Curriculum of Diploma Programme

in

Automobile Engineering

Department of Science, Technology and Technical Education (DSTTE), Govt. of Bihar

State Board of Technical Education (SBTE), Bihar

Semester – IV
Teaching & Learning Scheme

CourseCodes	Category of course	CourseTitles	Teaching & Learning Scheme (Hours/Week)					
			Classroom Instruction (CI)		Lab Instruction(LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
			L	T				
2433401	**PCC**	**Automobile Engine**	03	-	-	02	05	04
2425402	**PCC**	**Fluid Mechanics & Hydraulic Machinery** (ME, ME (Auto), AE, FTS)	03	-	04	02	09	06
2433403	**PCC**	**Automobile Control System**	03	-	04	02	09	06
2425404	**PCC**	**Theory of Machines** (ME, ME (Auto))	03	-	04	02	09	06
2433405	**PCC**	**Auto-component Manufacturing Process**	03	-	04	02	09	06
2400108	**NRC**	**Essence of Indian Knowledge System and Tradition** (Common for All Programmes)	01	-	-	-	01	01
2400111	**NRC**	**Principles of Management**	01	-	-	-	01	01
Total			**17**	**-**	**16**	**10**	**43**	**30**

Note: Prefix will be added to course code if applicable (T for Theory Paper, P for Practical Paper and S for Term Work)

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

Semester - IV
Assessment Scheme

Course Codes	Category of course	Course Titles	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
			Theory Assessment (TA)		Term work & Self-Learning Assessment (TWA)		Lab Assessment(LA)		
			Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2433401	**PCC**	**Automobile Engine**	30	70	20	30	-	-	150
2425402	**PCC**	**Fluid Mechanics & Hydraulic Machinery** (ME, ME (Auto), AE, FTS)	30	70	20	30	20	30	200
2433403	**PCC**	**Automobile Control System**	30	70	20	30	20	30	200
2425404	**PCC**	**Theory of Machines** (ME, ME (Auto))	30	70	20	30	20	30	200
2433405	**PCC**	**Auto-component Manufacturing Process**	30	70	20	30	20	30	200
2400108	**NRC**	**Essence of Indian Knowledge System and Tradition** (Common for All Programmes)	25	-	-	-	-	-	25
2400111	**NRC**	**Principles of Management**	25	-	-	-	-	-	25
Total			**200**	**350**	**100**	**150**	**80**	**120**	**1000**

Note: Prefix will be added to course code if applicable (T for Theory Paper, P for Practical Paper and S for Term Work)

Note:

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activitie.

A) Course Code : **2433401(T2433401/S2433401)**

B) Course Title : Automobile Engine

C) Pre- requisite Course(s) : None

D) Rationale :

All automotive vehicles are powered by engines. Hence the fundamental knowledge of automobile engine is most essential for an automobile engineer. This basic course will acquaint the student with the design features and operating characteristics of different types of automobile engines including combustion process in petrol engines and diesel engines. This course also imparts adequate knowledge on engine cooling and lubrication system with reference to engine power, efficiency, and pollutants. This course forms the basis for the Advanced Automobile Engine.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

- **CO-1** Identify the different petrol and diesel engine components of the given vehicle
- **CO-2** Apply the basic engine terminology for selecting the best suited engine for the given application.
- **CO-3** Select the relevant coolant, lubricant and engine oil for the given situation.
- **CO-4** Choose the relevant fuel supply system components for the given petrol and diesel engines
- **CO-5** Perform basic calculations relating to the performance of automobile engines

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	PO-1 Basic and Discipline Specific Knowledge	**PO-2** Problem Analysis	**PO-3** Design/ Develop-ment of Solutions	**PO-4** Engineering Tools	**PO-5** Engineering Practices for Society, Sustainabilit yand Environment	**PO-6** Project Management	**PO-7** Life Long Learning	**PSO-1**	**PSO-2**
CO-1	3	-	-	2	-	-	2		
CO-2	3	3	2	2	3	-	-		
CO-3	3	2	-	2	-	-	-		
CO-4	3	3	2	2	2	-	-		
CO-5	3	2	-	2	2	-	2		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
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I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2433401

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Identify the types of engine. *TSO 1b.* Explain the parts of engine. *TSO 1c.* Differentiate between SI and CI engine. *TSO 1d.* Differentiate between 2 stroke and 4 stroke engine.	**Unit-1.0 Engine principles and Fundamentals** 1.1. Introduction 1.2. Basic engine nomenclature 1.3. Classification of automobile engines. 1.4. Engine specifications and application 1.5. Merits and Demerits of vertical and horizontal engines. 1.6. Four stroke SI and CI engine 1.7. Two stroke cycle engine. 1.8. Comparison of two stroke and four stroke cycle engines 1.9. Reasons for using single cylinder two stroke and four stroke cycle engines	**CO1, CO2**
TSO 2a. Describe the functions of different engine components. TSO 2b. Describe constructional features and materials of different components of the given engines with sketches. TSO 2c. Explain the valve timing diagram. TSO 2d. Explain the port timing diagram.	**Unit-2.0 Constructional Features of Automobile Engine Components** 2.1 Cylinder block, cylinder liner, types of liner, comparison of dry and wet liners, cylinder head, gaskets, type of gaskets etc 2.2 Piston, piston rings, Piston ring joints, piston pin. 2.3 Crank shaft, camshaft, connecting rod, valve, valve cooling, valve mechanisms, valve timing, port-timing diagram, manifolds, silencers, flywheel etc. 2.4 Types of camshaft drives. 2.5 Rotary and reed valve	**CO1, CO2**
TSO 3a. Explain the purpose of cooling. TSO 3b. Differentiate between air cooling system and water cooling systems. TSO 3c. Identify the parts of cooling system. TSO 3d. Describe attributes and effects of the given type of coolant and lubricant TSO 3e. Explain the purpose of lubrication. TSO 3f. Describe the properties of the given type of engine oil TSO 3g. Select the relevant coolant, lubricant and engine oil for the given situation.	**Unit-3.0 Engine Cooling and Lubrication System** **Part A** 3.1 Necessity and Function of engine cooling system 3.2 Cooling Systems- Air cooling system, water cooling systems, Comparison of air- & water-cooling systems. 3.3 Parts of cooling system: • Thermostat, water expansion tank, Temperature Indicator Pressure cap, water pump, fan and fan belt. • Radiator: Construction and type of radiator cores. • Types and Characteristics of a Coolant, and their effect on performance of engine cooling; **Part B** 3.4 Lubrication system: Need, Properties and additives of lubricating oil, Parts to be lubricated 3.5 Classification of Lubricating Oils on the basis of Viscosity (SAE) and Load (API) Severity rating; 3.6 Types of lubrication system: Splash, Pressure – wet sump and dry sump 3.7 Function of Components: Oil filters, Pump and its drive, pressure regulator, oil pressure gauge.	**CO3**
TSO 4a. Explain the working of the fuel injection systems in petrol engine	**Unit-4.0 Fuel Systems**	**CO4**

TSO 4b. Describe with sketches the working of the given type of fuel pump *TSO 4c.* Describe working of the given type of carburetion system *TSO 4d.* Explain the working of the diesel fuel injection systems with sketches *TSO 4e.* Identify different fuel supply components in the given diesel fuel injection systems *TSO 4f.* Describe with sketches the working of different fuel injectors. *TSO 4g.* Explain the meaning of Air fuel mixture ratio and its influence on the performance of a given engine	**Part A-Petrol Engine** 4.1. Fuel feed system in petrol engines 4.2. Mechanical fuel pump, electrical fuel pump 4.3. Principles of carburetion. 4.4. Simple Carburetor. 4.5. Starting, Idling & slow running, acceleration, Main metering system, choke system. 4.6. S.U. Carburetor, Solex Carburetor. 4.7. Carburetors used in two wheelers and four wheelers. **Part B- Diesel engine** 4.8 Requirement of fuel injection system. 4.9 Various components & Diesel Fuel injection system. 4.10 Types of fuel injection pumps for single and multi-cylinder engines, inline and rotary types of fuel injection pumps. 4.11 Types of fuel injectors. 4.12 Air fuel mixture ratio in a petrol and diesel engine and comparison. 4.13 Mixture requirement for Transient conditions.	
TSO 5a. Describe the different types of engine power. *TSO5b.* Calculate the different types of efficiency of an engine. *TSO 5*c. Perform the Morse test on a given engine *TSO 5d.* Interpret the given heat balance sheet.	**Unit-5.0 Engine Performance and Testing** 5.1. Engine Power – Indicated, Brake and Frictional Power. 5.2. Efficiency- Mechanical, Thermal, Relative and Volumetric. 5.3. Fuel Consumption- BSFC 5.4. Morse test, Motoring test. 5.5. Heat Balance Sheet.	**CO5**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self Learning: S2433401 Some sample suggested assignments, micro project and otheractivities are mentioned here for reference.

a. Assignments:

i Compare 2 stroke and 4 stroke engine.

ii Draw a neat sketch of the different components of automobile engine and write its application.

iii Compare air cooling system and water cooling system.

iv Differentiate between dry sump lubrication system and wet sump lubrication system

v Explain the working of Carburettor with a neat sketch.

Note: Some more Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Choose a modern engine. Search information on any one system from website. Prepare a report for the same.
2. Investigate valve timing diagram of a four stroke engine. Verify result with manufacturer's specification.
3. Make a few engines components/ their models using suitable material like thermocol /wood/ plastic.
4. Prepare a CAD production drawing of some engine components.
5. Collect the data /specification of different types of petrol engines commonly used in vehicles and compare it.
6. Prepare display charts for engine cooling system, Lubrication system, Diesel fuel injector system etc.,
7. Identify the advance fuel feeding systems used in modern vehicle and prepare report on it.

c. Other Activities:

1. Seminar topics
   - Comparison of air and water cooling system.
   - Functions of different automobile engine components.
   - Parts of cooling system and its application.

2 Visits:
   - Visit near-by automobile workshop and identify the different parts of automobile engine and prepare a report on the same.
   - Visit near-by automobile workshop and Carryout measuring practice and prepare report on:
     - Cylinder bore,
     - Connecting rod bore,
     - Inside diameter (ID) of a camshaft bearing
   - Visit near-by automobile workshop and observe overhauling of any one of the assemblies and prepare report on :
     - Cylinder head assembly
     - Piston and connecting rod Assembly
   - Visit near-by automobile workshop and observe working operation of the any one of the Fuels supply system:
     - fuel feed system in petrol engine
     - Diesel fuel injection system

     and prepare a report on the same.
   - Visit nearby automobile manufacturing plant and prepare a report of the same.

