Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fifth**

Course Title : **Advanced Manufacturing Processes**

Course Code : **22563**

1. RATIONALE

Mechanical technologists (diploma holders) have to work with men, machines and materials. With the advancements, newer difficult to machine materials and complex shapes with high surface finish is the demand of the manufacturing sector. To machine these materials and also the complex geometries with very high surface finish the student must have the knowledge of non – conventional machining processes like EDM, ECM, LBM, PAM, WJM, EBM, WEDM and also the conventional machining like milling processes, gear manufacturing, grinding, surface finishing, Broaching, boring processes etc. This course is aimed to make them achiever the various outcomes required for the given jobs.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain the functioning of advanced manufacturing processes and equipment.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Maintain the non conventional machining process to produce complex and hard to machine components.
b. Produce components using milling machine.
c. Choose relevant machining process to produce gears.
d. Maintain CNC machine to produce components effectively.
e. Prepare CNC part programs for simple components.
f. Maintain the functioning of automated equipment.

4. TEACHING AND EXAMINATION SCHEME

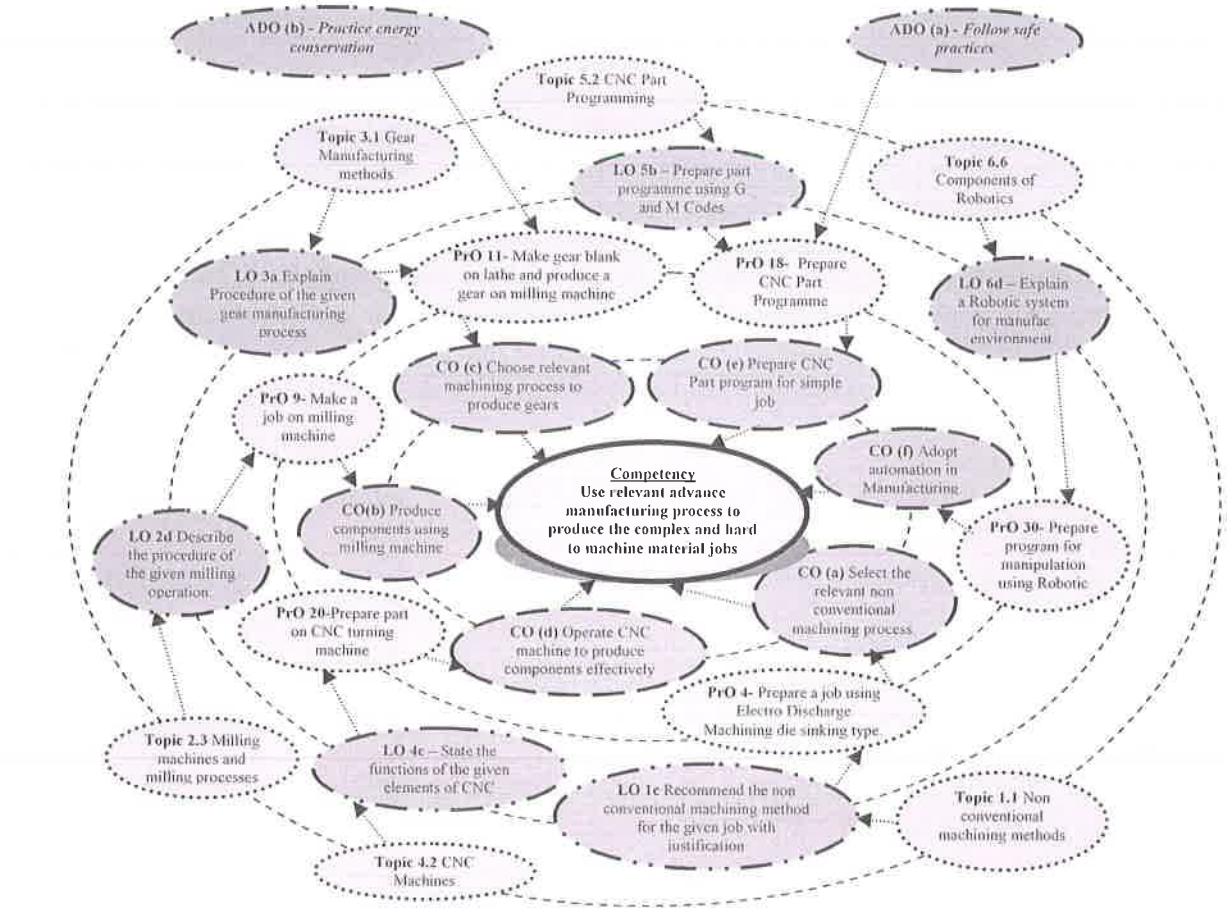
Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	4	8	3	70	28	30*	00	100	40	50#	20	50	20	100	40

