GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: COMPUTER AIDED MANUFACTURING (CAM)
(COURSE CODE: 3361901)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

The use of conventional machines is decreasing day by day. Evolution of information technology, variety of manufacturing concepts with zero lead time demand and quality consciousness has supported fast adaption of Computer Aided Manufacturing. CNC machines (computerized numerical control machines) are the main component in Computer Aided Manufacturing Systems. Efficient use of CNC machines requires excellent knowledge of programming and use of CNC tooling. In this course an attempt has been made to focus exclusively on constructional features of CNC machines, their programming and tooling, so that students may learn to use the CNC machines efficiently for manufacturing desired products. CAM is normally not only limited to machine tools but in real life its use has widened in almost all areas of manufacturing, processes and support activities.

2. COMPETENCIES:

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competencies.

- **Select required operating parameters, appropriate tools, tool holders, accessories and consumables for manufacturing a given job on CNC.**
- **Manufacture simple jobs using CNC part programming.**

3. COURSE OUTCOMES (COs).

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Identify different axes, machine zero, home position, controls and features of CNC machines.
ii. Select, mount and set cutting tools and tool holders on CNC.
iii. Prepare part programmes using ISO format for given simple components with and without use of MACRO, CANNED CYCLE and SUBROUTINE using ISO format.
iv. Interface software application for auto part programming.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
2	0	2	4	70	30	20	30	

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment.

5. COURSE DETAILS.

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I. **Fundamentals of CAM.**	1a. Differentiate between NC, CNC and DNC. 1b. Identify parameters governing for selection of CNC machines.	1.1 CAM - concept and definition. 1.2 NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) - concept, features and differences. 1.3 Advantages and limitations of CNC. 1.4 Selection criteria for CNC machines.
Unit- II **Constructional features of CNC machines.**	2a. Classify CNC machines. 2b. Identify role of main elements of CNC machines. 2c. Identify CNC axes. 2d. Preset tool on CNC machines. 2e. Use qualified tools and tool holders on CNC machines.	2.1 CNC machines: Types, classification, working and constructional features. 2.2 Spindle drives and axes drives on CNC machines. 2.3 Machine structure- Requirements and reasons. 2.4 Elements of CNC machines - Types, sketch, working and importance of: i. Slide ways. ii. Re-circulating ball screw. iii. Feedback devices (transducers, encoders). iv. Automatic tool changer (ATC). v. Automatic pallet changer (APC). 2.5 CNC axes and motion nomenclature. 2.6 CNC tooling : i. Tool presetting-concept and importance. ii. Qualified tools-definition need and advantages. iii. Tool holders- types and applications.

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – III **CNC Turning & Machining Centers.**	3a. List features of specified CNC turning and machining centre. 3b. Identify various work holding and tool holding devices.	3.1 CNC turning centres: i. Types. ii. Features. iii. Axes nomenclature. iv. Specification. v. Work holding devices -types, working and applications. vi. Tool holding and changing devices - types, working and applications. 3.2 CNC machining centres: i. Types. ii. Features. iii. Axes nomenclature. iv. Specification. v. Work holding devices-types, working and applications. vi. Tool holding and changing device types, working and applications.
Unit – IV **CNC part programming.**	4a. Interpret ISO format of CNC part programming with used codes. 4b. Prepare part programme by using applicable codes like G& M etc. 4c. Apply advanced CNC part programming features like canned cycle, do loop, subroutine etc., 4d. Describe procedure for Setting various compensations on CNC. 4e. Prepare part programme considering	4.1 Definition and importance of various positions like machine zero, home position, work piece zero and programme zero. 4.2 CNC part programming: programming format and structure of part programme. 4.3 ISO G and M codes for turning and milling-meaning and applications of important codes. 4.4 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation). 4.5 Simple part programming for milling using ISO format. 4.6 Importance, types, applications and format for: i. Canned cycles. ii. Macro. iii. Do loops. iv. Subroutine. 4.7 CNC turning and milling part programming using canned cycles, Do loops and Subroutine.

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
	various compensations.	4.8 Need and importance of various compensations: i. Tool length compensation. ii. Pitch error compensation. iii. Tool radius compensation. iv. Tool offset. 4.9 Simple part programming using various compensations.
Unit – V **Recent trends in CAM.**	5a. Select suitable standard for CAD/CAM interfacing. 5b. List source of variability for adaptive control. 5c. Interpret different FMS layouts. 5d. Correlate areas of CIM. 5e. Identify types and elements of robots. 5f. Describe concept of Rapid prototyping.	5.1 Interfacing standards for CAD/CAM - Types and applications 5.2 Adaptive control- definition, meaning, block diagram, sources of variability and applications. 5.3 Flexible Manufacturing System (FMS) - concept, evaluation, main elements and their functions, layout and its importance, applications. 5.4 Computer Integrated Manufacturing (CIM) - Concept, definition, areas covered, benefits. 5.5 Robotics- definition, terminology, classification and types, elements and applications. 5.6 Rapid prototyping - Concept and application

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Computer Aided Manufacturing	4	4	6	0	10
II	Constructional Features of CNC machines	5	6	4	4	14
III	CNC Turning & Machining Centers.	4	2	6	2	10
IV	CNC part programming.	10	4	6	14	24
V	Recent trends in CAM.	5	4	8	0	12
	Total	**28**	**20**	**30**	**20**	**70**

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy).

Notes:

a. This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

b. If mid-sem test is part of continuous evaluation, unit numbers I, II and III are to be considered.
c. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (outcomes in psychomotor and affective domain) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.
Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of Course Outcomes related to affective domain. Thus over all development of ***Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme)*** *would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx. Hours. required
1	II	**Demonstrate constructional features of CNC:** a. Demonstrate CNC machines and its operations. b. Identify major parts of CNC and draw sketch. c. Write specification of CNC taken for demonstration. d. Sketch important tool holders. e. Tabulate sensors / feedback devices with type, specification and purposes used on CNC taken for demonstration. f. Sketch display console. Also sketch symbols used on display console with meaning of each. g. State interfacing standards used.	06
2	IV	**CNC turning part programming:** Teacher will assign part drawings. Minimum five drawings having following details are to be assigned. This include parts- (i) Simple turning with steps, (ii) Turning with tapers, (iii) Turning with circular (concave / convex shape) interpolation, (iv) Turning using canned cycle - with threading or drilling or other and (v)Turning with use of subroutine or macro or do-loop. Students would: a. Sketch each part with dimensions. b. Prepare CNC part programme using G and M codes with ISO format.	10

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx. Hours. required
		c. Show various zeros and tool path on part sketch with color codes and dimensions. d. Simulate the prepared part programmes using available simulation softwares. e. Prepare the parts on CNC.	
3	IV	**CNC machining centre part programming:** Teacher will assign part drawings. Minimum three drawings having following details are to be assigned. This include parts- (i) Simple contour milling (ii) Contour milling with (convex / concave) circular interpolation and (iii) contour milling with drilling / tapping. Students would: a. Sketch each part with dimensions. b. Prepare CNC part programme using G and M codes with ISO format. c. Show various zeros and tool path on part sketch with color codes and dimensions. d. Simulate the prepared part programmes using available simulation softwares. e. Prepare the parts on CNC.	08
4	III	**Demonstration of CAD/CAM integration:** a. Demonstrate CAD / CAM integration. b. List interfacing standards.	02
5	ALL	**Industrial visit:** Visit nearby industry having CNC machines. List and state important features of them with detail specifications and name of manufacturers.	02
		Total Hours	28

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.
b. Term work report must not include any photocopy/ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
c. Mini project and presentation topic/area has to be assigned to the group of specified students in the beginning of the term by batch teacher, if applicable.
d. For practical ESE part, students are to be assessed for competencies achieved.

8. SUGGESTED LIST OF STUDENT ACTIVITIES.

SR.NO.	ACTIVITY
i.	Visit nearby industry having CNC machines. List and state important features of them.
ii.	Prepare specifications of various types of CNC machines with images and names of manufacturers.

iii.	Download images and videos of CNC machines and its parts. Prepare one VCD/DVD in a batch and submit to batch teacher.
iv.	Download free simulation softwares available on website and practice for part programming.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr. No.	Unit	Unit Name	Strategies
i.	I	Introduction.	Videos, Presentations, Demonstration.
ii.	II	Constructional Features of CNC machines	Videos, Presentations, Industrial Visits, Demonstration,
iii.	III	CNC Turning & Machining Centers..	Videos, Presentations, Industrial Visits, Demonstration,
iv.	IV	CNC part programming.	Simulation softwares, actual practice on CNC machines, Demonstration,
v.	V	Recent trends in CAM.	Videos, Presentations, Industrial Visits,

10. SUGGESTED LEARNING RESOURCES.

A. List of Books:

S. No.	Title of Book	Author	Publication
i.	CNC Machines.	Pabla B.S., Adithan M.	New Age International, New Delhi,2014(reprint).
ii.	Computer Numerical Control-Turning and Machining centers.	Quesada Robert	Prentice Hall 2014.
iii.	CAD/CAM.	Sareen Kuldeep	S.Chand 2012.
iv.	Introduction to NC/CNC Machines.	Vishal S.	S.K.Kataria & Sons. 2012.
v.	Computer Aided Manufacturing.	Rao P N, Tiwari N K, Kundra T	Tata McGraw Hill 2014.
vi.	CAD/CAM: computer aided design and manufacturing.	Groover Mikell P, Zimmered W Emory	Prentice Hall 2011.

B) List of Major Equipment/ Instruments with Broad Specifications:

Sr. No.	Resource with brief specification.
i.	CNC Turning Centre (Tutor or Productive)- Minimum diameter 25 mm, Length 120 mm with ATC. (Approximate)

ii.	CNC Machining Centre (Tutor or Productive)- X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, With ATC. (Approximate)
iii.	Simulation software likes: CNC Simulator Pro, Swansoft CNC, etc.
iv.	Latest version of CAD/CAM integration software like MASTER CAM, NX CAM. etc.

C. List of Software/Learning Websites.

i. http://www.nptel.ac.in
ii. http://www.youtube.com/watch?v=M3eX2PKM1RI
iii. http://www.youtube.com/watch?v=EHQ4QIDqENI&list=PLBkqkLQO 2nAt5MNLo eUhvkFS9M0p8y_1
iv. http://www.youtube.com/watch?v=hJFLcvtiNQI
v. http://www.youtube.com/watch?v=BIM1AyxfYkw.
vi. http://www.mtabindia.com
vii. http://www.swansoftcncsimulator.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics.

- **Prof K.P. Patel**, H.O.D, Mechanical Department, B.S.Patel Polytechnic, Kherva.
- **Prof J.B.Patel**, Sr. Lecturer, Mechanical Department, R.C.Technical Institute, Ahmedabad
- **Prof R.A.Prajapati**, Sr. Lecturer, Mechanical Department, R.C.Technical Institute, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. K.K. Jain,** Professor, Department of Mechanical Engineering, NITTTR, Bhopal
- **Dr. A.K. Sarathe,** Associate Professor; Department of Mechanical Engineering.

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			I
	iii.		2			I
	iv.		2			II
	v.		2			III
	vi.		2			IV
	vii.		2			IV
	viii.		2			IV
	ix.		2			V
	x.		2			V
2	a.			6		I
		OR				
	a.			6		I
	b.			4		II
		OR				
	b.			4		II
	c.				4	II
		OR				
	c.				4	II
3	a.		6			II
		OR				
	a.		6			II
	b.			4		V
		OR				
	b.			4		V
	c.			4		V
		OR				
	c.			4		V
4	a.	Given the simple part drawing of milling contour with circular interpolation, prepare the CNC part programme using G and M codes with ISO format.			7	IV
		OR				
	a.	Given the simple part drawing of milling contour with circular interpolation, prepare the CNC part programme using G and M codes with ISO format.			7	IV
	b.			4		IV

	c.			3		IV
5	a.	Given the simple part drawing, prepare the CNC turning part programme using G and M codes with ISO format. Include circular interpolation.			7	IV
	b.			4		III
	c.			3		III

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: TOOL ENGINEERING
(COURSE CODE: 3361902)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

Tools are as basic component for any machining process. The quality and efficiency of any machining operation basically depends upon quality of tools which in turn depends 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. Jigs and fixture plays an import roll in this process. 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 cutting tools, jigs and fixtures are also dealt with in this course. This course is therefore a core course for mechanical engineers.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competencies.

- **Develop the ability to select and/or design cutting tools, tool holders, dies, jigs and fixture for given simple component.**

3. COURSE OUTCOMES.

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Re-sharpen given cutting tool.
ii. Select proper tool for given manufacturing operation
iii. Interpret designation system of cutting tool and tool holder.
iv. Select locating and clamping devices for given component.
v. Select and design jig and fixture for given simple component.
vi. Classify and explain various press tools and press tools operations.
vii. Select a die for a given simple component.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment.

5. COURSE CONTENT DETAILS.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I. **Introduction.**	1a. Explain role of tool engineering in industries. 1b. Establish importance of process planning in tool engineering. 1c. Identify and select elements of universal acts in manufacturing operations.	1.1 Concept, meaning and definitions of tool, tool design and tool engineering. 1.2 Tools-types, classification, features & applications. 1.3 Tool engineering-functions and importance to enhance productivity and quality. 1.4 Importance of process planning in tool engineering. 1.5 Economy-concept, meaning, importance and principles in tool engineering. 1.6 Universal acts & their elements of a manufacturing operation with suitable simple example.
Unit – II **Cutting tools and tool holders.**	2a. List cutting tool materials. 2b. Interpret ISO-designation for carbide inserts. 2c. Describe process for re-sharpening commonly used cutting tools. 2d. Interpret ISO-designation for tool holders for carbide inserts. 2e. Mount tool holders on conventional milling and drilling machines.	2.1 Cutting tool materials-types, composition, properties and applications. 2.2 Carbide inserts-types, ISO-designation and applications. 2.3 Re-sharpening methods of following cutting tools: i. Drill. ii. Side and face milling cutter. iii. End mill. iv. Centre drill, type A and B. v. Gear hob. 2.4 Tool holders for turning and milling carbide inserts-types, ISO-designation and applications. 2.5 Tool holding and tool mounting systems for conventional milling and drilling machine tools.
Unit – III **Locating and clamping devices.**	3a. Explain location and 3-2-1 principle of location. 3b. Establish importance of degree of freedom in location. 3c. Select and use appropriate	3.1 Concept, meaning and definitions of location and clamping. 3.2 Use of locating and clamping principles in day-to-day supervision on shop floor. 3.3 Degree of freedom-concept and importance. 3.4 3-2-1 principle of location. 3.5 Locators: i. Types- ii. Sketches with nomenclature. iii. Working. iv. Applications.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	locator for given work piece. 3d. Select and use appropriate clamping device for given work-piece situation.	3.6 Fool proofing and ejecting. 3.7 Clamping devices: i. Types. ii. Sketches with nomenclature. iii. Working. iv. Applications.
Unit – IV **Jigs and fixtures.**	4a. Differentiate between jigs and fixtures. 4b. Select and design appropriate jig or fixture for given simple work-piece.	4.1 Concept, meaning, differences and benefits of jigs and fixtures. 4.2 Types, sketches with nomenclature, working and applications of jigs. 4.3 Types, sketches with nomenclature, working and applications of fixtures. 4.4 Steps to design jigs and fixture. 4.5 For given simple component: i. Select type (Jig or fixture). ii. Develop locating method. iii. Develop clamping method. iv. Design jig and fixture (as applicable). v. Prepare details and assembly sketches.
Unit – V **Press tools.**	5a. Select suitable press tool operation for given simple press tool component. 5b. Operate simple press tool. 5c. Calculate press tonnage and center of pressure for given press tool component. 5d. Determine dimensions of punch and die for given press tool component. 5e. Determine shear angle. 5f. Prepare scrap strip layout for given press tool component.	5.1 Press working processes-types, sketches and applications. 5.2 Press tools: types, working, components and their functions. 5.3 Concept, meaning, definitions and calculations of press tonnage and shut height of press tool. 5.4 Shear action in die cutting operation. 5.5 Centre of pressure: Concept, meaning, definition, methods of finding and importance. 5.6 Die clearance: Concept, meaning, definition, reasons, effects and methods of application. 5.7 Cutting force: Methods to calculate and methods of reducing. 5.8 Shear angle- concept, need and method to give shear angle on punch and die. 5.9 Scrap strip layout: - Concept, importance, method to prepare, and determining percentage stock utilization. 5.10 Types, working, and applications of stock stop, pilots, strippers and knockouts. 5.11 Cutting dies-types and applications.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	5g. Design progressive cutting die for given simple press tool component.	5.12 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.
Unit – VI **Dies and moulds.**	6a. Calculate bend radii, bend allowance and spring back for given simple part. 6b. Describe working of various dies. 6c. Select type of die/mould for given part.	6.1 Bending: 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. 6.2 Drawing dies-types and method to determine blank size for drawing operation. 6.3 Types, sketch, working and applications of drawing dies (embossing, curling, bulging, coining, swaging and hole flanging). 6.4 Forging dies- terminology, types, sketch, working and applications. 6.5 Sketch, working and applications of following dies/mould: i. Extrusion. ii. Plastic injection. iii. Blow moulding.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction.	3	2	4	0	6
II	Cutting tools and tool holders.	7	4	4	4	12
III	Locating and clamping devices.	7	4	4	4	12
IV	Jigs and fixtures.	10	4	5	7	16
V	Press tools.	10	4	2	8	14

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
VI	Dies and moulds.	5	4	6	0	10
	Total	**42**	**22**	**25**	**23**	**70**

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy).

Notes:

a. *This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.*
b. If mid-sem test is part of continuous evaluation, unit numbers I, II, III and V (Up to 5.5 only) are to be considered.
c. Ask the questions from each topic as per marks weight age. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (outcomes in psychomotor and affective domain) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of Course Outcomes related to affective domain. Thus over all development of Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme) would be assured.

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx. Hours. required
1	I	**Preparatory activity:** a. Tabulate most commonly used limits, fits and tolerance values. b. Tabulate BIS designation and applications of most commonly used tool materials. c. Tabulate machining processes and surface finish achieved. d. Demonstrate models of / actual jigs, fixtures and progressive cutting dies.	04
2	II	**Cutting tools re-sharpening.** a. Draw the cutting tool with nomenclature taken for re-sharpening. b. Re-sharpen any one cutting tool from following. i. Drill. ii. Side and face milling cutter.	04

		iii. Centre drill, type A. c. Freehand sketch set ups for grinding each angle.	
3	III, IV	**Design of fixture:** Faculty will demonstrate working of any one fixture. Faculty will assign one simple component for designing of fixture. Develop the design and: a. Sketch the component. b. Prepare production drawings of all parts of fixture (Details). c. Draw assembly.	06
4	III, IV	**Design of jig:** Faculty will demonstrate working of any one jig. Faculty will assign one simple component for designing of jig. Develop the design and: a. Sketch the component. b. Prepare production drawings of all parts of jig (Details). c. Draw assembly.	06
5	V	**Design of progressive die:** Faculty will demonstrate working of various press tools operations. Faculty will assign one simple component for designing of progressive cutting die. Develop the design and: a. Draw the component. b. Draw scrap strip layout. c. Calculate tonnage and centre of pressure. d. Work out dimensions of punches and die. e. Production drawings of die block, die shoe and stripper plate. f. Draw assembly which include punches, die, die shoe and stripper plate only.	08
		Total Hours	**28**

Notes:

a. Use only sketch-book to carry practice work as term work.
b. Production drawings include-drawings with dimensions-scale, surface finish symbols, limits/fits, tolerances, surface treatment/s, heat treatment/s and other notes/details required to manufacture the part.
c. Assembly drawing include minimum two views (one preferably sectional view if required) and parts list.
d. In examination, students are required to sketch freehand only.(For all questions).
e. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.
f. Term work report must not include any photocopy/ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
g. For practical ESE part, students are to be assessed for competencies achieved. They should be given experience/part of experience to perform as under.
    i. Design jig or fixture or progressive die for given simple part.