3. Self-learning topic
   - Prepare journals based on practical performed in laboratory.
   - Prepare power point presentation or animation for understanding constructional details and working of fuel system and cooling system.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work& Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	10%	10%	-	-	-	-
CO-2	30%	30%	30%	30%	30%	-	-
CO-3	20%	20%	25%	25%	25%	-	-
CO-4	30%	30%	25%	30%	30%	-	-
CO-5	10%	10%	10%	15%	15%	-	-
Total Marks	**30**	**70**	**20**	**20**	**10**	-	-
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application& above(A)
Unit-1.0 Engine principles and fundamentals	6	CO1, CO2	8	4	4	-
Unit-2.0 Constructional features of automobile engine components	14	CO1, CO2	20	4	10	6
Unit-3.0 Engine cooling and Lubrication system	10	CO3	14	4	4	6
Unit-4.0 Fuel Systems	12	CO4	20	4	10	6
Unit-5.0 Engine Performance and Testing	6	CO5	8	2	-	6
Total	**48**	**-**	**70**	**18**	**28**	**24**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested AssessmentTable for Laboratory (Practical): (Not Applicable)

P) Suggested Instructional/Implementation Strategies: S2433401 Different Instructional/ Implementation Strategies maybe appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Automobile Engineering	R. B. Gupta	Satya Prakashan, New Delhi ISBN-13: 9788176843799
2.	Automobile Engineering vol-II	Anil Chhikara	SatyaPrakashan, New Delhi ASIN : B0BW9TWWBN
3.	Automobile Engineering	K. M. Gupta	Umesh Publication ISBN-13: 5551234002614
4.	Automobile Engineering	Jain K. K., Asthana R. B.	Tata Mc-Graw Hill Publishing Co. Ltd. ISBN-13 : 978-0070445291
5.	Transmission and power train	W. H. Crouse & D.L. Anglin	Tata Mc-Graw Hill Publishing Co. Ltd. ISBN-13 : 978-0070146372

(b) Online Educational Resources:

1. http://www.youtube.com/watch?v=H7Iay0Ke_t4
2. http://www.youtube.com/watch?v=OQ9eI7mEmxw
3. http://www.youtube.com/watch?v=FfjGohWy-OU
4. http://www.youtube.com/watch?v=IKywZ730JFs
5. http://www.youtube.com/watch?v=eKKfJAaVBjE
6. http://www.youtube.com/watch?v=aUlS25r3XY0
7. http://www.youtube.com/watch?v=VcFQZ8NiF4o
8. http://www.youtube.com/watch?v=17FG-GzVJyI
9. http://www.youtube.com/watch?v=1-ksUrWmBo4
10. http://www.ehow.com/video_2327738_overview-shocks-suspension-system.html
11. Howstuffworks.com
12. Wikipedia.com

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

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A) Course Code : 2425402(T2425402/P2425402/S2425402)

B) Course Title : Fluid Mechanics & Hydraulic Machinery (ME, ME (Auto), AE, FTS)

C) Pre- requisite Course(s) : Engineering Mechanics

D) Rationale :

In engineering field knowledge of fluid properties, fluid flow and fluid machinery are essential in all fields of engineering. Hydraulic machines have important role in water supply, irrigation, power generation and also in most of the engineering segments. This course is intended to develop the skills to estimate loss in pipes, efficiency of hydraulic machines like turbine pumps etc. and select a pump for a particular application. Diagnose and rectify the faults in pumps and turbines, replace pressure gauges and other accessories on hydraulic machines turbines, and apply their knowledge in hydraulics to select appropriate devices like pressure gauges, valves, flow devices, pipes etc. for different field applications.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

- **CO-1.** Analyze various fluid characteristics.
- **CO-2.** Apply the fluid flow energy equations to real field situations.
- **CO-3.** Analyze various losses in flow through pipes
- **CO-4.** Select relevant turbine as per the situation.
- **CO-5.** Select a relevant pump as per the requirement

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	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**
CO-1	3	2	1	1	-	-	1	-	-
CO-2	2	2	1	1	-	-	1	-	-
CO-3	3	2	1	1	1	-	1	-	-
CO-4	3	2	-	1	1	1	1	-	-
CO-5	3	2	-	1	1	1	1	-	-

Legend: High (3), Medium (2), Low (1) and No mapping (-)

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J) Theory Session Outcomes (TSOs) and Units: T2425402

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.1a Compare the given two fluids based on the given physical properties. TSO.1b Choose the relevant pressure TSO.1c Measuring device for the given situation with justification. TSO.1d Calculate the Hydrostatic forces in the given situation as per the given data. TSO.1e Calculate pressure head for a given condition. TSO.1f Calculate centre of pressure and total pressure of regular immersed bodies. TSO.1g Calculate Metacentric height and Centre of buoyancy of the given floating body.	**Unit-1.0 Properties of Fluid and Fluid Pressure** 1.1 Introduction and classification of fluid. 1.2 Fluid properties- Density, Specific gravity, specific weight, specific volume, Dynamic & Kinematic viscosity, Surface tension, Capillarity, Vapour pressure, Compressibility, Bulk modulus. 1.3 Types of fluids: Ideal, Real, Newtonian, Non-Newtonian, Plastic 1.4 Pressure, Fluid pressure, pressure head, Pressure Intensity, Concept of absolute Vacuum, Gauge Pressure, Atmospheric Pressure, Absolute Pressure, 1.5 Pressure measurement- Manometer, U- tube manometer, Incline manometer, Inverted U manometer, Piezometer. 1.6 Concept of Total pressure, Centre of pressure, Pascal's law, Hydrostatic forces on plane and curved surface immersed in liquid and simple problems on it, Metacenter	**CO1**
TSO.2a Identify the given type of fluid flow. *TSO.2b* Identify the various forms of energy related to given fluid flow. *TSO.2c* Calculate the total energy in a given fluid. *TSO.2d* Apply the continuity equation to given real system. *TSO.2e* Solve numerical problems on Bernoulli equations	**Unit-2.0 Fluid Flow** 2.1 Various forms of energies applicable to fluid flow – Potential energy, Kinetic energy, Pressure energy, Total energy, Types of fluid flows- Steady, unsteady, uniform, non-uniform, laminar and turbulent flow, Path line and Stream line, Concept of datum pressure, Velocity and total head of fluid in motion. 2.2 Continuity equation, Energy equation- Steady flow energy equation and derivation of Bernoulli Theorem and its assumption and practical application. 2.3 Flow measurement- Construction, Working and application of Venturi meter, Orifice meter and Pitot tube, Derivations for discharge, coefficient of discharge, Vena-Contraction, coefficient of contraction and numerical problems.	**CO2**
TSO.3a Determine the flow is laminar or turbulent in the pipe flow. *TSO.3b* Calculate the different types of minor and major losses. *TSO.3c* Calculate the loss of head in fluid flow through pipes in a given situation as per the given data.	**Unit 3.0 Flow through Pipes** 3.1 Flow Through Pipes- Laminar and turbulent flows 3.2 Viscous flow- Concept of viscosity of fluids, Reynolds number and its criteria for plate and pipes, Darcy's Weisbach equation and Chezy's equation for frictional losses, loss of head due to friction in pipe, Hagen- Poiseuille formula	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO.3d Explain various losses in flow through pipes, fittings and valves. *TSO.3e* Solve numerical based on continuity equation, laws of friction and losses in flow through pipes. *TSO.3f* Explain the effect of water hammer due to the sudden change in velocity and pressure of the given fluid.	3.3 Flow through pipes- Pipes in series, Pipes in parallel, Head losses- various types of minor and major energy loss occur in fluid flow through pipes. H.G.L. and T.E.L., surge tank, water hammer and its effects.	
TSO.4a Calculate the impact of jet on flat plate. TSO.4b Calculate the impact of jet on curved plate. TSO.4c Calculate the force exerted by impact of jet plate in stationary and moving blades TSO.4d Draw the layout of hydroelectric power pant. TSO.4e Select suitable turbine for a given site/situation with justification. TSO.4f Describe the construction and working of the given water turbines. TSO.4g Describe the construction and working of the given draft tube. TSO.4h Calculate the work done, power, efficiency of turbines. TSO.4i Analyze the performance of turbine.	**Unit 4.0 Impact of jets & Hydraulic Turbines** 4.1 Impact of jet on flat and curved plate in stationary and moving blades, Simple Numerical on work done and efficiency. 4.2 Layout of hydroelectric power plant, Features of Hydroelectric power plant, Classification of hydraulic turbines, 4.3 Functions and working principle of Impulse and reaction turbine, Comparison of impulse and reaction turbine 4.4 Construction, function and working principle of Pelton wheel, Francis and Kaplan turbines, Draft tubes– types and construction, Concept of cavitation in turbines and benefit of draft tubes 4.5 Calculation of Work done, Power, efficiency of turbines, and Unit quantities 4.6 Selection of turbine on the basis of head and discharge available. 4.7 Safety precaution on turbines	**CO4**
TSO.5a Identify the different types of hydraulic pumps TSO.5b Describes construction and working of the given pump. TSO.5c Select suitable Pump for a given application with justification. TSO.5d Explain construction and working of the given reciprocating pump. TSO.5e Calculate the work done and overall efficiency and power required for the given pump. TSO.5f Analyze the performance of pumps.	**Unit-5.0 PUMPS** 5.1 Centrifugal Pumps – construction, working Principle and applications of centrifugal pump, Classification of centrifugal pump, impellers, casing, 5.2 Concept of multistage, Priming and its methods, Cavitation, Manometric head, Work done, Manometric efficiency, Overall efficiency. 5.3 Reciprocating Pumps- Construction, working principle and applications of single and double acting reciprocating pumps, Concept of Slip, Negative slip, Cavitation and separation. use of air vessels, Comparison of centrifugal and reciprocating pump 5.4 Submersible pump- Construction, working principle and application of submersible pump.	**CO5**

Note: One major TSO may require more than one theory session/period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425402