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

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

5. **COURSE MAP** (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.



6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

For practical number 1 to 13 write a detailed report on the machine specification, tool and work piece specifications, criterion of selection of process and performance parameters, process carried out, set up, working principle with sketches and name of other industrial components produced using same process.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare a job using Abrasive Jet Machining/Observe the same in an industry(Part I)	I	02
2	Prepare a job using Abrasive Jet Machining/Observe the same in	I	02

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	an industry. (Part II)		
3	Prepare a job using Electro Discharge Machining die sinking type/Observe the same in an industry. (Part I)	I	02
4	Prepare a job using Electro Discharge Machining die sinking type /Observe the same in an industry. (Part II)	I	02
5	Prepare a job using Electro Discharge Machining wire cut type /Observe the same in an industry. (Part I)	I	02*
6	Prepare a job using Electro Discharge Machining wire cut type /Observe the same in an industry. (Part II)	I	02*
7	Prepare a job using Electro Chemical Machining/Observe the same in an industry. (Part I)	I	02*
8	Prepare a job using Electro Chemical Machining/Observe the same in an industry. (Part II)	I	02*
9	Make a job on milling machine which includes plain milling, slotting by using end mill cutter or slitting saw, or side and face milling cutter. (Part I)	II	02*
10	Make a job on milling machine which includes plain milling, slotting by using end mill cutter or slitting saw, or side and face milling cutter. (Part II)	II	02*
11	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part I)	II	02*
12	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part II)	II	02
13	Make gear blank on lathe and produce a gear on milling machine by using dividing head. (Part III)	II	02
14	Prepare a job or assembly of jobs like Gear and shaft assembly, Shaft and keyway which involves operations like end mill, turning, grinding operations. (Part I)	III	02*
15	Prepare a job or assembly of jobs like Gear and shaft assembly, Shaft and keyway which involves operations like end mill, turning, grinding operations. (Part II)	III	02*
16	Operate CNC machines and try to change different parameters and controls to see their effect during machining. (Part I)	IV	02*
17	Operate CNC machines and try to change different parameters and controls to see their effect during machining. (Part II)	IV	02*
18	Prepare CNC part programme using G and M codes with ISO format for Simple contour milling of part. (Part-I)	V	02 *
19	Prepare part on virtual CNC machine simulator using part programme developed in PrO 18 and generate cycle time process sheet using CAM Software. (Part-II)	V	02*
20	Prepare part on CNC turning machine using part program developed in PrO 18. (Part-III)	V	02*
21	Prepare CNC part program using G and M codes with ISO format for Simple contour milling of part. (Part-I)	V	02*
22	Prepare part on virtual CNC machine simulator using part program developed in PrO 21 and generate cycle time process sheet using CAM Software. (Part-II)	V	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
23	Prepare part on CNC turning machine using part program developed in Sr. no. 21. (Part-III)	V	02*
24	Prepare CNC part program using G and M codes with ISO format for Turning parts using canned cycle - with threading or drilling or other. (Part-I)	V	02
25	Prepare part on virtual CNC machine simulator using part program developed in PrO 24 and generate cycle time process sheet using CAM Software. (Part-II)	V	02
26	Prepare part on CNC turning machine using part program developed in PrO 24. (Part-III)	V	02
27	Import solid model into CAM environment of any CAM software and perform manufacturing simulation. (Part-I)	V	02
28	Prepare part on CNC turning machine using automatic part program developed in PrO 27. (Part-II)	V	02
29	Observe and use Flexible Machine Station in an industry	VI	02
30	Prepare a simple program for manipulation of standard components using Robotic arm	VI	02*
31	Observe the Robotics system in an industry	VI	02
	Total		**64**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 24 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
a.	Preparation of machine set up	20
b.	Actual machining operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No	Equipment Name with Broad Specifications	PrO. No.
1.	Abrasive Jet machining	1,2
2.	Electro Discharge Machine	3 to 6
3.	Electro Chemical Machine: Tool area 10mmx30mm or 15mmx20mm; Cross Head Stroke 40 mm; Supply Single phase 230 V. A.C.; Electrical Output Rating 0 - 100 Amps and voltage from 0 - 25 V DC; Tool Feed Rate In the range of 0.2 to 1 mm / min.; Machining Time 0 to 1999 seconds, variable through touch screen.; Display For voltage, output current; feed rate electrolyte temp; Protection For Current overload, short circuit; USB Port For data storage; pulsating facility On time 100 microseconds to 1 second variable, off time 100 microseconds to 1 second variable, plus amplitude 1v-10v variable; LCD display For forward and reverse, feed rate settings, feed rate; Tool Area 300 square mm;	7,8
4.	Lathe machine, turning tool, boring tool, Standard dial bore gauge. Minimum 500 mm between centre, with required set of work holding devices, cutting tools, accessories and tool holders	11 to 13,
5.	Milling machine, face milling cutter, side and face milling cutter, end mill cutter. Minimum 500 mm longitudinal traverse, with required indexing head, set of work holding devices, cutting tools, accessories and tool holders.	15
6.	Drilling Machine (Bench type, or Column type, or if possible Radial): Minimum 25 mm capacity, with required set of work holding devices, cutting tools, accessories and tool holders.	11,12,13 ,15
7.	CNC Turning 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type minimum diameter 25 mm, Length 120 mm with ATC. (Suggested)	16 to 28
8.	CNC Milling 250 with standard accessories and multi controller changing facility with simulated control panel and related software. Training or Productive type-X axis travel - 225 mm, Y axis travel - 150 mm, Z axis travel - 115 mm, with ATC.(Suggested)	16 to 28
9.	CNC Simulation software and control pads (CAMLAB CNC Software, MasterCAM/NXCAM/, DONC CNC machine simulator, PRO, SWANSOFT, CAPSMILL and CAPSTURN IN cam software, DONCMILL AND DONCTURN software)	16 to 28
10.	PRO¬FICNC programming manuals and watch PROFICNC on https://youtu.be/3ghwlpmhwpm to integrated CNC machine with multiple industry standard CNC controllers like FANUC, SIEMENS, FAGOR AND	16 to 28