8. SUGGESTED LIST OF STUDENT ACTIVITIES.

SR.NO.	ACTIVITY
1	Download the catalogues for cutting tools, jigs and fixtures and prepare report on their features and specifications.
2	Visit nearby manufacturing unit and prepare the list with specifications of cutting tools, hand tools, press tools, measuring tools and consumables being used there.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr. No.	Unit	Unit Name	Strategies
1	I	Introduction.	Movie, Industrial visit.
2	II	Cutting tools and tool holders.	Demonstration of physical cutting tools and tool holders.
3	III	Locating and clamping devices.	Demonstration of physical locating and clamping devices in operation, video movies,
4	IV	Jigs and fixtures.	Demonstration with operations, video movies, Industrial visits.
5	V	Press tools.	Demonstration with operations, video movies, Industrial visits.
6	VI	Dies and mould.	Video movies, Industrial visits.

10. SUGGESTED LEARNING RESOURCES.

A. List of Books:

S. No.	Title of Book	Author	Publication
1.	Fundamentals of tool design	ASTME	PHI.
2.	Tool design.	Donaldson & Lecain.	TME
3.	Tool engineering	Doyal.	
4.	Principles of tool & jig design	M. H. A. Kempster.	
5.	Jigs and fixture	P. H. Joshi	TMGH
6.	Design Of Jigs Fixtures And Press Tools	C. Elanchezhian, T. Sunder Selwyn, B. Vijaya Ramnath	Eswar Press,2007, 2nd Edition
7.	Cutting tools standards.	-	BIS
8.	Production technology	-	HMT
9.	PSG Design data book	PSG, Coimbatore	PSG, Coimbatore

B. List of Major Equipment/ Instrument with Broad Specifications:

Sr. No.	Resource with brief specification.
1	Tool and cutter grinding machine.
2	Cutting tools, mainly set consisting assorted sizes of drill bits, set consisting assorted

	sizes of end mills, set consisting assorted sizes of side and face milling cutters, set consisting assorted sizes of centre drills-Type A and B, assorted carbide inserts,
3	Tool holders for carbide inserts, drill spindles/quills, milling machine quills,
4	Most commonly used set of locators and clamping devices, jigs and fixtures.
5	Models of jigs and fixtures.
6	Press-2.5 to 5 Tonnes,(Hydraulic or electrical operated), set of assorted sizes punches and dies,

C. List of Software/Learning Websites.

i. http://www.psgdesigndata.org
ii. http://www.carrlane.com
iii. http://www.nptel.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE.

Faculty Members from Polytechnics.

- **Prof. A.M. Talsaniya**, Lecturer in Mechanical Engineering, Sir BPI, Bhavnagar.
- **Prof. K.H. Patel**, Head of Mech. Engg. Dept., Dr. S.& S.S. Ghandhy College of Engg. & Tech., Surat
- **Prof. M.M. Jikar**, Head of Mech. Engg. Dept., N.G.PATEL POLYTECHNIC, Isroli, Bardoli.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. K.K. Jain,** Professor, Department of Mechanical Engineering,
- **Dr. A.K. Sarathe,** Associate Professor; Department of Mechanical Engineering.

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			I
	iii.			2		II
	iv.			2		II
	v.		2			III
	vi.		2			IV
	vii.		2			IV
	viii.		2			III
	ix.		2			V
	x.		2			V
2	a.			4		I
		OR				
	a.			4		I
	b.		4			II
		OR				
	b.		4			II
	c.		4			III
		OR				
	c.		4			III
	d.			2		V
		OR				
	d.			2		V
3	a.				4	II
		OR				
	a.				4	II
	b.		4			VI
		OR				
	b.		4			VI
	c.			6		VI
		OR				
	c.			6		VI
4	a.	Given simple component drawing, show the design of jig by freehand sketches of assembly with minimum two views. (Preferably one sectional view).			8	IV
		OR				
	a.	Given simple component drawing, show the design of fixture by freehand sketches of assembly. Also freehand sketch for locators.			8	IV
	b.			4		IV
	c.			2		II
5	a.	Given simple component for designing progressive cutting die, sketch scrap strip layout, calculate tonnage, calculate centre of pressure and determine dimensions of punch and die considering clearance.			8	V
	b.				2	III
	c.			4		III

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: INDUSTRIAL MANAGEMENT
(COURSE CODE: 3361903)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

Technicians of mechanical engineering disciplines are expected to work during most of their career at middle level. They are also expected to deal with workforce and management problems. In the present era of competition, optimum utilization of the resources with achieving higher productivity is essential for any industry to survive. Quality and cost controls are also other important factors which contribute to the day to day supervision issues. This course aims to deal effectively with such issues along with familiarization of acts and laws applied to industries.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competencies.

- **Recognize organization structure, human resource issues in industries and major provisions of factory acts.**
- **Plan, use, monitor and control resources optimally and economically.**

3. COURSE OUTCOMES (COs).

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Interpret given organization structure, culture, climate and major provisions of factory acts and laws.
ii. Explain material requirement planning and store keeping procedure.
iii. Plot and analyze inventory control models and techniques.
iv. Prepare and analyze CPM and PERT for given activities.
v. List and explain PPC functions.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	100
3	0	0	3	70	30	0	0	

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment.

5. COURSE CONTENT DETAILS.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I. **Introduction.** .	1a. Describe the types of organization structure. 1b. Identify factors affecting moral. 1c. Explain important provisions of factory act and labour laws.	1.1 System- concept, definition, types, parameters, variables and behavior. 1.2 Management – definition and functions. 1.3 Organization structure: i. Definition. ii. Goals. iii. Factors considered in formulating structure. iv. Types. v. Advantages and disadvantages. vi. Applications. 1.4 Concept, meaning and importance of division of labor, scalar & functional processes, span of control, delegation of authority, centralization and decentralization in industrial management. 1.5 Organizational culture and climate – meaning, differences and factors affecting them. 1.6 Moral-factors affecting moral. 1.7 Relationship between moral and productivity. 1.8 Job satisfaction- factors influencing job satisfaction. 1.9 Important provisions of factory act and labor laws.
Unit – II **Critical Path Method (CPM) and Programme Evaluation Review Technique (PERT).**	2a. Draw CPM and PERT diagrams based on given conditions and data. 2b. Determine critical path on CPM and PERT. 2c. Calculate floats on CPM and PERT.	2.1 CPM & PERT-meaning, features, difference, applications. 2.2 Understand different terms used in network diagram. 2.3 Draw network diagram for a real life project containing 10-15 activities, computation of LPO and EPO.(Take minimum three examples). 2.4 Determination of critical path on network. 2.5 Floats, its types and determination of floats. 2.6 Crashing of network, updating and its applications.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – III Materials Management.	3a. Apply the procedure for purchase. 3b. Practice the store keeping procedures. 3c. Interpret given inventory model. 3d. Derive Economic Order Quantity for given data. 3e. Identify applications of Material Requirement Planning (MRP).	3.1 Material management-definition, functions, importance, relationship with other departments. 3.2 Purchase - objectives, purchasing systems, purchase procedure, terms and forms used in purchase department. 3.3 Storekeeping- functions, classification of stores as centralized and decentralized with their advantages, disadvantages and application in actual practice. 3.4 Functions of store, types of records maintained by store, various types and applications of storage equipment, need and general methods for codification of stores. 3.5 Inventory control: i. Definition. ii. Objectives. iii. Derivation for expression for Economic Order Quantity (EOQ) and numeric examples. iv. ABC analysis and other modern methods of analysis. v. Various types of inventory models such as Wilson's inventory model, replenishment model and two bin model. (Only sketch and understanding, no derivation.). 3.6 Material Requirement Planning (MRP)-concept, applications and brief details about software packages available in market.
Unit – IV **Production planning and Control (PPC).**	4a. Schedule the operations based on available data using PPC techniques. 4b. Schedule using critical ratio scheduling technique 4c. Identify the factors and resources	4.1 Types and examples of production. 4.2 PPC : i. Need and importance. ii. Functions. iii. Forms used and their importance. iv. General approach for each type of production. 4.3 Scheduling- meaning and need for productivity and utilisation. 4.4 Gantt chart- Format and method to prepare. 4.5 Critical ratio scheduling-method and numeric examples.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	affecting the bottlenecking. 4d. Schedule using Gantt chart with the help of Annexure-I for given data.	4.6 Scheduling using Gantt Chart (for at least 5-7 components having 5-6 machining operations, with processes, setting and operation time for each component and process, resources available, quantity and other necessary data), At least two examples. 4.7 Bottlenecking- meaning, effect and ways to reduce.
Unit – V **Value Analysis (VA) and Cost Control.**	5a. Apply value analysis and cost control techniques for given case.	5.1 VA-definition, terms used, process and importance. 5.2 VA flow diagram. 5.3 DARSIRI method of VA. 5.4 Case study of VA-at least two. 5.5 Waste-types, sources and ways to reduce them. 5.6 Cost control-methods and important guide lines.
Unit – VI **Recent Trends in IM.**	6a. Describe recent practices being adopted in industrial management.	6.1 ERP (Enterprise resource planning) - concept, features and applications. 6.2 Important features of MS Project. 6.3 Logistics- concept, need and benefits. 6.4 Just in Time (JIT)-concept and benefits. 6.5 Supply chain management-concept and benefits.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction.	6	6	4	0	10
II	Critical Path Method (CPM) and Programme Evaluation Review Technique (PERT).	10	4	6	7	17
III	Materials Management.	8	6	4	4	14
IV	Production Planning and Control (PPC).	10	6	4	7	17
V	Value Analysis (VA) and Cost Control.	4	4	2	0	6
VI	Recent Trends in IM.	4	6	0	0	6
	Total	42	32	20	18	70

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy).

Notes:

a. This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.
b. If mid-sem test is part of continuous evaluation, unit numbers I, II (Up to 2.4 only) and IV (Up to 4.7 only) are to be considered.
c. Ask the questions from each topic as per marks weight age. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF PRACTICAL/EXERCISE

…….Not Required…….

8. SUGGESTED LIST OF STUDENT ACTIVITIES.

Sr. No.	Activity
i.	Given the data, prepare the network diagram and determine critical path, EPO, LPO and floats.
ii.	Given the data, prepare the scheduling using Gantt chart.
iii.	Perform value analysis for given case.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr. No.	Unit	Unit Name	Strategies
i.	I	Introduction.	Video movies.
ii.	II	Critical path method (CPM) and pre evaluation review technique (PERT).	Video movies, solving tutorials, real life industries situation, industrial visits.
iii.	III	Materials management.	Video movies, real life industries situation, industrial visits.
iv.	IV	Production planning and control (PPC).	Video movies, solving tutorials, real life industries situation, industrial visits.
v	V	Value analysis (VA) and cost control.	Analyzing real cases, video movies.
vi	VI	Recent trends in IM.	Industrial visits, movies.

10. SUGGESTED LEARNING RESOURCES.

A. List of Books:

S. No.	Title of Book	Author	Publication
i.	CPM & PERT principles and Applications.	L.S.Srinath.	
ii.	Modern Production Management.	Buffa.	
iii.	Materials Management.	N. Nair.	
iv.	Industrial Engineering & Management.	O. P. Khanna.	
v.	Value Analysis.	Mikes.	

B. List of Major Equipment/ Instrument with Broad Specifications:

Sr. No.	Resource with brief specification.
1	Necessary freeware-other softwares.

C. List of Software/Learning Websites.

i. www.youtube.com/watch?v=SF53ZZsP4ik
ii. www.youtube.com/watch?v=iPZlQ3Zx5zc
iii. web.stanford.edu/class/cee320/CEE320B/CPM.pdf
iv. www.criticaltools.com/**pert**chartex**pert**software.htm
v. en.wikipedia.org/wiki/Program_evaluation_and_review_technique
vi. www.netmba.com/operations/project/**pert**/

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics.

- **Prof. A. M. Talsaniya**, Lecturer in Mechanical Engineering, Sir BPI, Bhavnagar.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. Vandna Somkuwar,** Associate Professor, Department of Mechanical Engineering,
- **Dr. A.K. Sarathe,** Associate Professor; Department of Mechanical Engineering.

ANNEXURE – I

A. GIVE DETAILS OF EACH PART IN FOLLOWING FORMAT.

PART NUMBER			PART NAME	
MATERIAL			BATCH QUANTITY	
OP.NO.	PROCESS	SETTING TIME / BATCH (MIN).	OP. TIME / PIECE (MIN).	MACHINE

B. RESOURCE DETAILS:

NAME OF MACHINE	NUMBER OF MACHINES	MACHINE AVAILABLE FOR NUMBER OF HOURS / DAY (TOTAL FOR ALL SHIFTS).	NUMBER OF WORKING DAYS / MONTH.	TOTAL HOURS AVALABLE PER MONTH

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			I
	iii.		2			II
	iv.		2			II
	v.		2			III
	vi.		2			III
	vii.		2			IV
	viii.		2			IV
	ix.			2		V
	x.		2			VI
2	a.		4			I
		OR				
	a.		4			I
	b.			4		I
		OR				
	b.			4		I
	c.			3		II
		OR				
	c.			3		II
	d.			3		II
		OR				
	d.			3		II
3	a.		4			III
		OR				
	a.		4			III
	b.				4	III
		OR				
	b.				4	III
	c.		3			IV
		OR				
	c.		3			IV
	d		3			VI
		OR				
	d		3			VI
4	a.	Given the data, prepare network diagram and determine critical path. Number of events should not be more than 7.			7	II
		OR				
	a.	Given the data, prepare network diagram. Calculate EPO and LPO at each node. Number of events should not be more than 7.			7	II
	b.			4		III
	c.			3		IV
5	a.	Given the data, prepare the scheduling using Gantt chart. Number of the components should not be more than 4.			7	IV
	b.		4			V
	c.		3			VI

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: MANUFACTURING SYSTEMS
(COURSE CODE: 3361904)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

Manufacturing processes converts raw material to finished product for customer usage. Customer is the key player in market and needs and desires of customer has increased the varieties and features in products. This has increased the complexities at almost all the stages of manufacturing. Performance of a product depends on its quality in terms of accuracy of size, shape and constraints/relation between its features. Conversion cost and time can be optimized by judicious usage of energy, motions, resources, time etc without affecting the quality desired by the customer.

Manual operations have limitations in terms of power, precision and repetitions. Recent techniques / electronics devices provide precision machine control compare to conventional machines. Objective of leaning this subject is to make aware the students about the advance manufacturing practices/methods being implemented at leading industries across the globe, which ultimately leads to more customer satisfaction in terms of low cast and high quality.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills so that students are able to acquire following competency:

- **Identify and use the proper manufacturing systems to manufacture products at internationally competitive price with innovation and better quality.**

3. COURSE OUTCOMES (COs).

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Explain role of computers and information technology in manufacturing systems.
ii. Develop an FMS (Flexible Manufacturing System) layout for given simple part family, using group technology concepts to and make proper grouping as per their attributes.
iii. Recognize use of robotics, programmable logic controllers, microcontrollers and recent advances in the field of manufacturing.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment.

5. COURSE CONTENT DETAILS.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I **Introduction.**	1a. Develop familiarity with transformation and manufacturing systems. 1b. Describe role of computers in manufacturing industries. 1c. Identify the stage of given product on product life cycle. 1d. Identify the stage of specified technology on technology life cycle. 1e. Explain the need to manufacture products at international competitive price with better quality & innovation.	1.1 Evolution of transformation & manufacturing systems. 1.2 Need of attitude, knowledge & skill required for application of manufacturing systems. 1.3 Need for system approach. 1.4 Role of computers and information technology in manufacturing and manufacturing systems. 1.5 Product life cycle & its importance. 1.6 Technology life cycle. 1.7 Scope, importance and challenges in Indian context to manufacture products at international competitive price with better quality& innovation.
Unit – II **Group Technology (GT) & Cellular Layout.**	2a. Select type of production layouts for given parts. 2b. Select and develop GT codes for given parts. 2c. Identify features and develop part families of the given parts. 2d. Prepare cell layout of given part family.	2.1 GT - concept, definition, need, scope, & benefits. 2.2 Production layout-types, features and applications. 2.3 GT Layout -concept, need, benefits, comparison with conventional layout with examples. 2.4 GT- codification systems- types, method of coding and examples. 2.5 Part features- concept, types and examples. 2.6 Part family- concept, method to form and approach to form cell using part families. 2.7 Types and comparison of cell: manual and automatic cell, assembly cell. 2.8 Steps of cell design and cell layout.
Unit – III	3a. Identify role of major elements of FMS. 3b. Develop simple FMS layout for given data	3.1 Flexible Manufacturing System (FMS) –concept, definition and comparison with other manufacturing systems.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Flexible Manufacturing System (FMS).	and family of components.	3.2 Major elements of FMS and their functioning: i. Tool handling system. ii. Material handling system. iii. Automated guided vehicles (AGV). iv. Automated storage and retrieval system (AS/RS). v. Main frame computer. 3.3 FMS layout - concept, types and applications. 3.4 Data required developing an FMS layout. 3.5 Signal flow diagram and line balancing in FMS. 3.6 FMS layout illustrations (Minimum two).
Unit – IV **Robotics.**	4a. Describe the importance of robotics in industry. 4b. Select appropriate sensor for given application.	4.1 Robots-concept, definition, benefits and various areas of application in manufacturing systems. 4.2 Terminology used in robotics. 4.3 Robots-types, physical configuration, classification and selection criterion. 4.4 Axes nomenclature. 4.5 Types and uses of Manipulators & Grippers. 4.6 Sensors- types, classifications, working principle and applications of position, force & torque, proximity, vision, velocity & acceleration sensors. 4.7 Overview of robot programming methods & languages.
Unit – V **Programmable Logic Controller (PLC) & Micro-Controllers (MC).**	5a. Explain the need and importance of PLC and microcontrollers used in various equipments. 5b. Select appropriate control system for given situation. 5c. Prepare the circuit diagram for given condition using logic gates.	5.1 Role of control system in instrumentation 5.2 Open and close loop control system, types and block diagram. 5.3 Servomechanism and regulators with suitable examples. 5.4 Basic control actions - on-off, proportional, derivative, integral control, proportional derivative (PD), proportional integral (PI), p proportional integral and derivative (PID) control. 5.5 Basic digital logic gates: symbol, operation, truth-table and examples of

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		AND, OR, NOT, NAND, NOR, EX-OR, EX-NOR gates. 5.6 PLC: Concept, general constructional features, types of diagrams, working and major applications in manufacturing systems. 5.7 Use of SCADA (Supervisory Control And Data Acquisition) in PLC design. 5.8 Microcontrollers: introduction, hardware components, i/o pins, ports; selection of micro controllers & embedded controllers, applications.
Unit – VI **Recent Trends**	6a. Identify the applications of various advance techniques used in manufacturing	6.1 Computer Aided Process Planning (CAPP) - concept, types, features, methods and importance. 6.2 Computer Integrated Manufacturing (CIM): need, block diagram, functional areas covered and their importance. 6.3 Protocols in CIM- their features, functions and applications. 6.4 Computer Aided Inspection (CAI) - concept, benefit, types, working and examples. Coordinate Measuring Machine (CMM) - its working and applications. 6.5 Rapid Prototyping (RP): working principles, methods, applications and limitations, rapid tooling, techniques for rapid prototyping. 6.6 Artificial intelligence- concept, definition and application areas, neural network: working principles, applications and limitations. 6.7 Lean manufacturing - concept, sources of waste, benefits and applications. 6.8 Factory of future (FOF).