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1 Determine viscosity of given liquid	1.	Use viscometer to determine the viscosity of a given liquid.	CO1
LSO 1.2 Measure the rise of liquid level	2.	Measure the rise of liquid level using capillary action in capillary tube.	CO1
LSO 1.3 Measure specific gravity of any given fluid	3.	Determine the specific gravity of any given fluid	CO1
LSO 1.4 Measure the pressure of the given fluid.	4.	Use manometer/ incline manometer to measure the pressure of the given fluid.	CO1
LSO 1.5 Measure meta-centric height of ship model.	5.	Determine the meta-centric height of ship model.	CO1
LSO 2.1 Measure discharge through a pipe using Venturi meter.	6.	Determine Coefficient of Discharge of Venturi meter.	CO2
LSO 2.2 Measure discharge through a pipe using Orifice meter.	7.	Determine Coefficient of Discharge, coefficient of contraction and coefficient of velocity of Orifice meter.	CO2
LSO 2.3 Determine the coefficient of friction of flow through pipes.	8.	Determine coefficient of friction of flow through pipes.	CO2
LSO 2.4 Measure static pressure	9.	Experimentally justify Bernoulli's theorem for a viscous and incompressible fluid.	CO2
LSO 2.5 Measure pressure energy, kinetic energy and datum energy of a given flowing fluid	10	Determine the pressure energy, kinetic energy and datum energy of a given flowing fluid.	CO2
LSO 3.1 Measure discharge through given pipe	11	Determine discharge through a given pipe using orifice meter, pitot tube and venturi meter.	CO3
LSO 3.2 Determine Cc, Cd, Cv for different types of orifices.	12	Determine Cc, Cd, Cv for different types of orifices.	CO3
LSO 3.3 Determine head loss	13	Determine loss of head due to A. Sudden enlargement B. Sudden contraction C. Friction in pipes	CO3
LSO 3.4 Determine the different types of flow Patterns	14	Determine the different types of flow Patterns by Reynolds's experiment	CO3
LSO 3.5 Measure the flow characteristic	15	Measure the flow characteristic of given flowing fluids	CO3
LSO 3.6 Calculate the minor losses of flow through pipes.	16	Determination of minor losses of flow through pipes.	CO3
LSO 4.1 Calculate the overall efficiency of the given turbine.	17	Determine overall efficiency using Pelton turbine.	CO4
	18	Determine overall efficiency using Francis/Kaplan turbine.	CO4
LSO 4.2 Determine the reaction force produced by the impact of a jet of water on to various target vanes	19	Investigate the reaction force produced by the impact of a jet of water on to various target vanes	CO4
LSO 4.3 Plot characteristics curve of the given tubine	20	Plot the characteristic curves of • Pelton wheel • Francis Turbine • Kaplan turbine	CO4
LSO 5.1. Calculate overall efficiency of the given	21	Determine overall efficiency using Centrifugal pump.	CO5

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
pump.	22	Determine overall efficiency using Reciprocating pump.	CO5
LSO 5.2. Determine the performance characteristics and power required for the given pump	23	Determine the power required to drive the given reciprocating pump.	CO5
	24	Determine the performance characteristics of: • Centrifugal pump • Reciprocating Pump	CO5

L) Suggested Term Work and Self Learning: S2425402 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments:

i Explain the different types of pressure measuring devices.
ii Explain different types of discharge measuring devices.
iii Describe a hydroelectric power plant.
iv Differentiate the hydraulic turbine on the basis of head, input energy available.
v Explain the various types of head in the centrifugal pump.

b. Micro Projects:

i Prepare a pipe layout water supply of your lab from supply reservoir and calculate the loss of head.
ii Prepare a demonstration model of hydroelectric power plant.
iii Calculate running cost of your household pump and verify the electricity bill.
iv Visit a hydroelectric power plant and write report.
v Conduct market survey of hydraulic turbine suppliers and prepare report on technical specifications, area of applications, cost, material of different parts and maintenance procedure.
vi Download catalogue of pump manufacturer and compare their parameter.

c. Other Activities:

1. Seminar Topics:

- Different types of manometer and their applications.
- Comparison between orifice meter and venturi meter.
- Different types of hydraulic turbines and their application areas.
- Different types of hydraulic pumps and their application areas.

2. **Visit:**

- Visit nearby shops to identify different PVC and GI pipe fittings.
- Visit nearby shops to identify different pumps**.** Collect manufacturing catalogues related to the same and compare their salient features.

3. **Self-Learning Topics**:

- Prepare journals based on practical performed in laboratory.
- Use various mechanical measuring instruments and equipments related to fluid mechanics and machinery.
- Read and use specifications of the hydraulic machines and equipments.
- Prepare power point presentation or animation for understanding constructional details and working of different hydraulic machines.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	15%	10%	15%	-	-	20%	20%
CO-2	10%	20%	10%	25%	-	10%	20%
CO-3	15%	20%	15%	25%	33%	15%	20%
CO-4	30%	20%	30%	25%	33%	15%	20%
CO-5	30%	30%	30%	25%	34%	40%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Properties of Fluid and Fluid Pressure	9	CO1	11	3	4	4
Unit-2.0 Fluid flow	11	CO2	14	4	4	6
Unit-3.0 Flow through pipes	10	CO3	14	5	4	5
Unit 4.0 Impact of jets & Hydraulic Turbines	9	CO4	14	3	5	6
Unit-5.0 Pumps	9	CO5	17	4	4	9
Total Marks	**48**	**-**	**70**	**19**	**21**	**30**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Use viscometer to determine the viscosity of a given liquid.	CO1	40	50	10
2.	Measure the rise of liquid level using capillary action in capillary tube.	CO1	40	50	10
3.	Determine the specific gravity of any given fluid	CO1	40	50	10
4.	Use manometer/ incline manometer to measure the pressure of the given fluid.	CO1	40	50	10
5.	Determine the meta-centric height of ship model.	CO1	40	50	10
6.	Determine Coefficient of Discharge of Venturi meter.	CO2	40	50	10
7.	Determine Coefficient of Discharge, coefficient of contraction and coefficient of velocity of Orifice meter.	CO2	40	50	10
8.	Determine coefficient of friction of flow through pipes.	CO2	40	50	10
9.	Experimentally justify Bernoulli's theorem for a viscous and incompressible fluid.	CO2	40	50	10
10.	Determine the pressure energy, kinetic energy and datum energy of a given flowing fluid.	CO2	40	50	10
11.	Determine discharge through a given pipe using orifice meter, pitot tube and venturi meter.	CO3	40	50	10
12.	Determine Cc, Cd, Cv for different types of orifices.	CO3	40	50	10
13.	Determine loss of head due to • Sudden enlargement • Sudden contraction • Friction in pipes	CO3	40	50	10
14.	Determine the different types of flow Patterns by Reynolds's experiment	CO3	40	50	10
15.	Measure the flow characteristic of given flowing fluids	CO3	40	50	10
16.	Determination of minor losses of flow through pipes.	CO3	40	50	10
17.	Determine overall efficiency using Pelton turbine.	CO4	40	50	10
18.	Determine overall efficiency using Francis/Kaplan turbine.	CO4	40	50	10
19.	Investigate the reaction force produced by the impact of a jet of water on to various target vanes	CO4	40	50	10
20.	Plot the characteristic curves of • Pelton wheel • Francis Turbine • Kaplan turbine	CO4	40	50	10
21.	Determine overall efficiency using Centrifugal pump.	CO5	40	50	10

S. No.	Laboratory Practical Titles	Relevant COs Number (s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
22.	Determine overall efficiency using Reciprocating pump.	CO5	40	50	10
23.	Determine the power required to drive the given reciprocating pump.	CO5	40	50	10
24.	Determine the performance characteristics of: • Centrifugal pump • Reciprocating Pump	CO5	40	50	10

Legend:
PRA*: Process Assessment
PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment and Tools: The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments. As well as aid to procure equipment by administrators.

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
1	Red wood viscometer	Electrically Heated with Digital temperature controller cum indicator	1
2	Capillary tube	Capillary tube of different diameters, beaker/petri dish,	2
3	Beaker, Pipette, Electronic balance, Thermometer	The Electronic Digital Balance 2kg x 0.5 gram, Beaker 500 ml, Pipette 50 ml , digital thermometer	3
4	manometer	Glass tube 50 mm, Complete set up for pressure measurement, wall or stand mounted, Mercury as manometeric fluid	4
5	Differential Manometer	Glass tube 50 mm, Complete set up for demonstration of pressure measurement, wall or stand mounted, Mercury as manometeric fluid	4
6	Venturimeter setup for measurement of discharge	Complete set up for measurement of discharge including power supply, water tank, and all accessories and instruments.	6,11
7	Orificemeter setup for measurement of discharge	Complete set up for measurement of discharge including power supply, water tank, and all accessories and instruments.	7,11
8	Setup for Bernoulli's Theorem	Complete set up for to verify the Bernoulli's theorem including power supply, water tank, and all accessories and instruments.	9
9	Setup for Friction losses through Pipes	Complete set up for friction losses including power supply, water tank, and all accessories and instruments.	8

S. No.	Name of Equipment	Broad Specifications	Relevant Experiment Number
10	Setup for losses due to enlargement & contraction in pipes	Complete set up of enlarge and contraction pipe, including power supply, water tank, and all accessories and instruments.	8, 10, 13
11	Reciprocating Pump test rig	Complete setup to test performance parameter of reciprocating pump up to 5 HP	22,23,24
12	Centrifugal Pump test rig	Complete setup to test performance parameter of Centrifugal Pump up to 5 HP	21,24
13	Pelton wheel test rig	Complete setup to test performance parameter and characteristics	17,20
14	Kaplan turbine test rig	Complete setup to test performance parameter and characteristics	18,20
15	Francis turbine test rig	Complete setup to test performance parameter and characteristics	18,20
16	Impact of jet apparatus	Complete set up including Sump Tank, Measuring tank, nozzles and vanes.	19
17	Reynolds Apparatus	Complete setup consisting of Borosilicate Glass tube, Stainless steel Dye vessel, Copper/Stainless Steel Capillary Tube, Water Tank, arrangement for flow measurement, stop watch and power supply	14
18	Metacentric height apparatus	Complete setup for Metacentric height calculation including tank , ship model	5

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Hydraulics, Fluid Mechanics and Hydraulic Machines.	Khurmi R.S. Khurmi N.	S. Chand and Co. Ltd., New Delhi, 2014 • ISBN-10: 8121901626 • ISBN-13: 978-8121901628
2.	Fluid mechanics and hydraulic machines.	Bansal R.K.	Laxami Publication, New Delhi, 2018 • ISBN-10: 8131808157 • ISBN-13: 978-8131808153
3.	Fluid mechanics and hydraulic machines	Rajput R.K.	S. Chand and Co. Ltd.,New Delhi, 2006 • ISBN-10: 8121916666 • ISBN-13: 978-8121916660
4.	Hydraulics & Fluid Mechanics Including Hydraulics	Modi P.N. Seth S.M.	Rajsons Publications Pvt Ltd, New Delhi ,2017 • ISBN-10: 8189401262 • ISBN-13: 978-8189401269
5.	Textbook of Fluid Mechanics and Hydraulic Machines	Pati Sukumar	McGraw Hill Education New Delhi, 2017 •ISBN-10: 1259006239 •ISBN-13: 978-1259006234

(b) Online Educational Resources:

1. Nptel course- http://nptel.ac.in/courses/112105171/
2. fluid and their propertie-https://www.youtube.com/results?search_query=fluid+and+their+propertie
3. Continuity equation-- https://www.youtube.com/results?search_query=Continuity+equation+
4. Pressure measurement- https://www.youtube.com/results?search_query=Pressure+measure
5. Pascal's law - https://www.youtube.com/results?search_query=Pascal%E2%80%99s+law
6. Metacenter-- https://www.youtube.com/results?search_query=2.4%09Metacenter
7. buoyancy - https://www.youtube.com/results?search_query=buoyancy
8. Fluid flow energy equation - https://www.youtube.com/results?search_query=Fluid+flow+energy+equation
9. Fluid flow - https://www.youtube.com/results?search_query=Fluid+flow+
10. Flow measurement- https://www.youtube.com/results?search_query=2.%09Flow+measurement
11. Venturimeter- https://www.youtube.com/results?search_query=Venturimeter
12. Classification of hydraulic turbines- https://www.youtube.com/results?search_query=5.1%09Classification+of+hydraulic+turbines+
13. Francis Turbine - https://www.youtube.com/results?search_query=%29+Francis+Turbine+
14. Kaplan turbine- https://www.youtube.com/results?search_query=Kaplan+turbine
15. Centrifugal pumps- https://www.youtube.com/results?search_query=Centrifugal+pumps-+
16. Reciprocating pumps- https://www.youtube.com/results?search_query=Reciprocating+pumps-

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(C) Others:

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

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A) Course Code : 2433403(T2433403/P2433403/S2433403)

B) Course Title : Automobile Control System

C) Pre- requisite Course(s) :

D) Rationale :

Automobile control systems play a pivotal role in modern vehicles, overseeing crucial components like the engine, transmission, brakes, and steering to ensure the vehicle operates efficiently, safely, and reliably. By optimizing performance, these systems improve fuel economy and reduce harmful emissions, addressing the escalating environmental concerns and the imperative to cut down greenhouse gas emissions.

In the third semester, the course on Automobile Transmission System covers topics related to transmission control systems, while in the fifth semester, the Advanced Automobile Engines course explores into engine control systems. The course encompasses Brake and Braking Control Systems, Suspension and its Control Systems, and steering systems. It also introduces cutting-edge technologies such as sensors and actuators. Understanding these systems is essential for automotive engineers, offering a solid foundation and preparing students for exciting careers in this dynamic field.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

After completion of the course, the students will be able to-

CO-1. Apply the concept of open and closed loop system in different automobile control systems

CO-2. Choose suitable braking control system for different types of vehicles.

CO-3. Examine conditions of given steering gear-box, steering mechanism and its linkages for better control of the vehicles

CO-4. Identify relevant suspension system for stability of different types of vehicles

CO-5. Diagnose sensor and actuators related issues which affects the performance, fuel economy and greenhouse gas emissions problems of the vehicles

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	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**
CO-1	3	2	2	2	1	-	2		
CO-2	3	2	2	2	1	-	2		
CO-3	3	2	2	2	2	-	2		
CO-4	3	2	2	2	-	-	1		
CO-5	3	2	2	3	-	-	1		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2433403	Automobile Control System	03	-	04	02	09	06

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2433403	Automobile Control System	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2433403

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Describe the different types of control systems used in automobiles *TSO 1b.* Differentiate between Open-loop vs. closed-loop control systems *TSO 1c.* Explain the different component of an automobile control system	**Unit-1.0 Introduction to Automobile Control Systems** 1.1 Basics of control systems 1.2 Types of control systems used in automobiles 1.3 Open-loop vs. closed-loop control systems 1.4 Components of an automobile control system	**CO1**
TSO 2a. Classify the different types of brakes. *TSO 2b.* Describe the properties of brake fluid. *TSO 2c.* Draw the sketches of given brakes. *TSO 2d.* List the advantages of Antilock brake system over the others braking system. *TSO 2e.* Explain the different component of Brakes. *TSO 2f.* Suggest the suitable friction materials for a given type of brakes.	**Unit-2.0 Brake and Braking Control System** 2.1 Purpose and requirement of brakes 2.2 Layout of braking system 2.3 Component of brake 2.4 Construction and working of mechanical, hydraulic, Air braking system and Exhaust brake. 2.5 Construction and working of Disc brake and drum brake and their materials 2.6 Brake fluid, Brake shoes and brake clearance. 2.7 Friction materials and its characteristics. 2.8 Braking Control Systems: • Antilock braking system (ABS) • Electronic Brake-force Distribution (EBD) • Traction Control System (TCS)	**CO2**
TSO 3a. Draw and explain the given types of front Axle. *TSO 3b.* Describe the given types of stub Axle. *TSO 3c.* Explain the given type of steering gear box. *TSO 3d.* Draw the various parts of steering geometry. *TSO 3e.* Suggest the suitable type of front axle for given vehicle. *TSO 3f.* List the advantages of power steering over the manual steering.	**Unit-3.0 Steering and front axle** 3.1 Purpose and requirement 3.2 Steering mechanism and function. 3.3 Steering geometry- camber, caster, king pin inclination, toe in and toe out. 3.4 Ackerman principle of steering mechanism 3.5 Constructional details of steering gear box - Rack& pinion and Re-circulating ball type, Worm and roller types' steering gear box. 3.6 Power steering necessity, construction and working. 3.7 Types of front axle- Dead axle, Live axle 3.8 Types of stub axle arrangements- Elliot, Reverse Elliot, Lemoine type	**CO3**
TSO 4a. Describe the necessity of suspension system. *TSO 4b.* Draw and explain the given types of suspension system. *TSO 4c.* List the advantages of Air suspension system over spring suspension system. *TSO 4d.* Identify the different parts of a given suspension system. *TSO 4e.* Explain the working of Electronic Stability Control (ESC) and Adaptive Suspension Systems *TSO 4f.* Suggest the suitable suspension	**Unit-4.0 Suspension and its Control System** *4.1* Purpose and function of suspension system. *4.2* Classification of suspension system. *4.3* Types- Rigid and independent suspension system *4.4* Shock absorber construction and working *4.5* Different type of spring- Torsion bar, Air spring, Leaf spring, Coil spring, Hydrodynamic spring. *4.6* Air suspension system	**CO4**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
control system for the given vehicle.	*4.7* Suspension Control Systems: • Electronic Stability Control (ESC) • Adaptive Suspension Systems	
TSO 5a. Explain the function and application of sensors used in automobiles such as speed, temperature, pressure, position sensors etc., *TSO 5b.* Identify the location of various sensors used in modern vehicle *TSO 5c.* Explain the function and application of actuators used in automobiles *TSO 5d.* Diagnose sensor and actuators related issues	**Unit - 5.0 Sensors and Actuators** 5.1 Role and types of sensors used in Automobiles (e.g., speed sensors, temperature sensors, pressure sensors, Position sensors, Air flow measurement sensor, Combustion knock sensors, Exhaust Oxygen level sensor etc.) 5.2 Actuators and their functions (e.g., fuel injectors, throttle actuators, brake actuators, etc.)	**CO5**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2433403

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify the suitable tools for dismantling the hydraulic braking system *LSO 1.2.* Identify the major components of hydraulic braking system *LSO 1.3.* Follow service manual procedure for checking the components of hydraulic braking system *LSO 1.4.* Re-assemble or installing the hydraulic braking system	1	Dismantle hydraulic braking system and assemble it.	CO 2
LSO 2.1. Identify the suitable tools for dismantling the given brake assembly *LSO 2.2.* Identify the major components of the given brake assembly *LSO 2.3.* Follow service manual procedure for checking the components of given braking system *LSO 2.4.* Re-assemble or installing the given brake assembly.	2	Perform assembly of any one the following brake system: (a)Air braking system (b)Vacuum assisted braking system	CO 2
LSO 3.1. Identify the suitable tools for dismantling the given brake assembly *LSO 3.2.* Follow service manual procedure for dismantling and checking the components of given brake assembly *LSO 3.3.* Re-assemble the hydraulic brake assembly	3	Dismantle and assemble any one of the following Brake: (a)Disc brake (b) Drum brake	CO 2
LSO 4.1. Observe the operation of Anti-lock Braking System (ABS) *LSO 4.2.* Check the performance of ABS sensors in preventing wheel lock-up during braking	4	Prepare report on the working principles and operation of Anti-lock Braking System (ABS)	CO 2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 5.1. Locate the position of Electronic Stability Control (ESC) in a given vehicle *LSO 5.2.* Observe the working principles of Electronic Stability Control (ESC)	5	Prepare report on the working principles and operation of Electronic Stability Control (ESC)	CO 2
LSO 6.1. Identify the different components of a given Steering Systems. *LSO 6.2.* Enlist the specification and function of each component of the given steering system *LSO 6.3.* Prepare report with referring to service manual	6	Prepare report on the constructional details, working principles and operation of the following Automotive Steering Systems. (a) Manual Steering Systems (b) Power steering Systems	CO 3
LSO 7.1. Identify the major components of the given steering assembly *LSO 7.2.* Follow service manual for checking the components of given Steering assembly *LSO 7.3.* Re-assemble the given Steering assembly.	7	Perform assembly of steering system of a given vehicle.	CO 3
LSO 8.1. Demonstrate different Steering geometry parameters in a given vehicle. *LSO 8.2.* Use suitable tools and equipment to determine different angles as part of steering geometry	8	Measure Steering geometry parameters in given vehicle.	CO 3
LSO 9.1. Identify the different components of a given Suspension Systems. *LSO 9.2.* Enlist the specification and function of each component of the given Suspension system *LSO 9.3.* Prepare report with referring to service manual	9	Prepare report on the constructional details, working principles and operation of the following Automotive Suspension Systems: (a) Mac-pherson strut type (b) Wishbone type suspension.	CO 4
LSO 10.1. LSO 10.1 Identify the different components of the given leaf spring *LSO 10.2.* Check and overhaul the given leaf spring	10	Overhaul and Inspection of semi elliptical leaf spring	CO 4
LSO 11.1. Identify the suitable tools for dismantling the given shock absorber *LSO 11.2.* Dismantle the given shock absorber *LSO 11.3.* Check and assemble the given shock absorber while following the service manual	11	Practice on removing, inspection and assembling of telescopic type hydraulic shock absorber	CO 4
LSO 12.1. Locate the given sensor *LSO 12.2.* Check the sensor for loose connections or worn insulation *LSO 12.3.* Use suitable measuring instruments to measure the various parameters	12	Verifying the functionality of different sensors in the vehicle engine: a) Speed sensors b) Temperature sensors c) Pressure sensors	CO 5
LSO 13.1. Trace the location of different types of sensors in a given vehicle engine *LSO 13.2.* Observe the function and operation of various sensors used in vehicle engine *LSO 13.3.* Prepare report with respect to constructional and operation of sensors	13	Prepare report on the following sensors (any two): a) Air flow measurement sensor b) Combustion knock sensors c) Exhaust Oxygen level sensor d) Position sensors	CO 5
LSO 14.1. Trace the position of different actuators in a given vehicle *LSO 14.2.* Observe the functionality of various actuators used in vehicle *LSO 14.3.* Prepare report with respect to Constructional features, working principles and applications of actuators	14	Prepare report on the various types of actuators used in modern vehicles along with its applications.	CO 5

L) **Suggested Term Work and Self Learning: S2433403** Some sample suggested assignments, micro project and otheractivities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Collect the different types of Braking system used in vehicle and compare it.
2. Collect the data of different types of Steering mechanism used in vehicle with their comparison.
3. Collect the data of different types of suspension system used in vehicle from market.
4. Prepare a list of different Sensors and actuators used in a vehicle along with their applications.
5. Develop a prototype for a smart braking system that utilizes sensors and actuators to improve vehicle safety and stability.
6. Develop a driver assistance system that uses sensors and cameras to detect obstacles and provide alerts to the driver.
7. Develop an automatic parking system that uses ultrasonic sensors and actuators to guide a vehicle into a parking spot.

c. Other Activities:

1. Seminar Topics:
   - Working of Antilock Braking system.
   - Visual representation of different types of Suspension control system being used in vehicle.
   - Application of different sensors in a vehicle.
   - Power steering.