S. No	Equipment Name with Broad Specifications	PrO. No.
	MITSUBISHI.	
11.	Any Latest educational version of CAD/CAM integration software .	16 to 28
12.	Robotic Arm	31

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Non-Conventional Machining Processes	1a. Describe with sketches the working principle of the given non - conventional machining method and draw set up of the same. 1b. Describe advantages, limitations and applications of the given non - conventional machining method. 1c. Recommend the non conventional machining method for the given job with justification. 1d. Recommend the process parameters for the given job and non-conventional machining process with justification.	1.1 **Fundamentals of Non – conventional methods** – Needs and types of non – conventional methods. Importance of methods. 1.2 **Working principle, set up, process parameters of** – EDM, , WEDM ECM, PAM, AJM, USM, EBM and LBM. 1.3 **Advantages, limitations and applications of** - EDM, , WEDM ECM, PAM, AJM, USM, EBM and LBM.
Unit– II Milling Machines and Milling Processes	2a. Explain with sketches the working of the given milling machine. 2b. Draw sketches of the given milling machine parts and cutters. 2c. Describe the procedure of the given milling operation. 2d. Explain the procedure of the indexing for the given gear manufacturing	2.1 **Milling:** - Working Principle of milling machine, types of milling machines 2.2 **Milling cutters** – Different types of cutters used in milling, face milling cutter, end milling cutter, Staggered tooth milling cutter, side and face milling cutter, form milling cutters, metal slitting saw etc. 2.3 **Milling Processes** – Plain milling, face milling, side milling, end milling, Straddle milling, gang milling, slotting, slitting, Up milling and down milling 2.4 **Cutting Parameters** – Cutting speed, feed. 2.5 **Dividing head** – types, function of dividing head, method of indexing, index plates.
Unit– III Gear Manufactu	3a. Explain with sketches procedure of the given gear manufacturing	3.1 **Gear manufacturing methods** – Function and types of gears, gear manufacturing methods,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
ring	process. 3b. Draw sketches of the given gear hob, hobbing process or gear shaping process. 3c. Explain with sketches the given gear finishing process. 3d. Recommend the process parameters for the given gear manufacturing and finishing process with justifications.	3.2 **Gear hobbing** – Working principle, types of gear hobbing, advantages, limitations and applications of gear hobbing 3.3 **Gear shaping** – Gear shaping by pinion cutter, gear shaping by rack cutter, advantages, limitations and applications of both the methods and Comparison of gear hobbing and gear shaping 3.4 **Gear finishing methods** – Need of gear finishing, gear finishing methods, a) Gear shaving b) Gear grinding c) Gear burnishing d) Gear lapping e) Gear honing
Unit-IV Fundamentals of Computer Aided Manufacturing (CAM)	4a. State the functions of the given element(s) of the CNC Machine 4b. Select tool(s) and tool holder(s) used on a CNC machine for the given job with justification 4c. Explain the given work and tool holding and changing device(s) used on a CNC turning centre 4d. Explain the given work and tool holding and changing device(s) used on a CNC Machining centre	4.1 CAM concept, NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) - concept, features and differences. 4.2 CNC machines: Types, classification, working and constructional features Advantages, limitations and selection criteria. 