Government Polytechnic, Mumbai

(Academically Autonomous Institute, Government of Maharashtra)

Name of the Programme : Diploma In Rubber Technology (Sandwich Pattern)

Learning and Assessment Scheme (P23)	**With Effect from Academic Year: 2023-24**
Duration Of Programme : 6 Semester	**Duration: 16 WEEKS**
Semester: Fourth	**Scheme: (P23)**

Sr. No	Course Title	Course Type	Course Code	Total IKS Hrs for Sem.	Learning Scheme					Credits	Paper Duration (hrs.)	Assessment Scheme													
					Actual Contact Hrs./Week			Self-Learning (Term Work + Assignment)	Notional Learning Hrs / Week			Theory					Based on LL & TL					Based on Self Learning		Total Marks
																	Practical							
												FA- TH		SA-TH	Total		FA-PR		SA-PR			SLA		
					CL	TL	LL					T1	T2	Max	Max	Min	Max	Min	Max PR	Max OR	Min	Max	Min	
1	Industrial Engineering & Management	DSC	ME23114	1	3	-	2	1	6	3	2.5	20	20	60	100	40	25	10	-	-	-	25	10	150
2	Thermoplastic Elastomer	DSC	RT23401	3	3		-	1	4	2	2.5	20	20	60	100	40	-	-	-	-	-	25	10	125
3	Rubber Compounding and Product Testing	DSC	RT23402	3	3	-	2	1	6	3	2.5	20	20	60	100	40	25	10	25*	-	10	25	10	175
4	Basic Machine Tools and Operations	SEC	RT23403	3	3	-	2	1	6	3	2.5	20	20	60	100	40	25	10	-	-	-	25	10	150
5	Vulcanization Systems	DSC	RT23404	3	3	-	2	1	6	3	2.5	20	20	60	100	40	25	10	-	25	10	25	10	175
6	Rubber Compounding Materials	DSC	RT23405	3	3	-	2	1	6	3	-	-	-	-	-	-	25	10	50	-	-	25	10	100
7	Entrepreneurship Development*# (MOOC)	AEC	SL23407	-	-	-	-	6	6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL				-	18	-	10	12	40	20	-	100	100	300	500	-	125	-	75	25	-	150	-	875

Abbreviations: CL- Classroom Learning, TL- Tutorial Learning, LL-Laboratory Learning, FA - Formative Assessments -Summative Assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination

Note:

1. **FA-TH represents average of two class tests of 30 marks each conducted during the semester.**
2. **If candidate is not securing minimum passing marks in FA-PR of any course, then the candidate shall be declared as "Detained" in that semester.**
3. **If candidate is not securing minimum passing marks in SLA of any course, then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.**
4. **Notional Learning hours for the semester are (CL+LL+TL+SL) hrs.* 15 Weeks**
5. **1 credit is equivalent to 30 Notional hrs.**
6. *** Self learning hours shall not be reflected in the Time Table.**

Course Category: Discipline Specific Course Core (DSC): 2, Discipline Specific Elective (DSE): 0, Value Education Course (VEC): 1, Intern. /Apprentice. /Project. /Community (INP): 0, Ability Enhancement Course (AEC): 2, Skill Enhancement Course (SEC): 2, Generic Elective (GE): 0

Department Co coordinator,
Curriculum Development Cell,

Head of Department,
Rubber Technology Department

In-Charge
Curriculum Development, Cell

Principal
Government Polytechnic Mumbai

Programme : Diploma in Mechanical Engineering/ Rubber Technology (Sandwich Pattern)													
Course Code: ME23114					**Course Title: Industrial Engineering & Management**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hrs. 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	**-**	**2**	**1**	**6**	**3**	**20**	**20**	**60**	**25**	**-**	**-**	**25**	**150**

Total IKS hrs. for course: 1

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination

Note:

1. FA-TH represents total TWO class tests of 20 marks each conducted during the term.
2. SA-TH represents End term exam of 60 marks.
3. FA-PR represents Term work of 25 marks.
4. SLA represents self-learning assessment.

Rationale

The diploma mechanical engineer has to utilize the available resources like men, materials, machines, methods of manufacturing etc. for better productivity by eliminating wastefulness in production processes. This needs measurement of methods, and work i.e. method study and time study. Industrial engineering parts of this course help students to apply industrial engineering concepts to maximize the efficiency of a plant by best use of man, machine, materials etc. Engineers working in an industry have to manage the various resources for smooth functioning of industry. Management part of this course introduces management principles, managerial skills, safety aspects, and industrial acts to engineer.

Industry / Employer Expected Outcome:

Apply industrial engineering concepts, and managerial skills in industry.

Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course-based learning-

CO1	Prepare job sequence over the machines by applying industrial engineering concepts.
CO2	Apply work study and time study techniques to optimize manufacturing processes.
CO3	Apply ergonomic principles for designing simple mechanical work station.
CO4	Apply Management Concept and Managerial Skills
CO5	Manage different industrial resources efficiently.
CO6	Interpret different Industrial Safety norms and Industrial Acts

Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
1	1.1 Describe Needs and Objectives of Industrial Engineering. 1.2 Describe methods of improving productivity. 1.3 Enlist the principles of plant layout design. **1.4** Prepare detail sequence of operation for manufacturing the given component.	**Process Engineering** 1.1 Industrial Engineering: Definition, Needs and Objectives. 1.2 Production: concept, Types of Production, Batch production, Job Production and Continuous production system, and their comparison. 1.3 Productivity: Definition, Labour productivity, Material productivity and Machine productivity. Methods of improving productivity. 1.4 Plant Layout: Objectives, Types of plant layout, Principles of plant layout design, Factors affecting plant layout, Symptoms of bad plant layout. 1.5 Production Planning and Control (PPC): Definition, Functions of PPC, Operation routing, Job Sequencing (n jobs and 2 machines), Line balancing (simple numerical), Gantt chart **Course Outcome: CO1 Teaching Hours: 9 Marks: 12 (R-4, U-4, A-4)**
2	2.1 Perform method study for manufacturing of given component. 2.2 Prepare relevant charts using recording techniques. 2.3 Perform time study for manufacturing of given component. 2.4 Calculate standard time for the given activity using work measurement.	**Method Study, Time Study & Motion Study** **2.1** Method Study (Work Study): Definition and objectives of method study, Procedure of method study, Selection of work for method study. Therbligs **2.2** Charting Techniques: Outline process chart, Flow process chart, Flow diagram, Travel chart, Two handed process chart, String diagram. **2.3** Time Study (Work Measurement): Definition and objectives of time study. Procedure, Equipment required to conduct time study, **2.4** Factors affecting rate of work, Types of elements, Rating and allowances, **2.5** Calculation of standard time. **Course Outcome:CO2 Teaching Hours: 10 Marks:14 (R-4, U-6, A-4)**

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
3	3.1 Apply ergonomics concept to improve working conditions in the given industrial environment. 3.2 Apply ergonomic principles to the given component.	**Ergonomics**Ergonomics: Concept, need, Man-machine relationship, anthropometric and functional anatomy of data. **3.2** Ergonomics in design of control members-push button, knobs, levers, crank , hand wheel **3.3** Ergonomic considerations applied to types and location of display. **Course Outcome:CO3 Teaching Hours:06 Marks:06 (R-2, U-2, A-2)**
4	4.1 Describe Principles of Management 4.2 Enumerate Managerial skills.	**Management Concept and Managerial Skills** **4.1** Management: Definition, role and importance of management, **4.2** Principles of Management, levels of management and their functions. **4.3** Organization, Management, Administration, relation between administration and management. **4.4** Managerial skills **COURSE OUTCOME: CO4 TEACHING HOURS :08 MARKS: 10 (R-2, U-4, A-4)**
5	5.1 Understand the significance of Industrial Resource Management. 5.2 Describe objectives of personnel management. 5.3 Describe objectives of materials management. 5.4 Describe objectives of financial management.	**Industrial Resource Management** **5.1 Personnel Management:** Need, objectives, functions of personal management, Training and development. **5.2 Materials Management:** Definition of Inventory, inventory control, objectives of inventory control, ABC analysis. **5.3 Financial Management:** Need, objectives, functions, Types and sources of capital, Budgets and account, Balance sheet, Elements of costing. **COURSE OUTCOME: CO5 TEACHING HOURS :06 MARKS: 10 (R-2, U-4, A-4)**

Unit No.	Theory Learning Outcomes (TLO's) aligned to CO's.	Topics / Sub-topics
6	6.1 Describe General safety norms for industrial unit. 6.2 Interpret various industrial acts.	**Industrial Safety and Industrial Acts** Need of safety measures **6.2** General safety norms for industrial unit **6.3** Accident: Definition, types of industrial accidents, general causes of accidents. **6.4** Industrial Acts : Indian Factories Act, Industrial Dispute Act, Workman Compensation Act, Minimum wages Act. Labour CODE. **COURSE OUTCOME: CO6 TEACHING HOURS :06 MARKS: 08 (R-2, U-4, A-2)**

Laboratory Learning Outcome and Aligned Practical / Tutorial experiences.