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction.	04	02	04	00	06

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
II	Group Technology (GT) & Cellular Layout.	06	04	04	04	12
III	Flexible Manufacturing System (FMS).	06	04	04	04	12
IV	Robotics.	10	07	04	04	15
V	Programmable Logic Controller (PLC) & Microcontrollers.	10	07	04	04	15
VI	Recent Trends.	06	06	04	00	10
	Total	42	30	24	16	70

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy).

Notes:

a. This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.
b. If mid-sem test is part of continuous evaluation, unit numbers I, II, IV and VI are to be considered.
c. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain**) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of Course Outcomes related to affective domain. Thus over all development of **Programme Outcomes** (as given in a common list at the beginning of curriculum document for this programme) would be assured.

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	--	**Presentation on "How it's made":** Faculty will assign any one part from Annexure-I. (Each student will have different part in a batch). Student will download movies/content and will present with the concept "How it's made". Note: Each student will make his/her folder having the name as <batch number_Enrollment number> and will save his/her	04

		downloaded content. A DVD is to be made which will contain folders of all students. Same DVD is to be submitted.	
2	II	**GT codes:** Faculty will ask each student to bring at least one component having mechanical features and having more than 5-6 machining operations. Each student will also prepare the drawing and process plan (As per attached Annexure-II).Then the data will be interchanged by batch students. Collection of parts and making drawing and process plans will be as home assignment. Fcaulty will assign this task in very first period of practice. Students would: a. Prepare drawing of part brought by the student. b. Prepare process plan as per Annexure-II for the part brought by student. c. Interchange part drawings and process plans. (No photo copies are allowed. Each student in a batch will have total drawings and process plans equal to number of students in a batch who have brought parts. This may be also given as home assignment). d. Prepare feature matrix. e. Select GT coding system and assign GT code to each part.	04
3	III	**FMS layout:** Students would: a. Develop part family (May be 3-6 parts) from all parts.(Taken in Ex. No. 2 above.) This is to be carried out logically from feature matrix. b. Assume quantities of each part of part family developed in a. above. c. Assume additional data for following: i. Number of shifts and working hours in each shift. ii. Average number of working days in a month. iii. Utilisation factor of FMS unit. d. Prepare process time matrix. (Suggested format is attached as per Annexure-III). e. Determine type and number of work stations. f. Perform necessary calculations and prepare conceptual FMS layout.	06
4	IV	**Demonstration:** Students would: a. Demonstrate working of following: i. Robot-anyone. ii. Sensors-each one from force & torque type, velocity and acceleration type, proximity type, position type and vision type. iii. PLC-anyone. iv. MC-anyone. v. Control system-anyone. b. Sketch following. i. Configuration sketch of robot demonstrated. ii. Working sketch of sensors demonstrated. iii. Block diagrams of PLC and MC demonstrated. iv. Circuit diagram of control system demonstrated.	06

5	All	**Mini project (In the group of 4-6 students):** Students would: a. Prepare at least one from the following (as approved by the faculty): i. Prepare simple circuit using application of sensor. ii. Prepare simple robot using available kit. iii. Prepare ladder diagram for any one real life PLC application. iv. Build and operate the functionality of basic or advance logic gates. b. Prepare report which includes sketches, specifications, observation tables, parameters, truth tables, applications, etc. (as applicable). c. Present the project.	04
6	All	**Industrial visit and report :** Students would: Visit any one advanced manufacturing system /CAD-CAM based industry/centre of excellence/exhibition and prepare brief report on it.	04
		Total Hours	**28**

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.
b. Term work report must not include any photocopy /ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
c. Mini project and presentation topic/area has to be assigned to the group of specified students in the beginning of the term by batch teacher.
d. For practical ESE part, students are to be assessed for competencies achieved. They should be given to:
    i. Code the given part using GT coding system.
    ii. Identify the features of given part.
    iii. Prepare simple FMS layout based on given inputs.
    iv. Prepare simple circuit diagram for given conditions using logic gates.
    v. Prepare simple ladder diagram for given conditions for PLC.
    vi. Select the suitable sensor for given conditions.
    vii. Identify robotic elements. Select suitable gripper for given part. Sketch geometrical configuration of given type of robot. Identify various terminologies with robot model/sketch.

8. SUGGESTED LIST OF STUDENT ACTIVITIES.

Sr. No.	Activity
i.	Prepare a list of mechanical features based product/products in the market that faces challenges related to quality or cost; but has a market potential.
ii.	Visit nearby industry and present a case study covering the scope of this subject.
iii.	Visit or participate in the technical events, exhibition, conference, seminar (with presentation).
iv.	Collect / download videos / presentations / case study on advances in manufacturing systems.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr. No.	Unit	Unit Name	Strategies
i.	I	Introduction.	Presentation, Video.
ii.	II	Group Technology (GT) & cellular layout.	Presentation, Video, Assignment, Industrial Visit, demonstration of real parts with features identification.
iii.	III	Flexible Manufacturing system (FMS).	Presentation, Video, Simulated models.
iv.	IV	Robotics.	Demonstration, Video, Presentation, Industrial Visit, Mini Project.
v.	V	Programmable Logic Controller (PLC) & Microcontrollers.	Demonstration, Video, Presentation, Industrial Visit, Mini Project.
vi.	VI	Recent trends.	Video, Case study, Industrial Visit, Seminars.

10. SUGGESTED LEARNING RESOURCES.

A. List of Books:

S. No.	Title of Book	Author	Publication
i.	CAD/CAM/CIM.	P. Radhakrishnan & S. Subranarayan.	New Age Intentional
ii.	Computer Integrated Design & Manufacturing.	Bedworth, Wolfe and Anderson	McGraw Hill International Publication.
iii.	Mechatronics.	-	HMT
iv.	Introduction to Robotics.	Arthur J. Critchlow	McMillan publication
v.	Robotics for engineers.	Yorom Koran	McGraw Hill Publication
vi.	Computer aided manufacturing.	Rao, Tiwari & Kundra.	Tata McGraw Hill Publication
vii.	Computer Aided Design & Manufacturing.	Dr Sadhu Singh.	KP
iii.	Computer Integrated Manufacturing.	S.K.Vajpayee.	PHI
ix.	Automation, Production and Computer integrated Manufacturing.	Mikell P. Groover.	PHI
x.	Mechatronics.	Bradleg and Offers.	Chapman and Hall
xi.	Practical Robotics.	Willium C. Burns Jr. & Janet Evans Worthington	PHI
xii.	Basic electronics.	Mehta ,V.K.	S.Chand Publication, New Delhi.

B. List of Major Equipment/ Instrument with Broad Specifications:

Sr.No.	Resource with brief specification.
i.	Kits on robotics.
ii.	Set of sensor / transducer demonstration and operation trainer kit. (This should include sensors/transducers as per syllabus.)
iii.	Analog to digital and digital to analog trainer modules.
iv.	Digital logic trainer board.
v.	PLC trainer.
vi.	Microcontroller trainer.

C. List of Software/Learning Websites.

i. http://www.vlab.com
ii. http://www.mtabindia.com
iii. http://www.nptel.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics.

- **Prof. J. P. Parmar**, Lecturer in Mechanical Engineering, C. U. Shah Polytechnic, Surendranagar.
- **Ms A. Y. Pathak**, Lecturer in Mechanical Engineering, Sir Bhavsinhji Polytechnic Institute, Bhavnagar.
- **Prof. M. M. Jikar** HOD, Mechanical Engineering Department, N. G. Patel Polytechnic, Bardoli.
- **Prof. A. M. Talsaniya**, Lecturer in Mechanical Engineering, Sir Bhavsinhji Polytechnic Institute, Bhavnagar.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. K.K. Jain,** Professor, Department of Mechanical Engineering
- **Dr. A.K. Sarathe,** Associate Professor; Department of Mechanical Engineering.

ANNEXURE – I

LIST OF PARTS FOR "HOW IT'S MADE"

SR. NO.	TOPIC	SR. NO.	TOPIC
1	Glass.	31	Plastic bags.
2	Capsules (medicine).	32	PVC room/mobile house.
3	Tablets (medicine).	33	Pipes-ERW, seam less, PVC/steel, small to very large size.
4	Safety pin.	34	Oil paint.
5	Plastic chair.	35	Refilling of gas cylinders.
6	Springs.	36	Televisions / computer monitors.
7	Chain (cycle).	37	Drug (liquid) manufacturing.
8	Bearings.	38	Diamond polishing.
9	Plastic bottle.	39	Lamps- conventional (resistance).
10	Milk/oil pouch packaging.	40	CFL lamps.
11	PCBs.	41	LED lamps.
12	Nut/bolts.	42	Car assembly.
13	Crank shaft.	43	Truck assembly.
14	Piston/cylinder.	44	Aero plane assembly.
15	Vitrified tiles.	45	Any other as specified by teacher.
16	Electrical wires / cables.		
17	Steel wire ropes.		
18	Electrical switches.		
19	Pouch printing.		
20	Cloth manufacturing. (Textile).		
21	Cloth printing (Textile).		
22	Embroidery machine working.		
23	Bottling. (Of soda, beverages, etc.)		
24	Lathe bed.		
25	Bikes engine.		
26	Computer's hard disc.		
27	Circlips.		
28	Oil seals.		
29	Semiconductors.		
30	Product made from Micro machining .		

ANNEXURE –II

PROCESS SHEET/DETAILS- TO BE MADE FOR EACH PART SEPARATELY.

Part No/Id:		Raw material:	
Name of the Part:		Raw weight:	
Drawing No:		Finished wt:	

Op. No	Name of Operation	Size, tolerance, surface finish, etc. required	Machine details	Machining Parameters			Tools, Jig, Fixture, coolant, etc. required	Measuring instruments required	Locating surface (Give surface numbers in sketch)	Clamping surface (Give surface numbers in sketch)	Time		Remarks
				speed	feed	Depth of cut					Set up (Min.)	Machining (Min.)	

ANNEXURE – III
PROCESS TIME MATRIX

PART NUMBER	QUANTITY PER UNIT TIME (MAY BE PER WEEK OR MONTH OR YEAR)	TIME PER PIECE (IN MINUTES) AND TOTAL TIME FOR GIVEN QUANTITY FOR MAJOR PROCESSES FROM WORK CENTRE POINT OF VIEW.													
		TURNING													
		TIME / PIECE	TOTAL TIME	TIME / PIECE	TOTAL TIME	TIME / PIECE	TOTAL TIME	TIME / PIECE	TOTAL TIME	TIME / PIECE	TOTAL TIME	TIME / PIECE	TOTAL TIME	TIME / PIECE	TOTAL TIME
TOTAL															

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			I
	iii.		2			II
	iv.		2			II
	v.			2		III
	vi.			2		III
	vii.				2	IV
	viii.				2	IV
	ix.		2			VI
	x.		2			VI
2	a.		7			IV
		OR				
	a.		7			IV
	b.			4		V
		OR				
	b.			4		V
	c.		3			V
		OR				
	c.		3			V
3	a.				4	II
		OR				
	a.				4	II
	b.				4	III
		OR				
	b.				4	III
	c.		3			V
		OR				
	c.		3			V
	d		3			VI
		OR				
	d		3			VI
4	a.				4	V
	a.				4	V
	b.		3			VI
		OR				
	b		3			VI
	c.			4		IV
	d			3		VI
5	a.			4		I
	b.			4		II
	c.		6			III

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: FABRICATION TECHNOLOGY
(COURSE CODE 3361905)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

This course focuses on fabrication of different machine parts and process equipment used in various engineering application. This course would help students to learn application of different tools, equipment & machineries used in fabrication of process equipment and various fabrication works in deferent engineering application. This course also tries to develop safety consciousness in students for fabrication work. Students also become conversant with related manufacturing codes & standards of process equipment e.g. ASME, TEMA, BIS - 2825, BS - 5500. This also provides opportunity for hands on practice for student to develop skills and to understand basic technical requirement for process equipment fabrication. This course thus provides necessary knowledge and skills required in fabrication industry, and hence it is a key course for mechanical engineers.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency.

- **Plan and supervise fabrication of different process equipment using appropriate methods, various fabrication standards, codes and safety norms.**

3. COURSE OUTCOMES (COs).

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Interpret the fabrication drawings and plan the fabrication processes requirements and calculate the materials requirements.
ii. Develop welding documents like WPS, WPQ, SWP and WTP.
iii. Suggest steps for erection, installation and commissioning of fabricated equipment.
iv. Follow safety norms during fabrication process.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I **Introduction**	1a. List the factors affecting weldability. 1b. Explain importance of weldability. 1c. Compare different power sources. 1d. List national and international level third party agencies.	1.1 Need and scope of fabrication technology in industries. 1.2 Weldability-concept, meaning, definition and factors affecting it and its importance. 1.3 Power source-classification, advantages, limitations, features, applications and selection criteria. 1.4 List of national and international fabrication industries and third party inspection agencies.
Unit – II **Drawing Interpretation.**	2a. Interpret manufacturing/ welding drawings. 2b. Prepare bill of materials, parts list and quantity. 2c. Explain procedure for weld edge preparation. 2d. Develop WPS, WPQ, WTP and SWP documents. 2e. Interpret different terms of code.	2.1 Welding location of elements, welding general nomenclature, welding symbols as per IS: 696-1972, welding supplementary symbols, abbreviations used for welding processes and welding position. 2.2 Interpretation and method to work out bill of material for following types of drawings: i. Welding / fabrication. ii. Process and instrumentation. iii. Piping isometric. 2.3 Types, sketch, edge preparation and applications of weld - square butt, groove, fillet, plug, Types of joint butt, lap, corner, tee and edge, Types of weld edge preparation 2.4 Welding documents - Weld Test Plan (WTP) and Shop Weld Plan (SWP). 2.5 Introduction to ASME section IX Welding Procedure Specification (WPS) and Welder Performance Qualification (WPQ). 2.6 Need and application areas of different codes used in fabrication industries remaining ASME sections, ASTM, AWS, IS, BIS, JIS, EN, DIN, TEMA, EJMA.
Unit – III	3a. Use equipment/ machineries for edge preparation.	3.1 Equipment/machines used for edge preparation, their working & features. 3.2 Preheating and inter-pass: need, method and applications.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Fabrication Processes and Safety.	3b. Select preheating, post heating and PWHT method. 3c. Explain different methods of relieving thermal stresses. 3d. Set different arc welding parameters. 3e. Explain advance welding methods and welding automation. 3f. Explain various fabrication procedures. 3g. Calculate Ovality, shell plate orientation and arc length. 3h. Identify fabrication stages for equipment to be fabricated. 3i. Describe safety norms to be followed during fabrication activities.	3.3 Post heating-need, method and applications. 3.4 Post Weld Heat Treatment (PWHT)-need, methods, applications and selection criteria. 3.5 Methods of relieving thermal stresses. 3.6 Arc welding parameters-setting criteria: i. Voltage. ii. Current. iii. Welding speed. iv. Welding feed. v. Arc length. 3.7 Advance welding methods and their applications. i. Ultrasonic welding. ii. Laser beam welding. iii. Electron beam welding. iv. Friction stir welding. 3.8 Welding automation. 3.9 Process equipment fabrication procedures: i. Plate edge bending and rolling. ii. Weld edge preparation. iii. Marking procedures of shell and dish end. iv. Plate cutting by gas and plasma arc with automation. v. Shell alignment by string and laser beams. vi. Orientation marking on shell for nozzles. vii. Reference line marking by dumpy level. viii. Ovality measurement of shell and it's rectification by spiders. ix. Profile checking by template. x. Circularity measurement by swing arm method. xi. Offset rectification by wedge. xii. Strip cladding and overlay 3.10 Fabrication steps/stages of: i. Electrical power/communication transmission tower. ii. Pressure vessel. iii. Heat exchanger. 3.11 Need, precautions and safety norms during welding and fabrication process.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – IV Inspection and Testing.	4a. Distinguish weld defects and thermal distortion. 4b. Identify factors affecting weld quality. 4c. Explain testing and inspection procedures.	4.1 Common weld defects, their causes and remedies; 4.2 Thermal distortion-concept, meaning, definition, causes, effect and types. 4.3 Methods and equipments used to control thermal distortion. 4.4 Weld quality-concept, meaning, definition, importance and affecting factors 4.5 Introduction to inspection and testing. 4.6 Stages of inspection. 4.7 Types, methods of testing and importance of destructive testing (DT).(tensile test, compressive test, impact test, bend test, hardness test.) 4.8 Types, methods of testing and importance of Non Destructive Testing (NDT). (Liquid penetrate testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography Testing, Eddy Current Testing) 4.9 Special types of test like Hydro test, Pneumatic test, and Leak test by soap water and helium gas.
Unit – V Surface preparation, Finishing and Coating Methods.	5a. Explain surface preparation, finishing and coating method.	5.1 Surface preparation methods, sand blasting and ball blasting. 5.2 Surface finishing methods, brushing and grinding. 5.3 Surface colour coating by brush, roller and spray applications.
Unit – VI Installation, Erection and Commissioning.	6c. Describe steps for erection, installation and commissioning of various fabricated equipment. 6c. Suggest steps for erection, installation and commissioning for given equipment.	6.1 Erection steps for common fabrication structure. 6.2 Erection steps for equipment to be fabricated. 6.3 Erection steps for piping. 6.4 Installation and commissioning procedures for plant machineries and fabricated equipment.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction.	4	6	0	0	6
II	Drawing Interpretation	14	9	5	6	20
III	Fabrication Processes and Safety.	8	5	5	4	14
IV	Inspection and Testing.	8	7	3	4	14
V	Surface Preparation, Finishing and Coating Methods	4	0	8	0	8
VI	Installation, Erection and Commissioning.	4	0	3	5	8
	Total	**42**	**27**	**24**	**19**	**70**

