sharma	S. Chand Publishing	(2012), ISBN: 9788121923620

*Latest edition of all above books should be referred

(b) Open source software and website address:

3. https://www.youtube.com/watch?v=Mn9jpqI8rao
4. https://www.youtube.com/watch?v=bUrp8JMRwx4andvl=en
5. https://www.youtube.com/watch?v=qaG_vxsfLUg
6. https://www.youtube.com/watch?v=EgTzD_8dUFc
7. https://www.youtube.com/watch?v=CrWxJ58la1E
8. https://www.youtube.com/watch?v=Pb20Rkx25yA
9. https://www.youtube.com/watch?v=Hp7UC5ite5M
10. https://www.youtube.com/watch?v=lcrK2Po8fJI
11. https://www.youtube.com/watch?v=_E1GCE2dDcY
12. https://www.youtube.com/watch?v=7yzvno4AvKw
13. https://www.youtube.com/watch?v=yoUxqeAN0So
14. https://www.youtube.com/watch?v=_r7djWX8X34
15. https://www.youtube.com/watch?v=Us7kjBmRL-Q
16. https://www.youtube.com/watch?v=S9qzJat3Mzk
17. https://www.youtube.com/watch?v=I71YrXafg0o
18. https://www.youtube.com/watch?v=wulJZzORm3wandpbjreload=10
19. https://www.youtube.com/watch?v=i5ZGSMXw5nU
20. https://www.youtube.com/watch?v=WJ_VlWd0EsA
21. https://www.youtube.com/watch?v=93-VH01ACB4
22. https://www.youtube.com/watch?v=MtNTFvP0uI
23. https://www.youtube.com/watch?v=eqKa2gv9Kx0
24. https://www.youtube.com/watch?v=m8EoGASM0SI
25. http://ignou.ac.in/upload/bme059unit-3.pdf
26. http://www.ignou.ac.in/upload/jig.pdf

(c) Others:

1. Learning Packages
2. Manufacturers' Manual
3. Manufacturers' Catalog
4. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Single point cutting tools	Turning tool, facing tool, threading tool, shaper tool	LE 1.1 to LE1.4
2	Tool inserts	WC, Coated WC, CBN, PCBN	
3	Drill Bits	M12/M16/M20 size	
4	Grinding Machine	Grinder Size 100 mm min.	
5	Tool holders	Milling Cutter mandrill, Drill tool holder, Tool post of Lathe machine (Qty one each)	
6	Clamping devices	for drilling machine, Milling machine, Chucks (Qty one each)	LE 2.1, LE2.2
7	Locators	Pin type, round head type, flat type	
8	Press tools	Different Press tools	LE 4.1 to LE4.4

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Select proper cutting tool insert and tool holders for different machining operations.	2	3	3	2	1	1	2	2	1	2	-	2	2
CO-2 Select locating and clamping devices for components.	2	3	3	2	1	1	1	2	1	2	-	2	2
CO-3 Select Jig and Fixture for components and machining operations.	2	3	3	2	2	1	2	2	2	2	-	2	3
CO-4 Use Press tools and Press tools operations.	2	3	3	2	2	1	2	2	2	2	-	2	3
CO-5 Select proper Die for forming simple components.	2	3	3	2	2	1	2	2	2	2	-	2	3

Legend:1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-1 Select proper cutting tool insert and tool holders for different machining operations.	SO1.1 SO1.2 SO1.3 SO1.4 SO1.5 SO1.6	LE1.1-LE1.4	Unit 1.0 Single point cutting tools and inserts 1.1-1.8	As mentioned in relevant page number
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-2 Select locating and clamping devices for components.	SO2.1 SO2.2 SO2.3 SO2.4	LE.2.1-LE2.2	Unit 2.0 Locating and Clamping devices 2.1-2.6	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-3 Select Jig and Fixture for components and machining operations.	SO3.1 SO3.2 SO3.3	LE3.1-LE3.3	Unit 3.0 Jigs and Fixtures 3.1-3.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-4 Use Press tools and Press tools operations.	SO4.1 SO4.2 SO4.3 SO4.4	LE4.1-LE4.4	Unit 4.0 Press tool Design 4.1-4.11	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-5 Select proper Die for forming simple components.	SO5.1 SO5.2 SO5.3	LE5.1-LE5.3	Unit 5.0 Bending, Drawing and Forging Dies 5.1-5.4	

A) Course Code : 2037682(037)

B) Course Title : Advanced Manufacturing Processes

C) Pre-requisite Course Code and Title :

D) Rationale :

Cost, time and product quality are the main factors which play major role in manufacturing. With the advancements, newer difficult to machine materials and complex shapes with high surface finish is the demand of the manufacturing sector and conventional manufacturing processes alone cannot cater this need. To machine these materials and also the complex geometries with very high surface finish, the student must have the knowledge of non – conventional machining, casting, metal forming, joining processes along with special conventional manufacturing processes like gear manufacturing, surface finishing, Broaching, boring etc. This course is aimed to make the students aware of basic understanding of these processes and to select the relevant machining process which suits for the given job.

E) Course Outcomes:

CO-1 Select the non conventional machining process to produce complex machine components.

CO-2 Explain the advancements in casting process.

CO-3 Explain different advanced welding and metal forming processes.

CO-4 Select relevant machining process to produce gears.

CO-5 Apply recent trends in Computer Aided Manufacturing to produce components effectively.

F) Scheme of Studies:

S. No	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037682 (037)	Advanced Manufacturing Processes	2	-	1	3
2	Mechanical Engineering	2037692 (037)	Advanced Manufacturing Processes(Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credit

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S. No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037682 (037)	Advanced Manufacturing Processes	70	20	30	-	-	120
2	Mechanical Engineering	2037692 (037)	Advanced Manufacturing Processes(Lab)	-	-	-	30	50	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Select the non conventional machining process to produce complex machine components.

(Approx. Hrs: L=P+T=16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Describe recent trends and challenge in manufacturing. SO1.2 Explain electro discharge machining. SO1.3 Suggest appropriate advance machining process for a given application with justification. SO1.4 Identify safe practices adopted during the given advance manufacturing process.	LE1.1 Prepare the job using electrical discharge machining. LE1.2 Prepare the job using electrochemical machining. LE1.3 Prepare a job using abrasive jet machining. LE1.4 Prepare a job using Electron beam machining.	**Unit 1.0 Non-Conventional Machining Processes** 1.1 Need of advance manufacturing, manufacturing trends and challenges, manufacturing aspects. 1.2 Types of non conventional machining processes and energy source utilized. 1.3 Working principle, setup, Process parameter Advantages, limitation and application and safe practices of- Electrical discharge machining (EDM), Wire Electrical discharge machining (WEDM), Electrochemical Machining (ECM), Plasma arc machining (PAM), Abrasive jet machining (AJM), Ultrasonic Machining (USM), Electron Beam Machining (EBM), Laser beam machining (Cutting)	• Electro Chemical Grinding

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Explain the recent trends in non-conventional manufacturing processes.
ii. Compare the conventional manufacturing with advanced manufacturing process.

iii. Explain working and setup of the given non-conventional machining process with schematic diagram.
iv. Describe advantages, limitations and applications of the given non - conventional machining method.
v. Recommend the process parameters for the given job and non-conventional machining process with justification.

b. Mini Project:

1. Prepare a list of industrial components which are produced through non conventional machining processes and describe the manufacturing procedure of the same in brief.
2. Prepare a technical report on specifications, operating procedure, selection of operational parameters, details about tool/work holders used, machine setting, product details being manufactured using Non-conventional machining processes.

c. Other Activities (Specify):

1. Develop/download Flash/Animations to explain various concepts of advance machining processes.
2. Watch various videos on you tube or any particular website related to advanced machining processes used to produce a component.

CO-2 Explain the advancements in casting process.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Design the riser and runner for casting. SO2.2 Explain the Evaporative pattern casing process. SO2.3 Describe the Shell molding process. SO2.4 Describe the continuous casting process for the given component. SO2.5 Describe the centrifugal casting process for the given component.	LE2.1 Design a gating system for given application. LE2.2 Prepare a casting product using shell molding process. LE2.3 Prepare a casting product using high pressure die casting.	**Unit 2.0 Advanced Casting Processes** 2.1 Metal casting basics, Gating and riser design, 2.2 Working principle, set up, process parameters, Advantages, limitations and applications of Evaporative pattern casing process (EPC), Centrifugal and pressure die casting, Slush casting, Hybrid EPC process, Vacuum EPC, Shell Molding Process.	• Plastic Molding Processes

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Identify the factors affecting the runner and riser design.
ii. List the recent trends in manufacturing process.
iii. Describe advantages, limitations and applications of the given advanced casting method.
iv. Compare the Hybrid EPC and Vacuum EPC.
v. Explain working and setup of the given advanced casting process with schematic diagram.

b. Mini Project:

i. Prepare a list of industrial components which are produced through advanced casting processes and describe the manufacturing procedure of the same in brief.

ii. Prepare a technical report on specifications, operating procedure, selection of operational parameters, machine setting, product details being manufactured using advanced casting processes.

c. Other Activities (Specify):

i. Develop/download Flash/Animations to explain various concepts of advanced casting processes.
ii. Watch various videos on you tube or any particular website related to advance casting processes used to produce a component.
iii. Prepare a chart showing the methods for identifying various casting defects.

CO-3 Explain different advanced welding and metal forming processes.

(Approx. Hrs: L+P+T=16)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Explain the given advance welding method. SO3.2 Explain the given advance forming method. SO3.3 Select relevant welding method for the given component. SO3.4 Select relevant forming method for the given component.	LE3.1 Prepare a job of a given design using electron beam welding. LE3.2 Prepare a job of a given design using laser beam welding. LE3.3 Prepare a job of a given design using Ultrasonic welding.	**Unit 3.0 Advanced Welding and Forming Processes** 3.1 Working principle, setup, Process parameter Advantages, limitation and application- Orbital TIG welding, Electron beam welding (EBW), Laser beam welding (LBW), ultrasonic welding. Industrial adhesive and Adhesive bonding 3.2 Advanced Metal forming- High energy rate forming, Electro-magnetic forming, explosive forming, Electro-hydraulic forming, Stretch forming, Contour roll forming.	• Stretch forming applications

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Identify the factors affecting the runner and riser design.
ii. List the recent trends in advanced welding and forming processes.
iii. Describe advantages, limitations and applications of the given advanced forming/welding method.
iv. Compare the stretch forming and Contour roll forming.
v. Explain working and setup of the given advanced welding and forming processes with schematic diagram.

b. Mini Project:

i. Prepare a list of industrial adhesive with their areas of application.
ii. Prepare a list of industrial components which are produced through advanced welding and forming process(s) and describe the manufacturing procedure of the same in brief.

iii. Prepare a technical report on specifications, operating procedure, selection of operational parameters, machine setting, product details being manufactured using advanced welding and forming process(s).

c. Other Activities (Specify):

1. Develop/download Flash/Animations to explain various concepts of advanced welding and forming processes.
2. Watch various videos on you tube or any particular website related to advance casting processes used to produce a component.
3. Prepare a chart showing the methods for identifying various welding defects.