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
1	LLO 1.1 Prepare the drawing of a component LLO 1.2 Enlist the operations to be performed to manufacture the given job. LLO 1.3 Prepare process plan.	Prepare detailed process plan for manufacturing of hexagonal nut/Hexagonal headed bolt/stud/plain washer/given component	04	CO1
2	LLO 2.1 Prepare the drawing of a component LLO 2.2 Enlist the operations to be performed to manufacture the given job. LLO 2.3 Prepare chart of sequence of operation.	Prepare chart of sequence of operation for manufacturing of hexagonal nut/Hexagonal headed bolt/stud/plain washer/given component	02	CO1

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
3	LLO 3.1 Prepare the drawing of a component. LLO 3.2 Enlist the operations to be performed to manufacture the given job. LLO 3.3 Analyse the motions involved in machining operations of the given job.	Apply the method study approach to analyse the motions involved in machining operations of the given job.	02	CO2
4	LLO 4.1 Prepare the drawing of a component. LLO 4.2 Enlist the operations to be performed to manufacture the given job. LLO 4.3 Measure time components involved in machining operation of a given job.	Apply work measurement technique to analyse the time components involved in machining operation of a given job using stop watch.	04	CO2
5	LLO 5.1 Prepare the drawing of a component. LLO 5.2 calculate the time components to perform operations to manufacture the given job. LLO 5.3 Calculate standard time to perform operations to manufacture the given job.	Calculate the standard time for all the operations involved in step turning process.	02	CO2
6	LLO 6.1 Identify the activity to be performed. LLO 6.2 Enlist the therbligs required LLO 6.3 Prepare motion chart of given activity using therbligs symbols.	Prepare motion chart of given activity using standard symbols of therbligs	02	CO3
7	LLO 7.1 Identify the component. LLO 7.2 Apply ergonomic	Use ergonomic principle for given component	02	CO3

Sr No	Laboratory Learning Outcome **(LLO)** aligned to CO's.	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hrs.**	**Relevant COs**
	principle for given component			
8	LLO 8.3 Identify organization. LLO 8.4 identify type of management. LLO 8.5 Enlist the functions of key posts.	Identify any one organization, and describe how it is managed /administered. Enlist the functions of key posts.	04	C04
9	LLO 9.1 Identify organization. LLO 9.2 Enlist various resources required. LLO 9.3 Identify how various resources are managed.	Identify any one organization, and describe how various resources are managed in it.	04	CO5
10	LLO 10.1 Identify general safety norms to be followed in industrial unit LLO 10.2 Enumerate key features of Indian Factories Act. LLO 10.3 Enumerate key features of Industrial Dispute Act LLO 10.4 Enumerate key features of Workman Compensation Act LLO 10.5 Enumerate key features of Minimum wages Act.	Describe general safety norms to be followed in industrial unit, and key features of Indian Factories Act, Industrial Dispute Act, Workman Compensation Act, Minimum wages Act.	04	CO6

Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

Note: Student are required to complete any two micro projects from the suggested list given below. Similar micro projects could be added or given to the students by the concern faculty.

1. Prepare detailed process plan for manufacturing of given component.
2. Prepare chart of sequence of operation for manufacturing of given component
3. Apply the method study approach to analyse the motions involved in machining operations of the given job.
4. Apply work measurement technique to analyse the time components involved in machining operation of a given job using stop watch.

5. Calculate the standard time for all the operations involved to perform operations on given job.
6. Prepare motion chart of given activity using standard symbols of therbligs.
7. Collect ergonomic data for given domestic/office items or control panels of 2 wheeler/ 4 wheeler.
8. Identify any one organization, and describe how it is managed /administered. Enlist the functions of key posts.
9. Collect information about general safety norms followed in industries.
10. Collect information about Indian Factories Act, Industrial Dispute Act, Workman Compensation Act, Minimum wages Act.

I. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks		
		R Level	U Level	A Level
1	**Process Engineering**	4	4	4
2	**Method Study & Time Study**	4	6	4
3	**Ergonomics**	2	2	2
4	**Management Concept and Managerial Skills**	2	4	4
5	**Industrial Resource Management**	2	4	4
6	**Industrial Safety and Industrial Acts**	2	4	2
	Total	**16**	**24**	**20**

Assessment Methodologies/Tools

A) Formative assessment (Assessment for Learning)

Each experiment/ assignment to be assessed on following rubrics (10 marks)

Neatness , completeness	Understanding & timely completion	Attendance & Regularity	Total
04 Marks	04 Marks	02 Marks	10 Marks

B) Summative Assessment (Assessment of Learning)

End term Theory examination of 60 marks.

Suggested COs - POs Matrix Form

CO's	Programme Outcomes (PO's)							PSO's	
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO- 1	PSO- 2
CO1	3	1	-	1	2	2	3	1	3
CO2	3	2	-	2	2	2	3	2	3
CO3	3	2	-	2	2	2	3	2	3
CO4	3	2	-	-	2	3	3	2	3
CO5	3	2	-	-	2	3	3	2	3
CO6	3	2	-	-	2	3	3	2	3
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

II. Suggested Learning Materials / Books

Sr. No.	Title	Author, Publisher, Edition and Year Of publication	ISBN
1	Industrial Engineering And Management	O.P. Khanna, Dhanpat Rai,	ISBN-10 818992835X
2	Industrial Engineering and Production Management	Martand T Telsang, S Chand	ISBN-13. 978-8121917735
3	Ergonomics at Work: Human Factors in Design and Development	D.J.Oborne. . John Wiley & Sons Ltd, 3rd Edition - 23 January 1995.	ISBN-13: 978-0471952350 ISBN-10: 9780471952350.
4	Principles of management	Omvir Chaudhary, Prakash singh. New Delhi New age international (P) Ltd. 2011.	isbn 978 81 224 3039 4
5	Industrial Organization And Management	Sahu, K. C., Basu, S.K., Rajiv b., phi	ISBN-10 8120344219

Learning Websites & Portals

Sr.No	Link / Portal	Description
1	www.nptel.ac.in/courses	

III. Academic Consultation Committee/Industry Consultation Committee:

IV.

Sr. No	Name	Designation	Institute/Organization
1	Dr S.G. Jadhav	Assistant Professor	V.J.T.I., Matunga, Mumbai-19
2	Mr. C. R. Khaire	Lecturer in Mechanical Engineering	K.J. S. P.,Vidyavihar, Mumbai
3	Dr. V.U. Rathod	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai
4	Mr. S. B. Bidgar	Lecturer in Mechanical Engineering	Government Polytechnic, Mumbai

Coordinator,
Department of Mechanical Engineering

Head of Department
Department of Mechanical Engineering

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Rubber Technology (Sandwich Pattern)													
Course Code: RT23401					**Course Title: Thermoplastic Elastomers**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hrs. 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	**-**	**-**	**1**	**4**	**2**	**20**	**20**	**60**	**--**	**--**	**--**	**25**	**125**

Total IKS Hrs. for course: 3hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.
3. FA-PR represents the term work.
4. SA-PR represents the end term practical examination.

I. Rationale

Thermoplastic Elastomers are versatile materials that combine the elasticity of rubbers with the process of plastics, industries and employee's possibility of a relatively new class of polymers which differ from conventional rubber in the sense that this product behaves like rubber at normal temperature but can be processed like plastic elevated temperature. There this are new engineering elastomers entering automobile and engineering sector as high performance material.

II. Industry / Employer Expected Outcome

Diploma Graduates will possess a strong understanding of Thermoplastic Elastomers (TPEs), including their properties, processing techniques, and applications, enabling them to contribute effectively to product development, material selection, and quality control in industries such as automotive, medical, and consumer goods. They will also demonstrate practical skills in TPE testing, troubleshooting, and sustainable material practices, aligning with industry standards and innovation needs.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	Know about the importance of Thermoplastic Elastomers in rubber field.
CO2	Learn about Thermoplastic Styrene Block Copolymer.
CO3	To Understand about Polyester Thermoplastic Elastomers.
CO4	Know & study about thermoplastic polyolefin rubbers.
CO5	Know & study about thermoplastic polyolefin rubber.
CO6	Learn the importance of thermoplastic polyamide Elastomer.

IV.Course Content Details:

UnitNo.	Theory Learning Outcomes (TLO's)aligned to CO's	Topics / Sub-topics
1.	**TLO 1a.** Explain monomer, oligomer, polymer. **TLO 1b.** Differentiate between Different polymer with examples. **TLO 1c**. To analysis of Average molecular weight. **TLO 1d.** Determination of Number - Average & Weight-Average Molecular Weight	**Introduction of TPE** 1.1 Definition and Characteristics of TPE. 1.2 Advantages of TPE 1.3 Disadvantages of TPE 1.4 Classification of TPE **Course Outcome:CO1** **Teaching Hours: 6 hours** **Marks: 10**
2.	**TLO2a.** Differentiate between Homopolymer, Copolymerand Terpolymer. **TLO2b.** Identify different linear, Branched, cross linkedpolymer. **TLO2c**. understand the concept of Random, Block Copolymer and Graft copolymers. **TLO2d.** Explain Geometrical Isomerism.	**Thermoplastic Styrene Block Copolymers** 2.1 Structure and Composition 2.2 Synthesis and Manufacturing 2.3 Properties Composition relationship 2.4 Compounding 2.5 Mixing & Processing 2.6 Application **Course Outcome: CO2** **Teaching Hours: 8 hours** **Marks: 10**
3	**TLO3a.** Explain Chain Polymerization. **TLO3b.** Understand Step polymerization. **TLO3c**. Understand the concept of Miscellaneous Polymerization.	**Polyester Thermoplastic Elastomers** 3.1Structure and chemistry 3.2Synthesisand Manufacturing 3.3Commercial Elastomer Grades 3.4 Dynamic Properties 3.5 Special Polyester Thermoplastic Elastomers(Hytrel) 3.6 Processing 3.7 Application **Course Outcome: CO3** **Teaching Hours: 8 hours** **Marks: 10**
	TLO4a. Understand the concept of Mass Polymerization, Bulk	**Thermoplastic Polyolefin Elastomer** 4.1 Structure and chemistry