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy)

Notes:

a) This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

b) If mid-sem test is part of continuous evaluation, unit numbers I,II (Up to 2.3 only),III and V are to be considered.

c) Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain**)**	Approx. Hours. Required
1	II	**Interpretation of fabrication drawing:**	04

		Teacher will issue one fabrication drawing and one piping drawing for interpretation. a. For fabrication / welding drawing: Students would: i. Name the item which has been drawn and given for interpretation. ii. Prepare bill of materials. (Parts name, part material, raw material size and quantity). iii. Tabulate welding / fabrication symbols used with interpretation of each. iv. Calculate shell plate size, dish end plate and pipe and flange sizes for nozzle (as applicable). v. Orientation marking of nozzle on shell and dish end, if applicable. b. For piping isometrics drawings : Students would calculate i. Start-end point co-ordinates. ii. Pipe length and size required for loop. iii. Total no. of joints required for loop. iv. Total no. of supports required for loop. v. Total no. of elbows, T joints, reducers for loop etc. vi. Erection in inch-meter. vii. Weld joints in inch-dia.	
2	III	**Prepare WPS and WPQ:** Prepare one WPS (Welding Procedure Specification) and one WPQ (Welder Performance Qualification) based on given variables and data.	2 Hrs
3	I to V	**Complex job as mini project work:** Fabricate one complex job by using welding processes in group of 4 to 6 students, from the following suggested areas. i. Model fabrication of industrial shade. ii. Model fabrication transmission tower. iii. Heat exchanger. iv. Condenser, radiator. v. Bridge structure. vi. Model of ship. vii. Domestic applications (car shades, grills, gate, sign boards, etc.). viii. Frames/truss. ix. Food processing vessels. x. Piping for transferring oil, gas, water, etc. xi. EOT crane structure. xii. Other equivalent structure assigned by teacher. This includes followings:	18 Hrs

		a. Sketches. b. Bill of material. c. Steps to fabricate. d. Method employed for weld edge preparation. e. Selection of welding process and process parameters. f. List of consumables used with specifications and quantity. g. Pre and/or post weld heat treatment processes used. h. WPS and WPQ. i. Presentation including photographs/video of actual work being carried out. (Option of flexi time based work can also be practiced. For this option, it may not be necessary to exactly follow the time table slots. This can be on continuous base also).	
4	V	**Prepare SWP and WTP:** Prepare one Shop Weld Plan (SWP) and one Weld Test Plan (WTP) for typical pressure vessel job. a. Sketch the job. b. List the steps followed to prepare plans. c. Prepare plans.	2 Hrs
5	VI	**Liquid penetrate testing:** a. Demonstrate liquid penetrate testing of weldment. b. Write specification of test liquid. c. List steps followed. d. Sketch the path tested. e. Write conclusion with interpretation. f. Attach photograph.	2 Hrs
		Total Hours	**28 Hrs**

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher. PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.
b. Term work report must not include any photocopy/ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
c. Mini project and presentation topic/area has to be assigned to the group of specified students in the beginning of the term by batch teacher, if applicable.
d. For practical ESE part, students are to be assessed for competencies achieved. They should be given experience/part of experience to perform.

8. SUGGESTED LIST OF STUDENT ACTIVITIES:

SR.NO.	ACTIVITY

i.	Visit fabrication industry and prepare report on equipment/machineries specification, problem faced in operating equipment/machineries and safety precautions.
ii.	Submit assignment given by subject teacher.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr.No.	Unit	Unit Name	Strategies
i.	I	Introduction to Fabrication Technology.	Lecture on fabrication technology and it's uses.
ii.	II	Drawing interpretation.	Use drawings from various fabrication industries related to equipment fabrication, structural fabrication, piping isometrics etc. and explain to students, movies, industrial visits.
iii.	III	Fabrication processes and safety.	Use video/animations available on internet related to various fabrication processes, industrial visits, demonstration.
iv.	IV	Inspection and testing.	Use various inspection and testing related presentations from various websites, movies, actual demonstration, and industrial visits.
v.	V	Surface preparation, finishing and coating methods.	Use charts and posters to show the surface preparation, finishing and coating activity, movies, industrial visits, demonstration.
vi.	VI	Installation, erection and commissioning.	Show operational manuals for installation, erecting and commissioning procedures for equipments and visit industry site where actual installation, erection and commissioning activities ongoing.

10. SUGGESTED LEARNING RESOURCES.

A) List of Books:

S. No.	Title of Book	Author	Publication
i.	Welding technology.	Khanna,O.P	Dhanpat Rai Publications, New Delhi - 22nd Edition
ii.	Welding engineering and technology.	Parmar, R.S.	Khanna Publishers, New Delhi - 1st edition
iii.	Modern arc welding Technology.	Nadkarni, S.V.	Advani oerlikon, Mumbai – 6th edition
iv.	Structural steel fabrication and erection	Saxena, S.K.; Asthana, R.B.	Somaiya Publishers, New Delhi – 3rd edition

v.	Metal cutting science and production technology	Jain, K.C.; Agrawal L.N.	Khanna Publishers, New Delhi - 4th edition

B) List of Major Equipment/ Instrument with Broad Specifications:

SR.NO.	Resource with brief specification.	
i.	Welding power source rectifier.	1. AC input 440 volts, 3 ph, 50 Hz. 2. DC output 115 volts- 230 volts. 3. Output wattage (1 to 5 kW).
ii.	Portable Plate rolling machine.	1. Three high rolling machine with 0.5 meter length with max. plate thickness capacity up to 10mm. 2. 3-phase induction motor with 5kW capacity. 3. Suitable reduction gear box.
iii.	Gas cutting set.	1. Acetylene and oxygen gas cylinder. 2. Pressure regulator and gas flow measuring device. 3. Cutting torch with back fire arrester. 4. Various nozzle tip set (2 to 6 mm).

C) List of Software/Learning Websites.

i. https://www.engineering.osu.edu
ii. www.aws.org
iii. www.careersinwelding.com
iv. www.weldingalloys.com
v. www.adorweldingacademy.com
vi. www.themanufacturinginstitute.org
vii. www.asme.org
viii. www.weldingdesign.com
ix. www.engineeringtoolbox.com
x. www.asnt.org
xi. www.twi-global.com
xii. http:///www.vlab.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics.

- **Prof. D. R. Katariya,**Lecturer in Mechanical Engineering, G.P.Bhuj.

- **Prof. P. L. Bhogayata,** Lecturer in Mechanical Engineering, Sir B.P.Institute, Bhavnagar.
- **Prof. D. M.Patel,**Principal, Shree V & K Patel Institute of Engineering, Kadi, Dist.: Mehsana.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. Vandana Somkuwar,** Associate Professor, Department of Mechanical Engineering,
- **Dr. K.K. Jain,** Professor, Department of Mechanical Engineering,

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			II
	iii.		2			II
	iv.				2	II
	v.				2	IV
	vi.				2	IV
	vii.			2		V
	viii.			2		V
	ix.			2		VI
	x.			2		VI
2	a.		5			II
		OR				
	a.		5			II
	b.			5		II
		OR				
	b.			5		II
	c.				4	II
		OR				
	c.				4	II
3	a.		5			III
		OR				
	a.		5			III
	b.			5		III
		OR				
	b.			5		III
	c.				4	III
		OR				
	c.				4	III
4	a.		7			IV
		OR				
	a.		7			IV
	b.			3		IV
	c.		4			II

5	a.		5			V
	b.		5			VI
	c.		4			I

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: POWER PLANT ENGINEERING
(COURSE Code: 3361906)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

Availability of power is the one key area where most of the Indian industry is facing problems. In India, even today, short fall of power generation is about 30 percent. Fuel supply and distribution is also an area where country is still developing smooth lines of supply. Since power and energy is required by every sector of economy, the growth in this sector is must if Indian economy grows in any sector. Many of the job opportunity in private as well as public sector are therefore waiting for students in this field. Hence, this course attempts to provide them basic knowledge of the technologies available at plant level and would also acquaint them with the latest technological advances taking place in this sector.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency.

- **Apply knowledge of mechanical engineering related to power generation systems, their control and economics in different type of power plants for their operation and maintenance.**

3. COURSE OUTCOMES (COs).

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Identify elements and their functions of steam, hydro, diesel, nuclear, wind and s olar power plants.
ii. Operate equipments of different power plants.
iii. Analyze economics of power plants and list factors affecting the power plants
iv. Determine performance of power plants based on load variations.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
03	00	02	05	70	30	20	30	

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment.

5. COURSE CONTENT DETAILS.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I. **Introduction to Power plants.**	1a. Describe energy conversion in power plants. 1b. List features of National Grid. 1c. Identify elements and their functions of hydro, diesel and nuclear power plants.	1.1. Energy needs of India. 1.2. Introduction to power plants & their importance, power plants concepts, types and energy conversion in each type. 1.3. National Grids. 1.4. Hydro power plant: General arrangement & its operation, classification, advantages and disadvantages, technical data of hydro power plants in Gujarat. 1.5. Diesel power plant: General arrangement & its operation, classification, advantages and disadvantages, technical data of diesel engine power plants in Gujarat. 1.6. Nuclear power plant: general arrangement & its operation, classification, basic nuclear physics fundamentals, criteria for selection of installation of nuclear power plant, advantages and disadvantages, technical data of nuclear power plants in Gujarat, safe disposal of nuclear waste.
Unit – II **Steam power Plants.**	2a. Plot different heat cycles on P-V and T - s diagram. 2b. Calculate different parameters for heat cycles.	**A. Heat Cycles** 2.1 Working of Rankine cycle, reheats cycle regenerative cycle, reheat regenerative cycles and plot them on P-v and T-s diagram. 2.2 Simple numerical based on above.
	2c. Sketch working of different high pressure boilers. 2d. Identify various elements of FBC boilers and describe their functions.	**B. High Pressure Boilers**. 2.3 Working sketch and working of high pressure boilers: Lamont boiler, Benson boiler, Loeffler boiler, Velox boiler, Schmidt Hartman boiler, Ramsin boiler 2.4 Stirling boiler (three steam drum, two mud drum boiler)-sketch and working. 2.5 Fluidized bed combustion boilers(FBC): principle, need, types, different arrangement, control system and advantages over other boiler systems. 2.6 Need of water treatment plant for boilers.
	2e. Sketch layout of modern thermal power plant. 2f. Identify parts and state functions of stea	**C. Important Auxiliaries of Steam Power Plants.** 2.7 Schematic diagram of modern thermal power plant. 2.8 Super heaters and air pre heaters.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	m traps, heaters and fuel handling system. 2g. Explain concept of ESP.	2.9 Fuel handling systems-methods of coal handling like pulverized fuel system, etc. 2.10 Concept of Electro-Static Precipitators (ESP).
	2h. Describe various control systems of power plant. 2i. Explain working of various temperatures and feed water control systems. 2j. Explain importance and need of record keeping	**D. Steam Power Plant Controls** 2.11 Effect of load variation in steam power plant. 2.12 Area and centralized control system of power plants. 2.13 Basic elements and requirements of good control system of power plant. 2.14 Instrumentations used in modern power plants. 2.15 Concept of Steam temperature control and feed water control systems. 2.16 Need of record keeping.
Unit – III **Gas Turbine Power Plant.**	3a. Sketch and label arrangements of gas turbine power plant. 3b. Compare different methods to improve efficiency in gas turbine power plant. 3c. Calculate thermal efficiency of gas turbine power plant.	3.1 Introduction to gas turbine power plant. 3.2 Concept of Brayton cycle. 3.3 Arrangement of open and close cycle with constant pressure gas turbine power plant. 3.4 Components of gas turbine power plant. 3.5 Essential auxiliaries of gas turbine power plant. 3.6 Methods to improve the thermal efficiency of a simple open cycle constant pressure gas turbine power plant (No derivation). 3.7 Simple numerical based on above. 3.8 Advantages of gas turbine power plant over others.
Unit – IV **Solar and Wind Power Plants.**	4a Explain wind and solar power plant 4b Observe conversion system for solar power plant. 4c Project potential of wind and solar power in India	4.1 Wind power plant: introduction, advantages and disadvantages. 4.2 Introduction to solar power plant. 4.3 Solar cell and solar panel. 4.4 Conversion systems for solar energy: i. Low temperature system with flat plate collector. ii. Medium temperature system with concentrator collector. iii. Tower concept for power generation. iv. Satellite solar power. v. Zero energy house concept. 4.5 Potential of solar and wind energy in India.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – V **Economic Analysis of Power Plants.**	5a Calculate performance of power plants based on load variations.	5.1 Cost of electrical energy. 5.2 Selection of type of generation. 5.3 Performance and load deviation of power plants. 5.4 Simple numerical based on above.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Power Plants.	08	8	4	0	12
II	Steam Power Plant.	20	12	12	6	30
III	Gas Turbine Power Plant.	05	2	4	6	12
IV	Solar and Wind Power Plants.	04	4	4	0	08
V	Economic Analysis of Power Plants	05	0	2	6	08
		42	**26**	**26**	**18**	**70**

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy).

Notes:

a. This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.
b. If mid-sem test is part of continuous evaluation, unit numbers I , II (Up to 2.6 only) and III are to be considered.
c. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.
d. In examination, example of same chapter is to be asked in place of example.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

*Note: Here only **outcomes in psychomotor domain** are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain **outcomes in affective domain** which would in turn lead to development of Course Outcomes related to affective domain. Thus over all development of **Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme)** would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	I to IV	**Preparatory activity:** a. Prepare list of various major power plants installed in Gujarat along with their total capacity. b. Visit websites of NTPC, BHEL etc and find out the technical information about their machineries or Plants.	02
2	II	**Study of high pressure boilers (any three):** Students would**:** a. Demonstrate working of boilers and different components on them. (Actual or Video). b. Draw schematic diagram with labels for each. c. Write specification of each boiler. d. List functions and explain working of different components of each boiler.	02
3	I to IV	**Presentation (In a group of 4 - 6 students):** Faculty will assign any one topic from following. i. Steam based power plant. ii. Gas turbine power plant. iii. Solar power plant. iv. Wind power plant. v. Nuclear power plant. Students would**:** a. Download technical specifications/ catalogues, videos or any other suitable presentations on given topic. b. Tabulate comparison of different power plants of same category, based on their different technical aspects. c. Prepare the presentation and present the same during the laboratory hours in front of your classmates.	06
4.	I to IV	**Model preparation and exhibition (In a group of 08 - 12 students):** Faculty will assign any one topic from following. i. Steam based power plant along with auxiliaries. ii. Gas turbine power plant. iii. Solar power plant. iv. Wind power plant. v. Nuclear power plant. vi. Any other relevant assigned by batch teacher. Students would prepare a model on the topic assigned by batch teacher using preferably waste material. a. Prepare work distribution matrix. b. Prepare the schematic diagram. c. Prepare model diagram with dimensions. d. List steps to be followed to prepare the model.	12

		e. Prepare the model and list the difficulties and remedial measures undertaken. f. Prepare charts/ PPTs/ videos or other supporting materials for open air seminar presentation if required. g. Arrange exhibition of the model prepared in the department. Above developed model should be demonstrated in the institute with open air seminar and present the same amongst the students and faculty. Students should explain their findings and learning to other students. Record the movie of exhibition.	
5.	I to V	**Industrial visit:** Faculty would Arrange industrial visit on any one of followin g (Compulsory): i. Thermal power plant. ii. Gas turbine power plant. iii. Nuclear power plant. iv. Wind turbine power plant. Student would prepare report on visit. Report should include specification of plant, circuit diagram, working principle of major components, etc.	06
		Total Hours	**28**

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.
b. Term work report must not include any photocopy/ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
c. Mini project/ model preparation and presentation topic/area has to be assigned to the group of specified students in the beginning of the term by batch teacher, if applicable.
d. Each student will make his/her folder having the name as <batch number-enrollment number> and will save his/her downloaded content, presentation and all soft content of experiment number 4 (Model preparation). A DVD is to be made which will contain folders of all students. Same DVD is to be submitted to batch teacher.
e. For practical ESE part, students are to be assessed for competencies achieved.

8. SUGGESTED LIST OF STUDENT ACTIVITIES.

SR.NO.	ACTIVITY
1	Prepare charts of different high pressure boilers, gas turbine cycles, steam turbine power plant, wind turbine power plant, solar power plant, etc. on half imperial drawing sheet. Attach the same with term work.
2	Visit websites of reputed power companies such as NTPC, NHPC, NPCIL, BHEL,GEDA, SUZLON, GE, SIEMENS, ENERCON etc.
3	Download videos for working of different power plants.
4.	Prepare chart on any one component of any power plant on half imperial drawing sheet. Attach the same with term work.
5.	Visit diesel power plant available in your institute/ nearer to your institute and understand different elements, working, circuits, and specifications.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr. No.	Unit	Unit Name	Strategies
1	II	Introduction to power plants.	Videos, industrial visits.
2	II	Steam power plant.	Videos, industrial visits, models, actual demonstration of parts / working models.
3	III	Gas turbine power pla nt.	Videos, industrial visits, models, actual demonstration of parts / working models.
4	IV	Solar and wind power plants.	Videos, industrial visits, models, actual demonstration of parts / working models.
5	V	Economic analysis of power plants.	Examples, tutorials, industrial visits, case examples.

10. SUGGESTED LEARNING RESOURCES.

A. List of Books:

S. No.	Title of Book	Author	Publication
1.	Power Plant Engineering.	Dr. P C Sharma	S. K. Kataria
2.	Power Plant Engineering.	Domkundwar	
3.	Power Plant Engineering.	P K Nag	Tata Mc Graw Hill
4.	Power Plant Engineering.	Black & Veatch	Springer, 1996
5.	Power Plant Engineering.	C. Elanchezhian, L. Saravanakumar, B. Vijaya Ramnath	I.K. International Publishing House
6.	Power Station Engineering and Economy.	Bernhardt G A Sarotzki, William A Vopat	Tata Mc Graw Hill
7.	A Text Book of Power Plant Engineering.	R K Rajput	Laxmi Publications,
8.	Power Plant Control and Instrumentation.	David Lindsley	The Institute Of Electrical Engineers
9.	Nuclear Power Plant Engineering.	James H. Rust	Haralson Publishing Company
10.	Steam power plant engineering.	Louis Allen Harding	J. Wiley & Sons, inc

B. List of Major Equipment/ Instrument with Broad Specifications:

Sr.No.	Resource with brief specification.
1	Demonstration models of steam power plant and its auxiliaries, Gas turbine power plant and its auxiliaries, wind turbine power plant and its auxiliaries, nuclear power plant and its auxiliaries, solar power plant and its auxiliaries, etc.

