Program Name : **Diploma in Plastic Engineering**

Program Code : **PS**

Semester : **Fourth**

Course Title : **Mould Manufacturing**

Course Code : **22456**

1. RATIONALE

Plastics diploma engineer (also called technologist) have to deal with mould making in the specialized areas of manufacturing. They have to participate in changing trend for replacing the metal by plastic materials in industries. Hence they need to work as mould maker in the plastic industries which is in demand and ever increasing. In the process of mould making diploma plastic engineer have to work with conventional and modern machining tools like lathe, milling, slotting, grinding, lapping, buffing, super finishing, electro discharge machine, and CNC machines etc. This course has been developed in the way that imparts skills and competences for selections of materials, manufacturing various mould components, their assembly and heat treatment process.

2. COMPETENCY

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

- **Fabricate simple injection, blow and thermoforming moulds using relevant fabrication methods and machines for specified tasks.**

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. Identify different components of mould.
b. Select suitable material for making different components of mould.
c. Fabricate mould components by operating appropriate machine tool.
d. Apply suitable heat treatment and finishing method for a given mould.
e. Assemble various mould parts.
f. Use software for making 3D models of mould components.

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
3	-	4	7	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, **'#':** No Theory Examination

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.

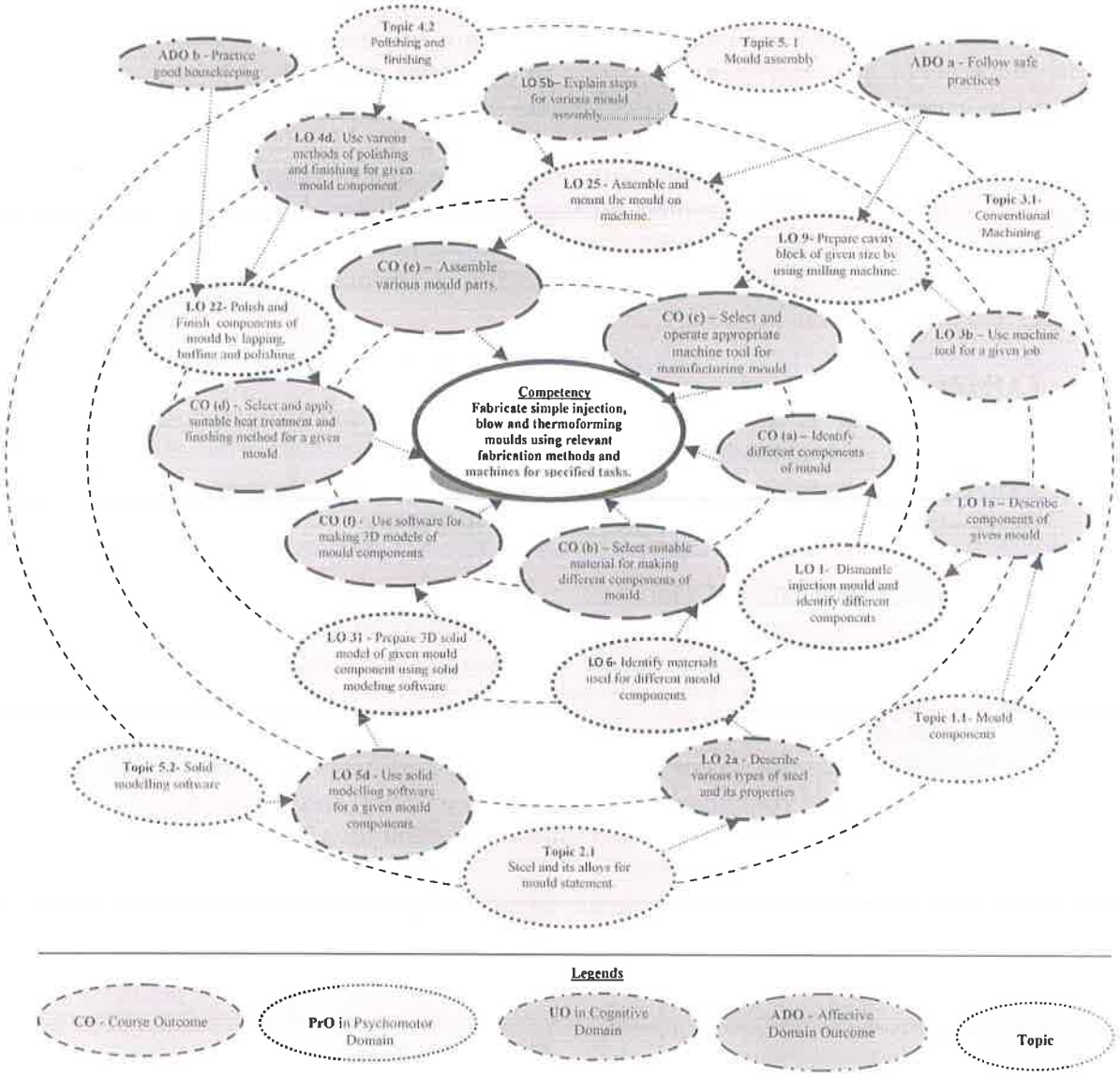

Figure 1 - Course Map

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

S. No.	Practical Outcomes (PrOs))	Unit No.	Approx. Hrs. Required
1	Dismantle injection mould and identify different components of mould	I	02*
2	Assemble dismantled injection mould	I	02*
3	Dismantle blow mould and identify different components of mould	I	02
4	Assemble dismantled blow mould	I	02
5	Determine hardness of different materials of mould components	II	02*
6	Identify materials used for different mould components	II	02
7	Prepare cavity plate using milling machine and band saw/power hack saw	III	02
8	Prepare drilled holes on cavity plate using drilling machine	III	02
9	Prepare cavity block of given size by using milling machine	III	02
10	Prepare cavity of given shape by using EDM/milling machine	III	02*
11	Prepare drilled and tapped holes on cavity using drilling machine	III	02
12	Make sections for feed system in cavity by using drilling machines	III	02
13	Install cavity in cavity plate by fastening nut and bolts	III	02
14	Prepare core plate using milling machine and band saw/power hacksaw	III	02
15	Prepare drilled holes on core plate using drilling machine	III	02