4	Polymerization, Solution Polymerization, Emulsion Polymerization, Suspension polymerization.	4.2 Synthesis and Manufacturing 4.3 Properties Composition relationship 4.4 Processing 4.5 Application **Course Outcome: CO4** **Teaching Hours: 8 hours** **Marks: 10**
5	**TLO5a.** Differentiate between Glassy Solids & GlassTransition. **TLO5b.** Understand Transition & Associated Properties. **TLO5c**. Analyze Glass Transition Temperature & Molecular Weight, Glass transition Temperature & MeltingPoint. **TLO5d**. Determination of Degree of Crystallinity. **TLO5e**. Understand effect of Crystallinity on the propertiesof polymers.	**Thermoplastic Polyurethane Elastomers** 5.1 Preparation & Structure 5.2 Synthesis and Manufacturing 5.3 Properties Composition relationship 5.3.1 Molecular Weight Effects 5.3.2 Chemical c/s Effects 5.3.3 Environmental Stability & Stabilization 5.4 Compounding 5.5 Processing 5.6 Applications **Course Outcome: CO5** **Teaching Hours: 8 hours** **Marks: 8**
6	**TLO6a.** Determine types of Degradation. **TLO6b.** Understand concept of thermal and mechanical degradation. **TLO6c**. Analyze Degradation by ultra-sonic waves. **TLO6d**. Explain Oxidative and Ozone oxidation degradation.	**Thermoplastic Polyamides** 6.1Structure and Composition 6.2 Synthesis and Manufacturing 6.3 Properties Composition relationship 6.4 Compounding 6.5 Mixing & Processing 6.6 Application **Course Outcome: CO6** **Teaching Hours: 7 hours** **Marks: 12**

Note: Any one unit from the above five units, has to be preferably taught by alumni of Govt. Polytechnic Mumbai.

V. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

Note: Student are required to complete any two micro projects from the suggested list given below. Similar micro projects could be added or given to the students by the concern faculty.

1. Introduction of TPE (CO1)
   - Activity 1: Create a comparative chart or infographic highlighting the definition, characteristics, advantages, and disadvantages of TPEs compared to other elastomers (e.g., thermoset elastomers).
   - Activity 2: Write a short report (500-700 words) on the classification of TPEs, including examples of each type and their unique properties.
   - Self-Learning Task: Research and present a case study on a real-world application of TPEs, explaining why TPEs were chosen over other materials.
2. Thermoplastic Styrene Block Copolymers (CO2)
   - Activity 1: Develop a flowchart or diagram illustrating the synthesis and manufacturing process of thermoplastic styrene block copolymers.

- Activity 2: Conduct a small experiment or simulation (using software like MATLAB or Excel) to analyze the properties-composition relationship of styrene block copolymers.
- Self-Learning Task: Prepare a presentation on the applications of styrene block copolymers in industries such as automotive, footwear, or adhesives.

3. Polyester Thermoplastic Elastomers (CO3)
   - Activity 1: Create a detailed table comparing commercial elastomer grades of polyester TPEs, including their properties and applications.
   - Activity 2: Write a technical report on Hytrel, focusing on its structure, dynamic properties, and processing techniques.
   - Self-Learning Task: Research and summarize the environmental impact of polyester thermoplastic elastomers and their recyclability.
4. Thermoplastic Polyolefin Elastomer (CO4)
   - Activity 1: Design a poster or infographic explaining the structure and chemistry of thermoplastic polyolefin elastomers.
   - Activity 2: Perform a literature review on the properties-composition relationship of polyolefin elastomers and present your findings in a short video or presentation.
   - Self-Learning Task: Investigate and document the processing techniques used for polyolefin elastomers in the packaging industry.
5. Thermoplastic Polyurethane Elastomers (CO5)
   - Activity 1: Prepare a detailed report on the molecular weight effects and chemical cross-section effects on the properties of TPU.
   - Activity 2: Develop a process flow diagram for the compounding and processing of TPU.
   - Self-Learning Task: Research and present a case study on the applications of TPU in medical devices or sports equipment.
6. Thermoplastic Polyamides (CO6)
   - Activity 1: Create a comparative analysis of synthesis and manufacturing methods for thermoplastic polyamides.
   - Activity 2: Conduct a small experiment or simulation to study the properties-composition relationship of polyamides.
   - Self-Learning Task: Prepare a detailed report on the applications of thermoplastic polyamides in the automotive or electronics industry.

VI. Specification Table:

Unit No.	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	**Introduction of TPE**	04	04	02	10
2	**Thermoplastic Styrene Block Copolymers**	04	04	02	10
3	**Polyester Thermoplastic Elastomers**	04	04	02	10
4	**Thermoplastic Polyolefin Elastomers**	04	04	02	10
5	**Thermoplastic Polyurethane Elastomers**	04	02	02	08
6	**Thermoplastic Polyamides**	04	06	02	12
	Total	24	24	12	60

VII. Suggested COs - POs Matrix Form

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)	
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PSO-1**	**PSO-2**
CO1	2	3	2	1	3	3	2	3	2
CO2	2	2	1	2	2	3	2	3	3
CO3	2	3	3	3	2	2	3	3	2
CO4	3	2	3	2	3	3	2	2	2
CO5	2	3	1	2	3	2	2	3	3
CO6	3	2	1	2	2	3	2	2	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

VIII. Suggested Learning Materials / Books:

Sr. No.	Title	Author, Edition and Year Ofpublication	ISBN
1	Handbook of Elastomers: New Development & Technology	Anil K. Bhowmick, Howard L. Stephens	----
2	Handbook of Thermoplastic Elastomer	Benjamin M. Walke	----
3	Handbook of Thermoplastic Elastomer	N. R. Legge, G.Holden, H. E. Sehroeder	----

IX. Learning Websites & Portals:

Sr. No.	Link / Portal
1	**https://youtu.be/GmHtt-OFNWc?si=jCSWjrLU4Lr-shSv**
2	**https://youtu.be/mE0dNmQ0Ihc?si=zxgGVXPWj_PowIlz**
3	**https://youtu.be/asNsbr2_xL8?si=2Wvc_tVqvnbl7--z**

X. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Ravindra Barde	Industry Expert	Sidhhi Elasto Pvt. LTD.
2	Mr. Dharmesh Dhanani	Industry Expert	Elphiepoly Pvt. LTD.
3	Mr. Sahil Ranoliya	Lecturer in Rubber Technology	AIRIA
4	Mr. Sahil Soliya	Lecturer in Rubber Technology	AIRIA

Coordinator,
Curriculum Development,
Department of Rubber Technology

Head of Department
Department of Rubber Technology

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Rubber Technology (Sandwich Pattern)													
Course Code: RT23402					**Course Title : Rubber Compounding & Product Testing**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hrs. 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	**-**	**2**	**1**	**6**	**3**	**20**	**20**	**60**	**25**	**25***	**-**	**25**	**175**

Total IKS Hrs. for course: 3hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA - Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination.

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.
3. FA-PR represents the term work.
4. SA-PR represents the end term practical examination.

I. Rationale

A Rubber technologist must understand fully testing of unvulgarized rubber compound for its processing & Curing characteristics. This will able him to determine whether the compound he has prepared is satisfactory and whether the product cured is according to specification. Understanding of various national & international standards will be required for day to day working in testing laboratory.

II. Industry / Employer Expected Outcome

Understanding of testing methods of incoming raw materials, raw rubbers, textiles etc. for various test will enable him to know if raw materials are received as per required quality.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Summarize the importance of testing, calibration and need of standardization in Rubber industries.
CO2	To learn methods of testing of raw material.
CO3	To learn methods of testing of compounded rubber.
CO4	To learn methods of testing of vulcanized rubber.
CO5	Identify suitable test for ageing properties.
CO6	To learn about electrical test & permeability.

IV.Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's)aligned to CO's	Topics / Sub-topics
1.	**TLO 1a.** To understand the Importance of Testing Rubber **TLO 1b.** Precision and Accuracy **TLO 1c**. Specimen Preparation **TLO 1d.** Standard Temperature **TLO 1e.** Preparation of Test Pieces	**Importance of Testing in Rubber Industries** **1.1** Introduction **1.2** Precision, Accuracy & Validity **1.3** Specimen Preparation **1.4** Standard Temperature **1.5** Organizations Producing Standards **1.5.1** SAE **1.5.2** DIN **1.5.3** JIS **1.5.4** ASTM **1.5.5** ISO **1.5.6** BIS **1.5.7** ITTAC **1.5.8** ETRTO **1.5.9** TRA **1.6** Preparation of Test Pieces **Course Outcome:CO1** **Teaching Hours 8 hours,Marks: 8**
2.	**TLO2a.** To study various Raw material test of Rubber **TLO2b.** Burning, Chemical and Acetone extract test **TLO2c**.Ash content test **TLO2d.** Moisture content Test	**Raw material test** 2.1 Burning test 2.2 Chemical test 2.2.1 Acetone extract test 2.2.2 Chloroform extract 2.2.3 ASTM solution 2.3 Ash content test 2.4 Moisture content Test **Course Outcome: CO2** **Teaching Hours 8 hours Marks: 8**
3	**TLO3a.** Tests on Unvulcanised Rubbers **TLO3b.** Compression Plastimeters and Plasticity Retention index **TLO3c**. Function of Mooney viscometers and Rheometer **TLO3d.** Determination of Specific gravity	**Tests on Unvulcanised Rubbers** 3.1 Viscoelastic Flow Behavior 3.1.1 Compression Plastimeters 3.1.2 Plasticity Retention index 3.1.3 Mooney viscometers 3.1.4 Rheometers (ODR & MDR) 3.2 Scorch & Cure rate 3.3 Tack 3.4 Determination of Specific gravity 3.5 Green Strength 3.6 Shrinkage **Course Outcome: CO3** **Teaching Hours:8 hours ,Marks: 12**
	TLO4a. Understand the physical properties **TLO4b** Dead load and Durometer tests **TLO4c.** Tensile Stress-strain	**Testing for Physical Properties** 4.1 Density 4.2 Hardness 4.2.1 Dead load tests 4.2.2 Durometer Tests