C. List of Software/Learning Websites.

i. http://nptel.ac.in/courses/112105051/
ii. https://www.youtube.com/watch?v=Ota2_LUuar0
iii. https://www.youtube.com/watch?v=Ota2_LUuar0
iv. https://www.youtube.com/watch?v=3dJAtHaSQ98
v. https://www.youtube.com/watch?v=xokHLFE96h8
vi. http://www.tatapower.com/businesses/renewable-energy.aspx
vii. http://www.cleanlineenergy.com/technology/wind-and-solar
viii. https://www.youtube.com/watch?v=kbuLfXgw4Gs
ix. https://www.youtube.com/watch?v=r9q80sSHxKM
x. https://www.youtube.com/watch?v=GZKKWz_tX1c
xi. download other power plant related videos from youtube.com for study purpose.

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics.

- **Prof. S. R. Pareek**, Head of Department, Mechanical Engineering, Tolani F.G. Polytechnic, Adipur.
- **Prof. M. N. Patel**, LME, Government Polytechnic,ChhotaUdepur.
- **Dr. Shah Atul S**., LME, Dr. S & SS Ghandhy Collageof Engineering and Technology, Surat.
- **Prof.Haresh G Ranipa**, LME, Shri N M GopaniPolytechnic, Ranpur.
- **Prof.PatadiyaViren N**., LME, N.M.Gopani Polytechnic, Ranpur.
- **Prof.(Smt.) Krutika V Prajapati**, LME, Parul Institute of Engineering and Technology, Vadodara.
- **Prof. Patel Rameshbhai Babubhai**, LME, R.C.T.I., Ahmedabad.
- **Prof. Ajbani Vimlesh Chandrakant**, LME, Government Polytechnic, Ahmedabad.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. A.K. Sarathe,** Associate Professor; Department of Mechanical Engineering.
- **Dr. K.K. Jain,** Professor, Department of Mechanical Engineering,

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			I
	iii.		2			II
	iv.		2			II
	v.		2			II
	vi.		2			II
	vii.		2			III
	viii.		2			IV
	ix.		2			IV
	x.		2			V
2	a.		3			IV
		OR				
	a.		3			IV
	b.			3		IV or V
		OR				
	b.			3		IV or V
	c.		4			II
		OR				
	c.		4			II
	d.			4		II
		OR				
	d.			4		II
3	a.				3	II
		OR				
	a.				3	II
	b.				3	II
		OR				
	b.				3	II
	c.			4		II
		OR				
	c.			4		II
	d			4		III
		OR				
	d			4		III
4	a.				3	III
	a.				3	III
	b.			4		I
		OR				
	b			4		I
	c.				7	V
5	a.		4			I
	b.			4		II
	c.				3	III
	d.			3		IV

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks

distribution pattern maintaining distribution of marks as per specification table)

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: THERMAL SYSTEMS AND ENERGY EFFICIENCY
(COURSE CODE: 3361907)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

Thermal systems are most important part of industrial sector. In the absence of proper operation & maintenance of thermal systems it becomes difficult to manage economic use of energy and its conservation with the least damage to the environment. This course provides the underpinning knowledge and skills related to principles, types & working of these systems like boilers, heat exchangers, furnaces, HVAC etc. which are normally high energy consumption devices. Study of this course would help students to choose proper design and specifications of these high energy consuming devices so that energy is saved in resulting low cast of production as well as less damage to environment. This course is therefore a key course for thermal engineers.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Apply concepts, laws and principles of thermal systems to operate and maintain them for efficient use of energy and its conservation as per industrial norms & regulations.**

3. COURSE OUTCOMES (COs).

The theory should be taught and practicals should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Select available energy sources in a given situation.
ii. Determine boiler performance based on energy efficiency parameters.
iii. Analyze performance of furnace for a particular application.
iv. Determine the performance of heat exchanger in a given situation.
v. Calculate load of HVAC systems.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
03	00	02	05	70	30	20	30	150

Legends: **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination (**3 hours duration**); **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I. **Introduction to Energy Sources and Thermal Systems.**	1a. Compare various energy sources & forms. 1b. Differentiate various renewable and non-renewable energy sources. 1c. Explain Energy conservation and related act. 1d. Describe basic concepts of various thermal systems.	1.1 Energy sources: i. Primary and secondary. ii. Commercial energy and non-commercial. iii. Various forms of energy, i.e. potential energy (chemical, nuclear or stored mechanical, gravitational energy), kinetic energy (radiant, thermal, motion, sound, electrical energy) and high grade energy and low grade energy. iv. Renewable and nonrenewable. 1.2 Energy conservation and its importance. 1.3 Overview of Energy Conservation Act 2001. 1.4 Introduction to various thermal systems like furnace, steam generation and distribution system, heat exchanger, HVAC(Heating, Ventilating and Air Conditioning) and refrigeration system, cogeneration system (concept, need and principle based on steam and gas turbine cogeneration system), air compressor.
Unit – II **Boilers.**	2a. Determine performance of boilers by direct and indirect method. 2b. Analyze effect of energy efficiency parameters on performance of boiler. 2c. Describe energy saving measures in steam distribution system.	2.1 Performance evaluation of typical boiler system (Attached data sheet is allowed in exams): i. Indirect method. ii. Direct method. 2.2 Energy efficiency measures in boiler system. 2.3 Steam distribution system and concept of steam pipe sizing. 2.4 Steam traps-operation and maintenance of: i. Float and thermostatic. ii. Thermodynamic. iii. Inverted bucket. iv. Thermostatic with thermal element (Bellow or bi-metallic strip). 2.5 Energy saving in steam distribution systems.
Unit – III **Furnaces.**	3a. Describe concept and types of furnaces. 3b. Determine the performance of heat treatment furnaces.	3.1 Concept of furnace. 3.2 Classification and working of furnaces: i. Forging furnace. ii. Rerolling mill furnace (batch type, continuous pusher type, continuous steel reheating furnace,(pusher type, walking hearth type, rotary hearth

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	3c. Derive energy efficiency parameters.	type, continuous recirculating bogie type etc.). 3.3 Heat transfer in furnaces. 3.4 Performance evaluation of typical heat treatment furnace system (Attached data sheets are allowed in exams). i. Indirect method. ii. Direct Method. 3.5 Energy efficiency measures in furnace systems.
Unit – IV **Heat Exchangers and Air Compressor.**	4a. Differentiate heat exchangers. 4b. Determine performance of Heat exchangers based on given method. 4c. Describe energy saving measures in air compressor.	4.1 Heat exchangers: types and classification. 4.2 Performance evaluation of heat exchangers based on LMTD and NTU methods (Attached data sheets are allowed in exams). 4.3 Air compressor: Free air delivery (Attached data sheets are allowed in exams), energy saving measures.
Unit – V **HVAC systems.**	5a. Use concept of HVAC and refrigeration system. 5b. Calculate load of HVAC system based on given data	5.1 Concept of HVAC and refrigeration system. 5.2 Selection criteria for suitable refrigeration system. 5.3 Load calculation for refrigeration/ air conditioning system, such as: room, restaurant, cold storage, theatre, conference hall, sweet shop, etc. (Attached data sheets are allowed in exams). 5.4 Energy efficiency measures in refrigeration/ air conditioning systems.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Energy Sources and Thermal Systems.	06	02	04	02	08
II	Boilers.	08	02	03	09	14
III	Furnaces.	08	02	04	12	18
IV	Heat Exchangers and Air Compressors.	10	02	03	09	14
V	HVAC systems.	10	02	04	10	16
	Total	42	10	18	42	70

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy).

Notes:

a. This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.
b. Duration of End Semester Examination (Theory) is 3 hours.
c. If mid-sem test is part of continuous evaluation, unit numbers I, II and IV are to be considered.
d. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.
e. Use of enclosed data sheets are to be allowed to student during examination (They should be provided by the examining agency).
f. In examination, example of same chapter is to be asked in place of example.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain**) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note: *Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes related to affective domain****. Thus over all development of* ***Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme****) would be assured.*
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	I to V	Preparatory activity: a. Visit laboratory/ workshop and identify various thermal systems such as heat exchangers, boilers, furnaces, air compressors, etc. Write down technical specifications of the same along with manufactures. b. Compare price of various fuels. c. Plot sankey diagram for given data. d. Interpret terms and equations of data sheets provided with the curriculum.	04
2	II	**Case study (based on real life example):** a. Calculate losses in the boiler using given data by direct and indirect method. b. Prepare sankey diagram. c. Prepare heat balance sheet. d. List various instrumentation required to measure the required data.	04
3	III	**Case study (based on real life example):**	04

		a. Calculate losses in the furnace using given data by direct and indirect method. b. Prepare sankey diagram. c. Prepare heat balance sheet. d. List various instrumentation required to measure the required data.	
4	IV	**Case study (based on real life example):** a. Calculate efficiency and over all heat transfer co efficient of heat exchanger based on given data. Use LMTD or NTU methods. b. List various instrumentation required to measure the required data. **OR** a. Write technical specifications of any heat exchanger available in vicinity. b. Determine its performance based on the technical data available. Tabulate the observation. c. List the parameters which lead to energy losses in heat exchangers. Also show the effect of such parameters. d. Recommend your suggestions for energy saving in heat exchangers.	04
5	V	**Case study (based on real life example):** a. Calculate air conditioning load of given room/ conference hall. Use standard data sheets. (Volume not more than 80-100 m^3.) b. List various instrumentation required to measure the required data.	06
6	V	**Case study (based on real life example):** a. Calculate refrigeration/ air conditioning load of given theater/ restaurant/cold storage. Use standard data sheets. (Volume >200 m^3.) b. List various instrumentation required to measure the required data.	06
		Total Hours	**28**

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.

b. Term work report must not include any photocopy/ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.

c. For practical ESE part, students are to be assessed for competencies achieved. They should be given experience/part of experience to perform.

8. SUGGESTED LIST OF STUDENT ACTIVITIES.

SR.NO.	ACTIVITY
1	List thermal systems employed in your house, shops, malls in nearby area. Identify the parameters which lead to energy losses. List energy saving measures.
2	Visit any industry and find the major areas boilers/ furnaces/ air compressor system/ heat exchangers etc. from point of energy conservation.

3	Present seminar on energy conversion act 2001 and latest amendments.
4	Visit any small shop where refrigeration repairing or maintenance work is done. List the equipments used in the refrigeration maintenance with its technical data. Prepare a layout of shop. List different work carried out for maintenance in refrigeration/ air conditioning. Prepare a report along with photographs of the equipments.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr. No.	Unit	Unit Name	Strategies
1	I	Introduction to energy sources and thermal systems.	Demonstration of systems, movies, industrial visits, on-hand practice on available systems.
2	II	Boilers.	Standard data of boiler room and other auxiliaries from real life example, Industrial visits, movies.
3	III	Furnaces.	Standard data of furnace room and other auxiliaries from real life example, Industrial visits, movies.
4	IV	Heat exchangers and air compressors.	Standard data of any heat exchanger from thermal plant and air compressor room as well as air compressor system, Industrial visits, and movies.
	V	HVAC systems.	Standard data of load calculation to compare with the calculated load calculations, industrial visits, demonstration of plants having HVAC systems.

10. SUGGESTED LEARNING RESOURCES.

A. List of Books:

S. No.	Title of Book	Author	Publication
1.	Materials science	R.S.Khurmi, R.S.Sedha	S.Chand
2.	Material science	O. P. Khanna	
3.	Guide book for NCE for EM & EA (Vol I to IV)	--	Bureau of Energy Efficiency
4.	Energy Conservation Guide book	Steven R. Patrick, Dale R. Patrick, Stephen W. Fardo	
5.	Energy Management Handbook	Wayne C. Turner	
6.	The Efficient Use of Energy	The Rt Hon Tony Benn, MP	BSI, 2 Park street, London

B. List of Major Equipment/ Instrument with Broad Specifications:

Sr.No.	Resource with brief specification.
1	Experimental setup for Heat exchanger (Plate Heat Type heat exchanger is preferable) Facilities preferable are: In/ out flow quantity of both fluids, In/ Out temperature of both fluids, In/ out pressure drop of both fluids, specific heat of both fluids, number of passes available etc. This parameters are required to measure performance of heat exchanger.

2	Experimental setup for air compressor, boiler already prescribed in thermal engineering-I.

C. List of Software/Learning Websites.

i. http://nptel.ac.in/courses/112101005/downloads/Module_4_Lecture_7_final.pdf
ii. http://btech.mit.asia/downloads/svlomte/HT2011.pdf
iii. http://powermin.nic.in/acts_notification/pdf/ecact2001.pdf
iv. www.energymanagertraining.com (register for free guide book downloads)
v. http://www.ureda.uk.gov.in/upload/downloads/Download-7.pdf
vi. http://www.fao.org/docrep/t0269e/t0269e05.htm
vii. http://energy.gov/eere/government-energy-management
viii. http://www.sari energy.org/PageFiles/What_We_Do/activities/SAWIE/wiser /cap_dev_program_for_afghan_women_march_22-30_2010/ PRESENTATIONS/24032010/ENGLISH/Energy_Conservation_Act_2001_NT_Nair.pdf

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- **Prof. Haresh G. Ranipa**, LME, Shri N M Gopani Polytechnic, Ranpur.
- **Prof. Patadiya Viren N**., LME, N.M.Gopani Polytechnic, Ranpur.
- **Prof. (Smt.) Krutika V. Prajapati**, LME, Parul Institute of Engineering and Technology, Vadodara.
- **Prof. Patel Rameshbhai Babubhai**, LME, R.C.T.I., Ahmedabad.
- **Prof. Ajbani Vimlesh Chandrakant**, LME, Government Polytechnic, Ahmedabad.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. A.K. Sarathe,** Associate Professor; Department of Mechanical Engineering.
- **Dr. K.K. Jain,** Professor, Department of Mechanical Engineering.

DATA SHEETS (Allowed in Final Examinations) :

1. BOILERS:

Direct method:

$$Boiler\ Efficiency(\eta) = (Heat\ output / Heat\ input) \times 100$$

$$\boxed{Boiler\ Efficiency(\eta) = \frac{M \times (h_g - h_f)}{mf \times GCV} \times 100}$$

where, M = Quantity of steam generated per hour in kg/ hr
mf = Quantity of fuel used per hour in kg/ hr
GCV = Gross calorific value of fuel (kCal/ kg of fuel)
h_g = Enthalpy of saturated steam in kCal/ kg of steam
h_f = Enthalpy of feed water in kCal/ kg of water
Temperatures are in degree centigrade and pressure in kg/ cm^2

Indirect Method:

Conversion of proximate analysis into ultimate analysis,

$$\boxed{\begin{aligned} \%C &= 0.97C + 0.7(VM + 0.1A) - M(0.6 - 0.01M) \\ \%H &= 0.036C + 0.086(VM - 0.1A) - 0.0035M^2(1 - 0.02M) \\ \%N_2 &= 2.10 - 0.020VM \end{aligned}}$$

Where, %C = % of fixed carbon
A = % of ash
VM = % of volatile matter
M = % of moisture in general notations.

Theoretical air required for combustion:

$$\text{Theoretical air required for combustion} = [11.6\text{C} + \{34.8(\text{H}_2 - \frac{O_2}{8})\} + 4.35S]/100\ kg/kg\ of\ fuel$$

$$\%Excess\ air\ supplied(EA) = \frac{O_2\%}{21 - O_2\%} \times 100 = \frac{7900[(CO_2\%)_t - (CO_2\%)_a}{(CO_2\%)_a[100 - (CO_2\%)_t]} \rightarrow From\ flue\ gas\ analysis$$

$$(CO_2\%)_t = Theoretical\ CO_2$$

$$(CO_2\%)_a = Actual\ CO_2\%\ measured\ in\ flue\ gas = \frac{Moles\ of\ C}{Moles\ of\ N_2 + Moles\ of\ C}$$

$$Moles\ of\ N_2 = \frac{Wt\ of\ N_2\ in\ theoretical\ air}{Mol.wt\ of\ N_2} + \frac{Wt\ of\ N_2\ in\ fuel}{Mol.wt\ of\ N_2}$$

$$Moles\ of\ C = \frac{Wt\ of\ C\ in\ fuel}{Molecular\ Wt\ of\ C}$$

$$Actual\ mass\ of\ air\ supplied / kg\ of\ fuel(AAS) = [1 + \frac{EA}{100}] \times theoretical\ air$$

$$Total\ mass\ of\ dry\ flue\ gas = (C \times \frac{44}{12}) + (AAS \times \frac{77}{100}) + [(AAS - Theoretical\ Air) \times \frac{23}{100}] + (S \times \frac{64}{32}) + N_2$$

$$\%Loss\ due\ to\ dry\ flue\ gas = L_1 = \frac{m_d \times Cp \times (T_f - T_a)}{GCV\ of\ fuel} \times 100 = Total\ AAS + 1$$

Where, m_d = Mass of dry flue gas in kg/ kg of fuel
= Combustion product from fuel: $CO_2+SO_2+N_2$ in fuel+N_2 in actual mass of air supplied+O_2 in flue gas(H_2O/water vapour in the flue gas should not be considered)
Cp = Specific heat of flue gas in kCal/ kg degree C
Tf = Flue gas temperature in degree C
Ta = Ambient temperature in degree C

$$\%Heat\ loss\ due\ to\ evaporation\ of\ water\ formed\ due\ to\ H_2\ in\ fuel = L_2 = \frac{9H_2[584 + Cp(T_f - T_a)]}{GCV\ of\ fuel} \times 100$$

$$\%Heat\ loss\ due\ to\ moisture\ present\ in\ fuel = L_3 = \frac{M[584 + Cp(T_f - T_a)]}{GCV\ of\ fuel} \times 100$$

$$\%Heat\ loss\ due\ to\ moisture\ present\ in\ air = L_4 = \frac{AAS \times Humidity\ factor \times Cp(T_f - T_a) \times 100}{GCV\ of\ fuel}$$

where (for L_3 to L_4), H_2 = kg of hydrogen present in fuel on 1 kg basis
Cp = Specific heat of superheated steam in kCal/ kg degree C
T_f = Flue gas temperature in C
T_a = Ambient temperature in C
584 = Latent heat corresponding to partial pressure of water vapour
M = kg moisture in fuel on 1 kg basis
AAS = Actual mass of air supplied per kg of fuel
Humidity factor = kg of water/ kg of dry air

DBT (Degree C)	WBT degree C	Relative Humidity	Kg water per kg of dry air(Humidity Factor)
20	20	100	0.016
20	14	50	0.008
30	22	50	0.014
40	30	50	0.024

$$Heat\ loss\ due\ to\ incomplete\ combustion = L_5 = \frac{\%CO \times C}{\%CO + \%CO_2} \times \frac{5744}{GCV\ of\ fuel} \times 100$$

Where, L5 = %Heat loss due to partial conversion of C to CO
CO = Volume of CO in flue gas leaving economiser %
CO_2 = Actual volume of CO_2 in flue gas%
C = Carbon content kg/ kg of fuel

OR

When CO is obtained in ppm during the flue gas analysis
CO formation(Mco) = CO(in ppm)*M_f*28*10^{-6}
M_f = Fuel consumption in kg/ he
L_5 = Mco*5744

$$\%Heat\ loss\ due\ to\ radiation\ \&\ convection = L_6 = 0.548[(\frac{T_s}{55.55})^4 - (\frac{T_a}{55.55})^4]$$
$$+[1.957 \times (T_s - T_a)^{1.25} \times \sqrt{[\frac{(196.85V_m + 68.9)}{68.9}]}$$

Where, L_6 = Radiation loss in W/m^2
V_m = Wind velocity in m/s
T_s = Surface tmperature (K)
T_a = Ambient temperature (K)

$$\%Heat\ loss\ due\ to\ unburnt\ in\ fly\ ash = L_7 = \frac{Total\ ash\ collected\ \ per\ kg\ of\ \ fuel\ burnt \times GCV\ of\ \ fly\ ash \times 100}{GCV\ of\ \ fuel}$$

$$\%Heat\ loss\ due\ to\ unburnt\ in\ bottom\ ash = L_8 = \frac{Total\ ash\ collected\ \ per\ kg\ of\ \ fuel\ burnt \times GCV\ of\ \ bottom\ ash \times 100}{GCV\ of\ \ fuel}$$

Boiler Efficiency in % η = 100 - (Addition of %L_1 to %L_8)

2. Furnace:

Specific energy consumption = Quantity of fuel or energy consumed/ quantity of material processed.