CO-4 Select relevant machining process to produce gears.

(Approx. Hrs: L+P+T=14)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Draw and explain the gear manufacturing process. SO4.2 Explain the gear finishing process. SO4.3 Recommend the process parameter for gear manufacturing and finishing process with justification.	LE4.1 Perform gear shaping operation using pinion cutter. LE4.2 Perform gear shaping operation using Rack cutter. LE4.3 Produce gear using hobbing process.	**Unit 4.0 Gear Manufacturing** 4.1 Types of gear and Gear manufacturing methods. 4.2 Gear Hobbing- Types and working principle of gear hobbing, Advantages, limitations and application. 4.3 Gear Shaping-Gear Shaping by pinion cutter, Gear Shaping by rack cutter, Advantages, limitation and application of both the methods and comparison of gear hobbing and gear shaping. 4.4 Gear Finishing methods- Need of gear finishing and different methods of gear finishing like: a) Gear shaving b) Gear grinding c) Gear burnishing d) Gear lapping e) Gear honing f) Gear tooth rounding	• Helical gear manufacturing

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. List various gear manufacturing processes.
ii. Describe advantages, limitations and applications of the given gear manufacturing method.
iii. Compare gear shaping and gear hobbing.
iv. Explain working and setup of the given gear manufacturing method with schematic diagram.
v. Explain the given gear finishing method with advantages and limitations.

b. Mini Project:

i. Prepare list of various gears with their areas of application.

ii. Visit a gear manufacturing industry and prepare a technical report on specifications, operating procedure, selection of operational parameters, machine setting, details of tool and work holding devices used to manufacture various gears.

c. Other Activities (Specify):

1. Watch various videos on you tube or any particular website related to processes used to produce and finish gears.
2. Prepare a chart showing photo of various gears.

CO-5 Apply recent trends in Computer Aided Manufacturing to produce components effectively.

(Approx. Hrs: L+P+T=21)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Explain the merits of the given Additive manufacturing process. SO5.2 Explain the construction and working of the given 3D printer /Rapid prototyping machine. SO5.3 Explain the procedure to print the given component(s) using 3D printer/Rapid prototyping machine. SO5.4 Compare Fixed and flexible Automation on given parameters with justification. SO5.5 Justify the use of Group Technology for the given situation. SO5.6 Justify the use of FMS in the given situation. SO5.7 Manipulate a Robotic system for the given manufacturing environment	LE5.1 Print a simple and a complex component modeled in LE2.1 and 2.2 of Computer Aided Modeling & Manufacturing course using 3D printer LE5.2 Prepare a simple program for manipulation of standard components using Robotic arm	**Unit 5.0 Recent trends in CAM** 5.1 Additive manufacturing: 3D printing, Rapid prototyping. 5.2 Construction and working of 3D printer. 5.3 Type and properties of material for 3D printer and Rapid prototyping machine. 5.4 File format: STL (Stereo Lithography). 5.5 3D printer software: part import, orientation, processing and printing. 5.6 Computer Integrated Manufacturing (CIM): concept, definition, areas covered and benefits. 5.7 Automation-Define, need of automation, high and low cost automation, examples of automations. 5.8 Types of Automation - Fixed (Hard) automation, programmable automations and Flexible automations (Soft). 5.9 Group Technology-concept, basis for developing part families, part classification and coding with example, concept of cellular manufacturing. Advantages and limitations.	• CAD-CAM integration

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		5.10 Flexible Manufacturing System (FMS): concept, evaluation, main elements and their functions, layout and its importance, applications. 5.11 Robot: definition, terminology, classification and types 5.12 Components of Robot: manipulator, end effectors, actuators, sensors, controller, processor, software and applications.	

SW-5 Suggested Sectional Work (SW):

a. Assignments:

i. Explain the merits of popular Additive manufacturing processes.
ii. Explain the construction and working of the given 3D printer.
iii. Explain the procedure to print the given component(s) using 3D printer/Rapid prototyping machine.
iv. Justify the use of FMS in the given situation.
v. List various industrial applications of robots.

b. Mini Project:

i. Prepare list of industrial robots and their usage.
ii. 3D printing/RPT: Each student will visit a nearby institute/industry. Collect information regarding working, construction, specification of 3D printer/Rapid prototyping machine and prepare a report.
iii. Collect information about the different materials available for 3D printing their cost and mechanical properties.

c. Other Activities (Specify):

1. Prepare power point presentation (including animation) for Flexible Manufacturing Systems/Cellular Manufacturing/ Group Technology.
2. Visit institute/industry having FMS/3D printer/Rapid Prototyping machine.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Non-Conventional Machining Processes	4	4	6	14
II	Advanced Casting Processes	2	4	6	12
III	Advanced Welding and Forming Processes	4	4	8	16

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
IV	Gear Manufacturing	4	4	4	12
V	Recent trends in CAM	4	4	8	16
	Total	**18**	**20**	**32**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Title	Assessment of Laboratory Work (Marks)			30 Marks are allocated for performance under ESA based on following performance parameters:
		Performance		Viva-Voce	
		PRA	PDA		
LE1.1	Prepare the job using electrical discharge machining.	15	10	5	• Preparation of machine set up • Setting and operation • Safety measures • Observations and Recording • Interpretation of result and conclusion • Answer to sample questions • Submission of report/sheets in time
LE1.2	Prepare the job using electrochemical machining.	15	10	5	
LE1.3	Prepare a job using abrasive jet machining.	15	10	5	
LE1.4	prepare a job using Electron beam machining.	15	10	5	
LE2.1	Design a gating system for given application.	15	10	5	
LE2.2	Prepare a casting product using shell molding process.	15	10	5	
LE2.3	Prepare a casting product using high pressure die casting.	15	10	5	
LE3.1	Prepare a job of a given design using electron beam welding	15	10	5	
LE3.2	Prepare a job of a given design using laser beam welding.	15	10	5	
LE3.3	Prepare a job of a given design using Ultrasonic welding.	15	10	5	
LE4.1	Perform gear shaping operation using pinion cutter.	15	10	5	
LE4.2	Perform gear shaping operation using Rack cutter.	15	10	5	
LE4.3	Produce gear using hobbing process.	15	10	5	
LE5.1	Print a simple and a complex component modeled in LE2.1 and 2.2 of Computer Aided Modeling & Manufacturing course using 3D printer	15	10	5	
LE5.2	Prepare a simple program for manipulation of standard components using Robotic arm	15	10	5	

* Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30** Marks as per assessment scheme

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration
11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
12. Brainstorming
13. Others

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	Manufacturing Technology	R. K. Rajput	CBS,2 edition, 2006, ISBN-10: 8123908946 ISBN-13:	(2010),ISBN: 9788123908946
2.	Manufacturing Process	O. P. Khanna	Dhanpat Rai Publishing Company Private Limited, New Delhi	(2013),ISBN: 9383182040
3.	Introduction to Basic Manufacturing Processes and Workshop Technology	Rajender Singh	New Age International	(2006), ISBN: *9788122423167*
4.	Production Technology	P. C. Sharma	S. Chand Publishing	(1999) ISBN: *9788121901116*
5.	Elements of Workshop Technology Vol. I	Hajra Choudhury	Media Promoters and Publishers Pvt Ltd.	(2008) ISBN: 9788185099149
6.	A Course In Workshop Technology (Manufacturing Processes Vol. 1)	B. S. Raghuwanshi	Dhanpat Rai and Co., New Delhi	(2014) ISBN:
7.	Manufacturing Technology Vol. I & II	P. N. Rao	McGraw Hill	2016) ISBN: 9781259062575
8.	CAD/CAM: Computer-Aided Design and Manufacturing	Groover	Pearson Education India	*(2006*) ISBN: 9788177584165

*Latest edition of all above books should be referred

(b) Open source software and website address:

1. Advance Manufacturing- https://nptel.ac.in/courses/112107078/
2. Gating and riser design- https://www.youtube.com/results?search_query=Gating+and+riser+design
3. Evaporative pattern casing process- https://www.youtube.com/results?search_query=Evaporative+pattern+casing+process
4. Centrifugal and pressure die casting- https://www.youtube.com/results?search_query=Centrifugal+and+pressure+die+casting
5. Hybrid EPC process - https://www.youtube.com/results?search_query=Hybrid+EPC+process

6. Electron beam welding- https://www.youtube.com/results?search_query=Electron+beam+welding
7. laser beam welding- https://www.youtube.com/results?search_query=Laser+beam+welding+
8. metal forming- https://www.youtube.com/results?search_query=metal+forming
9. advance machining process- https://www.youtube.com/results?search_query=advance+machining+process
10. Gear manufacturing - https://www.youtube.com/results?search_query=Gear+manufacturing+

Flexible Manufacturing System

11. https://www.autodesk.com/products/fusion-360/blog/computer-aided-manufacturing-beginners/
12. https://www.youtube.com/watch?v=JrmYZIrcuMs
13. https://www.youtube.com/watch?v=7L0VbqrNDAY
14. https://www.youtube.com/watch?v=FdipJNG_vV8
15. https://czjyjc.en.made-in-china.com/?gclid=CjwKCAiAlajvBRB_EiwA4vAqiMrva9tozNpSAsfjQdD6-d4Ju3vZ2hFfamuwJsQX-zPLu2zpPF244hoCzYcQAvD_BwE
16. https://www.youtube.com/watch?v=MwgobIVj4fU

Robotics

17. https://www.youtube.com/watch?v=Br2eEpiiwvU
18. https://www.youtube.com/watch?v=YGtg4OPSFhc
19. https://www.youtube.com/watch?v=nlrr5b1XWoY
20. https://www.youtube.com/watch?v=q-XHWifmAFA

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Manufacturers' Catalog
5. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Electron beam welding machine	Suitable for lab work	LE3.1
2	laser beam welding	Suitable for lab work	LE3.2
3	Ultrasonic welding	Suitable for lab work	LE3.3
4	electrical discharge machining machine	Suitable for lab work	LE1.1
5	electrochemical machining machine	Electro Chemical Machine: Tool area 10mmx30mm or 15mmx20mm; Cross Head Stroke 40 mm; Supply Single phase 230 V. A.C.; Electrical Output Rating 0 - 100 Amps and voltage from 0 - 25 V DC; Tool Feed Rate In the range of 0.2 to 1 mm / min.; Machining Time 0 to 1999 seconds, variable through touch screen.; Display For voltage, output current; feed rate electrolyte temp; Protection For Current overload, short circuit; USB Port For data storage; pulsating facility On time 100 microseconds to 1 second variable, off time 100 microseconds to 1 second variable, plus amplitude 1v-10v variable; LCD	LE1.2

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
		display For forward and reverse, feed rate settings, feed rate; Tool Area 300 square mm;	
6	Abrasive jet machining machine	Suitable for lab work	LE1.3
7	Electron beam machining machine	Suitable for lab work	LE1.4
8	3D Printer	10 x 10 x 10 heated bed 3D printer with PLA and ABS material.	LE5.1
9	Robotic Arm	6 degree of freedom with programming facility	LE5.2