4	**TLO4d.** Tear test **TLO4e.** Abrasion test	4.3 Tensile Stress-strain 4.4 Compression stress- strain 4.5 Shear stress-strain 4.6 Flexural(Bending) Stress- strain 4.7 Tear test 4.8 Rebound Resilience, 4.9 Flex-cracking & Cut growth test 4.10 Heat Build-up 4.11 Abrasion test Note: BIS or ASTM to be used for explanation of above **Course Outcome: CO4** **Teaching Hours:8 hours, Marks: 14**
5	**TLO5a. Effect of Temperature** **TLO5b.** Heat ageing **TLO5c**..Effect of gases and ozone **TLO5d**. Flame resistance.	**Effect of Temperature & Environmental Resistance** 5.1 Low temperature properties 5.2 Heat ageing 5.3 Effect of liquids (ASTM Oils) 5.4 Volume Swelling 5.5 Water absorption 5.6 Effect of gases 5.7 Effect of ozone 5.8 Flame resistance. **Course Outcome: CO5** **Teaching Hours: 5 hours ,Marks: 8**
6	**TLO6a.** Electrical Tests & Permeability **TLO6b.** Test on Insulating Rubbers **TLO6c**. Power factor and permittivity **TLO6d**. Constant Volume and pressure Method **TLO6e.** Vapor Permeability	**Electrical Tests & Permeability** 6.1Resistance or resistivity 6.1.1 Test on Insulating Rubbers 6.1.2 Test on Conducting and Anti-Static Rubbers 6.2 Surface charge 6.3 Electric strength 6.4 Tracking resistance 6.5 Power factor and permittivity 6.6 Gas Permeability 6.6.1 Constant Volume Method 6.6.2 Constant Pressure Method 6.6.3 Carrier gas Methods 6.6.4 High pressure measurements 6.7 Vapor Permeability 6.8 raw material test. **Course Outcome: CO6** **Teaching Hours: 8 hours, Marks: 10**

Note: Any one unit from the above five units, has to be preferably taught by alumni of Govt. Polytechnic Mumbai.

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	**Sr. No**	**Laboratory Experiment / Practical Titles / Tutorial Titles**	**Number of hours.**	**Relevant COs**
Identify different types of rubbers (e.g., natural rubber, synthetic rubber) based on their **flame characteristics, odor, and residue** during a burning test.	1	Identification of rubbers by burning test.	02	CO2
Determine the **moisture content** and **ash content** of rubber samples using gravimetric analysis.	2	Determination of moisture content and ash content of rubber.	04	CO2
Measure the **Mooney viscosity** of rubber samples using a Mooney viscometer.	3	Determination of Mooney viscosity of rubbers.	02	CO3
Perform the **acetone extract test** to determine the percentage of **soluble components** (e.g., oils, plasticizers, and additives) in a rubber compound.	4	Analysis of rubber compound by Acetone extract test.	04	CO3
Measure the **Mooney viscosity** and **Mooney scorch time** to assess the **processing safety** and **cure characteristics** of rubber compounds.	5	Determination of Mooney Viscosity, Mooney scorch and Rheomatric properties of rubber compound.	02	CO3
Determine the **specific gravity** of vulcanized rubber using a density measurement method.	6	Determination of Specific gravity , tensile strength , Elongation at Break and modulus properties of vulcanized rubber compound.	04	CO4
Measure the **compression set** of vulcanized rubber to evaluate its **elastic recovery** after deformation.	7	Determination of compression set of vulcanized rubber.	02	CO4
Assess the **flex resistance** of rubber compounds using the DeMattia flex test.	8	Determinations of DeMattia flex resistance of compound.	04	CO4
Measure the **volume swell** of vulcanized rubber after immersion in fluids/solvents.	9	Determination of volume swell and retention of physical properties of vulcanized rubber compound in fluids/solvents.	02	CO5
Conduct an **accelerated ageing test** on rubber samples using an oven or environmental chamber.	10	Determine retention of physical properties of rubber on accelerated ageing test.	04	CO5
		Total	**30**	

VI.Suggested Micro Project / Assignment/ Activities for Specific Learning / SkillsDevelopment (Self Learning):

Note: Student are required to complete any five micro projects from the suggested list given below. Similar micro projects could be added or given to the students by the concern faculty.

1. Comparative Study of International Standards (CO1)
   - Compare and contrast the **testing standards** of **ASTM, ISO, and BIS** for rubber testing.
   - Create a detailed report or presentation highlighting the differences in **specimen preparation, testing conditions, and acceptance criteria** for a specific test (e.g., tensile strength).
   - **Outcome:** Understand the importance of standardization and its impact on global trade and quality assurance.

2. Precision and Accuracy in Rubber Testing (CO1)
   - Conduct an experiment to measure the **precision and accuracy** of a specific rubber test (e.g., hardness or tensile strength) using multiple trials.
   - Analyze the data statistically and present the results in a report.
   - **Outcome:** Develop skills in data analysis and understand the importance of repeatability and reproducibility in testing.

3. Raw Material Testing: Burning and Chemical Tests (CO2)
   - Perform **burning tests** and **chemical tests** (e.g., acetone extract, chloroform extract) on different rubber samples.
   - Create a comparative chart showing the results and their implications for material identification and quality control.
   - **Outcome:** Gain hands-on experience in raw material testing and interpretation of results.

4. Mooney Viscosity and Rheometric Analysis (CO3)
   - Measure the **Mooney viscosity** and **rheometric properties** (e.g., scorch time, cure rate) of unvulcanized rubber compounds.
   - Analyze the relationship between viscosity and processability.
   - **Outcome:** Understand the role of viscoelastic behavior in rubber processing and quality control.

5. Physical Properties Testing: Tensile and Tear Strength (CO4)
   - Conduct **tensile stress-strain** and **tear strength** tests on vulcanized rubber samples using ASTM or BIS standards.
   - Prepare a report comparing the results and discussing their significance in product design and application.
   - **Outcome:** Develop skills in mechanical testing and interpretation of stress-strain behavior.

6. Environmental Resistance Testing: Heat Ageing and Ozone Resistance (CO5)
   - Perform **heat ageing** and **ozone resistance** tests on rubber samples.
   - Measure the retention of physical properties (e.g., tensile strength, elongation) after exposure and analyze the results.
   - **Outcome:** Understand the effects of environmental factors on rubber performance and durability.

7. Electrical Properties Testing: Resistivity and Permittivity (CO6)
   - Measure the **electrical resistivity** and **permittivity** of insulating and conducting rubber samples.
   - Analyze the results and discuss their implications for applications in electrical and electronic industries.

- **Outcome:** Gain knowledge of electrical testing methods and their relevance in material selection.

8. Gas and Vapor Permeability Testing (CO6)
   - Conduct **gas permeability** tests using the constant volume or constant pressure method on rubber samples.
   - Compare the permeability of different rubber compounds and discuss their suitability for specific applications (e.g., seals, membranes).
   - **Outcome:** Understand the principles of permeability testing and its importance in material selection.

9. Abrasion Resistance and Heat Build-Up Testing (CO4)
   - Perform **abrasion resistance** and **heat build-up** tests on vulcanized rubber samples.
   - Analyze the results and correlate them with the material's performance in high-stress applications (e.g., tires, conveyor belts).
   - **Outcome:** Develop skills in evaluating wear resistance and thermal properties of rubber.

10. Low-Temperature Properties and Flex-Cracking Resistance (CO5)
    - Conduct **low-temperature flexibility** and **flex-cracking resistance** tests on rubber samples.
    - Analyze the results and discuss the material's suitability for applications in cold climates or dynamic environments.
    - **Outcome:** Understand the impact of temperature on rubber performance and durability.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	**Importance of Testing in Rubber Industries**	02	02	04	08
2	**Raw material test**	04	02	02	08
3	**Tests on Unvulcanised Rubbers**	04	04	04	12
4	**Testing for Physical Properties**	04	06	04	14
5	**Effect of Temperature & Environmental Resistance**	04	02	02	08
6	**Electrical Tests & Permeability**	04	04	02	10
	Total	22	20	18	60

VIII. Suggested COs - POs Matrix Form

Course Outcome s (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)	
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PSO-1	PSO-2
CO1	3	2	3	3	3	2	2	3	2
CO2	3	2	1	2	2	2	2	3	3

CO3	3	2	3	3	2	2	3	3	2
CO4	3	2	3	2	3	3	2	3	2
CO5	3	2	1	2	3	2	2	3	3
CO6	3	2	1	2	2	2	1	2	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

IX. Suggested Learning Materials / Books:

Sr. No.	Title	Author, Edition and Year Ofpublication	Publisher,
1	Physical Testing of Rubber	Roger Brown	Chapman & Half Publication
2	Rubber Technology Compounding & Testing	John S. Dick	Hanser Publication

X. Learning Websites & Portals:

https://www.youtube.com/watch?v=9N5SS8f1auI
https://www.youtube.com/watch?v=P8u2s7s4N3c&t=10s
https://www.youtube.com/watch?v=j1ov7qWfJbM

XI. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Ravindra Barde	Industry Expert	Sidhhi Elasto Pvt. LTD.
2	Mr. Dharmesh Dhanani	Industry Expert	Elphiepoly Pvt. LTD.
3	Mr. Sahil Ranoliya	Lecturer in Rubber Technology	AIRIA
4	Mr. Sahil Soliya	Lecturer in Rubber Technology	AIRIA

Coordinator,
Curriculum Development,
Department of Rubber Technology

Head of Department
Department of Rubber Technology

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Rubber Technology (Sandwich Pattern)													
Course Code: RT23403					**Course Title: Basic Machine Tools and Operations.**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hours. 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	**-**	**2**	**1**	**6**	**3**	**20**	**20**	**60**	**25**	**--**	**--**	**25**	**150**

Total IKS Hrs. for course: 3hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA - Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.
3. FA-PR represents the term work.
4. SA-PR represents the end term practical examination.