Direct Method:

$$Thermal\ efficiency of\ \ furnace = \frac{\text{Heat in stock (material) in kCal}}{\text{Heat in fuel in kCal}} \times 100$$

$$Heat\ imparted\ to\ stock\ Q = mCp(t_2 - t_1)$$

Where, Q = Quantity of heat in kCal
m = Mass of material in kg
Cp = Mean Specific Heat in kCal/ kg degree C
t_2 = Final temperature desired in degree C
t_1 = Initial temperature of the charge before it enters the furnace in degree C

Indirect Method:

Calculation of air quantity and specific fuel consumption:

$$\text{Theoretical air required for combustion} = [11.6C + \{34.8(H_2 - \frac{O_2}{8})\} + 4.35S]/100\ kg/kg\ of\ \ fuel$$

$$Excess\ air\ \text{supplied}\ (EA) = \frac{O_2\%}{21 - O_2\%} \times 100$$

$$Actual\ mass\ of\ \ air\ \text{supplied}\ /\ kg\ of\ \ fuel\ (AAS) = [1 + \frac{EA}{100}] \times theoretical\ air$$

$$Total\ mass\ of\ dry\ flue\ gas = Mass\ of\ C + Mass\ of\ N_2 in\ fuel + Mass\ of\ SO_2 + Mass\ of\ N_2 in\ Combustion\ air\ \text{sup}\ plied + Mass\ of\ O_2 in\ flue\ gas$$

or

$$= (C \times \frac{44}{12}) + (AAS \times \frac{77}{100}) + [(AAS - Theoretical\ Air) \times \frac{23}{100}] + (S \times \frac{64}{32}) + N_2$$

Above values can be taken from proximate or ultimate analysis of fuel.

Specific fuel consumption(F) = Amount of fuel consumed in kg per hour/ amount of billet in tonne per hour

Heat input calculation for furnace heat balance sheet (one tonne basis):

Heat Input = Combustion heat of fuel Q_1+ Sensible heat of fuel Q_2
= (fuel consumption per tonne of billet*GCV)+ (fuel consumption per tonne of billet*Cp of fuel*Temperature difference of flue gas to atmosphere)
= $Q_1 + Q_2$ in kCal per tonne of billet.

Heat out to furnace calculation for heat balance sheet (on one tonne basis):

$$Heat\ carried\ away\ by\ 1 tonne\ of\ billet = Q_3 = 1000 kg/tonne \times Cp(T_o - T_i)$$

Where, To = Temperature of billet at outlet of furnace in degree C
Ti = Temperature of atmosphere at outlet
Cp = Specific heat of billets in lCal/ kg/degree C

Sensible heat loss in flue gases:

$$Heat\ loss\ in\ flue\ gas = Q_4 = Sensible\ heat\ loss = m \times Cp_{fg} \times (T_1 - T_a)$$

Where, m = Amount of fuel consumped per tonne of billet in kg/ tonne of billet.
C_{pg} = Specific heat of flue gas ~ 0.24 kCal/ kg/degree C
T_1 = Temperature of flue gas in degree C
Ta = Temperature of atmosphere at base in degree C
Assumption: 1 kg of oil require 14 kg of air to burn fully.

$$Heat\ loss\ due\ to\ formation\ of\ water\ formed\ due\ in\ fuel = Q_5 = \frac{F \times (M + 9H_2)[584 + Cp_{\text{sup}.heat\ wat}(T_1 - T_a)]}{GCV\ of\ fuel} \times 100$$

Where, $Cp_{\text{super heated water}}$ = Specific heat of superheated water vapour in kCal/ kg/degree C

$$Heat\ loss\ due\ to\ moisture\ in\ combustion\ air = Q_6 = F \times AAS \times Humidity\ of\ air \times Cp_{\text{sup}\ heat\ wat}(T_1 - T_a)$$

$$Heat\ loss\ due\ to\ partial\ combustion\ of\ \ to\ CO = Q_7 = \frac{F \times \%CO \times C}{\%CO + \%CO_2} \times 5654$$

Amount of heat loss from furnace body and other sections Q_7

= heat loss from furnace body ceiling q1 + heat loss from furnace side wall q2+ bottom q3 + heat loss from flue gas duct between furnace exit and air pre heater q4

$$q1 = (h \times \Delta T^{1.25} \times A_i) + (4.88 \times \varepsilon \times [(\frac{T_w}{100})^4 - (\frac{T_a}{100})^4] \times A_i)$$

Where,

h	=	Natural convective heat transfer rate for ceiling in kCal/ m^2 h degree C
Tw	=	External temperature of ceiling in degree C
Ta	=	Room temperature in degree C
Δt	=	Tw- Ta
Ai	=	Ceiling surface area in m^2
ε	=	emissivity of furnace body surface

$$q2 = (h \times \Delta T^{1.25} \times A_i) + (4.88 \times \varepsilon \times [(\frac{T_w}{100})^4 - (\frac{T_a}{100})^4] \times A_i)$$

Where,

h	=	Natural convective heat transfer rate for side wall in kCal/ m^2 h degree C
Tw	=	External temperature of side wall in degree C
Ta	=	Room temperature in degree C
Δt	=	Tw- Ta
Ai	=	side wall surface area in m^2
ε	=	emissivity of furnace body surface

q3 = Bottom: But as bottom surface area is not exposed to the atmosphere, here it is ignored.

$$q4 = (h \times \frac{\Delta T}{D^{1.25}}^{1.25} \times A_i) + (4.88 \times \varepsilon \times [(\frac{T_w}{100})^4 - (\frac{T_a}{100})^4] \times A_i)$$

Where,

h	=	Natural convective heat transfer rate for duct in kCal/ m^2 h degree C
Tw	=	External temperature of flue gas duct in degree C
Ta	=	Room temperature in degree C
Δt	=	Tw- Ta
Ai	=	external flue gas duct in m^2
ε	=	emissivity of furnace body surface
D	=	Outside diameter of flue gas duct

Q_8 = q1+ q2+ q3+ q4 kCal per hour/ Amount of billet (t/ hr)

$$Radiation\ heat\ loss\ through\ furnace\ opening = Q_9 = hr \times A \times \varphi \times 4.88[(\frac{T_f}{100})^4 - (\frac{T_0}{100})^4] / t$$

Where,

hr	=	Open time during the period of heat balancing
Tf	=	Furnace temperature in degree C
To	=	base temperature in degree C
A	=	Area of opening in m^2
φ	=	Co efficient based on the profile of the furnace opening
	=	Dia. of shortest side/ wall thickness
t	=	Amount of billet in ton/ hour

Q10 = Other types of unaccounted heat losses like heat carried away by the cooling water in flue damper and furnace excess door, Radiation from furnace bottom, Heat accumulated by refractory, Instrumental error or any other errors etc.

$Q_{heat\ balance}$: (Q_1+Q_2) = $(Q_3+Q_4+Q_5+Q_6+Q_7+Q_8+Q_9+Q_{10})$

3. HEAT EXCHANGER.

Over all heat transfer co efficient:

$$Q = UA \times LMTD$$

Where, Q = Heat transfer in kCal/ hr
U = Overall heat transfer co efficient in kCal/ hr/ m^2/ degree C
A = Heat transfer area in m2
LMTD = Logarithmic Mean Temperature difference in degree C

$$\varepsilon = Heat\ exchanger\ effectiveness = \frac{Actual\ heat\ transfer\ rate\ in\ kCal/hr}{Max.\ possible\ heat\ transfer\ rate\ in\ kCal/hr} = \frac{Q}{Q_{max}} = \frac{Q}{C_{min} \times \Delta T_{max}}$$

Where, Cmin = Lower of two fluid heat capacities in kCal/ hr degree C
ΔTmax = Max. temp. difference from terminal stream temperature. in degree C

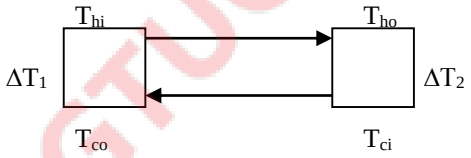
$$Heat\ duty\ of\ hot\ fluid = Q_h = W \times C_{ph} \times (T_{hi} - T_{ho})$$
$$Heat\ duty\ of\ cold\ fluid = Q_c = w \times C_{pc} \times (T_{co} - T_{ci})$$

Where, C_{ph} & C_{pc} = Specific heat of hot and cold fluid respectively in kCal/ kg Degree K
$T_{hi/\ ho}$ & $T_{co/ci}$ = Temperature at inlet (i) and outlet (o) of hot and cold fluids respectively in degree C
W, w = Hot and cold fluid flow respectively.

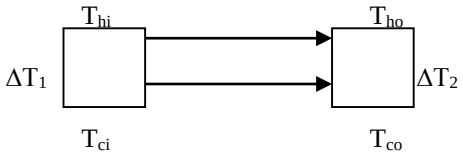
$$Heat\ duty\ of\ heat\ exchanger\ Q = Sensible\ heat\ q_s + Latent\ heat\ q_l$$
$$q_s = W \times C_{ph} \times (T_{hi} - T_{ho})/3600 = w \times C_{pc} \times (T_{co} - T_{ci})/3600 \ldots\ldots in\ kW$$
$$q_l = W \times \lambda_h / 3600 = w \times \lambda_c / 3600 \ldots . in\ kW$$

Where, λ_h & λ_c = Latent heat of condensation for hot fluid and latent heat of vaporization for cold fluid in kJ/ kg

$$Hot\ fluid\ pressure\ drop = \Delta P_h = P_i - P_o$$
$$Hot\ fluid\ temperature\ range = \Delta T_h = T_{hi} - T_{ho}$$
$$Cold\ fluid\ pressure\ drop = \Delta P_c = P_i - P_o$$
$$Cold\ fluid\ temperature\ range = \Delta T_c = T_{co} - T_{ci}$$



Counter flow heat exchanger



Parallel flow heat exhcanger

$$LMTD\ for\ counter\ flow = \frac{(T_{hi} - T_{co}) - (T_{ho} - T_{ci})}{\ln[(T_{hi} - T_{co}) - (T_{ho} - T_{ci})]}$$
$$LMTD\ for\ parallel\ flow = \frac{(T_{hi} - T_{ci}) - (T_{ho} - T_{co})}{\ln[(T_{hi} - T_{ci}) - (T_{ho} - T_{co})]}$$

LMTD correction factor F: (where two dimensionless numbers R and S are to be used as below)

$$R = \frac{T_a - T_b}{t_b - t_a} \qquad P = \frac{t_b - t_a}{T_a - t_a}$$

Where, T_a & T_b = Inlet and outlet temperature of shell side fluid
t_a & t_b = Inlet and outlet temperature of tube side fluid

For R≠1, compute as following:

$$\alpha = \left[\frac{1-RP}{1-P}\right]^{\frac{1}{N}} \quad \& \quad S = \frac{\alpha - 1}{\alpha - R} \quad \& \quad F = \frac{\sqrt{R^2-1}\ln\left(\frac{1-S}{1-RS}\right)}{(R-1)\ln\left[\frac{2-S(R+1-\sqrt{R^2+1})}{2-S(R+1+\sqrt{R^2+1})}\right]}$$

For R=1, compute as following:

$$S = \frac{P}{N-(N-1)P} \quad \& \quad F = \frac{S\sqrt{2}}{(1-S)\ln\left[\frac{2-S(2-\sqrt{2})}{2-S(2+\sqrt{2})}\right]}$$

Where, N = No of shell side passes
S & α = Parameters used to calculate LMTD correction factors

Corrected LMTD	=	F*LMTD
Overall heat transfer co efficient U	=	Q / (A* Corrected LMTD)

4. REFRIGERATION AND AIR CONDITIONING LOAD CALCULATIONS: (Use standard Refrigeration Tables for values of different factors)

a. External roof and walls (sensible):

$$Q = UA[(TETD_P \times F_C) + (TETD_A \times F_R)]$$

Where, U = Overall heat transfer co efficient for roof walls in W/m^2 degree K
A = Area of wall in m^2
TETD = Total Equivalent Temperature Difference,
Time Integrated peak and average respectively
F = Convective and radiative factor respectively for walls

b. Glass Conduction (sensible):

$$Q = UA\Delta T$$

Where, U = Overall heat transfer co efficient for glass in W/m^2 degree K
A = Area of glass in m^2
ΔT = Outside and inside temperature difference in degree C.

Glass Solar load (sensible):

$$Q = A[SC\{(F_C \times SHGF_P) + (F_R \times SHGF_A)\}]$$

Where, A = Glass Area m^2
SHGF = Solar heat gain factor for peak and average
SC = Shading co efficient
F = Convective and radiative factor respectively for glass

c. Ceiling/ Roof/ Floor/ Partition sensible (not exposed):

$$Q = UA\Delta T$$

Where, U = Overall heat transfer co efficient for Ceiling/ Roof/ Floor/ Partition in W/m^2 degree K
A = Area of Ceiling/ Roof/ Floor/ Partition in m^2
ΔT = Outside and inside temperature difference in degree C.

d. People Or Occupants (sensible and latent):

$$Q_s = No\ of\ occupants\ in\ space \times Sensible\ heat\ gain\ \ factor\ per\ occupant$$
$$Q_s = No\ of\ occupants\ in\ space \times Latent\ heat\ gain\ \ factor\ per\ occupant$$

e. Lights (sensible):

$$Q = Input \times Allowance \times Use$$

Where, Input = Input rating from electrical plants or lighting fixture data
Allowance = Usage of tube lights ~1.2
Use = Actual wattage in use/ installed wattage and to be decided based on application.

f. Motors and other load (sensible):

$$Q = Power\ of\ motor \times Load\ \ factor \times Use\ \ factor$$

Where, Power of motor = Name plate details of motor
Load factor = Depends on relative placement of motor and load
Use factor = Generally taken as 1 if not specified.

g. Appliances (sensible):

$$Q_s = No\ appliances\ in\ space \times Sensible\ heat\ \ factor$$
$$Q_s = No\ of\ \ appliances\ in\ space \times Latent\ heat\ \ factor$$

h. Ventilation and Infiltration (sensible):

$$Q_s = 20.43 \times Q_m (t_o - t_i) W$$
$$Q_L = 49.1 \times Q_m (W_o - W_i) W$$

Where, Qm = Outside air in m^3/ min infiltration or ventilation which ever is more.
t = Outside and inside temperature difference respcetively in degree K.
W = Humidity ratio difference of outside and inside in gms/ kg

i. Ventilation and Infiltration (latent):

$$Infiltration\ for\ room = HLWG / 60$$
$$Door\ \text{inf}\ iltration = door\ opening \times Factor / 60$$

Where, H = Room height in m.
W = Room width in m
L = Room Length in m
G = Factor for infiltration

5. AIR COMPRESSOR AND FREE AIR DELIVERY:

Load unload test of compressor for compressed air system leakage:

$$\%Leakage = \frac{Time\ for\ load\ in\ minutes}{Time\ for\ load + Time\ for\ unload\ in\ minutes} \times 100$$

$$System\ leakage\ quantity = \frac{Time\ for\ load\ in\ minutes}{Time\ for\ load + Time\ for\ unload\ in\ minutes} \times Comp.capacity\ in\ m^3/\min$$

Free air delivery by nozzle method:

$$Q_{free} = c \times \pi \times \frac{d^2}{4} \times \frac{T_a}{P_a} \left[\frac{2(P_{bn} - P_n)(P_{bn} - R)}{T_{bn}} \right]^{1/2}$$

Where, Q_{free} = Free air delivery in m^3/ sec
c = Flow constant to be specified
d = diameter of nozzle in m
T_a = Absolute inlet temperature in degree K
P_a = Absolute inlet pressure in kg/ cm^2
P_{bn} = Absolute pressure before nozzle in kg/ cm^2
P_{bn}-P_n = Difference of pressure across nozzle in kg/ cm^2
R = Gas constant for air and is taken as 287.10 J/ kg K
T_{bn} = Absolute temperature before nozzle in degree K

Isothermal efficiency = Isothermal Power/ Actual measured input power

Isothermal Power = $PV\log_e r$/ 36.7

Where, P = Absolute inlet pressure in kg/ cm^2
V = Free air delivery in m^3/ hr
r = pressure ratio P_d/P
P_d = Delivery Pressure m^3/ hr

Volumetric Efficiency = [Free air delivery (in m^3/ min) / Compressor displacement (in m^3/ hr)]*100
= [Free air delivery (in m^3/ min)/ ($0.785*D^2*L*N*X*n$)

Where, D = Cylinder bore in m
V = Free air delivery in m^3/ hr
L = Stroke length in m
N = RPM of compressor or speed in RPM
x = Single or double acting compressor cylinder
n = Nos. of cylinder in compressor

Specific power consumption at rated discharge pressure = Power consumption in kW/ Free air delivered m^3/ hr

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			II
	iii.		2			III
	iv.		2			IV
	v.		2			V
	vi.		2			I
	vii.		2			II or III
	viii.		2			IV
	ix.			2		IV
	x.				2	I
2	a.			3		II
		OR				
	a.			3		II
	b.			3		II
		OR				
	b.			3		II
	c.				4	III
		OR				
	c.				4	III
	d.			4		V
		OR				
	d.			4		V
3	a.			3		II
		OR				
	a.			3		II
	b.			3		IV
		OR				
	b.			3		IV
	c.				4	II
		OR				
	c.				4	II
	d				4	III
		OR				
	d				4	III
4	a.				3	IV
		OR				
	a.				3	IV
	b.			4		III
		OR				
	b			4		III
	c.				7	V
5	a.			4		I
	b.				4	III
	c.				3	V
	d.				3	IV

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: HYDRAULIC SYSTEMS
(COURSE CODE: 3361908)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

The laws, principles and concepts of hydraulics play very important role in the innovation, development and improvement of engineering processes and devices. Different types of hydraulic elements like pumps, valves and actuators are essential elements in all the manufacturing industries. This course is designed to develop understanding of hydraulic systems which are widely used for operation and controls in machine tools, material handling, automobile, marine, mining, metal processing, equipment and other fields. This course also enables the diploma students to operate and troubleshoot different types of hydraulic systems in industries.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills in students so that they are able to acquire following competency:

- **Use and maintain hydraulic machineries based on fluid laws and characteristics.**

3. COURSE OUTCOMES.

The theory should be taught and practicals should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

i. Select hydraulic fluid based on given conditions.
ii. Select, operate and maintain various hydraulic elements such as pumps and actuators.
iii. Operate and maintain various hydraulic control valves and accessories.
iv. Design hydraulic circuits by selecting suitable components for a given application.
v. Operate and maintain various hydraulic devices such as hydraulic brake, power steering, jack etc.
vi. Install, maintain, and troubleshoot various hydraulic systems.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS.