4.3 Elements of CNC machines - Types, sketch, working and importance of: Slide ways; Re-circulating ball screw; Feedback devices (transducers, encoders); Automatic tool changer (ATC); Automatic pallet changer (APC); 4.4 CNC tooling : Tool presetting-concept and importance; Qualified tools- definition need and advantages; Tool holders- types and applications. 4.5 CNC turning centres: Types; Features; Axes nomenclature; Specification; Work holding devices -types, working and applications. 4.6 CNC machining centres: Types; Features; Axes nomenclature; Specification; Work holding devices-types, working and applications.
Unit V– CNC Part Programming	5a. Interpret the given CNC part programming code(s). 5b. Prepare part programme using G and M codes for the given job. 5c. Apply advanced CNC part programming features like canned cycle, do loop, subroutine etc. in the given	5.1 Definition and importance of various positions like machine zero, home position, work piece zero and programme zero. 5.2 CNC part programming: programming format and structure of part programme. 5.3 ISO G and M codes for turning and milling-meaning and applications of important codes.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	situation. 5d. Explain procedure for setting the given compensation(s) on the given CNC machine.	5.4 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation). 5.5 Simple part programming for milling using ISO format. 5.6 Importance, types, applications and format for: Canned cycles; Macro; Do loops; Subroutine; 5.7 CNC turning and milling part programming using canned cycles, Do loops and Subroutine. 5.8 Need and importance of various compensations: Tool length compensation; Pitch error compensation; Tool radius compensation; Tool offset. 5.9 Simple part programming using various compensations. 5.10 Virtual CNC machine simulators. Generation of generating shop documentation using a CAM software, cycle time sheets, tools list with tool layout, spindle utilization graphs, program for different control systems and different configuration of machines
Unit-VI Automation and Robotics	6a. Compare Fixed and flexible Automation on given parameters with justification. 6b. Justify the use of Group Technology for the given situation. 6c. Justify the use of FMS in a given situation. 6d. Explain a Robotic system used for a given manufacturing environment. 6e. Select different components of Robotics with justification.	6.1 Automation-Define, need of automation, high and low cost automation, examples of automations. 6.2 Types of Automation - Fixed (Hard) automation, programmable automations and Flexible automations (Soft).Comparison of types of automations. 6.3 Group Technology- concept, basis for developing part families, part classification and coding with example, concept of cellular manufacturing. Advantages and limitations. 6.4 Flexible Machining System- Introduction, concept, definition and need, sub systems of FMS, comparing with other manufacturing approaches. 6.5 Introduction to Robotics- definition of robot and robotics, advantages disadvantages and applications. 6.6 Components of Robotics manipulator, end effectors, actuators, sensors, controller, processor and software.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Non conventional Machining Processes	10	02	04	06	12
II	Milling Machines and Milling Processes	10	02	04	06	12
III	Gear Manufacturing	10	02	02	06	10
IV	Fundamentals of Computer Aided Manufacturing	10	02	04	06	12
V	CNC Part Programming	14	04	04	08	16
VI	Automation and Robotics	10	02	02	04	08
Total		**64**	**14**	**20**	**36**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews.