I. Rationale:

This curriculum is designed to equip students with the **technical knowledge**, **practical skills**, and **safety awareness** required to excel in the manufacturing and welding industries. By focusing on both theory and hands-on training, the curriculum ensures that students are well-prepared for entry-level roles, advanced studies, and lifelong learning in their chosen fields. It aligns with industry needs, promotes safety and quality, and fosters innovation, making it a vital component of technical education

II. Industry / Employer Expected Outcomes:

Employers expect workers to proficiently operate lathe, drilling, and milling machines, performing key operations and adhering to safety protocols. They should be skilled in grinding and boring machines, ensuring precision and safety in all tasks. Expertise in various welding techniques, with the ability to troubleshoot defects, is also required. Overall, a strong focus on operational efficiency and safety is essential across all machinery and processes.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Identify the parts and functions of a center lathe and interpret its specifications**.**
CO2	Identify the parts and functions of a radial drilling machine and interpret its specifications.

CO3	Identify the parts and functions of a column and knee type milling machine and interpret its specifications.
CO4	Select and use appropriate grinding wheels based on abrasives, bonds, grit, grade, and structure.
CO5	Follow safety precautions while operating a boring machine.
CO6	Identify and analyze welding defects, their causes, and remedies.

IV. Course Content Details:

UnitNo.	Theory Learning Outcomes (TLO's)aligned to CO's	Topics / Sub-topics
1.	1. Understand the working principles and classifications of lathe machines. 2. Identify the components and functions of a center lathe, and perform common lathe operations. 3. Apply safety precautions while operating lathe machines to ensure safe work practices.	**Lathe Machines:** **1.1** Lathe Machines: Working principle of lathe, Classification of lathe, **1.2** Parts and their functions of center lathe, specifications of lathe. **1.3** Lathe operations- different operations performed on lathe machine turning, facing, chamfering, parting off, knurling, drilling, taper turning, taper turning methods **1.4** Safety precautions to be followed while working on lathe machine **Course Outcome: CO1** **Teaching Hours :8 hoursMarks: 10**
2.	1. Understand the working principles and classifications of drilling machines. 2. Identify the components and functions of drilling machines and perform various drilling operations. 3. Follow safety procedures to prevent accidents while using drilling machines.	**Drilling Machines:** **2.1** Working principle, Classification of drilling machines **2.2** parts and their functions of radial drilling machine, specification of drilling machine **2.3** Drilling machine operations- different operations performed on drilling machine drilling boring, reaming, counter boring **2.4** Safety precautions to be followed while working on drilling machine **Course Outcome: CO2** **Teaching Hours 7 hours,Marks: 10**
	1. Comprehend the working principles and classifications of milling machines. 2. Perform various milling operations including indexing and gear cutting while understanding machine parts.	**Milling machine:** **3.1** Working principle, classification of Milling machines, **3.2** different parts and their functions of Column and Knee type milling machine, specification of milling machine Milling machine operations **3.3** different operations performed on milling machine

3	3. Apply proper safety measures while working with milling machines to maintain a safe working environment.	milling, slab milling, straddle milling, gang milling, end milling, side milling Indexing, principle of indexing, simple dividing head, gear cutting with simple indexing, **3.4** Safety precautions while working on milling machines. **Course Outcome: CO3** **Teaching Hours:8 hours , Marks: 10**
4	1. Understand the types and working principles of grinding machines. 2. Identify the components, specifications, and grinding wheel characteristics for proper usage. 3. Apply safety precautions while performing grinding operations to avoid accidents.	**Grinding Machines** **4.1** Working principle, Types of Grinding machines, parts and their functions of bench grinding machine **4.2** Specification of grinding machine Grinding operations-, Grinding wheel, abrasives, bonds, grit, grade, structure **4.3** Standard marking system for grinding wheel **4.4** Safety precautions to be followed while working on grinding machine **Course Outcome: CO4** **Teaching Hours:8 hours Marks: 10**
5	1. Comprehend the working principles and classifications of boring machines. 2. Identify the components and functions of horizontal boring machines and perform various boring operations. 3. Follow safety guidelines to ensure safe operation of boring machines.	**Boring Machines** **5.1** Working principle, Classification of boring machines, **5.2** Different parts and their functions of horizontal boring machine, **5.3** specification of boring machine. Operations of boring machine **5.4** Safety precautions while working on boring machine **Course Outcome: CO5** **Teaching Hours: 07 hours Marks: 10**
6	1. Understand the principles and classifications of welding processes, including arc, gas, and resistance welding. 2. Recognize common defects in welding and apply corrective actions. 3. Implement safety protocols during welding operations to minimize hazards and ensure quality work.	**Welding Processes** **6.1** Principle of welding processes, **6.2** Classification of welding processes, Arc welding process- working and applications Gas welding (Oxyacetylene welding)- **6.3** Types of flames, working and applications. Resistance (Spot) welding – principle, working and applications. Defects in welding **6.4** Their causes and remedies Safety precautions to be followed in welding processes. **Course Outcome: CO6** **Teaching Hours: 07 hours Marks: 10**

Note: Any one unit from the above five units, has to be preferably taught by alumni of Govt. Polytechnic Mumbai.

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr. No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hours.	Relevant Cos
Demonstrate the ability to perform plain turning and facing operations with precision on a lathe machine.	1	Performing Plain turning and facing operation on lathe machine	4	CO1
Perform step turning and taper turning operations on a lathe, ensuring dimensional accuracy.	2	Performing step turning and taper turning operation on lathe machine.	4	CO1
Carry out thread cutting, grooving, and chamfering operations with attention to detail and accuracy.	3	Performing Thread cutting, grooving, and chamfering operations on lathe machine.	4	CO1
Perform drilling and tapping operations efficiently, maintaining the correct alignment and depth.	4	Performing drilling and tapping operation on drilling machine	2	CO2
Demonstrate the ability to perform gear cutting on a blank using a milling machine.	5	Performing gear cutting operation on a blank using milling machine	4	CO3
Execute surface grinding operations on a given job, ensuring a smooth, flat surface finish.	6	Performing surface grinding of given job on belt /bench grinding machine.	4	CO4
Observe and understand the boring operation through industrial visits or video demonstrations.	7	Industrial Visit/video demonstration to observe boring operation	4	CO5
Perform arc welding operations to prepare various types of joints (T, lap, butt) with attention to weld quality.	8	Preparation of a 'T' joint/Lap joint/butt joint using arc welding process	4	CO6
		Total	**30**	

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

Note: Student are required to complete any two micro projects from the suggested list given below. Similar micro projects could be added or given to the students by the concern faculty.

1.Design **and Fabricate a Simple Lathe Tool Post:**

Create a simple lathe tool post, understanding the classification, working principle, and specifications of lathe machines.

2.Model **and Turn a Step Shaft on a Lathe:**

Perform step turning on a lathe machine, applying various lathe operations such as turning, facing, and taper turning.

3. Make **a Part with Knurling and Chamfering:**

Demonstrate the ability to perform knurling and chamfering operations on a lathe machine to create a part with these features.

4. Design **a Simple Drilling Jig for Radial Drilling Machine:**

Create a jig for a radial drilling machine and perform drilling, reaming, and counter boring operations on a sample work piece.

5. Design **and Cut a Keyway Using Milling Machine:**
   Use a milling machine to perform keyway cutting and demonstrate an understanding of indexing and gear cutting principles.
6. Fabricate **a Component Using Slab Milling and End Milling Operations:**
   Design and manufacture a small component using slab milling and end milling operations on a milling machine.
7. Prepare **and Grind a Precision Surface Using a Bench Grinder:**
   Perform surface grinding on a given job using a bench grinder, selecting the correct grinding wheel based on material and application.
8. Perform **Horizontal Boring on a Sample Component:**
   Set up and operate a horizontal boring machine to bore a precise hole through a workpiece, adhering to safety protocols.
9. Weld **a Simple Butt Joint Using Arc Welding:**
   Prepare a simple butt joint and weld it using the arc welding process, demonstrating proper technique and safety measures.
10. Create **and Weld a 'T' Joint Using Oxyacetylene Welding:**
    Design a 'T' joint and use oxyacetylene welding to fabricate the joint, demonstrating the correct flame types and welding methods.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R	U	A	Total
		Level	Level	Level	Marks
1	**Lathe Machines**	4	4	2	10
2	**Drilling Machine**	4	4	2	10
3	**Milling Machine**	2	4	4	10
4	**Grinding Machine**	4	4	2	10
5	**Boring Machine**	4	4	2	10
6	**Welding Processes**	2	4	4	10
	Total	20	24	16	60

VIII. Suggested COs - POs Matrix Form

Course Outcome s (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)	
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PSO-1	PSO-2
CO1	2	2	2	2	1	1	2	3	1
CO2	2	3	2	1	1	1	2	2	2
CO3	3	2	2	2	1	1	2	1	1
CO4	3	2	2	1	2	1	2	3	3
CO5	2	2	2	3	2	1	3	3	2
CO6	2	2	2	2	2	2	2	2	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

IX. Suggested Learning Materials / Books:

Sr. No.	Title	Author, Edition and Year Ofpublication	ISBN
1	Elements of Workshop Technology Vol. I (Manufacturing Processes)	Hajra Chawdhury, Media Promotors and Publications Pvt. Ltd. 15th Ed, 2008	978-8185099149
2	Elements of Workshop Technology Vol. II (Machine Tools)	Hajra Chawdhury, Media Promotors and Publications Pvt. Ltd. 15th Ed, 2008	ISBN-9788185099156
3	Production Engineering	P. C. Sharma S. Chand Publication	ISBN-8121901111, ISBN-9788121901116
4	A course in of Workshop Technology Volume.	B S Raghuwanshi, Dhanpatrai & Sons, 2017	ISBN-978-1020092015
5	Introduction to Manufacturing Processes	Jhon Schey, Mcgraw Hills, 2012	ISBN-978-0071-169110