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Select the non conventional machining process to produce complex machine components.	2	3	3	2	1	1	2	2	1	2	-	2	2
CO-2 Explain the advancements in casting process.	2	3	3	2	1	1	1	2	1	2	-	2	2
CO-3 Explain different advanced welding and metal forming processes.	2	3	3	2	2	1	2	2	2	2	-	2	3
CO-4 Select relevant machining process to produce gears.	2	3	3	2	2	1	2	2	2	2	-	2	3
CO-5 Apply recent trends in Computer Aided Manufacturing to produce components effectively.	2	3	3	2	2	1	2	2	2	2	-	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-1 Select the non conventional machining process to produce complex machine components.	SO1.1 - SO1.4	LE1.1-LE1.4	Unit 1.0 Non-Conventional Machining Processes 1.1-1.3	As mentioned in relevant page number
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-2 Explain the advancements in casting process.	SO2.1 - SO2.5	LE.2.1-LE2.3	Unit 2.0 Advanced Casting Processes 2.1-2.2	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-3 Explain different advanced welding and metal forming processes.	SO3.1 - SO3.4	LE3.1-LE3.3	Unit3.0 Advanced Welding and Forming Processes 3.1-3.2	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-4 Select relevant machining process to produce gears.	SO4.1 SO4.2 SO4.3	LE4.1-LE4.3	Unit-4.0 Gear Manufacturing 4.1-4.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-5 Apply recent trends in Computer Aided Manufacturing to produce components effectively.	SO5.1 - SO5.7	LE5.1 LE5.2	Unit-5.0 Recent trends in CAM 5.1-5.12	

A) Course Code : 2037683(037)

B) Course Title : Industrial Refrigeration

C) Pre-requisite Course Code and Title :

D) Rationale :

The study of Industrial refrigeration concepts is part of, a comprehensive study of components associated with medium and low temperature machinery and defrosts cycles, a further study of the unique circuitry involved and hands on experience with various commonly used commercial refrigeration equipment. The course affords the student with a viable and important overview of what makes the Industrial and Commercial Refrigeration Profession unique in the HVAC Industry.

E) Course Outcomes:

CO-1 Apply the concepts of refrigeration to Food Preservation.

CO-2 Analyze commercial structures for refrigeration.

CO-3 Apply the concepts of Low Temperature Refrigeration.

CO-4 Apply the concepts of refrigeration to Industrial Applications.

CO-5 Use Air-Conditioning in transport systems.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037683(037)	Industrial Refrigeration	2	-	1	3
2	Mechanical Engineering	2037693(037)	Industrial Refrigeration(Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037683(037)	Industrial Refrigeration	70	20	30	-	-	120
1	Mechanical Engineering	2037693(037)	Industrial Refrigeration(Lab)	-	-	-	30	50	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Apply the concepts of refrigeration for Food Preservation.

(Approx. Hrs: L+P+T=15)

Session Outcomes (SO	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Explain different refrigeration method in food preservation. SO1.2 Explain the freezing methods for food preservation. SO1.3 Select the freezing method for preserving the given food with justification. SO1.4 Describe use of refrigeration in cold storage and commercial cabinets.	LE-1.1 Determine the performance parameters of food preservation test rig. LE-1.2 Identify the performance parameters of cold storage test rig. LE-1.3 Determine the performance of cold storage using test rig.	**Unit 1.0 Food Preservation systems** 1.1 Refrigeration system for food preservation 1.2 Factors contributing to food spoilage, causes of food spoilage, methods of food preservation, 1.3 Methods of food preservation like heat processing, dehydration, chemical preservation, oils and spices, canning and pasteurization, freezing. 1.4 Freezing for preservation of food- slow or sharp freezing, Quick freezing, Immersion freezing, Indirect contact freezing, Air blast freezing. 1.5 Milk chilling plant, Cold storage and commercial cabinets for different applications like reach in refrigerators, walk in cooler, display cases, refrigerated vehicles.	• Enumerate COP of refrigeration system you have seen. • Refrigerated storage of unfrozen foods

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Enumerate the factors contributing to food spoilage refrigeration
ii. Explain the refrigeration methods for perishable items.

b. Mini Project:

i. Visit cold storage unit (at least 03) and prepare report on the basis of given criteria like comparative study, methods, etc
ii. Visit of preservative unit of any departmental store (05) and prepare report on the basis of given criteria like comparative study, methods, etc

CO-2 Analyze commercial structures for refrigeration.

(Approx. Hrs: L+P+T=22)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Describe air-conditioning of houses, offices, hotels and restaurants. SO2.2 Describe air-conditioning of theatres and auditoriums SO2.3 Explain air-conditioning use of refrigeration in hospital and medical application. SO2.4 Select refrigeration method for given commercials structure. SO2.5 Explain HVAC system types. SO2.6 Name high impact energy code items related to HVAC equipment and controls. SO2.7 List the steps in verifying fan power calculations	LE2.1 Determine performance parameters on air-conditioning test rig. LE2.2 Determine performance parameters on air-conditioning of fixed volume cabinet LE2.3 Identify important HVAC controls, including economizers. LE2.4 Determine fan power	**Unit 2.0 Commercial Structures refrigeration** 2.1 Commercial HVAC SYSTEM - Air-conditioning for thermal and humidity comfort, Ventilation, Space pressurization and its working 2.2 Type of HVAC systems – single split system ,multi split system ,VRF AND VRV SYSTEM 2.3 Air conditioning - Refrigerant-based, Non-refrigerant: 2.4 System Capacity Sizing, Ventilating-Mechanical ventilation, natural ventilation, hvac – economizers “free cooling” 2.5 Air-conditioning of houses, offices, hotels , restaurants, departmental stores and shopping complex. 2.6 Air-conditioning of theatres and auditoriums, 2.7 Air-conditioning of hospitals and medical establishment 2.8 Energy code items related to hvac equipment and controls	• Thermoelectric refrigeration • Magnetic refrigeration

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Enumerate the factors affecting to determine the capacity of air conditioning unit.

ii. Describe the factors for selecting HVAC for the given commercial building.

b. Mini Project:

i. Visit of air-conditioning unit of any theatres and auditoriums. (02) and prepare a report on the basis of given criteria,

ii. Visit of air-conditioning unit of any hospitals. (02) and prepare a report on the basis of given criteria,

CO-3 Apply the concepts of Low Temperature Refrigeration.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Select	LE3.1 Determine the	**Unit 3.0 Low Temperature**	• Cryogenic

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
engineering material as per the given situation with justification . SO3.2 Select cryogenic fluid for the given situation with justification. SO3.3 Explain supper conducting material. SO3.4 Describe the properties of engineering materials at cryogenic temperatures. SO3.5 List the applications of cryogenic systems.	properties of cryogenic fluid. LE3.2 Determine the properties of engineering material at cryogenic temperature.	**Refrigeration** 3.1 Meaning and definition of cryogenics, Importance of cryogenics studies 3.2 Properties of engineering materials at cryogenic temperatures, mechanical properties ,thermal properties, electric & magnetic properties, 3.3 Super conducting materials ,thermo electric materials, composite materials, 3.4 Properties of cryogenic fluids. 3.5 Applications of cryogenic systems: Super conductive devices such as bearings, motors, magnets, space technology, cryogenics in biology and medicine, food preservation and industrial applications.	Hazards, Physical hazards, Chemical hazards, Physiological hazards

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Give the different safety measures to avoid Cryogenic Hazards.

ii. Compare the properties of different materials under cryogenic temperature.

b. Mini Project:

i. Visit and submit report on cryogenic plant for air liquefaction.

CO-4 Apply the concepts of refrigeration to Industrial Applications.

(Approx. Hrs: L+P+T=15)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Explain the principles of ice production. SO4.2 Describe the principles of ice manufacturing. SO4.3 Select the water treatment method for making ice with justification. SO4.4 Describe the refrigeration	LE4.1 Determine performance parameters on ice plant tutor. LE4.2 Determine performance parameters of air conditioning tutor. LE4.3 Determine performance of water chilling plant. LE4.4 Check & Adjust of different	**Unit-4.0 Ice production and Industrial Applications** 4.1 Introduction, principles of ice production, different methods of ice manufacturing 4.2 Treatment of water for making ice, Brines, freezing tanks, ice cans, quality of ice. 4.3 Types and design of industrial icemakers- Block ice made in plants,	• Non conventional Refrigeration System:- Thermo-Acoustic, Magnetic, Vortex-tube, Pulse-Tube Refrigeration

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
methods for the given application. SO4.5 Select the refrigerant for breweries with justification.	refrigerant controls, floats, Solenoid Valves, Safety switches, LE4.5 Charge refrigerants & check performance	Shell ice ,Flake ice, Tube ice, Plate ice and Slush, slurry or binary ice. 4.4 Production of dry ice. 4.5 Ice-cream manufacturing, refrigeration for breweries, selection of refrigerant for breweries. Air conditioning in textile and photographic industries 4.6 Refrigeration in the chemical industry	

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. Draw the various processes on psychrometric chart and write their uses in various air conditioning systems

ii. Identify the psychrometric process occurred in air conditioning system.

b. Mini Project:

i. Make a tutorial model of mini ice cream plant.

c. Other Activities

i. Visit the air conditioning system in textile and photographic industries

CO-5 Use Air-Conditioning in transport systems.

(Approx. Hrs: L+P+T=15)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Estimate the heating load for the automobile air conditioning. SO5.2 Calculate the heat load of railway air-conditioning. SO5.3 Calculate the marine air conditioning cooling load for the given space. SO5.4 Select the air-conditioning system for the air craft with justification. SO5.5 Identify the elements effecting railway air-conditioning	LE5.1 Determine the cooling load for automobile car. LE5.2 Estimate the total heat load of practical workshop using anemometer, calorimeter, sling psychrometer LE5.3 Determine the properties of air by using sling psychrometer.	**Unit 5.0 Transport Air Conditioning** 5.1 Introduction, automobile air conditioning. 5.2 Refrigeration systems for transport refrigeration 5.3 Railway air-conditioning, 5.4 Marine air conditioning, 5.5 Aircraft air conditioning 5.6 Application of refrigeration in pharmaceutical & medical needs like storage and containment during transportation	• Refrigerated Trucks

SW-5 Suggested Sectional Work (SW):

a. Assignments:

i. Visit the nearby automobile workshop center and list out the details of air conditioning system in use.
ii. Identify application of refrigeration in Medical Industry and submit a report

b. Mini Project:

i. Visit the nearby railway air conditioning maintenance workshop and prepare the report.
ii. Visit websites and search on different air craft refrigeration and prepare the report