16	Prepare core block of given size by using milling machine	III	02
17	Prepare core of given shape by using EDM/ lathe & milling machines	III	02*
18	Prepare drilled and tapped holes on core for ejector pins using drilling machine	III	02
19	Install core in core plate by fastening nut and bolts	III	02
20	Prepare Sprue bush by using lathe, drilling machine	III	02
21	Select proper register/locating ring, guide pillars and guide bushes for given application	III	02
22	Polish and Finish components of mould by lapping, buffing and polishing	IV	02*
23	Carry out heat treatment process for mould components	IV	02
24	Prepare bench fitting of mould components and rectify observed defects if any.	V	02
25	Assemble and mount the mould on machine.	V	02
26	Practice 2-D Sketching commands in solid modeling software	V	02
27	Practice 2-D editing commands in solid modeling software	V	02
28	Practice 3-D Modeling commands like extrude, revolve, rib, round chamfer in solid modeling software	V	02
29	Practice 3-D Modeling commands like blend, sweep, swept blend,. in solid modeling software	V	02
30	Prepare orthographic views of given mould components by using solid modeling software.	V	02
31	Prepare 3D solid model of given mould component using solid modeling software.	V	02*
	Total		62

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 12 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.	Setting of machine tools	10
b.	Operate machine tools skillfully	25
c.	Inspection of mould components	10
d.	Assembly of moulds skillfully	30
e.	Follow Safety measures	10
f.	Work in team	10
g.	Answer to sample questions	5
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. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
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 and
- '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	Expt. S. No.
1	Lathe machine with standard accessories and attachments. Max swing over bed : 450 mm. Admit between centers: 555 mm Spindle bore: 52 mm. Power of motor : 3hp	17, 20
2	Drilling machine with standard accessories and attachments. Drilling capacity in steel 20 mm. Spindle traverse 125 mm. Vertical adjustment of spindle head 425mm. Speed range of spindle 375 -	8, 11, 12, 15, 18, 20

S. No.	Equipment Name with Broad Specifications	Expt. S. No.
	3220 rpm.	
3	Milling machine with standard accessories and attachments. Table size 135 x 310 mm. Axis traverse 800 x 265 x 400 Feed rate 0 - 800 rev	7, 9, 10,14, 16, 17
4	Buffing/ lapping machine with standard accessories and attachments.	22,24
5	Band saw/ Power hacksaw	7, 14
6	Muffle/Induction furnace heating capacity upto 1300^0C	23
7	Standard Rockwell hardness tester	5
8	Measuring tools like vernier calliper, micrometer etc.	7 to 26
9	EDM with standard accessories and attachments.	10, 17
10	Any one solid modelling software like ProE/Creo/CATIA/ANSYS/Solid Works/Solid Edge/UNIGRAPHICS	26 to 31