X. Learning Websites & Portals

Sr. No	Link / Portal	Description
1	**www.mechanicalbooster.com**	Automobile, Manufacturing process
2	**www.britanica.com>technology**	Drilling and lathe machine
3	**www.nptel.ac.in/content/storage/courses/112105127**	Principles of fluid dynamics, vehicle analysis and design
4	**www.pds.gov.in>download>plasticprocessingte**	Schemes for food security, ration cards

	chniques	and essential goods
5	**www.blog.robotiq.com>whataredifferentypesof industrialrobots**	Automation, Robotics,
6	**www.nptel.ac.in/content/storage2>courses>pdf**	Free online courses, lecturers and certifications in engg.
7	**www.easyengineering.nt>maintenanceengineeri ng**	Resourses, study materials, academic and exam preparation
8	**www.forgottenbooks.com>doenloads>machinef oundationerection**	A digital library offering books for free online reading

XI. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	**Name**	**Designation**	**Institute/Organization**
1	Dr. V. U. Rathod	Lecturer in Mech. Dept. , I/C Workshop Supdt.	Govt. Polytechnic, Mumba
2	Mr. E. C. Dhembare	Lecturer in Mech. Dept. Coordinator Rubber Tech Industry Expert	Govt. Polytechnic, Mumba
3	Mr. Sunil Kumar Shrivastav	Senior Lecturer, in Rubber Technology Dept.	Arizona Techzeal
4	Mr. Sahil Ranoliya	Lecturer in Rubber Technology	Member AIRIA
5	Mr. Sahil Soliya	Lecturer in Rubber Technology	Member AIRIA

Coordinator,
Curriculum Development,
Department of Rubber Technology

Head of Department
Department of Rubber Technology

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Rubber Technology (Sandwich Pattern)													
Course Code: RT23404					**Course Title : Vulcanization Systems**								
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hrs. 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	**-**	**2**	**1**	**6**	**3**	**20**	**20**	**60**	**25**	**--**	**25**	**25**	**175**

Total IKS Hrs. for course: 3hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA - Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.
3. FA-PR represents the term work.
4. SA-PR represents the end term practical examination.

I. Rationale

This course offers a comprehensive study of rubber vulcanization, covering raw rubber characteristics, vulcanization principles, and the properties of both unvulcanized and vulcanized rubber. Students will learn about various vulcanizing agents like sulfur, peroxides, and accelerators, and their effects on rubber compounds. It emphasizes the relationship between vulcanization processes and rubber properties, including strength, hardness, and heat stability. Practical aspects such as different vulcanization techniques, including batch and continuous methods, are also explored. Students will gain expertise in assessing vulcanization states and optimizing rubber properties for industrial applications. This course is highly relevant for those pursuing careers in rubber manufacturing, automotive, and materials engineering.

II. Industry / Employer Expected Outcome:

Employers expect students to demonstrate a thorough understanding of rubber vulcanization processes and their impact on rubber properties, ensuring high-quality production in manufacturing settings. They should be proficient in selecting and applying various vulcanizing agents, accelerators, and curing systems for optimal rubber performance. Industry professionals will look for skills in assessing vulcanization states and understanding the relationship between process parameters and product characteristics. Additionally, students should be capable of troubleshooting and optimizing vulcanization techniques to meet specific material requirements in industries like automotive and rubber manufacturing.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning.

CO1	Understand raw rubber characteristics, vulcanization, and structural changes in vulcanized rubber.
CO2	Learn about vulcanizing agents (sulfur, peroxides) and their effects on curing systems and accelerators.
CO3	Classify and select accelerators for rubber compounds, understanding their role in vulcanization.
CO4	Assess vulcanization states using techniques like crosslink density and Mooney scorch time.
CO5	Analyze the relationship between vulcanization structure and rubber properties to optimize performance.
CO6	Apply various vulcanization techniques, including batch and continuous methods, for specific rubber applications.

IV. Course Content Details:

Unit No.	Theory Learning Outcomes (TLO's)aligned to CO's	Topics / Sub-topics
1.	1. Understand raw rubber characteristics and structural changes during vulcanization. 2. Differentiate between vulcanized and unvulcanized rubber. 3. Identify vulcanizing agents and their roles in rubber curing.	**Introduction** **1.1** Characteristics of Raw Rubber 1.2 Definition of Vulcanization 1.3 Properties of Unvulcanised Compound 1.4 Difference between Vulcanized Rubber and Unvulcanised Rubber 1.5 Structural Changes observed in Rubber After Vulcanization, 1.6 Structure of Rubber Vulcanizate. 1.7 Vulcanizing agent: 1.7.1 Cross linking agents 1.7.2 Activators 1.7.3 Accelerators 1.7.4 Sulphur donors **Course Outcome: CO1** **Teaching Hours:8 hours, Marks: 8**
2.	1. Classify sulfur and its types. 2. Understand peroxide curing chemistry and its advantages. 3. Explore other curing systems like metal oxides and diamine cures.	**Types of Vulcanizing agents & their effects** 2.1 Classification of Sulphur 2.1.1 Insoluble Sulphur 2.1.2 Soluble 2.2 Theory of Sulphur 2.2.1 Conventional cure system 2.2.2 Efficient cure system 2.2.3 Semi Efficient cure system 2.2.4 Accelerator system selection & adjustment, 2.2.5 Sulphur donors 2.3 Peroxides:

		2.3.1 Classification of Peroxides and their Structures & Examples of Peroxides 2.3.2 Half life period & Decomposition temp. 2.3.3 Chemistry of peroxide cure & Reaction mechanism 2.3.4 Compounding Aspects of peroxide Cure 2.3.5 Advantages & Disadvantages of Peroxides cure over sulphur vulcanization 2.3.6 Peroxide cure of saturated and unsaturated Elastomers 2.4 Theory of metal oxide vulcanization with reaction mechanism 2.5 Theory of resing curing in butyl rubber 2.6 Theory of diamine cure system in Fluoroelastomers 2.7 Theory of Diisocynate cure system in polyurethane **Course Outcome: CO2** **Teaching Hours 8 hours, Marks: 14**
3	1. Classify and understand the role of accelerators in vulcanization. 2. Learn about specific accelerator types and their effects. 3. Select accelerators for optimizing rubber compound vulcanization.	**Accelerators** **3**.1 Classification of Accelerators 3.1.1Aldehyde amine 3.1.2 Guanidine 3.1.3 Thiazole 3.1.4 Thiophosphate 3.1.5 Sulfenamides 3.1.6 Thiourea 3.1.7 Thiuram 3.1.8 Dithiocarbamate 3.1.9 Xanthates 3.2 Selection of Accelerators for Rubber Compounds **Course Outcome: CO3** **Teaching Hours:8 hours Marks: 10**
4	1. Understand crosslink density and evaluate it using swelling techniques. 2. Measure cure in thick articles and analyze with rheometer curves. 3. Learn the practical significance of Mooney scorch time.	**The assessment of state of vulcanization** 4.1 Concept of Cross link density 4.2 evaluation of cross link density by the swelling techniques. 4.3 Discussion of methods of measuring cure, Calculation of cure in thick articles, 4.4 The relation between curing system type & properties 4.5 Vulcanization process analysis by Rheometers curve & the product Properties 4.6 Mooney Scorch time & Its practical significance **Course Outcome: CO4** **Teaching Hours:8 hours Marks: 8**
	4. Analyze how vulcanization affects properties like strength and hardness. 5. Understand the impact of vulcanization on fatigue, heat stability,	**Relations between Structure and Properties of Vulcanizates** 5.1 Modulus and Strength 5.2 Hardness 5.3 Resilience and Heat Build-up 5.4 Fatigue Properties 55 Heat Stability 5.6 Swelling

5	and aging. 6. Relate properties such as swelling and abrasion to vulcanization techniques.	5.7 Low Temperature Properties 5.8 Abrasion 5.9 Compression Set 5.10 Aging 5.11 Dynamic Properties and Rolling Friction **Course Outcome: CO5** **Teaching Hours:5 hours 10 Marks:**
6	1. Learn classification and methods of batch and continuous vulcanization. 2. Understand batch techniques like molding and autoclave curing. Explore continuous methods like fluidized bed vulcanization and rot cure.	**Vulcanisation Techniques:** **6**.1 Classification of Vulcanization Techniques. 6.2 Batch Vulcanization Techniques 6.2.1 Moulding 6.2.2 Autoclave 6.2.3 Hot Air Oven Curing, 6.2.4 Lead Curing, 6.2.5 Free Heating. 6.3 Continuous vulcanization 6.3.1 Liquid Curing Method 6.3.2 Fluidized Bed Vulcanization 6.3.3 Continuous Vulcanization in Stem Pipes 6.3.4 Rotocure, 6.3.5 hot air tunnel vulcaznization techniques **Course Outcome: CO6** **Teaching Hours: 8 hours Marks: 10**

Note: Any one unit from the above five units, has to be preferably taught by alumni of Govt. Polytechnic Mumbai.