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Food Preservation systems	4	5	5	14
II	Commercial Structures refrigeration	2	6	6	14
III	Low Temperature Refrigeration	2	6	6	14
IV	Ice Production and Industrial Applications	4	5	5	14
V	Transport Air Conditioning	2	6	6	14
	Total	**14**	**28**	**28**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Determine performance parameters on food preservation test rig.	15	10	5
LE1.2	Identify the performance parameters of cold storage test rig.	15	10	5
LE1.3	Determine the performance of cold storage using test rig.	15	10	5
LE2.1	Determine performance parameters on air-conditioning test rig.	15	10	5
LE2.2	Determine performance parameters on air-conditioning of fixed volume cabinet	15	10	5
LE2.3	Identify important HVAC controls, including economizers.	15	10	5
LE2.4	Determine fan power	15	10	5
LE3.1	Determine the properties of cryogenic fluid.	15	10	5
LE3.2	Determine the properties of engineering material at cryogenic temperature.	15	10	5
LE4.1	Determine performance parameters on ice plant tutor	15	10	5
LE4.2	Determine performance parameters of air conditioning tutor	15	10	5
LE4.3	Determine performance of water chilling plant.	15	10	5
LE4.4	Check & Adjust of different refrigerant controls, floats, Solenoid Valves, Safety switches	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE4.5	Charge refrigerants & check performance	15	10	5
LE 5.1	Determine the cooling load for automobile car.	15	10	5
LE5.2	Estimate the total heat load of practical workshop using anemometer, calorimeter, sling psychrometer	15	10	5
LE5.3	Determine the properties of air by using sling psychrometer.	15	10	5

* Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical'

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30** Marks as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Field Trips
7. Portfolio Based Learning
8. Demonstration
9. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)

L) Suggested Learning Resources:

(a) Books :

S. No.	Title	Author	Publisher(pl add place and ISBN no)	Edition and Year
1.	Refrigeration and Air Conditioning	Rajput R.K	S.K. Kataria, Delhi	Latest
2.	Refrigeration and Air Conditioning	Arora, Domkundwar.S	Dhanpat Rai, Delhi	Latest
3.	Refrigeration and Air Conditioning	Khurmi R.S, gupta J.K	S. Chand	Latest
4.	Refrigeration and Air Conditioning	Domkundwar. S,	Dhanpat Rai, Delhi	Latest
5.	Principles of Air Conditioning.	Lang Paull .V	CBS publishers	Latest
6.	Refrigeration and Air Conditioning	Manohar Prasad	New age international (P) limited, New Delhi	Latest
7.	Refrigeration and Air Conditioning	.Arora C.P	McGraw Hill education (India) (P) limited, New Delhi	Latest
8.	Principles of Refrigeration	Roy J. Dossat	Pearson education, New Delhi	Latest
9.	Principles of Refrigeration and Air Conditioning, 1982.jmk	Stoeker, W.F. and Jones, J.P.	McGraw Hill, New York, Second Edition	Latest

S. No.	Title	Author	Publisher(pl add place and ISBN no)	Edition and Year
10.	Basic Refrigeration and Air Conditioning.	P. N. Ananthanarayanan	Tata McGraw Hill, New Delhi	Latest
11.	Introduction to cryogenic engineering and gas application	Prof. Bose P.K.	Everest Publishing House	Latest

(b) Open source software and website address:

Unit-1

i. https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118406281.ch15
ii. https://www.researchgate.net/publication/287367381_Refrigeration_in_Food_Preservation_and_Processing
iii. https://www.mechlectures.com/applications-refrigeration-air-conditioning/
iv. http://www.fponthenet.net/article/95843/What-role-does-refrigeration-play-in-the-supply-chain-.aspx
v. https://www.newfoodmagazine.com/article/4448/emerging-technologies-for-food-refrigeration-applications/
vi. https://www.coolingindia.in/refrigeration-in-food-processing-cold-chain/
vii. https://www.danfoss.com/en/markets/food-and-beverage/dcs/food-processing-and-storage/#tab-overview
viii. www.nptel.com
ix. https://nptel.ac.in/course.html
x. http://www.ignou.ac.in/upload/Unit%207-32.pdf

Unit-2

i. https://www.irl.co.in/industries/food-processing.html
ii. www.nptel.com
iii. https://nptel.ac.in/course.html

Unit-3

i. https://nptel.ac.in
ii. https://www.thoughtco.com/cryogenics-definition-4142815
iii. https://www.google.com/search?rlz=1C1CHBD_enIN839IN839&q=cryogenic+refrigeration+applications&sa=X&ved=2ahUKEwi7iveDgarkAhUMu48KHRLyDGUQ1QIoAXoECAwQAg.
iv. http://uspas.fnal.gov/materials/17UCDavis/Cryogenics/6-Refrigeration%20and%20Liquefaction.ppt
v. https://cds.cern.ch/record/1974048/files/arXiv:1501.07392.pdf
vi. https://www.scienceabc.com/innovation/cryogenics-applications-cryogenics.html
vii. https://www2.jpl.nasa.gov/adv_tech/coolers/Cool_ppr/Chap%206-Refrig%20Sys%20for%20Achiev%20Cryo%20Temps_2016.pdf
viii. https://files.t-square.gatech.edu/access/content/group/XLS0105141953200902.200902/Presentations/Cryogenic%20Refrigeration.ppt

Unit-4

i. http://www.fao.org/3/Y5013E/y5013e05.htm
ii. https://dokumen.tips/documents/ice-making-plant-visit-report.html
iii. https://www.indiastudychannel.com/resources/145551-Construction-working-Ice-Plant.aspx
iv. http://www.ref-wiki.com/content/view/31303/28/

v. www.nptel.com
vi. https://nptel.ac.in/course.html
vii. https://www.mechlectures.com/applications-refrigeration-air-conditioning/
viii. http://www.ignou.ac.in/upload/Unit%207-32.pdf
ix. http://mechdiploma.com/explain-construction-and-working-ice-plant-neat-sketch

Unit-5

i. https://www.mechlectures.com/applications-refrigeration-air-conditioning/
ii. www.nptel.com
iii. https://nptel.ac.in/course.html
iv. http://www.ignou.ac.in/upload/Unit%207-32.pdf

Reference :

i. ASHRAE Handbook - Fundamentals and Equipment, 1993.
ii. ASHRAE Handbook – Applications, 1961.
iii. ISHRAE Handbook
iv. NPTL Lectures by Prof. RamGopal, IIT Kharagpur
v. Carrier Hadbook
vi. Jordan, R.C. and Priester, G.B., Refrigeration and Air Conditioning, Prentice – Hall of India Ltd., New Delhi, 1969
vii. Threlkeld, J. L., Thermal Environmental Engineering, Prentice Hall, New York, 1970.
viii. www.nptel.com

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

M) List of Major Laboratory Equipment and Tools: (with Broad specifications and in the format)

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1.	Food preservation test rig.	Laboratory Test Rig	LE1.1
2.	Freeze drying machine	Laboratory Test Rig	------
3.	Cold storage test rig	Laboratory Test Rig	LE1.2, LE1.3
4.	Air conditioning test rig.	Laboratory Test Rig	LE2.1,LE4.2
5.	Air-conditioning of fixed volume cabinet	Laboratory Test Rig	LE2.2
6.	Ice plant tutor	Laboratory Test Rig	LE4.1
7.	Water chilling plant	Laboratory Test Rig	LE4.3
8.	Air conditioner test rig for cooling load of automobile car.	Laboratory Test Rig	LE5.1
9.	Ice-cream manufacturing test rig.	Laboratory Test Rig	------

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Apply the concepts of refrigeration to Food Preservation.	2	3	3	2	1	2	1	2	2	2	-	3	3
CO-2 Analyze commercial structures for refrigeration	1	2	1	2	2	2	1	2	2	2	-	3	3
CO-3 Apply the concepts of Low Temperature Refrigeration	3	2	1	2	2	2	1	2	1	2	-	3	3
CO-4 Apply the concepts of refrigeration to Industrial Applications	2	2	2	1	2	1	3	2	2	2	-	3	3
CO-5 Use Air-Conditioning in transport systems	2	3	2	2	2	2	1	2	2	3	-	3	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-1 Apply the concepts of refrigeration to Food Preservation.	SO1.1 SO1.2 SO1.3 SO1.4	LE1.1 LE1.2 LE1.3	Unit-1.0 1.1,1.2,1.3,1.4,1.5	As mentioned in relevant page number.
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-2 Analyze commercial structures for refrigeration	SO2.1 - SO2.7	LE. 2.1 LE. 2.2 LE. 2.3 LE. 2.4	Unit-2.0 2,1,2.2,2.3,2.4,2.5,2.6,2.7.2.8	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-3 Apply the concepts of Low Temperature Refrigeration	SO3.1 SO3.2 SO3.3 SO3.4 SO3.5	LE3.1 LE3.2	Unit-3.0 3,1,3.2,3.3,3.4,3.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-4 Apply the concepts of refrigeration to Industrial Applications	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	LE4.1 LE4.2 LE4.3 LE4.4 LE4.5	Unit-4.0 4,1,4.2,4.3,4.4,4.5,4.6	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-5 Use Air-Conditioning in transport systems	SO5.1 SO5.2 SO5.3 SO5.4 SO5.5	LE5.1 LE5.2 LE5.3	Unit-5.0 5,1,5.2,5.3,5.4,5.5,5.6	

A) Course Code : 2037684(037)

B) Course Title : Wind and Solar Energy Appliances

C) Pre-requisite Course Code and Title :

D) Rationale :

Use of renewable sources of energy is the need of the era. Solar, Wind and Bio-fuel systems have become reality now and the share of these systems in global energy market is increasing day by day. India has set high targets of employing renewable sources of energy for all possible applications to reduce the dependency on the fossil fuels. This has increased the demand of trained manpower for installation, operation and maintenance of various systems and equipment used in Solar, wind and bio-fuel systems. This segment has huge potential for innovative solutions and opportunities for self-employment also. This course aims at equipping the diploma holders for installation, operation and maintenance of various mechanical equipment and systems used in Solar, Wind and bio-fuel systems.

E) Course Outcomes:

CO-1 Measure performance parameters related to Wind energy systems.

CO-2 Maintain mechanical devices and equipment of solar thermal systems.

CO-3 Maintain mechanical devices and equipment of solar PV systems.

CO-4 Maintain mechanical devices and equipment of Biogas plants.