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit – I **Fundamentals of Hydraulics.**	1a. Compare fluid power transmission with electrical and mechanical transmission. 1b. Describe various laws governing fluid flow. 1c. Select appropriate hydraulic fluid for given application.	1.1 Power transmission modes and comparison. 1.2 Fluid power – history, concept and definition. 1.3 Application of hydraulic and pneumatic in fluid power. 1.4 Hydrostatic and hydrodynamic-concept and definitions. 1.5 Definition and interrelationships of various terms (properties) used in hydraulics. 1.6 Laws governing fluid flow: i. Pascal's law. ii. Continuity equation. iii. Bernoulli's theorem. 1.7 Flow through pipes-types, pressure drop in pipes. 1.8 Hydraulic fluid - types, ISO/BIS standards and designations, properties and their advantages and limitations. 1.9 Hydraulic systems –applications, advantages and limitations.
Unit– II **Hydraulic Elements-I.**	2a. Select appropriate hydraulic pipe for given application. 2b. Describe pumping theory. 2c. Select and maintain appropriate pump for given application. 2d. Select and maintain appropriate hydraulic elements (actuators, motors and cylinders). 2e. Apply linear motion methods for cylinders in machineries.	2.1 Basic hydraulic system. 2.2 Hydraulic pipes – Types, standards, designation and specifications, pressure ratings, applications, selection criteria. 2.3 Pumping theory & classification. 2.4 General assembly sketch, main parts, working principle, working, applications and comparison of following pumps: i. External, Internal gear pumps & Ge-rotor.(Generator rotor). ii. Lobe. iii. Screw. iv. Vane. v. Piston. 2.5 Selection criteria of pumps. 2.6 Hydraulic Actuators - classification, construction, working and applications. 2.7 Cylinder cushions and mountings.

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
		2.8 Various methods of applying linear motion (horizontal, vertical, inclined, first class lever, second class lever, third class lever, bent lever, toggle lever mechanism).
Unit– III **Hydraulic Elements-II.**	3a. Use various hydraulic control valves. 3b. Differentiate between proportional and servo valve. 3c. Select and use various hydraulic accessories with its location on hydraulic system.	3.1 Classification of Hydraulic control valves. 3.2 Types, construction, working and applications of: i. Pressure control valves. ii. Directional control valves. iii. Flow control valves. iv. Proportional control valve (Proportional pressure relief valve, Proportional pressure reducing valve, Proportional direction valve). v. Servo control valves. (Mechanical hydraulic servo valve, Electro hydraulic servo valve, Single stage, two stage Flapper type, Jet pipe type). 3.3 Comparison of proportional and servo control valves. 3.4 Selection of control valves. 3.5 Hydraulic Accessories: types, construction, working and applications of: i. Strainers and filters. ii. Seals (static and dynamic). iii. Hydraulic reservoirs. iv. Hydraulic accumulators. v. Manifold. vi. Heat exchangers. vii. Oil level and pressure indicator.
Unit-IV **Hydraulic Circuit Design.**	4a. Describe ISO symbols and guiding rules for designing hydraulic system. 4b. Design hydraulic circuit based on given system requirements.	4.1 ISO symbols used in hydraulic circuits. 4.2 Circuit diagram, components, working and application of following hydraulic circuits: i. Control of single acting cylinder. ii. Control of double acting cylinder. iii. Pump unloading circuit.

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
		iv. Intensifier Circuit. v. Regenerative Circuit. vi. Synchronizing circuits. vii. Automatic Cylinder Reciprocation circuit. viii. Sequencing circuits. ix. Meter-in and Meter-out circuit. x. Two hand safety control. xi. Emergency cut-off control. 4.3 Hydraulic system design i. Method and steps of designing a hydraulic circuit from working conditions.
Unit-V **Hydraulic Devices.**	5a. Identify different parts in a given hydraulic device. 5b. Describe function and working of various parts in hydraulic devices.	5.1 Hydraulic Devices – Concept and applications. 5.2 Construction, working principle, major elements, performance variables and applications of following devices: i. Automotive hydraulic brake. ii. Industrial Fork lift. iii. Hydraulic jack. iv. Hydraulic press. v. Automotive power steering. vi. Hydraulic lift.
Unit-VI **Installation, Maintenance and Trouble-Shooting.**	6a. Describe steps for installation of various hydraulic components. 6b. Identify the various faults in the system and the remedial actions for them.	6.1 Installation of hydraulic system. 6.2 Causes and remedies for troubles arising in hydraulic elements. 6.3 Maintenance of hydraulic systems. i. Maintenance schedule. 6.4 Troubleshooting of hydraulic system.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (Theory):

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Hydraulics.	4	4	2	2	8
II	Hydraulic Elements-I.	8	4	4	4	12
III	Hydraulic Elements-II.	8	4	4	4	12
IV	Hydraulic Circuit Design.	12	4	8	6	18
V	Hydraulic Devices.	6	2	4	6	12
VI	Installation, Maintenance and Troubleshooting.	4	2	2	4	8
	Total	**42**	**20**	**24**	**26**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note:

a. This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.
b. If mid-sem test is part of continuous evaluation, unit numbers I, II and III are to be considered.
c. Ask the questions from each topic as per marks weight age. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The tutorial/practical/exercises should be properly designed and implemented with an attempt to develop different types of cognitive and practical skills **(Outcomes in cognitive, psychomotor and affective domain)** so that students are able to acquire the competencies. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	I	**Preparatory activity:** a. Tabulate properties of fluid, units and importance in fluid systems. b. Tabulate different hydraulic oil available in	02

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
		market, ISO / BIS designation, important properties and applications.	
2	II,III	**Demonstration of various hydraulic elements:** a. Demonstrate various hydraulic elements covered in theory classes.. b. Tabulate all hydraulic elements with name, symbol, sketch, specifications and applications. c. Design the hydraulic system circuit based on given input and parameters and using simulation software.	06
3	IV	**Performance:** a. Design, assemble and operate hydraulic system, based on given simple system requirements (Design mainly include selection and arrangement of elements). i. Control of single acting cylinder ii. Control of double acting cylinder iii. Meter-in and meter-out circuits iv. Regenerative Circuit v. Synchronizing circuits vi. Automatic Cylinder Reciprocation circuit vii. Sequencing circuits (manual & automatic) viii. Circuit using accumulator. b. Sketch the system diagram with symbols. c. Prepare the list of items and also list the steps of assembly. d. Observe and record the parameters. Change any one parameter and observe the effect on other parameters.	16
4		**Seminar presentation:** a. Prepare and present seminar topic individually. (Seminar topic has to be given by teacher). b. Download visual aids, videos, contents and other related instructional material for the given case / situation. (Case/situation has to be given by teacher) Present and discuss the same in your class.	4
		Total Hours	**28**

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.
b. Term work report must not include any photocopy /ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
c. Each student will make his/her folder having the name as <batch number Enrollment number> and will save his/her presentation and downloaded content. A DVD is to be made which will contain folders of all students. Same DVD is to be submitted.
d. Seminar presentation topic/area has to be assigned to the group of specified students in the beginning of the term by batch teacher.
e. For practical ESE part, students are to be assessed for competencies achieved. They should be given to perform any one pneumatic system from experiment number 3.

8. SUGGESTED LIST OF STUDENT ACTIVITIES.

Following is the list of proposed student activities such as:

i. Prepare journals based on practical performed in laboratory.
ii. Assignments on theories taught in classroom.
iii. Prepare/Download a dynamic animation to illustrate the following:
    - Working principle of hydraulic pumps.
    - Working principle of hydraulic valves and actuators.
    - Working of different types of hydraulic devices (applications).
iv. Download the catalogue of Hydraulic devices.
v. Arrange visit to nearby Hydraulic equipment based industries.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr.No.	Unit	Unit Name	Strategies
1	I	Fundamentals of hydraulics.	Demonstration of hydraulic devices, showing applications, videos.
2	II	Hydraulic elements-I.	Demonstration of elements working, dismantling of elements, presentations, actual uses, movies.
3	III	Hydraulic elements-II.	Demonstration of elements working, dismantling of elements, presentations, actual uses, movies.
4	IV	Hydraulic Circuit Design.	Demonstration of actual circuits, videos on steps to prepare circuit, on-hand practice, movies.
5	V	Hydraulic Devices.	Demonstration of hydraulic devices, showing applications, videos.
6	VI	Installation, Maintenance and Troubleshooting.	Demonstration of hydraulic devices in dismantled condition, exercise on identifying elements and faults, on-hand practice to maintain/repair simple devices, showing applications and videos.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

Sr. No.	Title of Book	Author	Publication
i.	Oil Hydraulic Systems	Majumdar, S.R.	Tata Mcgraw-Hill Publication, 3/e, 2013
ii.	Hydraulic and Pneumatic Controls	Srinivasan, R.	Vijay Nicole Imprints Private Limited, 2/e, 2008
iii.	Fluid Power Generation, Transmission and Control	Jagadeesha, T.	Universities Press (India) Private Limited, 1/e, 2014
iv.	Hydraulic And Pneumatics A Technician's & Engineer's Guide	Parr, Andrew	Jaico Publishing House, 2/e, 2013
v.	Hydraulic And Pneumatics Controls Understanding Made Easy	Shanmuga Sundaram, K.	S. Chand Company Ltd., 1/e, 2006
vi.	Industrial Fluid Power Vol. I, II, & III	Hedges, Charles S.	Womack Educational Publications, 3/e, 2009

B) List of Major Equipment/ Instrument with Broad Specifications

Sr. No.	Resource with brief specification.
i.	**Electro-hydraulic Trainer kit (with/without proportional valves)** Components required: Pump, Reservoir, pressure relief valve, check valves, Directional control valves (manual and electrically operated), Flow control valves(fixed and variable), pressure reducing valve, Cylinders, Motor, Accumulator, hosepipes, accessories and setup for electro-hydraulic circuits.
ii.	Working model of pumps, valves and actuators.
iii.	Cut section of various pumps, valves and actuators

C) List of Software/Learning Websites

i. www.boschrexroth.co.in
ii. http://www.automationstudio.com/
iii. http://www.howstuffworks.com/search.php?terms=hydraulics
iv. http://hyperphysics.phy-astr.gsu.edu/hbase/fluid.html#flucon
v. http://www.youtube.com/watch?v=FVR7AC8ExIM
vi. http://www.youtube.com/watch?v=iOXRoYHdCV0
vii. http://www.youtube.com/watch?v=qDinpuq4T0U
viii. http://www.youtube.com/watch?v=xxoAm3X4iw0

ix. http://www.youtube.com/watch?v=JsFcfudj3rE
x. http://www.youtube.com/watch?v=CoprDVmvKso
xi. http://www.youtube.com/watch?v=YxxSmz86zDg
xii. http://www.brighthubengineering.com/fluid-mechanics-hydraulics/
xiii. http://www.hypneu.com/index.html
xiv. http://www.nfpa.com/default.aspx
xv. www.festo.com
xvi. www.nptel.iitm.ac.in
xvii. Automation Studio 5.0 or higher version
xviii. Festo Fluidsim,
xix. Hypneu, AUTOMSIM, LVSIM®HYD, LogicLab, etc.

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE.

Faculty Members from Polytechnics.

- **Prof. P. S. Patel**, Lecturer in Mechatronics Engineering, B. S. Patel Polytechnic, Ganpat vidhyanagar, Kherva.
- **Prof. M. A. Patel**, Lecturer in Mechatronics Engineering, B. S. Patel Polytechnic, Ganpat vidhyanagar, Kherva.
- **Prof. H. M. Shah**, Lecturer in Mechanical Engineering, B. S. Patel Polytechnic, Ganpat vidhyanagar, Kherva.
- **Prof. H. R. Sapramer**, Lecturer in Mechanical Engineering, Sir Bhavsinhji Polytechnic Institute, Bhavnagar.

Coordinator and Faculty Members from NITTTR, Bhopal.

- **Dr. K. K. Jain,** Professor, Department. of Mechanical Engineering,
- **Dr. C. K. Chugh,** Professor, Department of Mechanical Engineering,

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			I
	iii.		2			II
	iv.		2			II
	v.		2			III
	vi.		2			III
	vii.		2			IV
	viii.		2			IV
	ix.			2		I
	x.		2			V
2	a.				3	I
		OR				
	a.				3	I
	b.			3		II
		OR				
	b.			3		II
	c.			4		III
		OR				
	c.			4		III
	d.				4	IV
		OR				
	d.				4	IV
3	a.				3	VI
		OR				
	a.				3	VI
	b.				3	III
		OR				
	b.				3	III
	c.	MINOR CIRCUIT		4		IV
		OR				
	c.	MINOR CIRCUIT		4		IV
	d.			4		V
		OR				
	d.			4		V
4	a.			3		VI
	a.			3		VI
	b.				4	II
		OR				
	b.				4	II
	c.	MAJOR CIRCUIT		7		IV

5	a.				4	V
	b.	SYMBOLS	4			IV
	c.			3		III
	d.				3	V

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PNEUMATIC SYSTEMS
(COURSE CODE: 3361909)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Sixth

1. RATIONALE.

Different types of pneumatic elements like compressors, valves and actuators are essential in all the manufacturing industries. This course is designed to develop understanding of such pneumatic systems which are widely used in machine tools, material handling, construction, mining, elevators, material processing equipment and other fields. This course also enables the diploma students to operate and troubleshoot different types of pneumatic systems in industries.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate and maintain pneumatic machineries based on fluid laws and characteristics.**

3. COURSE OUTCOMES (COs):

The theory should be taught and practicals should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Select pneumatic power system based on given conditions.
ii. Select, operate and maintain various pneumatic elements such as compressors, valves, actuators and accessories.
iii. Design pneumatic circuits by selecting suitable components for a given application.
iv. Use and maintain various pneumatic devices and systems.
v. Install, maintain, and troubleshoot various pneumatic systems.
vi. Develop hydro pneumatics circuit diagram for given application.

4 TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In cognitive domain)	Topics and Sub-topics
Unit – I **Fundamentals of Pneumatics.**	1a. Compare pneumatic with pneumatics. 1b. Select appropriate pneumatic fluid for given application. 1c. Describe different laws governing the compressible fluids (gases).	1.1 Definition and history of Pneumatics. 1.2 Pneumatic systems: i. Basic components. ii. Comparison to pneumatic systems. iii. Advantages and limitations. iv. Applications of pneumatics. 1.3 Compressible fluids - types, properties of air, applicable gas laws (Boyle's, Charles', Gay-Lussac' laws).
Unit– II **Pneumatic Elements.**	2a. Select appropriate air compressor, receiver for given application. 2b. Use and maintain of FRL unit in pneumatics. 2c. Describe piping layout. 2d. Select and maintain appropriate pneumatic elements (actuators, motors and cylinders). 2e. Select and maintain appropriate pneumatic control valves. 2f. Use logic valves in pneumatic circuit.	2.1 Basic pneumatic system. 2.2 Types, construction, working, specifications and selection criteria of following air preparation and conditioning elements: i. Air compressors ii. Air receivers iii. Air dryers iv. Air filters, regulators and lubricators (FRL unit). 2.3 Pneumatic pipes- materials, BIS, ASME and DIN designations, standards, properties and selection criteria. 2.4 Piping layout-important considerations, precautions and route optimization. 2.5 Pneumatic cylinders- types, construction, working, materials, specifications, mounting & cushioning. 2.6 Pneumatic motors- types, construction, working, specifications and applications. 2.7 Types, constructions, designations, working, applications and selection criteria of following: i. Directional control valves. ii. Flow control valves. iii. Pressure control valves. iv. Special valves- quick exhaust valve and time delay valve. v. Logic valves- shuttle valve and twin pressure valve. 2.8 Other fittings.

Unit	Major Learning Outcomes (In cognitive domain)	Topics and Sub-topics
Unit– III **Pneumatic Circuit Design.**	3a. Describe ISO symbols and guiding rules for designing pneumatic system. 3b. Describe various components of pneumatic circuit based on given system requirements. 3c. Design pneumatic logic circuit based on given system requirements.	3.1 ISO symbols used in pneumatic circuits. 3.1 Circuit diagram, components, working and application of following pneumatic circuits: i. Control of single acting cylinder. ii. Control of double acting cylinder. iii. Speed control circuit. iv. Automatic cylinder reciprocation circuit. v. Quick exhaust circuit. vi. Two step feed control circuit vii. Time delay circuit. viii. Two hand safety control circuit. 3.2 Pneumatic logic circuit design: i. Classic method, cascade method, step counter method, karnaugh-veitch maps and combinational circuit design. 3.3 Components of electrical controls- switches, relays, solenoids, timers. 3.4 Electro-pneumatic circuits: i. Reciprocation of cylinder using pressure switches. ii. Control of a cylinder using a single limit switch. iii. Automatic dual cylinder sequencing circuits.
Unit-IV **Pneumatic Devices.**	4a. Identify different parts in a given pneumatic device. 4b. Describe function and working of various parts in pneumatic devices.	4.1 Pneumatic devices – concept and need. 4.2 Construction, working principle, major elements, performance variables and applications of following devices: i. Automotive pneumatic brake. ii. Automotive air suspension. iii. Pneumatic drill. iv. Pneumatic gun (tools).
Unit-V **Installation, Maintenance and Trouble-Shooting.**	5a. Describe steps for installation of various pneumatic components. 5b. Identify the various faults in the system and the remedial actions for them.	5.1 Installation of pneumatic system. 5.2 Causes and remedies for troubles arising in pneumatic elements. 5.3 Maintenance of pneumatic systems: i. Maintenance schedule. 5.4 Troubleshooting of pneumatic system.

Unit	Major Learning Outcomes (In cognitive domain)	Topics and Sub-topics
Unit-VI **Hydro-Pneumatics.**	6a. Explain working of hydro-pneumatic elements. 6b. Compare hydro-pneumatic with pneumatic and pneumatic systems.	6.1 Hydro-pneumatics – concept, advantages and disadvantages. 6.2 Types, construction, working, circuit diagram and application of following hydro-pneumatic elements: i. Air oil reservoir. ii. Pneumatic series check unit. iii. Pneumatic parallel check unit. iv. Hydro pneumatic cylinder. v. Air oil intensifier. 6.3 Comparison between hydro-pneumatic, pneumatic and pneumatic systems.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Pneumatics.	4	4	2	2	8
II	Pneumatic Elements.	14	4	8	8	20
III	Pneumatic Circuit Design.	12	4	8	6	18
IV	Pneumatic Devices.	4	2	4	2	8
V	Installation, Maintenance and Troubleshooting.	4	2	4	2	8
VI	Hydro-Pneumatics.	4	2	2	4	8
	Total	**42**	**18**	**28**	**24**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Notes:

a. This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

b. If mid-sem test is part of continuous evaluation, unit numbers I, II and VI are to be considered.

c. Ask the questions from each topic as per marks weight age. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The tutorial/practical/exercises should be properly designed and implemented with an attempt to develop different types of cognitive and practical skills **(Outcomes in cognitive, psychomotor and affective domain)** so that students are able to acquire the competencies.