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr. No	Laboratory Experiment / Practical Titles / Tutorial Titles	No. of hours.	Relevant COs
Understand the significance of these parameters in rubber vulcanization.	1	Perform of experiments on ODR & Do study of Rheometer graph, Calculate cure time & Scorch time.	6	CO1
Prepare rubber compounds using **Conventional (CV)**, **Efficient (EV)**, and **Semi-Efficient (Semi EV)** vulcanization systems.	2	Prepare CV, EV & Semi EV Batch of Rubber compound and do comparison of Rheotest.	4	CO2
Measure and compare the **tensile strength** of vulcanized samples.	3	Prepare CV, EV & Semi EV Batch of Rubber compound and do comparison of tensile strength.	4	CO5
Perform compression tests to evaluate the elastic recovery and deformation behavior of each system.	4	Prepare CV, EV & Semi EV Batch of Rubber compound and do comparison of compression test.	4	CO5

Understand the chemistry and advantages of peroxide curing over sulfur vulcanization.	5	Prepare Rubber compound of peroxide cure in synthetic rubber.	4	CO2
Understand the role of curing agents and accelerators in CR vulcanization.	6	Prepare Rubber compound of CR using proper curing systems.	4	CO2
Measure and analyze the swelling resistance of rubber samples at different cure states.	7	Do study of effect of state of cure on swelling of rubber compound in fluids.	4	CO5
		Total	**30**	

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / SkillsDevelopment (Self Learning):

Note: Student are required to complete any four micro projects from the suggested list given below. Similar micro projects could be added or given to the students by the concern faculty.

1. Comparative Study of Vulcanized vs. Unvulcanized Rubber (CO1)
   - Prepare samples of **vulcanized** and **unvulcanized rubber** and compare their **mechanical properties** (e.g., tensile strength, elasticity).
   - Present findings in a report or presentation, highlighting the structural changes during vulcanization.

2. Effect of Different Vulcanizing Agents on Rubber Properties (CO2)
   - Prepare rubber compounds using **sulfur**, **peroxides**, and **metal oxides** as vulcanizing agents.
   - Compare their **cure characteristics** (e.g., cure time, scorch time) and **mechanical properties** (e.g., hardness, modulus).

3. Optimization of Accelerator Systems in Rubber Compounding (CO3)
   - Formulate rubber compounds using different **accelerators** (e.g., thiazole, sulfenamide, thiuram).
   - Evaluate their impact on **cure rate** and **final properties** of the vulcanizate.

4. Crosslink Density Measurement Using Swelling Techniques (CO4)
   - Measure the **crosslink density** of vulcanized rubber samples using **swelling tests** in solvents.
   - Correlate crosslink density with **mechanical properties** like tensile strength and hardness.

5. Analysis of Rheometer Curves for Different Cure Systems (CO4)
   - Generate **rheometer curves** for rubber compounds cured with **CV, EV, and Semi EV** systems.
   - Analyze the curves to determine **cure time**, **scorch time**, and **optimum cure**.

6. Study of Heat Aging on Vulcanized Rubber Properties (CO5)
   - Expose vulcanized rubber samples to **heat aging** and evaluate changes in **tensile strength**, **hardness**, and **elongation at break**.
   - Discuss the implications for rubber product durability.

7. Comparison of Batch vs. Continuous Vulcanization Techniques (CO6)
   - Prepare rubber samples using **batch** (e.g., molding, autoclave) and **continuous** (e.g., rotocure, hot air tunnel) vulcanization methods.
   - Compare their **curing efficiency** and **product properties**.

8. Effect of Peroxide Cure on Synthetic Rubber Properties (CO2)
   - Prepare and vulcanize synthetic rubber (e.g., EPDM) using **peroxide cure**.
   - Compare its properties (e.g., heat resistance, compression set) with sulfur-cured rubber.

9. Swelling Resistance of Rubber in Different Fluids (CO5)
   - Test the **swelling resistance** of vulcanized rubber in various fluids (e.g., oil, water, solvents).
   - Correlate swelling behavior with the **cure system** and **crosslink density**.

10. Design and Fabrication of a Rubber Product Using Optimal Vulcanization Techniques (CO6)
   - Design a simple rubber product (e.g., gasket, seal) and fabricate it using the most suitable **vulcanization technique**.
   - Evaluate the product's performance based on **mechanical properties** and **durability**.

VII. Specification Table:

Unit No	Topic Title	Distribution of Theory Marks			
		R Level	U Level	A Level	Total Marks
1	Introduction	4	2	2	8
2	Types of Vulcanizing agents & their effects	4	6	4	14
3	Accelerators	4	4	2	10
4	The assessment of state of vulcanization	4	2	2	8
5	Glass Transition Temperature and order in crystalline Rubbers & Polymers	4	2	4	10
6	Vulcanization Techniques:	4	2	4	10
Total		24	18	18	60

VIII. Suggested COs - POs Matrix Form

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)	
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PSO-1	PSO-2
CO1	2	3	2	1	3	3	2	3	2
CO2	2	2	1	2	2	3	2	3	3
CO3	2	3	3	3	2	2	3	3	2
CO4	3	2	3	2	3	3	2	2	2
CO5	2	3	1	2	3	2	2	3	3
CO6	3	2	1	2	2	3	2	2	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

IX. Suggested Learning Materials / Books:

Sr. No.	Title	Author, Edition and Year Ofpublication	Publisher,
1	Vulcanization of rubber	Hoffman	Hanser Publishers, Munich & Vienna
2	Rubber Technology	C.M. Blow	-------
3	Natural & Synthetic Rubber	H.J. Sterm	-------
4	Rubber Technology Hand Book	R.T. Vanderbil	R.T. Vanderbilt Co. Inc
5	Rubber Engineering	I.R.I.	I.R.I.

X. Learning Websites & Portals

Sr.No	Link / Portal
1	http://www.ajer.org/papers/rase-2-2013/Volume-3/BV120130813.pdf
2	https://en.wikipedia.org/wiki/Vulcanization
3	https://www.ias.ac.in/public/Volumes/reso/002/04/0055-0059.pdf
4	https://www.nocil.com/Downloadfile/DTechnicalNote-Vulcanization-Dec10.pd

XI. Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Ravindra Barde	Industry Expert	Sidhhi Elasto Pvt. LTD.
2	Mr. Dharmesh Dhanani	Industry Expert	Elphiepoly Pvt. LTD.
3	Mr. Sahil Ranoliya	Lecturer in Rubber Technology	AIRIA
4	Mr. Sahil Soliya	Lecturer in Rubber Technology	AIRIA

Coordinator,
Curriculum Development,
Department of Rubber Technology

Head of Department
Department of Rubber Technology

I/C, Curriculum Development Cell

Principal

Programme : Diploma in Rubber Technology (Sandwich Pattern)													
Course Code: RT23405	**Course Title : Rubber Compounding Materials**												
Compulsory / Optional: Compulsory													
Learning Scheme and Credits						**Assessment Scheme**							
CL	**TL**	**LL**	**SLH**	**NLH**	**Credits**	**FA-TH**		**SA-TH (2Hrs. 30mins.)**	**FA-PR**	**SA**		**SLA**	**Total**
						T1	**T2**			**PR**	**OR**		
3	**-**	**2**	**1**	**6**	**3**	**--**	**--**	**--**	**25**	**50**	**--**	**25**	**100**

Total IKS Hrs. for course: 3hrs.

Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, SLA- Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination, @$ Internal Online Examination

Note:

1. FA-TH represents an average of two class tests of 30 marks each conducted during the term.
2. SA-TH represents the end term examination.
3. FA-PR represents the term work.
4. SA-PR represents the end term practical examination.

I. Rationale

A rubber technologist must have an understanding of various compounding ingredients used in making the rubber articles as raw rubber is seldom useful without compounding. The ingredients used in compounding plays a very important part in the properties of final products, its cost of manufacturing and performance quality etc. It will help him understand the fundamental principles of selecting ingredients for compounding.

II. Industry / Employer Expected Outcome

To manufacture, produce, prepare, press, vulcanize, repair, retread, export, import, purchase, sell and generally to carry on business in tyres and semi-tyres.

III. Course Outcomes: Students will be able to achieve & demonstrate the following COs on completion of course based learning

CO1	To Understand the need of compounding.
CO2	To know about carbon black and its types and its role in rubber compounding.
CO3	Analyze the effects of different fillers on rubber compound.
CO4	To Know about different-different compounding materials.
CO5	To understand role of antidegrantes.
CO6	To understand art of compounding.

IV.Course Content Details:

UnitNo.	Theory Learning Outcomes (TLO's)aligned to CO's	Topics / Sub-topics
1.	1. Define compounding and explain the roles of ingredients like fillers, vulcanizing agents, and plasticizers in rubber formulations. **2.** Differentiate between general-purpose and specialty rubbers and explain the incorporation of fillers in rubber compounds.	**Compounding** 1.1Definition of Compounding 1.2 Characteristics of rubbers 1.3General purpose and specialty rubber 1.4 Incorporation of fillers 1.5Vulcanizing agents 1.6 Compounding ingredients **Course Outcome:CO1** **Teaching Hours: 6 hours Marks: 10**
2.	1. Describe the **manufacturing processes** and **properties** of carbon black and their impact on rubber vulcanizates. 2. Classify carbon black based on **particle size**, **structure**, and **DBP absorption** and analyze its effects on rubber properties.	**Carbon Black** **2**.1 Introduction 2.2 Properties 2.2.1 Physical Properties 2.2.2 Chemical Properties 2.2.3 Health & Safety 2.3 Manufacture 2.3.1 Lampblack 2.3.2 Channel Black 2.3.3 Thermal Black 2.3.4 Acetylene Black 2.3.5 Furnace Black 2.4 Characterization of Carbon Black 2.4.1 Particles size& Structure 2.4.2 Classification of carbon Black According to Particle size 2.4.3 DBP absorption 2.4.4 Acid value and PH 2.4.5 Ash content 2.4.6 Mesh size & Iodine Numbers 2.5 Effect of properties of carbon black on properties of rubber Vulcanizate. **Course Outcome: CO2** **Teaching Hours:10 hours Marks: 10**
3	1. Classify and describe the roles of **mineral** and **synthetic fillers** in rubber compounding. 2. Compare **precipitated silica** with other fillers and discuss their impact on rubber processing and performance.	**Precipitate Silica and Non- Black Fillers** 3.1 Mineral Fillers 3.1.1 Calcium Carbonate 3.1.2 Baryte 3.1.3 Ground Crystalline Silica 3.1.4 Clay 3.1.5 Talc 3.1.6 Alumina Tyrihydrate 3.2 Synthetic Fillers 3.2.1 Precipitated Calcium carbonate 3.2.2 Metal Oxide 3.2.3 Precipitated Silica 3.2.4 Silicates Page