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics are to be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-I General Mould Construction	1a. Describe components of the given mould. 1b. Describe function of given mould parts. 1c. Compare the construction of given core and cavities. 1d. Compare fixed half and moving half of given injection mould.	1.1 Construction and functions of mould components: impression, cavity and core, sprue bush, runner and gate system, register ring, guide pillars and bushes, integer and insert cavity plate, integer and insert core plates, bolster and its types, fixed half and moving half.
Unit-II Mould Making Materials	2a. Describe various types of steel and its properties. 2b. Describe various types of non ferrous materials and their properties. 2c. Explain criteria for selection of material for making of given mould components. 2d. Determine hardness of given material	2.1 Steel and its alloys for mould: Mould steel, Mild Steel, EN series 9-12 steel alloys, P-20, tool steel. 2.2 Non ferrous materials: Beryllium, Copper, Sheet metal, Aluminium, their essential properties and uses for particular mould parts. 2.3 Criteria for selection of material for mould making. 2.4 Hardness determination by using Rockwell hardness tester.
Unit-III Conventional and Modern Machining Techniques	3a. Describe principle of operation of various machine tools. 3b. Use machine tool for a given job. 3c. Describe Electro discharge for given machining process. (EDM) 3d. Describe concept of CNC machining	3.1 Conventional Machining: Lathe machine, milling machine, cylindrical grinding, surface grinding machine, jig boring machine, band saw/ power saw. 3.2 Modern machining: Electro discharge machine (EDM), EDM wire cut, concept of CNC machining and steps in CNC machining.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit- IV Heat Treatment, polishing and finishing	4a. Explain the need of heat treatment. 4b. Describe various heat treatment processes. 4c. Apply various heat treatment methods for given mould component. 4d. Use various methods of polishing and finishing for given mould component.	4.1 Heat treatment: Necessity and principle of heat treatment, Methods of heat treatment- Annealing, normalizing, tempering, hardening, nitriding, carburising, cyaniding. 4.2 Polishing and finishing: Tools, equipment and material, Methods like etching, emery polishing, diamond polishing, metal deposition, diffusion coating.
Unit-V Mould Assembly	5a. Inspect all mould components. 5b. Explain steps for various mould assembly. 5c. Troubleshoot the problems observed in bench fittings. 5d. Use solid modelling software for a given mould components.	5.1 Mould assembly: Inspection of all mould components, bench fitting, steps for mould assembly, attachment of mould to platen – direct and indirect bolting methods. 5.2 Solid modelling software: Application of any one computer software for mould making such as CAE, CATIA, PRO-E, ANSYS, CAM, Mould flow.(**No questions to be asked on solid modelling**)

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 (INTERNAL) DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**General Mould Construction**	06	3	3	4	10
II	**Mould Making Materials**	06	6	6	3	15
III	**Conventional and Modern Machining Techniques**	16	8	8	6	22
IV	**Heat Treatment, polishing and finishing**	10	6	6	3	15
V	**Mould Assembly**	10	4	4	0	08
Total		**48**	**27**	**27**	**16**	**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 ULOs. 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:

a. Prepare journals based on practical performed in laboratory.
b. Prepare chart for mould parts and its function.
c. List out materials for different parts of injection mould, blow mould etc.
d. Select one mould drawing from industry. Estimate the cost of mould by using bill of material and machining cost from market.
e. Download four mould manufacturing machines catalogues and study their technical specifications.

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. No. of practical's selection to be performed should cover all units.
g. Show demo of CAI computer software related to mould manufacturing.
h. Arrange a visit to tool room such as IGTR or any other mould manufacturing industry.
i. Arrange expert lecture on non-conventional or advanced mould manufacturing techniques.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs.. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. 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.

In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should 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. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty. Students should conduct following activities in group and prepare reports of about 4 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews.

i. **Raw Material Analytics:** Collect data (specifications, rates, terms and conditions, discounts, addresses) of raw materials manufacturers and suppliers of MS, P20, tool

steels, EN series materials, beryllium-copper, aluminum and sheet metal. Make class presentation.

ii. **Process Chart:** Make the chart for manufacturing processes of various mould components and make class presentation.

iii. **Mould assembly Chart:** Make the chart for step wise mould assembly and make class presentation.

iv. Any other micro-projects suggested by subject faculty on similar line.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Injection Moulds Design	Pye, R. G. W.	Longman ISBN-13:9780582016118
2	Mould Engineering	Rees, H.	Hanser ISBN 10:1569901317
3	Plastic Mould Engineering Handbook	Buckleitner, W.	Chapman and Hall ISBN 0412989514
4	Workshop Technology vol. 1 and 2	Chaudhary, H.	Media Promoters and Publishers, Bombay. ISBN 9788185099156
5	Workshop Technology	Raghuwanshi, B. S.	Dhanpat Rai and Sons. ISBN 10:0470534915
6	Plastics Mould Technology Vol I and Vol II	Nayak, S. K. Kuppuswamy, A. Rao, A. K.	An in house publication of CIPET

14. SOFTWARE/LEARNING WEBSITES

a. CAD, CAM, CAE, CATIA, PRO-E, CREO, ANSYS, software.
b. http://www.lathemachinesindia.com/lathe-machine.html
c. http://www.hnsa.org/doc/pdf/lathe.pdf
d. http://www.hnsa.org/doc/pdf/milling-machine.pdf
e. http://uhv.cheme.cmu.edu/procedures/machining/CH8.PDF
f. http://www.efunda.com/processes/heat_treat/introduction/heat_treatments
g. http://web.iitd.ac.in/~suniljha/MEL120/L4_Heat_Treatment_of_Metals.pdf
h. http://www.technologystudent.com/equip1/heat1.html
i. http://www.makeyourownmolds.com
j. http:// www.makeyourownmolds.com/silicone-plastique-video
k. http:// www.ceramicartsdaily.org/.../ceramic-mold-making-techniques
l. http://www.hacknmod.com/hack/8-mold-making-tips-and-techniques/
m. http:// www.cimatrontech.com/
n. http:// www.mmsonline.com/articles/from-mold-making-to-mold-manufacturing
o. https://www.ndl.iitkgp.ac.in