2. Visits: Visit nearby Automobile manufacturing industry/Auto workshop to gain practical knowledge about Suspension control system, braking system, steering mechanism and sensors & Actuators and prepare report on it.

3. Self-Learning Topics:
   - Identify the parts of front Axle.
   - Identify different sensors used in a given vehicle engine
   - Identify the parts of power steering.

M) **Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	10%	10%	-	-	-	-
CO-2	25%	25%	25%	25%	25%	25%	25%
CO-3	20%	20%	20%	25%	25%	25%	25%
CO-4	25%	25%	25%	25%	25%	25%	25%
CO-5	20%	20%	20%	25%	25%	25%	25%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above(A)
Unit-1.0 Introduction to Automobile Control Systems	6	CO1	8	4	4	-
Unit-2.0 Brake and Braking control system	12	CO2	18	4	8	6
Unit-3.0 Steering and front Axle	10	CO3	14	4	6	4
Unit-4.0 Suspension and its Control System	12	CO4	16	4	8	4
Unit-5.0 Sensors and Actuators	8	CO5	14	4	4	6
Total	**48**	**-**	**70**	**20**	**30**	**20**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No	Laboratory Practical Titles	Relevant COs Number(s)	PLA #/ELA # (Marks)		
			Performance		Viva-Voce (%)
			PRA (%)	PDA (%)	
1.	Dismantle hydraulic braking system and assemble it.	CO-2	40	50	10
2.	Perform assembly of any one the following brake system: (a)Air braking system (b)Vacuum assisted braking system	CO-2	40	50	10
3.	Dismantle and assemble any one of the following Brake: (a)Disc brake (b) Drum brake	CO-2	40	50	10
4.	Prepare report on the working principles and operation of Anti-lock Braking System (ABS)	CO-2	30	60	10
5.	Prepare report on the working principles and operation of Electronic Stability Control (ESC)	CO-2	30	60	10
6.	Prepare report on the constructional details, working principles and operation of the following Automotive Steering Systems. (a) Manual Steering Systems (b) Power steering Systems	CO-3	30	60	10
7.	Perform assembly of steering system of a given vehicle .	CO-3	40	50	10

8.	Measure Steering geometry parameters in given vehicle.	CO-3	40	50	10
9.	Prepare report on the constructional details, working principles and operation of the following Automotive Suspension Systems: Mc-pherson strut type (b)Wishbone type suspension.	CO-4	30	60	10
10	Overhaul and Inspection of semi elliptical leaf spring	CO-4	40	50	10
11	Practice on removing, inspection and assembling of telescopic type hydraulic shock absorber	CO-4	40	50	10
12	Verifying the functionality of different sensors in the vehicle engine: Speed sensors Temperature sensors Pressure sensors	CO-5	30	60	10
13	Prepare report on the following sensors (any two): Air flow measurement sensor Combustion knock sensors Exhaust Oxygen level sensor Position sensors	CO-5	30	60	10
14	Prepare report on the various types of actuators used in modern vehicles along with its applications.	CO-5	30	60	10

Legend:

PRA*: Process Assessment
PDA**: Product Assessment
Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools andSoftware	Broad Specifications	Relevant Experiment/ Practical Number
1	General purpose tools (Spanners, ring spanner and socket etc.,	6mm to 32 mm	All
2	Special purpose tools (Torque wrench)	Torque wrench range- 10 Nm to 200Nm.	All
3	A modern Car and Jeep of any make and model	Light Motor Vehicles: A modern Car and Jeep of any make and model like Maruti, Mahindra, TATA, Force Motors along with all relevant accessories and systems	All
4	Hydraulic brake assembly of LMV/HMV Vehicles	Actual working system of Hydraulic brake of: Multi cylinder four stroke S.I. vehicle with all accessories.	1
5	Disc brake in working condition with caliper assembly with all parts	Exhibiting Brake disc, Caliper assembly, tandem master cylinder, brake hoses, oil bottle, pedal, etc	3
6	Drum brake assembly in Working Condition	Brake drum, tandem master cylinder, oil container, brake hose, brake pedal.	3

S. No.	Name of Equipment, Tools andSoftware	Broad Specifications	Relevant Experiment/ Practical Number
7	Working model of Air Brake Assembly	Two brake drums, vehicular air compressor driven by suitable Electric Motor, air dryer, brake chamber, stop light, different valves, air pressure gauges. With all accessories.	2
8	Vacuum assisted braking system in working condition	Working model of Vacuum assisted braking system with all components	2
9	Brake control System: • Antilock braking system (ABS) • Electronic Brake-force Distribution (EBD) • Traction Control System (TCS)	Working model of Antilock braking system (ABS) ,Electronic Brake-force Distribution (EBD),Traction Control System (TCS)	4&5
10	Front axle (Rzeeppa Joint) with stand for Dismantling and assembly	Rzeppa joint of LMV	6&7
11	Full floating axle and semi-floating axle assembly.	Drum & axle casing should be with all components in working condition.	6&7
12	Steering assembly – 1.Rack & pinion 2.Worm & roller 3. Recirculating ball 4.Power steering 5. Electric Assisted Power Steering	1. Rack & Pinion with steering wheel, column, tie rod end. 2. Worm & Roller steering assembly with drop arm. 3. Recirculating Ball steering with pitman shaft and drop Arm. 4. Hydraulic working power steering with steering wheel, column, flow pipe, hydraulic pump, oil reservoir. 5. Electric Assisted Power Steering with Rack and pinion, Electric Motor and Motor Control Module	6,7&8
13	Actual Suspension System of LMV/HMV	Suspension system with: Mc-pherson strut type (b)Wishbone type suspension	9
14	Assemble of semi elliptical leaf spring		10
15	Working models of shock absorbers		11
16	Functional/experiment model of different type of sensors.	With Different type of sensors like Throttle Position Sensor, Manifold Absolute Pressure Sensor, Engine Coolant Temperature Sensor, Vehicle Speed Sensor, Oxygen Sensor, Crankshaft Position Sensor, Camshaft Position Sensor, Intake Air Temperature Sensor, Mass Air Flow Sensor, Knock Sensor with ECU.	12,13&14

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Automobile Engineering	Singh , Kripal	Standard Publication, New Delhi,2008 ISBN 13 : 9788180141034
2.	Automobile Engineering	Chikara , Anil	Satya Prakashan, New Delhi, 2007, ISBN: 9788176843515
3.	Automobile Engineering	Jain K. K., Asthana R. B.	Tata Mc-Graw Hill Publishing Co. Ltd. ISBN-13 : 978-0070445291
4.	Automobile Mechanics	Srinivisan ,S	McGraw- Hill, New Delhi,2003 ISBN-10: 0070494916
5.	Automobile Technology	Giri , N.K.	Khanna Publication, New Delhi, 2009 ISBN : 9788174091789
6.	Automotive Sensors	John Turner	SAE International; 1st Edition (ISBN-10: 0768010518)
7.	Automotive Technology: Principles, Diagnosis, and Service	James D. Halderman	Pearson Education; 5th Edition (ISBN-10: 0133994619)

(b) Online Educational Resources:

1. www.nptel.swayam
2. https://youtu.be/Twga0R_9qrE
3. https://youtu.be/UXn5lgtqrpA
4. https://youtu.be/ltufRS3xj30
5. https://youtu.be/kR-SLTNrnjQ

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

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

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A) Course Code **: 2425404(T2425404/P2425404/S2425404)**

B) Course Title **:** Theory of Machines (ME, ME (Auto))

C) Pre- requisite Course(s) **:**

D) Rationale **:**

Knowledge of various mechanism and machines is a pre-requisite for enabling a mechanical engineer to work in Mechanical/Automobile/Textile/Printing Industries. This course provides the knowledge of Kinematics and dynamics of different machine elements and popular mechanisms, CAM-follower, Belt-Pulley, Gears, Flywheel, Brake and Clutch to enable a diploma holder to carryout simple calculation, selection and to supervise maintenance related to these parts. This course also serves as pre-requisite for course "Design of Machine Elements" and "Automobile Engineering" to be studied in later semesters.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

- **CO-1** Develop CAM profiles based on different follower motions required for engineering applications.
- **CO-2** Select Suitable Drives for different industrial applications.
- **CO-3** Calculate critical parameters related to effective functioning of flywheel and governors.
- **CO-4** Calculate torque and power loss in various brakes, dynamometers, clutches and bearings used in various engineering applications.
- **CO-5** Balance various rotor systems to estimate unbalanced forces and moments in different devices.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	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**
CO-1	3	2	3	2	1	-	-		
CO-2	3	2	-	2	1	-	-		
CO-3	3	2	-	2	-	-	-		
CO-4	3	2	-	2	1	-	-		
CO-5	3	2	-	2	-	-	-		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2425404	Theory of Machines	03	-	04	02	09	06

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work& Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2425404	Theory of Machines	30	70	20	30	20	30	200