		Course Outcome: CO3 **Teaching Hours: 8 hours Marks:8**
4	1. Explain the roles of **plasticizers**, **process aids**, and **blowing agents** in rubber formulations. 2. Describe the functions of **accelerators**, **activators**, and **bonding agents** in rubber technology.	**Compounding Materials** 4.1 Plasticizers 4.1.1 Petroleum Oil Plasticizer 4.1.1.1 Aromatic Oil 4.1.1.2 Naphthenic Oil 4.1.1.3 Paraffinic Oil 4.1.2 Synthetic Plasticizer 4.1.3 Epoxydiesed vegetable oils 4.2 Process aids & Factices 4.2.1 Resins 4.2.2 Factices 4.3 Accelerators & Activator 4.3.1 Classification of accelerators 4.3.2 Zinc oxide and Stearic acids 4.4 Blowing Agents 4.4.1 Inorganic Blowing agents 4.4.2 Organic Blowing Agents 4.5 Bonding Agents 4.5.1 Resins 4.5.2 RF Resins 4.5.3 VP Latex 4.6 Peptisers, 4.7 Colors & Pigments 4.8 Coupling Agents **Course Outcome: CO4** **Teaching Hours: 06 hours Marks: 10**
5	1.Classify **antidegradants** and explain their role in enhancing the durability of rubber products. 2.Compare **staining** and **non-staining antioxidants** and analyze their effects on rubber aging resistance.	**Antidegrants** 5.1 Properties of Ant degradants 5.1.1 Discoloration and Staining 5.1.2 Volatility 5.1.3 Solubility and Migration 5.1.4 Chemical Stability 5.1.5 Physical Form 5.1.6 Ant degradants Concentration 5.2 Ant degradant Types 5.2.1 Non-Staining, Non-Discoloring Antioxidants 5.2.2Staining/Discoloring Antioxidants 5.2.3Antiozonants **Course Outcome: CO5** **Teaching Hours: 07 hours Marks: 10**
6	1.Explain the principles of compounding and the steps in formulating a rubber mix, including cost and specific gravity calculations. 2.Discuss the role of compounding in achieving desired vulcanizate properties and bonding rubber to non-rubber substrates.	**Principles of Compounding & Art of compounding** 6.1 Introduction 6.2 The ingredients & formulation of a mix 6.3 Compounding to meet processing requirements 6.4 Compounding of Vulcanizate properties 6.5 Compounding for Bonding to non-rubber substrates 6.6 Calculation of compound cost of a recipe 6.7 Calculation of compound volume of a recipe 6.8 Calculation of compound specific gravity of a recipe, 6.9 Formulation of mix

		6.10 Processing **Course Outcome: CO6** **Teaching Hours: 08 hours Marks: 12**

Note: Any one unit from the above five units, has to be preferably taught by alumni of Govt. Polytechnic Mumbai.

V. Laboratory Learning Outcome and Aligned Practical / Tutorial Experiences.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr. No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hours.	Relevant COs
Determination of Iodine Absorption no. Particle Size And DBP no of Carbon Black.	1	Determination of Iodine Absorption no. Particle Size And DBP no of Carbon Black.	02	CO2
Determination of Viscosity , Flash Point, Aniline Points of Processing Oil.	2	Determination of Viscosity , Flash Point, Aniline Points of Processing Oil.	04	C04
Determination of Melting Point and Solubility of Rubber Chemicals	3	Determination of Melting Point and Solubility of Rubber Chemicals	02	CO4
Determination of Moisture Contents of Fillers , Accelerators	4	Determination of Moisture Contents of Fillers , Accelerators	04	CO3
Determination of Ash Content , Moisture contents, pH of Calcium Carbonate , China Clay & Silica.	5	Determination of Ash Content , Moisture contents, pH of Calcium Carbonate , China Clay & Silica.	02	CO3
Mixing of Formulation as per given Mixing Sequence on a two roll mixing mill. Determination of specific gravity of rubber compound and comparing it with theoretical specific gravity.	6	Mixing of Formulation as per given Mixing Sequence on a two roll mixing mill. Determination of specific gravity of rubber compound and comparing it with theoretical specific gravity.	04	CO6
To Prepare Rubber compound to meet a given hardness	7	To Prepare Rubber compound to meet a given hardness	02	CO6
Blending Two Rubber and studying the changes in characteristic properties of the compound.	8	Blending Two Rubber and studying the changes in characteristic properties of the compound.	04	CO6
Prepare rubber compound for “”O”” ring and determine its physical properties	9	Prepare rubber compound for “”O”” ring and determine its physical properties	02	CO6
Comparative Study of Tensile, Tear strength & Abrasion Resistance of Natural Rubber and Styrene Butadiene Rubber	10	Comparative Study of Tensile, Tear strength & Abrasion Resistance of Natural Rubber and Styrene Butadiene Rubber	04	CO6
		Total	**30**	

VI. Suggested Micro Project / Assignment/ Activities for Specific Learning / Skills Development (Self Learning):

Note: Student are required to complete any two micro projects from the suggested list given below. Similar micro projects could be added or given to the students by the concern faculty.

1. Comparative Study of General Purpose vs. Specialty Rubbers
   - **Objective**: Compare the properties (e.g., tensile strength, elasticity, and chemical resistance) of general-purpose rubber (e.g., SBR) and specialty rubber (e.g., silicone rubber).

2. Effect of Carbon Black Particle Size on Rubber Vulcanizate Properties
   - **Objective**: Prepare rubber compounds with different carbon black particle sizes (e.g., furnace black vs. channel black) and analyze their impact on tensile strength, abrasion resistance, and hardness.

3. Preparation and Characterization of Rubber Compounds with Non-Black Fillers
   - **Objective**: Incorporate non-black fillers (e.g., precipitated silica, calcium carbonate) into rubber and evaluate their effects on mechanical properties.

4. Optimization of Plasticizers in Rubber Compounding
   - **Objective**: Test the effects of different plasticizers (e.g., aromatic oil, paraffinic oil) on the flexibility and processing of rubber compounds.5. Study of Accelerators in Vulcanization

5. Study of Accelerators in Vulcanization
   - **Objective**: Prepare rubber compounds with different accelerators (e.g., thiazoles, sulfenamides) and compare their curing time and vulcanizate properties.

6. Formulation and Cost Analysis of a Rubber Compound
   - **Objective**: Develop a rubber compound recipe, calculate its cost, and evaluate its specific gravity and volume.

7. Evaluation of Antioxidants in Rubber Aging
   - **Objective**: Test the effectiveness of staining (e.g., amine-based) and non-staining (e.g., phenolic) antioxidants in preventing rubber degradation.

8. Preparation of Rubber Compounds with Blowing Agents
   - **Objective**: Incorporate organic and inorganic blowing agents into rubber and study their effects on foam density and cell structure.

9. Bonding Rubber to Non-Rubber Substrates
   - **Objective**: Use bonding agents (e.g., RF resins, VP latex) to bond rubber to metal or fabric and evaluate the bond strength.

10. Characterization of Carbon Black Using Iodine Number and DBP Absorption
    - **Objective**: Perform experiments to determine the iodine number and DBP absorption of different carbon black samples and correlate these properties with rubber performance.

VII. Specification Table: Not Applicable

VIII. Suggested COs - POs Matrix Form

Course Outcome s (COs)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)	
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PSO-1	PSO-2
CO1	2	3	2	1	3	3	2	3	2
CO2	2	2	1	2	2	3	2	3	3
CO3	2	3	3	3	2	2	3	3	2
CO4	3	2	3	2	3	3	2	2	2
CO5	2	3	1	2	3	2	2	3	3
CO6	3	2	1	2	2	3	2	2	2
Legends: - High:03, Medium:02, Low:01, No Mapping: --									

IX. Suggested Learning Materials / Books:

Sr. No.	Title	Author, Edition and Year Ofpublication	Publisher,
1	Handbook of Rubber Technology	Hoffman	Hanser Publishers, Munich & Vienna
2	Rubber Technology	C.M. Blow	Butterworth Scientific, London.
3	Rubber Technology Hand Book	R.T. Vanderbilt	R.T. Vanderbilt Co. Inc

X. Learning Websites & Portals:

https://www.youtube.com/watch?v=9N5SS8f1auI
https://www.youtube.com/watch?v=P8u2s7s4N3c&t=10s
https://www.youtube.com/watch?v=j1ov7qWfJbM

XI.Academic Consultation Committee/Industry Consultation Committee:

Sr. No	Name	Designation	Institute/Organization
1	Mr. Ravindra Barde	Industry Expert	Sidhhi Elasto Pvt. LTD.
2	Mr. Dharmesh Dhanani	Industry Expert	Elphiepoly Pvt. LTD.
3	Mr. Sahil Ranoliya	Lecturer in Rubber Technology	AIRIA
4	Mr. Sahil Soliya	Lecturer in Rubber Technology	AIRIA

Coordinator,
Curriculum Development,
Department of Rubber Technology

Head of Department
Department of Rubber Technology

I/C, Curriculum Development Cell

Principal