a. Prepare journal based on practical performed in measurement laboratory. Journal consist of drawing, observations, required measuring tools, equipments, date of performance with teacher signature.
b) Tabulate various cutting tools materials with main elements, properties and applications.
c) List process parameters for various machines (Each student will be given different machine).
d) Calculate RPM for lathe, milling cutter and drill spindle; based on given data. (Each student should be given different data for diameters and cutting speeds)
e) Prepare a report on at least one industrial component with its complete technical details covering the points like design criterion, features included with Dimensional/Geometric constraints, manufacturing resource requirements, challenges in controlling its quality and cost, etc.
f) Collect the technical details about all production facilities available at nearby industry/industries.
g) Visit or participate in the technical events, exhibition, conference, seminar etc.
h) Collect/download at least four different machine tool catalogues including at least one special purpose, non-conventional or advanced machine.
i) Collect/download at least one catalogue each of cutting tool, work holding device and tool holder.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate actual components and products with various concepts of advance machining processes.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various concepts of advance machining processes.
i) Demonstrate the process properly before students start doing the same.
j) Encourage students to refer different websites to have deeper understanding of the subject.
k) Observe continuously and monitor the performance of students in Lab.
l) Arrange the industrial visits in such a way that students are able to observe advance machining processes.
m) Encourage students to watch various videos on you tube or any particular website related to advance machining processes used to produce a component.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a list of industrial components which are produced through non conventional machining processes and describe the manufacturing procedure of the same in brief
b. Prepare a list of domestic and industrial components on which Lapping, honing, buffing, Electroplating, Galvanizing, metal spraying and powder coating are performed. For each process collect information about the material, machines and other resources required. Also prepare list of industries in your state doing these processes.

c. Manufacture any product like a small assembly of components which has been designed in the course Design of Machine Elements. Student will prepare the report on following.
   i. Prepare production drawings of the assembly and details.
   ii. Manufacture the parts.
   iii. Note down work holding devices, cutting tools and cutting parameters used for each part and each operations. Summarize this in tabular form.
   iv. On completion, present and share the experience of this mini project with photos/videos of mini project execution and with work distribution executed. Use power point presentation.

d. Produce job with various machining methods:
   i. Part should include plain/taper turning, knurling, threading, cylindrical/surface grinding, etc.
   ii. Sketch the production drawing of the part.
   iii. Outline the processes.
   iv. Calculate/select, set, observe and record the cutting parameters for each process.
   v. List the cutting tools and measuring instrument like vernier caliper, micrometer or gauge if any you have used. Also state specifications of each.
   vi. List the work holding devices you have used. Also state specifications of each.
   vii. Produce the part

e. Produce a complex job:
   i. Part should include shaping, milling, drilling, tapping, boring, slotting, surface grinding, cylindrical grinding, super finishing like lapping, polishing etc.
   ii. Select and sketch the production drawing of the part.
   iii. Outline the processes. Prepare process plan for the same.
   iv. Prepare workshop layout and route sheet.
   v. Produce the part, Calculate/select, set, observe and record the cutting parameters for each process.
   vi. List the cutting tools you have used. Also state specifications of each.
   vii. List the work holding devices you have used. Also state specifications of each.

f. Prepare a technical report on specifications, operating procedure, selection of operational parameters, details about tool/work holders used, machine setting, product details being manufactured for each method/machine like gear forming/generating, honing/lapping/buffing machine, Non-conventional machine, Jig boring machine, Broaching machine etc.

g. Visit a work shop which contains latest industrial Turret lathe, Capstan lathe, Single spindle automats, Automatic machines. Write a detail report on working of such machine or machines, parts produced, and other relevant information. Identify the jobs produced on such machines and draw the sketches of jobs.