CO-5 Prepare project feasibility report for installation of renewable energy systems.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037684(037)	Wind and Solar Energy Appliances	2	-	1	3
1	Mechanical Engineering	2037694(037)	Wind and Solar Energy Appliances (Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037684 (037)	Wind and Solar Energy Appliances	70	20	30	-	-	120
2	Mechanical Engineering	2037694 (037)	Wind and Solar Energy Appliances (Lab)	-	-	-	30	50	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Measure performance parameters related to Wind energy systems.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Classify wind energy systems. SO1.2 Identify various components in the given wind energy system(s). SO1.3 Measure the output power of the turbine, rotation speed of the turbine, wind speed ,system voltage and system current using simple numerical situations. SO1.4 Explain the maintenance procedure of the given component of wind turbines.	LE1.1 Use vane anemometer for measurement of different locations for site selection for wind mill. LE1.2 Identify various components of wind turbines horizontal axis. LE1.3 Identify various components of wind turbines vertical axis. LE1.4 Calculate wind turbine power using suitable software. LE1.5 Measure the output power of the turbine, rotation speed of the turbine, wind speed, system voltage and system current.	**Unit 1.0 Wind Energy Systems** 1.1 Basics of wind energy conversion, site selection 1.2 Types of wind energy systems – large and small, commercial & domestic, grid connected & stand-alone. 1.3 Classification of wind turbines – horizontal axis & vertical axis, types of blades & vanes. 1.4 Wind turbine performance analysis and curves. 1.5 Generators used in wind energy systems- types, ratings, installation & maintenance procedure. 1.6 Tower, rotor, gearbox, power regulation, safety mechanisms. 1.7 Wind ventilators-types construction, installation & maintenance procedure 1.8 Grid connectivity – methods, agencies involved, schemes, commercial terms and conditions, documentation.	• Issues related to power generation through wind energy

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Explain various wind energy conversions systems with block diagrams.
ii. Derive the mathematical expression for finding wind power analytically.
iii. Differentiate between horizontal and vertical axes wind mill rotors.
iv. Measure the output power of the turbine, rotation speed of the turbine, wind speed, system voltage and system current using simple numerical situations.

b. Mini Project:

i. Prepare a maintenance chart of wind energy turbine rotors.
ii. Make a chart showing performance curves of different types of wind mills.
iii. Collect various technical data information about various wind energy projects in India.

c. Other Activities (Specify):

i. Seminar on Installation and maintenance of wind mills.
ii. Give Seminar on wind mills for economic and environment friendly power generation. (group work with group size of five students each)

CO-2 Maintain mechanical devices and equipment of solar thermal systems.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Classify Solar Thermal systems. SO2.2 Identify various components in the given Solar Thermal system. SO2.3 Select Solar Thermal system for a given application with justification. SO2.4 Select Solar Dryer system for a given application with justification. SO2.5 Describe maintenance procedure of the given Solar Thermal system.	LE2.1 Identify the components of Solar cooker. LE2.2 Use of pyranometer for measurement of solar radiation flux density. LE2.3 Assemble and dismantle solar drier. LE2.4 Assemble and dismantle solar flat plate collector.	**Unit 2.0 Solar Thermal Systems** 2.1 Alternative energy sources: primary, secondary and tertiary energy. 2.2 Classification of solar thermal systems 2.3 Solar thermal systems used for low temperature applications – Flat plate collectors with various types of tubes Domestic-Water heating systems. Commercial-Heating systems used for process heating Installation-standard procedure, precautions, Plumbing – piping, Valves. Maintenance- Routine maintenance, procedure for domestic and commercial water heater systems. Failure maintenance – Major causes, remedies. 2.4 Solar thermal systems used for high temperature applications and for power generation Concentrators used for steam generation Power generation systems 2.5 Solar dryers – Classification, construction, working and	• Parabolic solar collector and sun tracking system.

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		applications commercial, agro-products, domestic. 2.6 Choice of a system for a given Application- technical and financial criteria used for selection.	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. Explain different types of solar radiations and various earth and sun angles used in measurement of solar radiations.
ii. Classify Solar Thermal systems.
iii. Identify various components in the given Solar Thermal system.
iv. Prepare list of different types of solar collectors used in solar energy applications.
v. Select Solar Dryer system for a given application with justification.
vi. Describe maintenance procedure of the given Solar Thermal system.

b. Mini Project:

i. Visit to a commercial or industrial solar water heating installation of at least 500 liters per day capacity and write a report about collector layout, piping and fittings and measurement of performance of the system.
ii. Prepare a layout of solar water heating system for domestic/commercial use. Comprises of plumbing, insulations, control valves and support systems in bad weather conditions.
iii. Prepare a maintenance duty chart for solar water heating system.

c. Other Activities (Specify):

i. Use Flash/Animations to explain function and construction of Flat plate collector used for domestic water heating application and also used for process heating in commercial / industrial organization.

CO-3 Maintain mechanical devices and equipment of solar PV systems.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Classify various solar photovoltaic systems. SO3.2 Identify various components in the given solar photovoltaic system. SO3.3 Select Solar Photovoltaic systems for a given situation with justification. SO3.4 Describe	LE3.1 Assemble a solar PV cell, module, array system with and without battery connection LE3.2 Measure heat output, Maximum power, power output efficiency of solar PV panel. LE3.3 Simulation software to calculate PV energy output.	**Unit 3.0 Solar Photovoltaic Systems** 3.1 Classification of Solar Photovoltaic systems – Grid connected, Off-grid, stand-alone systems. 3.2 PV cells – types, merits and demerits 3.3 Photovoltaic system for power generation, solar cell modules and arrays, solar cell types, material, applications,	• Organic Solar cells.

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
maintenance procedure of the given Solar Photovoltaic System.		advantages and disadvantages 3.4 Panels – types. 3.5 Battery and other accessories – types, rating, methods of selection. 3.6 Solar pumping, solar refrigeration and air conditioning, heliostat, solar furnace 3.7 Recent trends and promotional schemes – Net metering. 3.8 Installation, commissioning and maintenance of Solar Roof Top systems, Stand-alone Street light.	

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Classify various solar photovoltaic systems.
ii. Identify various components in the given solar photovoltaic system.
iii. Select Solar Photovoltaic systems for a given situation with justification.
iv. Describe maintenance procedure of the given Solar Photovoltaic System.

b. Mini Project:

i. Prepare a report for selection of Solar lightning system for a small colony or your institute campus.
ii. Calculate rating of solar panels to be used based on energy requirement of your home.
iii. Prepare a report on design working and feasibility of Solar Pump.
iv. Prepare a report on Roof Top Solar system scope in India.
v. Prepare a small Solar charger/Solar car/Solar fan/Solar torch/Solar cooler/Solar street light etc.

c. Other Activities (Specify):

i. Collect videos different items powered by Solar PV cells/panels.

CO-4 Maintain mechanical devices and equipment of Biogas plants.

(Approx. Hrs: L+P+T=13)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Classify bio-energy systems. SO4.2 Identify various components in the given bio-energy system. SO4.3 List the different applications of	LE4.1 Identify various components in bio-energy systems such as bio-gas plants, gasifiers, digestors, bio-diesel plants. LE4.2 Maintenance of	**Unit 4.0 Bio-Energy Systems** 4.1 Classification of bio-fuels-biogas, biodiesel. 4.2 Systems for production of bio-fuels – bio-gas plants, gasifiers, digestors, bio-diesel plants -Layout, construction and principle	• Energy from dry and wet house hold waste

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
the given Bio-Gas system. SO4.4 Describe the procedure of installation of the given Bio-Gas plants. SO4.5 Explain the maintenance procedure of the given Smokeless Chulhas, Burners, Heaters and Engines.	various components of Bio-Gas system like smokeless chulhas, burners, heaters and engines.	of working 4.3 Applications of various bio-fuels- Domestic – heating, cooking, Commercial – process heating, power generation Systems used for utilization of bio-fuels – smokeless Chulhas, burners, heaters & engines. 4.4 Installation-procedure, precautions operating procedures of a Bio gas plant.	

SW-4 Suggested Sectional Work (SW):

d. Assignments:

i. Classify bio-energy systems.
ii. Identify various components in the given bio-energy system.
iii. List the different applications of the given Bio-Gas system.
iv. Describe the procedure of installation of the given Bio-Gas plants.
v. Explain the maintenance procedure of the given Smokeless Chulhas, Burners, Heaters and Engines.

e. Mini Project:

i. Prepare a report on performance, maintenance and success rate of existing Bio-Gas plants in nearby regions.
ii. Prepare small working models of already existing/improved/new Smokeless Chulhas, Burners, Heaters, Biogas plant.

CO-5 Prepare project feasibility report for installation of hybrid renewable energy systems.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Prepare layouts of the given hybrid systems. SO5.2 Describe the different performance parameters related to the given Wind-Solar PV hybrid system. SO5.3 Describe the procedure to test the performance of the given Wind-Solar	LE5.1 Assemble a wind-solar PV hybrid system LE5.2 Measure heat output and power output of a wind-solar PV hybrid system	**Unit 5.0 Hybrid Systems and Feasibility Studies** 5.1 Recent trends – hybrid systems. 5.2 Types of hybrid system. 5.3 Power output of hybrid system. 5.4 Installation-procedure, precautions, operating procedures of Wind-Solar PV hybrid system. 5.5 Choice of systems – technical and commercial feasibility	• PV solar panel and vertical wind mill hybrid systems

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
PV hybrid system. SO5.4 Prepare project feasibility report for installation of renewable energy systems.		assessment, costing of renewable energy systems.	

SW-5 Suggested Sectional Work (SW):

a. Assignments:

i. Describe the different performance parameters related to the given Wind-Solar PV hybrid system.

ii. Describe the procedure to test the performance of the given Wind-Solar PV hybrid system.

b. Mini Project:

i. Prepare a detailed report on the working of PV solar panel and vertical wind mill hybrid systems used in the middle of highways.

c. Other Activities (Specify):

i. Collect videos of various hybrid renewable energy systems.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Wind Energy Systems	4	6	4	14
II	Solar Thermal Systems	4	4	6	14
III	Solar Photovoltaic Systems	4	4	8	16
IV	Bio-Energy Systems	4	4	6	14
V	Hybrid Systems and Feasibility Studies	4	4	4	12
	Total	**20**	**22**	**28**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Use vane anemometer for measurement of different locations for site selection for wind mill.	15	10	5
LE1.2	Identify various components of wind turbines horizontal axis.	15	10	5
LE1.3	Identify various components of wind turbines vertical axis.	15	10	5
LE1.4	Calculate wind turbine power using suitable software.	15	10	5
LE1.5	Measure the output power of the turbine, rotation speed of the turbine, wind speed, system voltage and system current.	15	10	5
LE2.1	Identify the components of Solar cooker.	15	10	5
LE2.2	Use of pyranometer for measurement of solar	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
	radiation flux density.			
LE2.3	Assemble and dismantle solar drier.	15	10	5
LE2.4	Assemble and dismantle solar flat plate collector.	15	10	5
LE3.1	Assemble a solar PV cell, module, array system with and without battery connection.	15	10	5
LE3.2	Measure heat output, Maximum power, power output efficiency of solar PV panel.	15	10	5
LE3.3	Simulation software to calculate PV energy output.	15	10	5
LE4.1	Identify various components in bio-energy systems such as bio-gas plants, gasifiers, digestors, bio-diesel plants.	15	10	5
LE4.2	Maintenance of various components of Bio-Gas system like smokeless chulhas, burners, heaters and engines.	15	10	5
LE5.1	Assemble a wind-solar PV hybrid system.	15	10	5
LE5.2	Measure heat output and power output of a wind-solar PV hybrid system.	15	10	5

* Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practical's.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30** Marks as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Industrial Training
7. Field Trips
8. Portfolio Based Learning
9. Role Play
10. Demonstration
11. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
12. Brainstorming
13. Others