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2425404

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Identify various links in the given mechanism and their functions. *TSO 1b.* Identify inversions of the given mechanism. *TSO 1c.* Describe the constructional details of the given mechanism. *TSO 1d.* Select suitable mechanism for the given application with justification. *TSO 1e.* Explain different types of cams and cam followers with their motions. *TSO 1f.* Estimate displacement, velocity and acceleration diagram for the given follower motion. *TSO 1g.* Construct the radial cam profile from the given data ad follower motion.	**Unit-1.0 Introduction to Planar Mechanisms and Cams-Followers** **Introduction to Planar Mechanisms** 1.1 Kinematics of Machines: - Definition of Kinematics, Dynamics, Statics, Kinetics, Kinematic link, Kinematic Pair and its types, constrained motion and its types, Kinematic chain and its types, Mechanism, Machine and Structure. 1.2 Four link planar mechanisms and Inversions: i. Four bar chain: Locomotive coupler, Beam engine and Pantograph. ii. Single slider Crank chain: Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Slotted Lever Quick return mechanism. iii. Double Slider chain: Scotch Yoke mechanism, Elliptical trammel, Oldham's Coupling. **Cams and Followers** 1.3 Cam and follower terminology. Classification of Cams and Followers. Applications of Cams and Followers. 1.4 Types of follower motions-uniform velocity, uniform acceleration and S.H.M and their displacement, velocity and acceleration diagrams. 1.5 Drawing of profile of a radial cam based on given motion of reciprocating knife-edge and roller follower with and without offset. (graphical method only)	**CO1, CO2**
TSO 2a. Compare different types of drive *TSO 2b.* Calculate the length of belt, velocity ratio, angle of contact and ratio of tight side and slack side tension for the given belt drive arrangement. *TSO 2c.* Estimate power transmitted and condition for maximum power transmission in the given belt drive through simple numerical situation. *TSO 2d.* Describe the spur gear terminology *TSO 2e.* Identify different types of gear and gear trains. *TSO 2f.* Identify the different types of gear trains and their field of applications	**Unit-2.0 Power Transmission Elements** 2.1 Types of Drives – Belt, Chain, Rope, Gear drives &their comparison; 2.2 Belt Drives – Introduction to Flat belt, V-belt & its applications, materials used for flat and V-belts. Introduction of timing belt and pulley. Angle of lap, length of belt, Slip and creep. Determination of velocity ratio of tight side and slack side tension, centrifugal tension and initial tension, condition for maximum power transmission. Merits, demerits and selection of belts for given applications. (Simple numerical) 2.3 Gear Drives – Spur gear terminology; Law of gearing, Types of gears and gear trains, their selection for different applications;	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 2g. Calculate Train value & velocity ratio for the given gear trains using spur and helical gears only. *TSO 2h.* Select suitable drives for the given application with justification.	2.4 Gear trains- Train value & Velocity ratio for compound, reverted and simple epicyclic gear train; Methods of lubrication; 2.5 Chain Drives – Introduction to chain drives, Types of chains and sprockets, Methods of lubrication. Merits, demerits and selection of chains for given applications.	
TSO 3a. Explain the concept, function and terminology of governors. *TSO 3b.* Differentiate between flywheel and governor. *TSO 3c.* Draw a turning moment diagram for the given engine. *TSO 3d.* Apply the concept of fluctuation of speed and energy for the given flywheel. *TSO 3e.* Identify the working of different types of governor and their function. *TSO 3f.* Calculate the lift in case of the given governor. *TSO 3g.* Estimate mass and other geometric parameters of the given flywheel for given situation.	**Unit-3.0 Flywheel and Governors** 3.1 Flywheel: Concept, function and application of flywheel with the help of turning moment diagram for single cylinder 4-Stroke I.C. Engine (No Numerical); Co- efficient of fluctuation of energy, Coefficient of fluctuation of speed and its significance 3.2 Governors: Terminology of Governors; Comparison between Flywheel and Governor, Types and explanation with neat sketches (Centrifugal, Watt and Porter); Concept, function and applications. Equation for lift of governors. (No derivation) Terms related to governor like Sensitivity, stability, Isochronous, Governor Effort and Power. (No derivation)	**CO4**
TSO 4a. Explain various parts of the given brakes with their functions and constructional details. *TSO 4b.* Explain concept of self-locking and self-energizing. *TSO 4c.* Calculate braking force, braking torque and power lost in friction in the given shoe and band brake through simple numerical situation. *TSO 4d.* Describe working principle of the given clutch(s). *TSO 4e.* Explain various parts of the given clutch with their functions and constructional details. *TSO 4f.* Determine the power transmitted by the given clutch through simple numerical situation.	**Unit-4.0 Brakes and Clutches** 4.1 Brakes: Functions, Types, Applications Construction and working principle of i. Shoe brake ii. Band brake iii. Internal expanding shoe brake iv. Disc Brake 4.2 Concept of Self Locking & Self energizing brakes; Numerical problems to find braking force and braking torque for shoe & band brakes. Comparison between brakes and dynamometers; 4.3 Clutches: Classification, Functions and Applications, Construction and principle of working of i. Single-plate clutch, ii. Multi-plate clutch, iii. Centrifugal Clutch 4.4 Calculation of power loss assuming uniform pressure and uniform wear theory (No derivation).	**CO5**
TSO 5a. Explain the concept of balancing of single rotating mass *TSO 5b.* Describe the graphical method of balancing of several masses revolving in same plane *TSO 5c.* Explain concept and terminology used in vibration *TSO 5d.* Explain the method of balancing a rotating mass as per the given conditions.	**Unit-5.0 Balancing of Rotating Masses** 5.1 Balancing- Need and types of balancing, Effects of unbalanced masses. Concept and terminology used in vibrations. Causes of vibrations in machines; their harmful effects and remedies (No Numerical) 5.2 Balancing of single rotating mass in same and different plane; (Analytical Method) 5.3 Balancing of several masses revolving in same plane (Graphical method).	**CO5**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2425404

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify the given of mechanisms. *LSO 1.2.* Explain the construction and working of the given four link mechanism.	1.	Draw line diagrams with dimensions of the working models of all the inversions of following mechanisms available in the lab. • Slider Crank Mechanism • Double Slider Crank Mechanism • Four bar Mechanism	CO1
LSO 2.1. Correlate the sizes, arrangement and working of actual mechanisms with theoretical counterparts.	2.	Dismantle and assemble • Wiper mechanism of any four wheeler • Steering Mechanism of Tractor • Slider Crank mechanism of any IC Engine • Any other similar mechanisms	CO1
LSO 3.1. Draw follower motion as per the given requirement to get the actual values of lift of the follower related to corresponding cam rotation. *LSO 3.2.* Correlate the effect of Cam-Follower terminology like Angle of Ascent, Angle of Descent, Dwell, zero Offset, Basic Circle etc. on Cam profile. *LSO 3.3.* Draw profile of the given Cam as per given motion of the follower.	3.	Draw the profile of radial CAM without offset for given follower (Knife edge and Roller follower) to obtained desired follower motion. (Minimum two problem on A2 size sheet)	CO1
LSO 4.1. Draw follower motion as per the given requirement to get the actual values of lift of the follower related to corresponding cam rotation. *LSO 4.2.* Correlate the effect of Cam-Follower terminology like Angle of Ascent, Angle of Descent, Dwell, Offset, Basic Circle etc. on Cam profile. *LSO 4.3.* Draw profile of the given Cam as per given motion of the follower.	4.	Draw the profile of radial CAM with offset for given follower to obtained desired follower motion. (Minimum two problem on A2 size sheet)	CO1
LSO 5.1. Identify the given Cam and follower combination. *LSO 5.2.* Correlate the effect of Angle of Ascent, Angle of Descent, Dwell, Offset, Basic Circle etc. with actual functioning of Cam-Follower. *LSO 5.3.* Estimate lift, velocity and acceleration of the given Cam-Follower combination.	5.	Measure main dimension of a Tangent flank cam and estimate lift, velocity and acceleration at critical points.	CO1
LSO 6.1. Identify the given type of power transmission element. *LSO 6.2.* Explain the working of Chain sprocket mechanism. *LSO 6.3.* Identify the slack and tight side of the given drive. *LSO 6.4.* Estimate the value of slack and tight side tensions experimentally for different inputs and correlate them with theoretical counterparts.	6.	Measure slack side and tight side tension in Chain of sprocket of an experimental Bicycle setup.	CO2
LSO 7.1. Identify the given type of gear and gear train.	7.	Study of various types of gears and gear train	CO2

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 7.2. Identify the main parameters/parts/elements of the given spur and helical gear. *LSO 7.3.* Explain the functioning and arrangement of the given gear train.			
LSO 8.1. Correlate the sizes, arrangement and working of actual gear mechanisms with theoretical counterparts. *LSO 8.2.* Estimate the gear ratio and velocity ratio in actual gear trains experimentally.	8.	Find out velocity and gear ratio in • Lathe machine gear box. • Cane crushing machine. • Two wheelers • Drilling Machine	CO2
LSO 9.1. Correlate the experimental turning moment diagram with theoretical counterpart. *LSO 9.2.* Estimate value of Turning moment at corresponding crank rotation for the given engine/machine.	9.	Calculate and prepare turning moment diagram from given experimental data.	CO3
LSO 10.1. Identify the given type of governor. *LSO 10.2.* Explain the working of the given governor. *LSO 10.3.* Correlate the effect of governor speed on sleeve lift, upper arm inclination, lower arm inclination, radius of governor, height of the governor. *LSO 10.4.* Compare the measured values with theoretical counterparts,	10.	Measure the height, radius and mass of rotating ball for watt governor for different rotational speed	CO3
LSO 11.1. Identify the given type of governor. *LSO 11.2.* Explain the working of the given governor. *LSO 11.3.* Correlate the effect of governor speed and sleeve mass on sleeve lift, upper arm inclination, lower arm inclination, radius of governor, height of the governor. *LSO 11.4.* Compare the measured values with theoretical counterparts.	11.	Measure the height, radius and mass of rotating ball for porter governor for different rotational speed	CO3
LSO 12.1. Identify the given type of brake. *LSO 12.2.* Explain the working and construction of the given type of the brake. *LSO 12.3.* Estimate the braking torque required for the given brake in different load situations.	12.	Calculate the braking torque required for different brakes in different load situations	CO4
LSO 13.1. Identify the given type of dynamometer. *LSO 13.2.* Explain the working and construction of the given type of the dynamometer. *LSO 13.3.* Estimate the power required of the given IC engine at different speed situations.	13.	Use rope/band brake dynamometer to calculate power in an IC Engine.	CO4
LSO 14.1. Identify the given type of Clutch. *LSO 14.2.* Identify the main parameters/elements of the given clutch. *LSO 14.3.* Correlate the functioning and arrangement/construction of the given Clutch with the theoretical concepts.	14.	Dismantle and Assemble following • Single plate clutch • Multi plate clutch • Centrifugal clutch	CO4
LSO 15.1. Identify the given type of Brake.	15.	Dismantle and Assemble a internal expanding brake and Disc Brake.	CO4

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 15.2. Identify the main parameters/elements of the given Brake. *LSO 25.1.* Correlate the functioning and arrangement/construction of the given Brake with the theoretical concepts.			
LSO 16.1. Identify the input and output parameters/elements of the given clutch. *LSO 16.2.* Estimate the torque transmitting capacity of the given single and multi plate clutch.	16.	Estimate torque transmitting capacity of single and multi plate clutch with the help of working model.	CO4
LSO 17.1. Observe the unbalanced/vibrations caused by the given single/multi rotating masses. *LSO 17.2.* Measure the parameters required for calculation of unbalance force/moment in the given unbalance setup. *LSO 17.3.* Suggest suitable balanced mass value and position to make the given system unbalanced system.	17.	Perform balancing of many unbalanced rotating masses in single plane using rotating balancing machine.	CO5

A judicial mix of minimum 14 or more practical need to be performed, out of which, the practical marked as '' are compulsory.