h. Prepare a report on how to select parameters for machining Aluminum, Mild steel, Stainless steel and Inconel materials on CNC machine.

i. Comparative study of any two CNC turning centers or any two Vertical Machining centers and report the differences.

j. Comparative study of two different CNC systems for turning centers: Fanuc and Fagor using suitable virtual CNC machine simulator software.

k. Study and report 10 commonly used work piece materials and best grades of cutting tools that used to cut them efficiently.

l. Study machining process and reduce machining cycle time of parts from local CNC job shops.

m. Study of two different CNC systems for VMC: Siemens and MITSUBISHI M 70 with the help of CNC machine simulator software and furnish the report
n. Explore PRO¬FICNC programming manuals and watch PROFICNC on https://youtu.be/3ghwlpmhwpm to integrated CNC machine with multiple industry standard CNC controllers like FANUC, SIEMENS, FAGOR AND MITSUBISHI.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Manufacturing Science and Technology	Rao, K Vara Prasada	New Edge Publication, New Delhi, 2009, ISBN: 978-81-224-2759-2
2	Unconventional manufacturing processes	Singh M.K.	New Edge Publication, New Delhi, 2009, ISBN: 978-81-224-2244-3
3	A text book of Production Engineering	Sharma P.C.	S.Chand Publication, New Delhi 8th Edition 2012, ISBN 978812190116
4	Machine Tools Technology	Kandasami G. S.	Khanna Publishers, New Delhi, 2/e, 1989
5	Manufacturing ProcessesVol II	Bawa H.S.	McGraw Hill, New Delhi, ISBN - 0070583722
6	Fundamentals of Metal Machining and Machine Tools	Knight W. A., Boothroyd Geoffrey	McGraw-Hill Education, New Delhi, 2006, ISBN 1-57444-659-2
7	Production Technology	HMT, Banglore	McGraw-Hill Education, New Delhi, 2001, ISBN 13:978-0-07-96443-3
8	Advanced Machining Processes	Jain V. K.	Allied Publishers, Mumbai, 2009 ISBN 81-7764-294-4
9	CNC Machines.	Pabla B.S., Adithan M.	New Age International, New Delhi, 2014, ISBN: 9788122406696
10	Computer Numerical Control-Turning and Machining centres	Quesada Robert	Prentice Hall India, New Delhi, 2014 ISBN: 978-0130488671
11	CAD/CAM	Sareen Kuldeep	S. Chand, New Delhi, 2012 ISBN: 9788121928748
12	Introduction to NC/CNC Machines	Vishal S.	S.K. Kataria and Sons, New Delhi, 2010, ISBN: 978-8188458110
13	Computer Aided Manufacturing	Rao P N, Tiwari N K, Kundra T	Tata McGraw Hill, New Delhi, 2017 ISBN: 978-0074631034
14	CAD/CAM: computer aided design and manufacturing	Groover Mikell P, Zimmered W Emory	Prentice Hall, New Delhi, 2011 ISBN: 9780131101302

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

i. http://nptel.ac.in/video.php?subjectId=112105126
ii. http://nptel.ac.in/courses.php?disciplineId=112
iii. http://nptel.ac.in/courses/112104028/
iv. http://nptel.ac.in/courses/112105126/27
v. http://www.youtube.com/watch?v=bmooEZyivxo
vi. http://www.youtube.com/watch?v=mWy9awGv6so
vii. http://www.youtube.com/watch?v=mKES5Fyz9l0

viii. http://www.youtube.com/watch?v=BgGXQUeYNKw
ix. http://www.youtube.com/watch?v=eaeEn1Gs4aQ
x. http://www.youtube.com/watch?v=49GpJ7yhecg
xi. http://www.youtube.com/watch?v=XfYXelZ4IaY
xii. http://www.youtube.com/watch?v=SNWF_4jQ2pU
xiii. w.youtube.com/watch?v=pI1QGpmKqow
xiv. http://www.youtube.com/watch?v=N7NofmHWWPQ
xv. http://en.wikipedia.org/wiki/Microelectromechanical_systems
xvi. http://www.engineersgarage.com/articles/mems-technology
xvii. http://www.nptel.ac.in
xviii. http://www.youtube.com/watch?v=M3eX2PKM1RI
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