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher	Edition & Year
1.	Solar Photovoltaic: A Lab Training Module	Solanki, Singh Chetan, Arora, Brij M., VasiJuzer, Patil, Mahesh B.	Cambridge University Press, New Delhi,	(2009), ISBN: 9789382264590
2.	Solar Photovoltaic: Fundamentals, Technologies and Application	Solanki, Singh Chetan	PHI Learning, New Delhi	(2009),ISBN: 9788120351110
3.	Solar Energy	Sukhatme S.P., Nayak J.K.	Tata McGraw, New Delhi	(2010),ISBN: 9781259081965
4.	Solar Cells and Their Applications	Fraas Lewis M., Partain Larry D.	Wiley, UK	(2010),ISBN: 9780470446331
5.	Wind Power in Power Systems	Ackermann Thomas	John Wiley & Sons, UK	(2012), ISBN: 9781119942085
6.	Solar Energy: Principles of Thermal Collection and Storage	S. Sukhatme, J Nayak	McGraw Hill Education, New Delhi	(2008), ISBN: 978-0070260641
7.	Introduction to Bioenergy	Nelson Vaughn C., Kenneth L. Starcher	CRC press, UK,	(2015) ISBN 9781498716987
8.	Non-conventional Sources of Energy (Urja Ke Aparamparagat Sroat)	S.S.L. Patel	Standard Publishers Distributors, Delhi.	ISBN-978-81-8014-199-7 Year-2013
9.	Solar Energy Applications-Installation and Maintenance (Sour Urja Ke Anuprayog-Sansthapna Avam Rakhrakhav)	S.S.L. Patel	Standard Publishers Distributors, Delhi	ISBN-978-81-8014-247-5 Year-2017

(b) Open source software and website address:

Solar thermal

i. https://mnre.gov.in/file-manager/UserFiles/pdf/Students%20Workbook%20-%20Solar%20Thermal%20System.pdf
ii. http://www.climatetechwiki.org/technology/solar-thermal-hot-water
iii. http://nptel.ac.in/courses/112105050/m1l1.pdf
iv. http://nptel.ac.in/courses/108105058/15
v. https://www.youtube.com/watch?v=mpHZWYpKDJg

Solar photovoltaic

vi. https://www.nrel.gov/workingwithus/re-photovoltaics.html
vii. https://mnre.gov.in/solar-photovoltaic-systems
viii. https://www.renewableenergyworld.com/solar-energy/tech/solarpv.html
ix. https://www.youtube.com/watch?v=jxOvCnQfj_8
x. http://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/notused/Non-Conventional%20Energy%20Systems(28-05-07)/pdfs/chap04.pdf
xi. https://www.youtube.com/watch?v=Fuyq6WrM1EA

Wind power

xii. https://www.energy.gov/energysaver/buying-and-making-electricity/small-wind-electric-systems
xiii. http://synergyfiles.com/2015/04/small-scale-vs-large-scale-wind-turbines/

xiv. https://www.nrel.gov/workingwithus/re-wind.html
xv. https://www.youtube.com/watch?v=JJDyIOtr5yA
xvi. https://www.youtube.com/watch?v=NbZepCQUQTg
xvii. http://nptel.ac.in/courses/108108078/pdf/chap6/teach_slides06.pdf
xviii. http://nptel.ac.in/courses/108107028/module1/lecture1/lecture1.pdf
xix. Micro, Pico hydro power systems
xx. http://www.renewablesfirst.co.uk/hydropower/hydropower-learning-centre/what-is-the-difference-between-micro-mini-and-small-hydro/
xxi. https://www.youtube.com/watch?v=eXljm_axyu0
xxii. http://nptel.ac.in/courses/108108078/pdf/chap5/teach_slides05.pdf
xxiii. http://nptel.ac.in/courses/105105110/pdf/m5l01.pdf
xxiv. https://www.youtube.com/watch?v=JBrdUoU2uTE
xxv. https://www.youtube.com/watch?v=i9yCpuiMze0

Bio energy systems

xxvi. https://www.youtube.com/watch?v=DKvzVlN-sOQ
xxvii. https://www.bioenergyconsult.com/biomass-energy-systems/
xxviii. https://mnre.gov.in/bio-energy
xxix. http://nptel.ac.in/courses/108108078/7
xxx. http://nptel.ac.in/courses/102104057/3
xxxi. http://nptel.ac.in/courses/102104057/
xxxii. http://nptel.ac.in/courses/102104057/5
xxxiii. http://nptel.ac.in/courses/102104057/4

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Manufacturers' Catalog
5. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Vane anemometer	any make available in the market	LE 1.1 to LE1.5
2	3-bladed Geared Wind Turbine:	5/10/20/30 kW, Upwind with 20/30 m hydraulically operated tilt-up/tilt-down tubular tower or whichever lowest rating that is available in the market	LE 1.1 to LE1.5
3	Wind Solar PV Hybrid System	Wind (1kW) - Solar PV (1kW) Hybrid System	LE 1.1 to LE1.5 LE 5.1 & LE5.2
4	Pyranometer	any make available in the market.	LE2.1 to LE2.4
5	Solar dryer system	Solar dryer system	LE2.3
6	Solar Cooker	any make available in the market.	LE2.1
7	Solar water heater	flat plate/tube type -50 Liters.	LE2.4
8	Solar PV panel	Poly crystalline/Mono crystalline solar PV panel 20W X	LE3.1 to LE3.3
9	Smokeless Chulhas, Burners, Heaters and Engines.	Smokeless Chulhas, Burners, Heaters and Engines.	LE 4.2
10	Voltmeter, Ammeter	Voltmeter, Ammeter	All Experiments
11	Bio gas plant for lab	Bio gas plant for lab	LE 4.1 to LE4.2

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Measure performance parameters related to Wind energy systems.	2	3	3	2	1	1	2	2	1	2	-	2	2
CO-2 Maintain mechanical devices and equipment of solar thermal systems.	2	3	3	2	1	1	1	2	1	2	-	2	2
CO-3 Maintain mechanical devices and equipment of solar PV systems.	2	3	3	2	2	1	2	2	2	2	-	2	3
CO-4 Maintain mechanical devices and equipment of Biogas plants.	2	3	3	2	2	1	2	2	2	2	-	2	3
CO-5 Prepare project feasibility report for installation of renewable energy systems.	2	3	3	2	2	1	2	2	2	2	-	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-1 Measure performance parameters related to Wind energy systems.	SO1.1 SO1.2 SO1.3 SO1.4	LE1.1 - LE1.5	Unit 1.0 Wind Energy Systems 1.1-1.8	As mentioned in relevant page number
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-2 Maintain mechanical devices and equipment of solar thermal systems.	SO2.1 SO2.2 SO2.3 SO2.4 SO2.5	LE.2.1 - LE2.4	Unit 2.0 Solar Thermal Systems 2.1-2.6	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-3 Maintain mechanical devices and equipment of solar PV systems.	SO3.1 SO3.2 SO3.3 SO3.4	LE3.1 LE3.2 LE3.3 LE3.4	Unit3.0 Solar Photovoltaic Systems 3.1-3.8	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-4 Maintain mechanical devices and equipment of Biogas plants.	SO4.1 SO4.2 SO4.3 SO4.4 SO4.5	LE4.1 LE4.2	Unit-4.0 Bio Energy Systems 4.1-4.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-2,3	CO-5 Prepare project feasibility report for installation of renewable energy systems.	SO5.1 SO5.2 SO5.3 SO5.4	LE5.1 LE5.2	Unit-5.0 Hybrid System and Feasibility Studies 5.1-5.5	

A) Course Code : 2037685(037)

B) Course Title : Energy Management and Audit

C) Pre-requisite Course Code and Title :

D) Rationale :

Energy is a vital input for the development and economic growth of a country. The development of efficient energy systems is constrained by the depletion of fossil fuel, environment impacts such as the problem of global warming and associated climate change .Efficient and judicious use of energy sources is therefore becoming very important and there is significant need to understand the energy conservation and management. The energy audit helps in identifying the possible avenues in which energy can be saved. The course will equip the students with the knowledge of energy conservation techniques and audit procedures for effective energy management.

E) Course Outcomes:

CO-1 Interpret the energy scenario.

CO-2 Use Energy Management and energy Audit strategy

CO-3 Apply the concepts of material balance and Energy balance to different processes.

CO-4 Execute energy action planning, monitoring and targeting

CO-5 Estimate the energy efficiency in thermal utilities.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037685(037)	Energy Management and Audit	2	-	1	3
2	Mechanical Engineering	2037695(037)	Energy Management and Audit (Lab)	-	2	-	1

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037685(037)	Energy Management and Audit	70	20	30	-	-	120
2	Mechanical Engineering	2037695(037)	Energy Management and Audit (Lab)	-	-	-	30	50	80

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.
ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Course-Curriculum Detailing:

This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (L), Laboratory Instruction (P), T- Tutorial includes Sessional Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Session Outcomes (SOs) and finally Course Outcomes (COs) upon the completion of course.

CO-1 Interpret the energy scenario.

(Approx. Hrs: L+P+T=14)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO1.1 Explain various types of energy resources. SO1.2 Interpret the energy scenario and explain the energy needs for growing economy. SO1.3 Explain the importance of energy conservation. SO1.4 Explain the features and provisions of Energy Conservation Act 2001. SO1.5 Explain the terms associated with electrical and thermal basics of energy.	LE1.1 Prepare heat balance sheet for given boiler. LE1.2 Determine the flash and fire point temperatures of the given sample of oil. LE1.3 Determine the flash and fire point temperatures of the given sample of oil using Able's closed Cup apparatus. LE1.4 Determine the Absolute and Kinematic viscosity of a given lubricating oil at different temperatures using Saybolt Viscometer	**Unit 1.0 Energy Scenario and Development** 1.1 Classification of Energy – Primary & Secondary, Commercial and Non-commercial, Renewable and non-renewable. 1.2 Global and Indian energy scenario. 1.3 Energy needs of growing economy, energy pricing, energy security, energy strategy for the future. 1.4 Energy conservation Act 2001 and its features, notifications under the Act, Bureau of Energy Efficiency (BEE), State Designated Agencies, Integrated energy policy, National action plan on climate change. 1.5 Basics of Energy and its various forms: Recall various forms of energy, Grades of energy, Electricity basics – Direct Current and Alternative Currents. 1.6 Thermal Basics-fuels, thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, flash point, evaporation, condensation, steam, moist air and humidity and heat transfer, units and conversion, Metric Ton Oil Equivalent conversions.	• Building codes for energy conservation • Load control and maximum demand • Electricity Tariff

SW-1 Suggested Sessional Work (SW):

a. Assignments:

i. Prepare a chart showing primary & secondary, commercial & non-commercial and renewable energy resources.
ii. State the role of Central and State governments as provided in Energy conservation Act 2001.
iii. Differentiate between AC and DC current on the basis of following:
   a. Direction of current
   b. Voltage between two points of a circuit.
   c. Examples

b. Mini Project:

i. Prepare a report on environmental impacts arising out of energy uses in industries.
ii. Explore the World Wide Web and prepare a report on sector wise consumption of energy in India.