L) Suggested Term Work and Self Learning: S2425404 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

i Draw bicycle brake applying mechanism and identify the type of links and joints.
ii Draw line diagram of car and tractor steering mechanisms
iii Compare wiper mechanism of a typical bus with wiper mechanism of a typical car.
iv Compare slider crank mechanism used in a Bike and a Car.
v List the various types of machine where Cam and Follower are used.
vi Draw the profile of radial CAM for given follower to obtained desired follower motion. (Minimum two problem)
vii Measure slack side and tight side tension in belt of pulleys of a floor mill.
viii Calculate the length of belt for different belt arrangement.
ix Calculate velocity ratio, belt tensions, slip and angle of contact in the given belt drive arrangement through simple numerical situation.
x Estimate power transmitted and condition for maximum power transmission in the given belt drive through simple numerical situation.
xi Calculate mass of flywheel and coefficient of fluctuation of a flywheel through simple numerical situation.
xii Draw a turning moment diagram for a given engine through simple numerical situation.
xiii Measure the Kinetic Energy stored in the given flywheel after 15 seconds for a given starting torque.
xiv Determine the fluctuation of energy of two stroke and four stroke petrol engines and justify the size of flywheels.
xv Estimate the balancing mass and its position analytically and graphically for many given unbalance masses rotating in a single plane through a numerical situation.

b. Micro Projects:

i Prepare card sheet/stick/thermocole/Acrylic sheet models of at least four mechanisms (group work with group size of five students each)
ii Study a sewing machine and prepare a list of various mechanisms used in it.
iii Prepare a list of different mechanisms used in automobile, domestic appliances, devices, industrial machines etc. (group work with group size of five students each)
iv Collect photographs of all the mechanisms identified in Sr. no. (3) and prepare a chart (group work with group size of five students each)
v Collect different Cam and Follower combinations used in different devices and machines. (group work with group size of five students each).
vi Develop Acrylic models of various Cam-Follower combinations.
vii Prepare a slide show of working animation of cam and follower using open source software.
viii Collect specified contours Cams (Tangent Cams and Convex flanks Cams) from scarp market.
ix Market survey of belts for collecting specifications.
x Market survey of gears for collecting specifications.
xi Select V-belt for a given application through manufacturer catalog and justify.
xii Collect five samples of different types of used belts and fix them on a single board with labels. (group work with group size of five students each).
xiii Calculate the length of belt and open and cross belt drive
xiv Collect different types of gears from scrap market and fix them on a single board with labels. (group work with group size of five students each).
xv Explain the complete procedure of selection of a V-belt for a particular application using manufacturers catalog.
xvi Collect five photographs of different Epicyclic gear trains used in different devices.
xvii Field survey to collect information about different types of flywheels and governors also their applications.
xviii Identify and measure the dimensions of Flywheel used in various automobiles.
xix Calculate the size/mass of flywheel fitted to a shearing or punching machine and justify.
xx Collect photographs of various governors and flywheels fitted to different engine.
xxi Prepare a list in which you write the name of different types of clutch and brake used in automobile and bicycle.

c. Other Activities:

1. Seminar Topics:
   - Advancement in braking system used in automobile and bicycle
   - Application of CAM in IC engine
   - Necessity of balancing of rotating mass rotating in same plane
   - Use of flywheel and governor in automobile

2. Visits:
   - Visit nearby automobile workshop/industry/shop having clutch, cam and follower, Brakes, gears and governor facilities. Prepare report of visit with special comments on different brakes, clutch, governor, gear and cam arrangements used in automobiles.
   - Visit nearby automobile workshop and perform balancing of a car wheel with the help of a 'Vehicle Alignment and Balancing Shop' and justify the position and magnitude of Balancing mass used through analytical method.

3. Self-Learning Topics:
   - Slider Crank Mechanism and its applications.
   - Cams and followers used in IC engines.
   - Use of flywheel and governor IC Engine and other machines.
   - Function and Comparison between brakes and dynamometers
   - Comparison between Belt, Chain, Rope and Gear drives

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work& Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	20%	25%	20%	20%	20%	25%	20%
CO-2	25%	20%	20%	20%	20%	15%	20%
CO-3	25%	20%	20%	20%	20%	15%	20%
CO-4	15%	20%	20%	20%	20%	25%	20%
CO-5	15%	15%	20%	20%	20%	20%	20%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Introduction to Planar Mechanisms and Cams-Followers	10	CO1	16	5	4	7
Unit-2.0 Power Transmission Elements	10	CO3	14	4	2	8
Unit-3.0 Flywheel and Governors	10	CO4	14	4	4	6
Unit-4.0 Brakes and Clutches	10	CO5	14	4	4	6
Unit-5.0 Balancing of Rotating Masses	08	CO5	12	3	3	6
Total	**48**	**-**	**70**	**20**	**17**	**33**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Draw line diagrams with dimensions of the working models of all the inversions of following mechanisms available in the lab. • Slider Crank Mechanism • Double Slider Crank Mechanism • Four bar Mechanism	CO1	40	50	10
2.	Dismantle and assemble wiper mechanism of any four wheeler.	CO1	40	50	10
3.	Draw the profile of radial CAM with offset for given follower (Knife edge and Roller follower) to obtained desired follower motion. (Minimum two problem on A2 size sheet)	CO1	40	50	10
4.	Draw the profile of radial CAM without offset for given follower to obtained desired follower motion. (Minimum two problem on A2 size sheet)	CO1	40	50	10
5.	Measure main dimension of a Tangent flank cam and estimate lift, velocity and acceleration at critical points.	CO1	40	50	10
6.	Measure slack side and tight side tension in Chain of sprocket of a Bicycle.	CO2	40	50	10
7.	Study of various types of gears and gear train	CO2	40	50	10
8.	Find out velocity and gear ratio in • Lathe machine gear box. • cane crushing machine. • two wheelers • Drilling Machine	CO2	40	50	10
9.	Calculate and prepare turning moment diagram from given experimental data.	CO3	40	50	10
10.	Measure the height, radius and mass of rotating ball for watt governor for different rotational speed	CO3	40	50	10
11.	Measure the height, radius and mass of rotating ball for porter governor for different rotational speed	CO3	40	50	10
12.	Calculate the braking torque required for different brakes in different load situations	CO4	40	50	10
13.	Use rope brake dynamometer to calculate power in an IC Engine.	CO4	40	50	10
14.	Dismantle and Assemble following • single plate clutch • multi plate clutch • centrifugal clutch	CO4	40	50	10
15.	Dismantle and Assemble a internal expanding brake and Disc Brake.	CO4	40	50	10
16.	Estimate torque transmitting capacity of single and multi plate clutch with the help of working model.	CO4	40	50	10
17.	Perform balancing of many unbalanced rotating masses in single plane using rotating balancing machine.	CO5	40	50	10

Legend:

PRA*: Process Assessment

PDA**: Product Assessment

Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
1.	bicycle free wheel sprocket mechanism, Geneva mechanism, Ackerman's steering gear mechanism and foot operated air pump mechanism, slider crank mechanism, hooks joint, inversions of four bar mechanisms-locomotive coupler, Beam engine, Pantograph, Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper, Scotch Yoke mechanism, Elliptical trammel and Oldham's Coupling.	Working Models / wooden/thermocol Acrylic models/ metallic models	1, 2
2.	Different Types of cams, followers and cam/follower arrangements	Working Models / wooden/thermocol Acrylic models/ metallic models	3, 4, 5
3.	Various belt drives, chain and sprocket, various gear drives.	Actual items	6
4.	Different belts in different arrangements	Working models	6
5.	Working models of Gear trains - all types. (Simple, compound, reverted, epicyclical).	Working Models/ wooden/thermocol Acrylic models/metallic models	7, 8
6.	Any machine having flywheel (Single cylinder 4-Stroke I.C engine with flywheel)	IC Engine Lab	9
7.	Governors - all types	Working Models / wooden/thermocol Acrylic models/metallic models	10
8.	Various types of brake assemblies	Working and cut section models	11, 12, 15
9.	Dynamometers - all types	Rope Brake, Eddy current, Electrical	13
10.	Various types of clutch assemblies.	Working and cut section models	14, 16
11.	Vehicle Tyre balancing machine	Rim Diameter 10"-24" or 265 - 615 mm Rim Width 1.5" - 20" or 40 - 510 mm Distance between wheel and machine 0 - 25 cm. Balancing Accuracy 1 gm. Power Supply 220 - 240 V, 50 - 60 Hz Single Phase Motor 0.33 kW Maximum Power Consumption 0.6 kW. RPM 60 Wheels weighing upto 75 kg Dimensions with Wheel Guard WxLxH1350 (Hood open) x1220x1670	17

S. No.	Name of Equipment, Tools and Software	Broad Specifications	Relevant Experiment/Practical Number
		Net Weight with Wheel Guard 160 kg (Excluding Adaptors)	
12.	Static and Dynamic Balancing Apparatus	Weighing Capacity 10-50kg, Power Source Electric Voltage 240 V Frequency 50 Hz	17

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Theory of Machines	S S Ratan	Tata Mcgraw Hills;5th edition, 2019 ISBN-978-9353166281
2.	Theory of Machines	R. S. Khurmi J. K. Gupta	S. CHAND; 14th edition,2020 ISBN-978-8121925242
3.	Theory of machines	R.K.Bansal	Laxmi publications; Revised,2016 ISBN-978-8131808054
4.	Theory of machines	Jagdishlal	Metropolitan Book Co. (p) Ltd. ISBN-978-8120002722
5.	Dynamics of Machines	J. B. K. Das	Sapna Book House, 2008 ISBN-978-8128009112

(b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc22_me75/preview
2. https://www.youtube.com/watch?v=qmcriUdYBW0
3. https://nptel.ac.in/courses/112106270
4. https://nptel.ac.in/courses/112104121
5. https://onlinecourses.nptel.ac.in/noc20_me21/preview
6. https://www.youtube.com/watch?v=p075LPq3Eas&list=PL46AAEDA6ABAFCA78
7. user.engineering.uiowa.edu/~mie032/support/eg/eg07_section_views.pd
   web.aeromech.usyd.edu.au/.../Engineering%20Drawings%20Lecture%20Sectioning
8. http://nptel.iitm.ac.in/video.php?subjectId=112104121
9. http://www.technologystudent.com/gears1/gears7.htm
10. http://kmoddl.library.cornell.edu/model.php?m=20
11. http://www3.ul.ie/~kirwanp/whatisacamandfollowersyste.htm
12. http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT-Delhi/Kinematics%20of%20Machine/index.htm
13. http://elearning.vtu.ac.in/12/enotes/Des_Mac-Ele2/Unit6-RK.pdf

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

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

*****

A) Course Code : 2433405(T2433405/P2425405/S2425405)

B) Course Title : Auto-Component Manufacturing Process

C) Pre- requisite Course(s) :

D) Rationale :

The core automotive industry includes vehicle and components manufacturing industries which supports a wide range of business segments, both upstream and downstream, along with adjacent industries and leads to a multiplier effect for growth and economic development of nation. As a diploma engineer, students are supposed to manage operations of manufacturing in the industries. Therefore, they should have operational knowledge and skills to operate various machine tools to perform different types of manufacturing processes. This course enables students to know about various manufacturing processes used to manufacture various components of vehicles, to select proper tools and practices for working at workshop and also develops safety consciousness through performing job on machine tool.