***Note**: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development*

*of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Hours. required
1	I	**Preparatory activity:** Students would: a. Tabulate physical properties of compressible fluid, units and importance in fluid systems.	02
2	II	**Demonstration of various pneumatic elements:** Students would: a. Demonstrate various pneumatic elements covered in theory classes. b. Tabulate all pneumatic elements with name, symbol, sketch, specifications and applications. c. Based on given input and parameters, design the pneumatic system circuit using simulation software. Take printout also.	06
3	III,IV	**Performance:** Students would: a. Design, assemble and operate pneumatic system, based on given simple system requirements (Design mainly include selection and arrangement of elements). Perform at least 7 practical on kit. i. Control of single acting cylinder ii. Control of double acting cylinder iii. Meter-in and meter-out circuits iv. Automatic cylinder reciprocation circuit v. Quick exhaust circuit vi. Two step feed control circuit vii. Time delay circuit viii. Reciprocation of cylinder using pressure switches / limit switches ix. Synchronizing circuits x. Sequencing circuits (manual & automatic) b. Sketch the system diagram with symbols. c. Prepare the list of items and also list the steps of assembly. d. Observe and record the parameters. Change any one parameter and observe the effect on other parameters.	16
4		**Seminar presentation:** Students would: a. Prepare and present seminar topic individually. (Seminar topic has to be given by teacher). b. Download visual aids, videos, contents and other related instructional material for the given case / situation. (Case/situation has to be given by teacher) Present and discuss the same in your class.	4
		Total Hours	**28**

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.
b. Term work report must not include any photocopy /ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.
c. Each student will make his/her folder having the name as <batch number_Enrollment number> and will save his/her presentation and downloaded content. A DVD is to be made which will contain folders of all students. Same DVD is to be submitted.
d. Mini project and presentation topic/area has to be assigned to the group of specified students in the beginning of the term by batch teacher.
e. For practical ESE part, students are to be assessed for competencies achieved. They should be given to perform any one pneumatic system from experiment number 3.

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare/Download animation to illustrate working principle of Air compressors, valves, actuators and devices.
ii. Make comparative table for pneumatic and pneumatic systems.
iii. Download the catalogue of pneumatic devices.
iv. Arrange visit to nearby pneumatic equipment based industries.
v. Show video/animation films explaining the function of pneumatic compressors, valves, FRL unit, actuators and their accessories.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr.No.	Unit	Unit Name	Strategies
1	I	Fundamentals of pneumatics.	Demonstration of pneumatic devices, showing applications, videos.
2	II	Pneumatic elements.	Demonstration of elements working, dismantling of elements, presentations, actual uses, movies.
3	III	Pneumatic circuit design.	Demonstration of actual circuits, videos on steps to prepare circuit, on-hand practice, movies.
4	IV	Pneumatic devices.	Demonstration of pneumatic devices, showing applications, videos.
5	V	Installation, maintenance and troubleshooting.	Demonstration of pneumatic devices in dismantled condition, exercise on identifying elements and faults, on-hand practice to maintain/repair simple devices, showing applications and videos.
6	VI	Hydro-pneumatics.	Demonstration, industrial visits, movies.

10. SUGGESTED LEARNING RESOURCES.

A) List of Books.

Sr. No.	Title of Book	Author	Publication
1.	Pneumatic Systems	Majumdar, S.R.	Tata Mcgraw-Hill Publication, 3/e, 2013
2.	Pneumatic And Pneumatic Controls	Srinivasan, R.	Vijay Nicole Imprints Private Limited, 2/e, 2008
3.	Pneumatics Concepts, Design And Applications	Jagadeesha, T.	Universities Press (India) Private Limited, 1/e, 2014
4.	Pneumatic And Pneumatics A Technician's & Engineer's Guide	Parr, Andrew	Jaico Publishing House, 2/e, 2013
5.	Pneumatic And Pneumatics Controls Understanding Made Easy	Shanmuga Sundaram, K.	S.Chand Company Ltd., 1/e, 2006
6.	Industrial Fluid Power Vol. I, II, & III	Hedges, Charles S.	Womack Educational Publications, 3/e, 2009

B) List of Major Equipment/ Instrument with Broad Specifications.

Sr. No.	Resource with brief specification.
1	**Electro-pneumatic Trainer kit** Components required: Air compressor, Pressure relief valve, check valves, Directional control valves (manual, pilot operated and electrically operated), Flow control valves (fixed and variable), pressure reducing valve, Cylinders, Motor, Accumulator, tubes, quick exhaust valve, time delay valve, limit switches, pressure switches, proximity sensors, setup for electro-pneumatic circuits.
2	Working model of compressors, valves and actuators.
3	Cut section of various compressors, valves and actuators

C) List of Software/Learning Websites.

i. www.festo.com
ii. www.boschrexroth.co.in
iii. www.nptel.iitm.ac.in
iv. http://www.howstuffworks.com/search.php?terms=pneumatics
v. http://www.youtube.com/watch?v=MbKrIieogNc
vi. http://www.youtube.com/watch?v=7JuNbHb5NrQ
vii. http://www.youtube.com/watch?v=NakOoD-G0IY
viii. http://www.youtube.com/watch?v=bG2mCiQgbwE
ix. http://www.youtube.com/watch?v=cB3OCPqmUDQ
x. http://www.youtube.com/watch?v=5q7YasmwXCs
xi. http://www.youtube.com/watch?v=a5Ebx__l5-g
xii. http://www.nfpa.com/default.aspx

xiii. http://www.automationstudio.com/
xiv. http://www.hypneu.com/index.html
xv. Automation Studio 5.0 or higher version
xvi. Festo Fluidsim,
xvii. Hypneu, AUTOMSIM, LVSIM®PNEU, LogicLab, etc.

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE.

Faculty Members from Polytechnics.

- **Prof. P. S. Patel**, Lecturer, Department of Mechatronics Engineering, B. S. Patel Polytechnic, Kherva.
- **Prof. M. A. Patel**, Lecturer, Department of Mechatronics Engineering, B. S. Patel Polytechnic, Kherva.
- **Prof. H. M. Shah**, Lecturer, Department of Mechanical Engineering, B. S. Patel Polytechnic, Kherva.
- **Prof. H. R. Sapramer**, Lecturer, Department of Mechanical Engineering, Sir Bhavsinhji Polytechnic Institute, Bhavnagar.

Coordinator and Faculty Members from NITTTR, Bhopal.

- **Dr. K. K. Jain,** Professor, Department of Mechanical Engineering,
- **Dr. C. K. Chugh,** Professor, Department of Mechanical Engineering,

SUGGESTED QUESTION PAPER FORMAT

(This is for reference only and is in suggestive form. Paper setter may opt for other marks distribution pattern maintaining distribution of marks as per specification table)

Q.NO.	SUB Q.NO.	QUESTION	MARKS DISTRIBUTION			UNIT
			R	U	A	
1		Answer ANY seven from following.				14
	i.		2			I
	ii.		2			I
	iii.		2			II
	iv.		2			II
	v.		2			II
	vi.				2	III
	vii.		2			IV
	viii.			2		I
	ix.		2			VI
	x.		2			V
2	a.				3	I
		OR				
	a.				3	I
	b.				3	II
		OR				
	b.				3	II
	c.			4		II
		OR				
	c.			4		II
	d.				4	III
		OR				
	d.				4	III
3	a.				3	IV
		OR				
	a.				3	IV
	b.			3		V
		OR				
	b.			3		V
	c.	MINOR CIRCUIT		4		III
		OR				
	c.	MINOR CIRCUIT		4		III
	d.				4	VI
		OR				
	d.				4	VI
4	a.				3	V
		OR				
	a.				3	V
	b.			4		II
		OR				
	b.			4		II
	c.	MAJOR CIRCUIT		7		III
5	a.			4		IV
	b.				4	II
	c.	SYMBOLS	3			III
	d.			3		VI

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PROJECT - II
(COURSE CODE: 3361910)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	SIXTH

1. RATIONALE.

This course enables the students to exercise some of the knowledge and/or skills developed during the programme to new situation or problem for which there are number of engineering solutions. This course include planning of the tasks which are to be completed within the time allocated, and in turn, helps to develop ability to plan, , use, monitor and control resources optimally and economically. By studying this course abilities like creativity, imitativeness and performance qualities are also developed in students. Leadership development and supervision skills are also integrated objectives of learning this course.

2. COMPETENCY.

The course content should be taught and implemented with the aim to develop different types of skills so that students are able: to acquire following competencies.

- **Plan, use, monitor and control resources optimally and economically.**
- **Identify the problem and apply innovative, creative and logical approach for problem solving.**

3. COURSE OUTCOMES.

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Plan and identify materials, processes and other resources optimally.
ii. Develop innovative and creative ideas.
iii. Develop leadership, interpersonal skill and team work.
iv. Develop sense of environmental responsibility.
v. Purchase raw material/standard parts.
vi. Interpret the drawings, manufacture, assemble, inspect & if necessary modify the parts/unit/assembly of the project work.
vii. Familiar with fast changes in technology.

4. TEACHING AND EXAMINATION SCHEME.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
0	0	6	6	0	0	60	90	

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, ESE -End Semester Examination; PA - Progressive Assessment.

5. SUGGESTED LIST OF EXERCISES/PRACTICALS.

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (outcomes in psychomotor and affective domain) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of Course Outcomes related to affective domain. Thus over all development of Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme) would be assured.
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	**Preparatory Activity:** a. Keep project report of V semester course Project-I- 3351908. b. Appreciate the importance of course outcomes. c. Recall and strengthen know-how for engineering drawing fundamentals which includes: i. Most commonly used limits and fits with values. ii. Various machining processes and surface roughness symbols. d. Evaluate all the projects (Of Project –I- 3351908) drawings and select feasible project for execution in batch. (Total projects will be equal to number of students in a batch. Evaluate and select in such a way that selected project will be executed in groups. That is, there may be 3-5 projects, remaining will be dropped, and for selected project, there will be distribution of the students in group.)Attach selected project drawings. e. Recheck and correct (Minor corrections) if necessary, project production drawings of selected projects (The project drawings of the student prepared in course Project –I- 3351908).	08
2	**Work allocation matrix:** Prepare work allocation matrix along with provision of follow-up remarks and notes. (Suggested format of work allocation matrix with provision of follow-up is attached herewith in Annexure -I).	04
3	**Project execution:** Execute project preparation activities as per work allocation matrix. (Option of flexi time based work can also be practiced. For this option, it may not be necessary to exactly follow the time table slots. This can be on continuous base also.)	64
4	**Documentation and presentation:** Documentation of final project report which includes following in sequence.	08

	a. Title page-(Suggested as per Annexure-II.) b. Certificate –As per Annexure-III. c. Index. d. Preface/Acknowledgement. e. Course outcomes. f. Project title. g. Assembly and detail production drawings. h. List of activities (suggested as per Annexure – IV) and work allocation matrix. i. Plant layout with dimensions. j. List and specifications of machineries, equipments and tools. k. Bill of material with make or buy decision. l. Specifications of bought out parts. m. Process sheets-As per format given in course Industrial engineering. n. Flow process charts. o. Specification and consumption of consumables. p. Details of inspection / testing carried out. q. Details of rework / rectifications carried out. r. Cost estimation. s. Monitoring and control report/sheet. t. Notes on troubleshooting. u. Notes on individual achievement of skills / experience /problems / solutions. v. References. w. Day to day logbook as per Annexure-V. x. Presentation including moments at work-video/photographs in action.	
	TOTAL	84

Notes:

a. Prepare project report with MS Office with following guidelines.

PAGE:	A4 (ON ONE SIDE).
MARGINN:	TOP :15mm. BOTTOM :15mm. RIGHT :15mm. LEFT :30mm.
FONT:	ARIAL.
SIZE:	12-BOLD, CONTENT12, SPACING 18 POINTS,
HEADER:	TITLE OF THE PROJECT, PAGE NUMBER ON TOP RIGHT.
FOOTER:	ACADEMIC YEAR, SHORT NAME OF THE INSTITUTE.

b. Term work (hard copy) should also include experience logbook duly certified by workshop instructors (as applicable), Industry/Market/Field personnel (as applicable) and subject teachers.

c. Term work has to be defended (along with term work of V semester and VI semester) by practical / oral examination to be conducted by external and internal examiners. Power point presentation is also to be included.

6. SUGGESTED LIST OF STUDENT ACTIVITIES.

SR.NO.	ACTIVITY
1	Suggest further improvement / research which can be carried out.

7. SUGGESTED LEARNING RESOURCES.

A. List of Books:

i. Use of Library.
ii. Reference books.
iii. Hand books.
iv. Encyclopedia.
v. Magazines.
vi. Periodicals.
vii. Journals.
viii. Visits of industry, organizations related as per the requirement.
ix. Internet.

8. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics.

- K.H.Patel, Head of mechanical engineering department, Dr. S.S.and S. Gandhi College of engineering and technology, Surat.
- A.M.Talsaniya, Lecturer in Mechanical engineering, Sir BPI, Bhavnagar.

Coordinator and Faculty Members from NITTTR Bhopal.

- **Dr. K.K. Jain,** Professor, Department of Mechanical Engineering, NITTTR, Bhopal
- **Dr. A.K. Sarathe,** Associate Professor; Department of Mechanical Engineering.

ANNEXURE-I

WORK ALLOCATION MATRIX (SUGGESTED)

ENROLLMENT NO. OF STUDENT: **NAME OF STUDENT:** **BATCH:**

ACTIVITY NO.	SHORT DESCRIPTION OF ACTIVITY	WHO WILL PERFORM?	PLANNED DATES		ACTUAL DATES		WHO HAS / HAVE PERFORMED?	REASON/S FOR ANY DELAY / DEVIATION FROM PLANNING	INITIAL OF TEACHER
			STARTING	ENDING	STARTING	ENDING			
1	Preparing and maintaining logbook as per Annexure-V.								
2	Finalization of assembly and detail drawings (This must be production drawings with suitable scale along with dimensions, tolerances, surface roughness symbols, heat treatment / other treatments required, material , quantity per assembly for components drawings ,etc.								
3	Preparing master schedule and work allocation matrix in group.								
4	Preparation of bill of material.								
5	Collecting data and specifications of available resources-mainly material and machineries / equipment/facilities and tools.								
6	Make or Buy decision.								
7	Preparing specifications of bought-out parts.								

8	Preparation of process planning (sheets) for all components in standard format.								
9	List, quantities and specifications of consumables.								
10	Preparation of list of required tools-cutting tools, jigs, fixtures, measuring instruments and other tools along with necessary specifications and sketches if required.								
11	Identifying and locating required resources like material, machineries/equipments / facilities and tools.								
12	Preparing plant layout.								
13	Manufacturing of components.								
	a) <name of component 1>								
	b) <name of component 2>								
	c) <name of component 3>								
	d) <name of component 4>								
	n) <name of component n>								
14	Details of inspection carried out.								
15	Assembly.								
16	Details of testing carried out.								
17	Rework / rectification activities if required.								
18	1) Project monitoring and control, record keeping.								
19	Costing.								

20	Preparation of notes on troubleshooting.								
21	Preparation of notes individually on : a. Extent to which he/she has achieved learning outcomes. b. Own experience in executing project. c. He/ She has faced technical problems during execution of project and solutions found.								
22	Preparation of list of references.								
23	Preparation of project report.								
24	Presentation.								

ANNEXURE-II
TITLE PAGE

< NAME AND ADDRESS OF INSTITUTE>

TERM WORK REPORT

SUBJECT : PROJECT – II

SUBJECT CODE :

DISCIPLINE : MECHANICAL ENGINEERING

ENROLMENT NUMBER :

NAME OF STUDENT :

DIVISION / BATCH :

SUBMISSION

SUBMITTED - V SEM. : <DATE>

SUBMITTED-VI SEM. : <DATE>

ANNEXURE-III

CERTIFICATE

THIS IS TO CERTIFY THAT
SHRI / KUM.....
HAS SATISFACTORILY COMPLETED HIS / HER
TERMWORK IN THE SUBJECT
PROJECT – II (<SUBJECT CODE >)
WITHIN THE PRESCRIBED TIME LIMIT AND PRESCRIBED BOUNDARY.

DATE : *STUDENT*

DATE : *INSTITUTE GUIDE*

DATE: *HEAD OF DEPTT.*

DATE: *PRINCIPAL*

ANNEXURE-IV

SUGGESTED LIST OF ACTIVITIES.

1) Preparing and maintaining logbook as per Annexure-V.
2) Finalization of assembly and detail drawings (This must be production drawings with suitable scale along with dimensions, tolerances, surface roughness symbols, heat treatment / other treatments required, material , quantity per assembly for components drawings ,etc.
3) Preparing master schedule and work allocation matrix in group.
4) Preparation of bill of material.
5) Collecting data and specifications of available resources-mainly material and machineries / equipment/facilities and tools.
6) Make or Buy decision.
7) Preparing specifications of bought-out parts.
8) Preparation of process planning (sheets) for all components in standard format.
9) List, quantities and specifications of consumables.
10) Preparation of list of required tools-cutting tools, jigs, fixtures, measuring instruments and other tools along with necessary specifications and sketches if required.
11) Identifying and locating required resources like material, machineries/equipments / facilities and tools.
12) Preparing plant layout.
13) Manufacturing of components.
    a. <name of component 1>
    b. <name of component 2>
    d. <name of component 3>
    e. ..
    n. <name of component n>
14) Details of inspection carried out.
15) Assembly.
16) Details of testing carried out.
17) Rework / rectification activities if required.
18) Project monitoring and control, record keeping.
19) Costing.
20) Preparation of notes on troubleshooting.
21) Preparation of notes individually on :
    a. Extent to which he/she has achieved learning outcomes.
    b. Own experience in executing project.
    c. He/ She has faced technical problems during execution of project and solutions found.
22) Preparation of list of references.
23) Preparation of project report.
24) Presentation.

ANNEXURE-V

FORMAT FOR DAY TO DAY LOG BOOK

ENROLLMENT NUMBER OF THE STUDENT :	
NAME OF THE STUDENT :	

DATE:	HOURS	DETAILS OF WORK CARRIED OUT.	SIGNATURE OF TEACHER / GUIDE / INSTRUCTOR.

DATE:	HOURS	DETAILS OF WORK CARRIED OUT.	SIGNATURE OF TEACHER / GUIDE / INSTRUCTOR.