CO-2 Use Energy Management and energy Audit strategy.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO2.1 Explain the basic concepts of Energy management. SO2.2 Explain the basic concepts of energy audit. SO2.3 Explain the components of energy cost. SO2.4 Explain the instruments for energy audit. SO2.5 Select energy audit method for the given situation with justification. SO2.6 Select energy management strategy for a given situation with justification.	LE2.1 Measure electrical parameters- kVA, KW, PF, Hertz, Ampere, Volt etc using electrical measuring instruments LE2.2 Use Combustion analyzer. LE2.3 Use Water flow meter to measure water flow. LE2.4 Use speed measuring instruments and lux meter to measure speed of given component. LE2.5 Use leak detector to detect leak in given setup.	**Unit 2.0 Energy Management and Audit** 2.1 Definition, objectives and principles of energy management, energy management skills, energy management strategy. 2.2 Energy Audit: Need, types and methodology, energy conservation opportunities and measures, energy audit reporting formats 2.3 Components of energy costs, bench marking and energy performance, matching energy uses to requirement - maximizing system efficiencies, optimizing the input energy requirements, Fuel and energy substitution. 2.4 Energy audit instruments: Electrical measuring instruments for measuring electrical parameters e.g. kVA, KW, PF, Hertz, Ampere, Volt etc., Combustion analyser, Fuel efficiency	

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
		monitor, Contact and Infrared thermometer, pitot tube & manometer, water flow meter, speed measuring instruments, lux meter, leak detectors etc.	

SW-2 Suggested Sessional Work (SW):

a. Assignments:

i. State the main objectives of energy management.
ii. Explain the salient features of an energy management policy statement.
iii. List the commonly used utilities in an industry.
iv. State the advantages of benchmarking energy performance.

b. Mini Project:

i. Collect the electricity bills of your institute and graphically represent the monthly electricity consumption over a period of 12 months.
ii. Study the lighting system of your institute and identify extra lights in use.
iii. Make a walk through energy audit of your institute building and suggest energy saving opportunities. (Entire building or a particular department/lab/workshop can be taken for study)

CO-3 Apply the concepts of material balance and Energy balance to different processes.

(Approx. Hrs: L+P+T=20)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO3.1 Explain the basic principles of material and energy balance. SO3.2 Apply the concepts of material balance to different processes. SO3.3 Apply the concepts of energy balance to calculate energy/heat balance. SO3.4 Solve simple numerical problems on material and energy balance. SO3.5 Prepare flow chart for the given situation.		**Unit 3.0 Material and Energy Balance** 3.1 Basic Principles, San-key diagrams 3.2 Material balances for different processes 3.3 Energy balances, heat balances 3.4 Methods for preparing process flow chart 3.5 Procedure to carryout the material and energy bala nce in different processes.	

SW-3 Suggested Sectional Work (SW):

a. Assignments:

i. Explain the importance of material and energy balance in minimizing energy cost.
ii. Prepare Sankey diagram for a boiler system.
iii. Solve problems on material and energy balances.

b. Mini Project:

i. Visit any industry (min 03) and carry out the material and energy balance in different processes in industry.

CO-4 Execute energy action planning, monitoring and targeting.

(Approx. Hrs: L+P+T=26)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO4.1 Identify and explain the key elements of effective energy management system. SO4.2 Explain the importance of instituting a energy policy. SO4.3 Explain the process of force field analysis. SO4.4 Explain the organizational structure of energy management. SO4.5 Identify and define the elements of energy monitoring and targeting. SO4.6 Explain the techniques of data and information analysis.		**Unit 4.0 Energy Action Planning, Monitoring and Targeting** 4.1 Key elements, force field analysis, Energy policy purpose, perspective, contents, formulation, and ratification. 4.2 Organizing - location of energy management, top management support, managerial function, roles and responsibilities of energy manager, accountability. 4.3 Energy Monitoring and Targeting: Introduction & Elements of energy monitoring & targeting system. 4.4 Benchmarking, Data and information analysis and its graphical representation, CUSUM	

SW-4 Suggested Sectional Work (SW):

a. Assignments:

i. State the purpose of force field analysis with a suitable example.
ii. Explain the key steps in formulating a energy policy.
iii. State the importance of energy monitoring and targeting.

b. Mini Project:

i. Using internet, collect and prepare a report on energy policies of at least 10 reputed industries.

CO-5 Estimate the energy efficiency in thermal utilities.

(Approx. Hrs: L+P+T=18)

Session Outcomes (SOs)	Laboratory Instruction (P)	Class room Instruction (L)	Self Learning (SL)
SO5.1 Select the fuel for a given situation with justification. SO5.2 Explain the process of fuel combustion. SO5.3 Explain the schematic of boiler and classify the boilers. SO5.4 Evaluate the performance of boilers. SO5.5 Explain the energy conservation opportunities in boiler installations. SO5.6 Explain the purpose of insulation, insulation materials and their applications.	LE5.1 Determine the properties of the given fuel. LE5.2 Determine the efficiency of the boiler.	**Unit 5.0 Energy Efficiency in Thermal Utilities** 5.1 Fuels – Recall types of fuels and their properties – density, specific gravity, viscosity, flash point, pour point, specific heat, calorific value, ash content, carbon residue and water content. 5.2 Combustion of Fuels – Principles of combustion, 3T's of combustion, Stoichiometric combustion Combustion of coal oil and gas, simple numerical problems. 5.3 Energy Conservation in Boilers: Definition, Specification, Indian Boiler Regulation, Schematic of Boiler system, Classification of boiler – Packaged, Stoker fired, Pulverized fuel boiler, FBC boiler, Super critical boiler. 5.4 Performance evaluation of boilers - Boiler evaporation ratio and Boiler efficiency, Direct and indirect method of calculating boiler efficiency, Energy conservation opportunities in boiler systems. 5.5 Insulation: Purpose, types and application, economic thickness of insulation, heat savings and application criteria, Cold insulation.	• Energy efficiency of furnaces • Waste Heat Recovery • Cogeneration

SW-5 Suggested Sectional Work (SW):

a. Assignments:

i. State the Stoichiometric combustion equation for methane. How many Kg of carbon dioxide and water is generated by complete combustion of 1 kg of methane?
ii. Solve problems related to combustion of fuels.
iii. Solve problems related to performance evaluation of boilers.
iv. Solve problems related to economic thickness of insulation and heat loss calculation.

b. Mini Project:

i. Prepare a power point presentation on various types of insulating materials, their properties and applications.
ii. Prepare a power point presentation on cold insulation materials, their properties and applications.

c. Other Activities (Specify):

i. Visit a nearby sponge iron plant/thermal power plant and prepare a report on the measures taken to reduce heat losses.

Note: Performance under Laboratory and Sessional work may appear in more than one COs/SOs.

I) Suggested Specification Table (For ESE of Classroom Instruction):

Unit Number	Unit Titles	Marks Distribution			Total Marks
		R	U	A	
I	Energy Scenario and Development	4	4	2	10
II	Energy Management and Audit	2	2	12	16
III	Material and Energy Balance	2	2	12	16
IV	Energy Action Planning, Monitoring and Targeting	3	4	5	12
V	Energy Efficiency in Thermal Utilities	2	2	12	16
	Total	**13**	**14**	**43**	**70**

Legend: R: Remember, U: Understand, A: Apply and above

J) Suggested Specification Table (For ESE of Laboratory Instruction*):

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE1.1	Prepare heat balance sheet for given boiler.	15	10	5
LE1.2	Determine the flash and fire point temperatures of the given sample of oil.	15	10	5
LE1.3	Determine the flash and fire point temperatures of the given sample of oil using Able's closed Cup apparatus	15	10	5
LE1.4	Determine the Absolute and Kinematic viscosity of a given lubricating oil at different temperatures using Saybolt Viscometer	15	10	5
LE 2.1	Measure electrical parameters- kVA, KW, PF, Hertz, Ampere, Volt etc	15	10	5
LE 2.2	using electrical measuring instruments	15	10	5
LE2.3	Use Combustion analyzer.	15	10	5
LE2.4	Use Water flow meter to measure water flow.	15	10	5

Laboratory Instruction Number	Short Laboratory Experiment Titles	Assessment of Laboratory Work (Marks)		
		Performance		Viva-Voce
		PRA	PDA	
LE2.5	Use speed measuring instruments and lux meter to measure speed of given component.	15	10	5
LE5.1	Determine the properties of the given fuel.	15	10	5
LE5.2	Determine the efficiency of the boiler.	15	10	5

* Assessment rubric, process and product check list with rating scale need to be prepared by the course wise teachers for each experiment for conduction and assessment of laboratory experiments /practicals.

Legend: PRA: Process Assessment, PDA: Product Assessment

Note: Only one experiment has to be performed at the end semester examination of **30** Marks as per assessment scheme.

K) Suggested Instructional/Implementation Strategies:

1. Improved Lecture
2. Tutorial
3. Case Method
4. Group Discussion
5. Industrial visits
6. Field Trips
7. Portfolio Based Learning
8. ICT Based Teaching Learning (Video Demonstration, CBT, Blog, Face book, Mobile)
9. Brainstorming

L) Suggested Learning Resources:

(a) Books :

S. No.	Titles	Author	Publisher and Edition*
1.	General Aspect of Energy Management and Energy Audit	BEE Guide book	Bureau of Energy Efficiency, New Delhi
2.	Energy Efficiency in Thermal Utilities	BEE Guide book	Bureau of Energy Efficiency, New Delhi
3.	Energy Management Handbook	W. C. Turner	The Fairmont Press Inc. Georgia ISBN-13: 9781466578289
4.	Handbook of Energy Audit	Sonal Desai	McGraw Hill Education ISBN-13: 978-9339221331
5.	Energy Management Principles	C.B.Smith	Pergamon Press ISBN 9781483101569
6.	Efficient Operation of Boilers	National Productivity Council	National Productivity Council

*Latest edition of all above books should be referred

(b) Open source software and website address:

i. http://jnujprdistance.com/assets/lms/LMS%20JNU/Dual%20Degree%20Courses/PGD+MBA%20%20Energy%20Management/Sem%20III/General%20Aspects%20of%20Energy%20Management%20and%20Energy%20Audit.pdf
ii. https://beeindia.gov.in/sites/default/files/1Ch3.pdf

iii. https://shodhganga.inflibnet.ac.in/bitstream/10603/46067/11/11_chapter%201.pdf
iv. www.eren.doe.gov
v. www.oit.doe.gov/bestpractices
vi. www.pera.org
vii. www.energy-efficiency.gov.uk
viii. www.actionenergy.org.uk
ix. www.cia.org.uk
x. www.altenergy.com

(c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

M) List of Major Laboratory Equipment and Tools:

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1.	Electrical measuring instruments for measuring electrical parameters e.g. kVA, KW, PF, Hertz, Ampere, Volt etc.,	kVA meter – Dynamometer type, linear scale suitable for single and three phase measurements, Digital kWmeter suitable for single and three phase, Digital PF meter suitable for single and three phase. Portable frequency meter, Ammeter and voltmeter for single and three phase.	LE2.1
2.	Combustion analyzer	Suitable for measurement of O_2, CO_2, CO, NO, NO_2, NOx, SO_2	LE2.2
3.	Water flow meter	Suitable for measuring flow from 5-10 LPM	LE2.3
4.	Speed measuring instruments	Hand held Tachometer for speed measurement – contact and non-contact type	LE2.4
5.	Lux meter	Suitable for measuring light conditions at work place.	LE2.4
6.	Able's closed cup apparatus	Heating Power: 600-650 W,Frequency Rate: 50 Hz-60Hz, Accuracy: Less than 0.5%, Timing Accuracy: 0.1 second	LE 1.3,
7.	Boilers	Working Models of boilers suitable for the laboratory purpose.Packaged, Stoker fired, Pulverised fuel boiler, FBC boiler, Super critical boiler	LE5.2
8.	Saybolt Viscometer	As per ASTMD-88, power-1000-1500W,Temp-5-50 deg C	LE1.4
9.	Combustion analyzer	Frequency: 50 - 70 Hz Gas: O2, CO2, CO, NO, NO2, NOx, SO2 Voltage: 110-240 VAC	LE2.2
10.	Water flow meter	Accuracy-+-0.5 or 1% FSD, Display-Digital, Connection-Threaded	LE2.3
11.	Leak detector	Height: 20-22 cm, Display Type: Digital Sensitivity Methan: 50 ppm to 1 Vol %	LE2.5

N) Mapping of POs & PSOs with COs:

Course Outcomes (COs)	Programme Outcomes (POs)										Programme Specific Outcomes (PSOs)		
	PO-1 Basic knowledge	PO-2 Discipline knowledge	PO-3 Experiments and practice	PO-4 Engineering Tools	PO-5 The engineer and society	PO-6 Environment and sustainability	PO-7 Ethics	PO-8 Individual and team work	PO-9 Communication	PO-10 Life-long learning	PSO-1	PSO-2	PSO-3
CO-1 Interpret the energy scenario.	3	2	1	1	2	1	1	1	2	2	1	1	1
CO-2 Use Energy Management and energy Audit strategy.	3	3	1	2	1	1	1	1	1	2	2	1	3
CO-3 Apply the concepts of material balance and Energy balance to different processes.	3	3	1	1	2	2	1	1	1	2	1	2	3
CO-4 Execute energy action planning, monitoring and targeting.	3	3	1	2	2	2	1	2	1	2	1	1	2
CO-5 Estimate the energy efficiency in thermal utilities.	3	3	1	2	2	2	1	2	2	2	2	2	3

Legend: 1 – Low, 2 – Medium, 3 – High

O) Course Curriculum Map:

POs & PSOs No.	COs No.& Titles	SOs No.	Laboratory Instruction (P)	Classroom Instruction (L)	Self Learning (SL)
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-1 Interpret the energy scenario.	SO1.1 - SO1.5	LE1.1 LE1.2 LE1.3 LE1.4	Unit 1.0 Energy Scenario and Development 1.1,1.2,1.3,1.4,1.5,1.6	As mentioned in relevant page number
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-2 Use Energy Management and energy Audit strategy**.**	SO2.1 - SO2.6	LE2.1 LE2.2 LE2.3 LE2.4 LE2.5	Unit 2.0 Energy Management and Audit 2.1, 2.2 ,2.3, 2.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-3 Apply the concepts of material balance and Energy balance to different processes.	SO3.1 - SO3.5	-	Unit 3.0 Material and Energy Balance 3.1, 3.2, 3.3, 3.4, 3.5	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-4 Execute energy action planning, monitoring and targeting.	SO4.1 - SO4.6	-	Unit 4.0 Energy Action Planning, Monitoring and Targeting 4.1, 4.2, 4.3,4.4	
PO-1,2,3,4,5,6, 7,8,9,10 PSO-1,2,3	CO-5 Estimate the energy efficiency in thermal utilities.	SO5.1 - SO5.6	LE5.1 LE5.2	Unit 5.0 Energy Efficiency in Thermal Utilities 5.1, 5.2, 5.3, 5.4, 5.5	

A) Course Code : 2037662(037)

B) Course Title : Major Project

C) Pre- requisite Course Code and Title :

D) Rationale :

Project work plays a very important role in engineering educations in developing core technical skills, soft skills and higher level of cognitive, psychomotor and affective domain skills. It encourages the thinking process in the students.

Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in new situation or task to solve the problems of the industries.

Through project work, students get direct exposure to the world of work in their relevant field. They are intrinsically motivated to explore new things, new methods, new design and many more ideas.

They also develop many soft skills like confidence, communication skills, creative ability, inquisitiveness, learning to learn skills, lifelong learning skills, problem solving skills, management skills, positive attitude, ethics etc. through project work.

Normally in a curriculum document, there is a mention of project work in two different situations.

In situation one, Project work is reflected as Mini Project under each and every course curricular detailing, in the form of sessional work mentioned under different semesters. These projects are normally related to the developing skills in respective course of the specific programme.

In another situation, project work is reflected as a complete course or as a major project in the total programme structure, normally at higher semester either at 4^{th}, 5^{th} and 6^{th}, depending on the requirement of the programme Normally.

E) Course Outcomes: After completion of the project work of a course or full semester, the students will be able to -

CO-1 Integrate the Knowledge (K), Skills (S), Attitudes (A) developed in a new task or problem identified in the form of project work.

CO-2 Develop higher level of cognitive, psychomotor and affective domain skills relevant to the course/programme.

CO-3 Integrate the generic skills/soft skills/employable skills with relevant technical skills for successful completion of the project work.

CO-4 Develop the skills of innovativeness, creativity, resourcefulness, time management, problem solving abilities, interpersonal skills, pro-activeness, cost effectiveness, environment consideration and sustainability.

F) Scheme of Studies:

S.No.	Board of Study	Course Code	Course Title	Scheme of Studies (Hours/Week)			
				L	P	T	Total Credits(C) L+T+(P/2)
1	Mechanical Engineering	2037662(037)	Major Project	-	2	-	2^

Legend: L: Classroom Instruction (Includes different instructional strategies i.e. Lecture and other), P: Laboratory Instruction (Includes Practical performances in laboratory workshop, field or other locations using different

instructional strategies) T- Tutorial includes Sessional Work(SW) (includes assignment, seminar, mini project etc.) and Self Learning (SL), C: Credits

Note: * **^** One credit is carried forward from the Vth semester Major Project evaluation.

* SW & SL has to be planned and performed under the continuous guidance and feedback of teacher to ensure outcome of Learning.

G) Scheme of Assessment:

S.No.	Board of Study	Course Code	Course Title	Scheme of Examination					
				Theory			Practical		Total Marks
				ESE	CT	TA	ESE	TA	
1	Mechanical Engineering	2037662(037)	Major Project	-	-	-	80	40	120

Note: i. Separate passing is must for TA component of Progressive Assessment, both for theory and practical.

ii. Separate passing is must for End Semester Exam(Theory) and End Semester Exam(Practical).

H) Guidelines to Teachers for Implementation of the Project Work :

Once the project is identified and allocated to students, teacher's role is very important. Teachers act as guide, facilitator, catalyser, motivator to promote brain storming, thinking, creatively, initiativeness and many other skills in the students. Teachers should help or guide continually to monitor whether the students are proceeding in the right direction as per outcomes to be attained.

It is also suggested that teachers are not supposed to guide and plan each and every step from the point of view of execution of the project, otherwise it will curb their creativity or thinking process. Teachers have to see that he or she is able to create think tank for this fast technological world of work for the growth of our country.

Following points should be taken into consideration while planning and implementing the project work:-

1. Identification of project and allocation methodology :

Though the teachers and students, both are involved in identification of project titles, but the prime responsibility of identification of project titles goes to the teachers involved in implementing the course or programme. Teachers are fully aware of course/programme curriculum. They are also aware of related industrial problems. They try to explore the possibility of identification of project titles through these problems.

These small industrial problems in the form of project titles may be brought into the laboratories or workshop of institutions of a specific programme, which are equipped with all necessary facilities and resources to carry out the project work. These labs or workshop can function as miniature industry to solve the industrial problems in the form of simulated industrial projects. These projects may be integrated problem of courses or programme.

The project identified may be application type, product type, Research type and review type.

1.1 Criteria for Identification and Implementation of Project Titles :

Identification of project title is planned to be done based on many considerations like :

- Cost effectiveness
- Safety considerations
- Ethical issues
- Environmental considerations
- Improvised process
- Improvised equipment
- Simulated industry's problem

- Application or utility in the world of work.
- Relevance to the Curriculum
- Mapping of Outcomes of Project with POs and PSOs
- Feasibility of implementation of the project

2. Implementation and Evaluation of Project Work:

Once the identification of project titles and guide allocation process is over, quality of student's project, on different criteria including the report writing need to be continually monitored.

Projects planning, design, execution and report writing is done by the students under the guidance and feedback by respective teachers for attainment of courses specific outcomes, POs and PSOs.

Continual Monitoring, feedback and assessment mechanism on weekly progress/updates on action taken on different criteria and sub-criteria of the project work need to be planned for individual and team of students. Path breaking teachers who think out of the box are required to guide, monitor and evaluate the project work.

For objective, valid and reliable assessment, teachers should use different tools of assessment such as checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. Even the students may be encouraged to adopt self assessment techniques using the assessment rubrics.

2.1 Criteria of Evaluation of Project:

The different criteria of evaluation of project under different sub heads of project work completion are given below :

2.2.1 Project Planning :

Project planning, its action plan, steps of realizing the projects, may be specifically planned in advance based on feasibility, resources available, time allocation, finance and manpower requirement for each and every step or activity of project work.

Under project planning, many points need to be considered like -

- Selection of relevant industry based projects as per the requirement of curriculum
- Rationale/Application
- Objectives Set
- Literature survey
  Literature survey on the project title need to be done through abstract, journals, websites, open sources and other relevant sources available.
  It need to be ensured that objectives are written properly with clear specific, measurable and attainable statements. The sample size has to be delimited and decided as per the time limit allotted, feasibility and many other considerations.
  Objectives formulated will decide the further course of action, depth and breadth of the project and implementation plan.

2.2.2 Design, Development and Execution of Project :

Following important characteristic features of project are need to be given special emphasis during the implementation of the project work-

- Innovativeness

- Creativity
- Originality
- Pro-activeness
- Initiativeness
- Cost Effectiveness
- Resourcefulness
- Development of soft skills/generic skills

There may be deviation from planning, design and implementation of the project as per the requirement.

2.2.3 Quality of Report Writing :

Following points need to be taken care of for report writing-

- Report writing as per prescribed format
- Clarity of Objectives
- Presentation of Data
- Data Analysis, Interpretation and Result
- Quality of Product

2.2.4 Presentation & Discussion :

Quality of presentation of data need to be ensured using the following criteria -

- Clarity in Communication and Presentation
- Voice Audibility
- Use of Media and methods
- Satisfying the queries of audience
- Attainment of objectives set

2.2.5 Project's Potential :

Futuristic scope and recommendation for further studies related to project may be assessed from the following criteria -

- Papers published or award received
- Exhibition or Display or showcase of project in competition or exhibition or Tech Fest
- Evaluation of working of projects or prototype
- Relevance and Applications in the world of work
- Recognition in any form
- Related areas/sub areas for further studies

The students need to be assessed continuously based on the assessment rubric prepared by the implementing teachers on different stages of project work completion.