E) Course Outcomes (COs): The underpinning knowledge and the relevant skills associated with this competency are to be developed in the student to display the following COs:

After completion of the course, the students will be able to –

- **CO-1** Select appropriate manufacturing process and associated tools based on its benefit to satisfy functional requirements of automobile components
- **CO-2** Develop pattern and mould for the given casting process to produce casted various engine components
- **CO-3** Use relevant Metal hot and cold Working Processes and methods for the given application.
- **CO-4** Perform various metal joining processes (i.e. welding, soldering and brazing) for different materials in manufacturing auto components
- **CO-5** Execute relevant surface treatment processes for required job.
- **CO-6** Apply concept of modern manufacturing technology for green and sustainable growth of automobile industries.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes* (PSOs)	
	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**
CO-1	3	-	-	2	-	-	-		
CO-2	3	-	-	3	-		-		
CO-3	3	-	-	3	-	2	-		
CO-4	3	3	-	2	-	-	-		
CO-5	3	2	2	3	-	2	3		
CO-6	3	2	3	-	3	3	-		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2433405	Auto-Component Manufacturing Process	03	-	04	02	09	06

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work & Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2433405	Auto- Component Manufacturing Process	30	70	20	30	20	30	200

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating scales and rubrics)

TWA: Term work &Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty, but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2433405

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 1a. Describe various manufacturing processes and its applications in automobile. *TSO 1b.* Describe working principles of common machine Tools. *TSO 1c.* Describe factors affecting the selection of suitable Machine tool.	**Unit-1.0 Basics of Manufacturing Processes** 1.1. Nature, role and scope of manufacturing process. 1.2. Classification, Selection and Applications of each manufacturing processes 1.3. Fundamentals of Basic Machine Tools 1.4. Working principle and operation of: lathe, milling, drilling, shaper, planer and grinding machine. 1.5. Factors affecting the selection of suitable Machine tool.	**CO1**
TSO 2a. Classify different types of patterns, pattern allowances, *TSO 2b.* Explain various types of molding sands and its properties *TSO 2c.* Describe the need of gating system. *TSO 2d.* Explain with sketches the working of melting furnaces *TSO 2e.* Select different metal casting processes for casted various engine components in industries *TSO 2f.* Observe various Casting defects and its remedial measures	**Unit-2.0 Metal Casting Processes** 2.1 Basics and classification of metal casting methods. 2.2 Working principles of sand casting 2.3 Types of patterns, allowances and pattern materials 2.4 Types of moulding sands and its properties. 2.5 Introduction about Gating system 2.6 Working of melting furnaces. 2.7 Working principles and manufacturing methods for piston, piston rings, cylinder block, carburetors, engine head, oil pan, wet and dry liners. 2.8 Casting defects & remedial measures.	**CO2**
TSO 3a. Classify metal working methods. *TSO 3b.* Describe principles and applications of different metal working processes in automobile. *TSO 3c.* Explain with sketches the usage of different forging tools and salient features of different forging methods. *TSO 3d.* Select the forging sequence(s) for the given forging method(s) *TSO 3e.* Observe defects and its remedies in metal working process *TSO 3f.* Identify suitable Press machine for the given press operation with justification	**Unit-3.0 Metal Working Processes** 3.1 Fundamentals and classification of metal working methods. 3.2 Hot and cold working processes. 3.3 Working principles of: Rolling, Blanking, Piercing, Wire and Tube Drawing, Spinning, Forging, Bending, Embossing and Extrusion and applications of each processes in automobile. 3.4 Forging hand tools, forging methods and forging sequences for auto components – connecting rod, crankshafts, camshafts, valve, piston pin and spanners. 3.5 Defects observed in cold and hot working processes & its Remedial measures. 3.6 Classification, construction and working principle of press machine. 3.7 Material used in press work for automobile industry.	**CO1, CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant Cos Number(s)
TSO 4a. Describe different metal joining processes. *TSO 4b.* Identify appropriate metal joining process for the given jobs *TSO 4c.* Explain working principle of welding process. *TSO 4d.* Describe principles, application and limitation of gas welding and arc welding. *TSO 4e.* Describe special welding processes. *TSO 4f.* Compare welding, soldering, brazing and braze welding. *TSO 4g.* Identify defects and remedial measures in the process of welding job	**Unit-4.0 Metal Joining Processes** 4.1 Basics and classification of metal joining methods 4.2 Types of Welding joints 4.3 Working principles, application, and limitations of Gas Welding, Arc Welding, 4.4 Special welding processes such as TIG, MIG, friction welding, Resistance Welding, Laser beam welding and Electron beam welding. 4.5 Working principle of Soldering, Brazing and Braze Welding. 4.6 Defects and Remedial Measures in Welding.	**CO4**
TSO 5a. Select the relevant surface cleaning process for the given materials. *TSO 5b.* Explain with sketches the relevant surface coating process for the given component. *TSO 5c.* Explain with sketches the relevant surface finishing process for the given component. *TSO 5d.* List the applications of the given surface treatment processes with justification.	**UNIT 5.0 Surface Treatment Processes** 5.1 Surface Cleaning Processes: acid alkaline, electrolytic cleaning, blasting and tumbling. 5.2 Metallic Surface Coating: Electroplating, Galvanizing, Metal Spraying and Powder Coating. 5.3 Surface finishing methods: honing, buffing, lapping and polishing.	**CO5**
TSO 6a. Compare conventional and non-conventional manufacturing processes. *TSO 6b.* Explain need and role of automation in automobile industry. *TSO 6c.* Describe working principles of advance machine tools. *TSO 6d.* Illustrate working principle, application and limitations of various non-conventional manufacturing processes. *TSO 6e.* List applications of automatic material handling tools. *TSO 6f.* Describe Additive manufacturing.	**Unit-6.0 Modern Manufacturing Processes** 6.1 Classification, comparison between conventional and non- conventional machining processes 6.2 Need and Role of Automation in manufacturing of automobile industry. 6.3 Basic concepts of NC, CNC, DNC, CIM, GT, FMS. 6.4 Application of Automated Material handling tools like AGVs, AS/RS and Robots. 6.5 Working principles, applications, and limitations of Electrical Discharge Machining (EDM), Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Laser Beam Machining (LBM), Electron Beam Machining (EBM) 6.6 Classification, basic principles and need of Additive Manufacturing.	**CO6**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2433405

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.1. Identify various manufacturing processes.	1.	Identify various manufacturing processes & its applications in Automobile industry.	CO1

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 1.2. List out applications of manufacturing processes in automobile industry.			
LSO 2.1. Identify operation carried out on lathe, milling, drilling, shaper, planer and grinding machine. *LSO 2.2.* Identify various tools used for performing various operations on lathe, milling, drilling, shaper, planer and grinding machine.	2.	Demonstrate operation of conventional machine tools such as lathe, milling, drilling, shaper, planer and grinding machine.	CO1
LSO 3.1. Interpret given pattern drawing. *LSO 3.2.* Calculate pattern allowances for the given component.	3.	Prepare a pattern for the given components/drawings, considering pattern allowance.	CO2
LSO 4.1. Identify all the elements of sand casting mould. *LSO 4.2.* Prepare mould for the given casting pattern.	4.	Prepare a mould using a prepared pattern, and molding sand. Also pour molten metal and get the casting. (Use wax in place of molten metal for the purpose of demonstration.)	CO2
LSO 5.1. Identify the defects produced in casted parts. *LSO 5.2.* Suggest remedial measures to reduce casting defects.	5.	Observe and Check casting defects of given casting parts	CO3
LSO 6.1. Perform operation on smithy	6.	Prepare a simple job using hot/cold forging/hot smithy process.	CO4
LSO 7.1. Identify various defects of given hot/cold metal working process *LSO 7.2.* Suggest remedial measures to reduce casting defects.	7.	Observe and check defects of given hot/cold metal working process	CO4
LSO8.1. Interpret metal joining process through arc welding. *LSO 8.2* Suggest safety precautions required during arc welding process.	8.	Prepare a job using arc welding. This includes cutting of raw material and edge preparation.	CO5
LSO 9.1. Prepare a job using gas welding process with proper safety precautions.	9.	Prepare a job using gas welding. This includes cutting of raw material and preparation of pre-weld parts.	CO5
LSO 10.1. Prepare a job using special welding processes such as TIG, MIG, Friction welding, Resistance welding, laser beam & Electron beam welding.	10.	Prepare a job using special welding processes	CO5
LSO 11.1. Prepare an individual job using soldering and brazing process with proper safety precautions.	11.	Prepare two jobs, one using soldering and another using brazing.	CO4
LSO 12.1 Identify surface finishing process for various automobile components. *LSO 12.2* Write advantage of various types of surface finishing operations. *LSO 12.3* Differentiate between various types of surface finishing operations.	12.	Demonstrate any one surface finishing operation (honing, buffing, lapping & polishing).	CO4
LSO 13.1. Prepare a chart on, any two modern manufacturing process.	13.	Make a chart on, any two modern manufacturing process. (EDM, USM, AJM, LBM and EBM.)	CO6

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 14.1. Prepare a report on Automation in Manufacturing technology.	14.	Make a report on Automation in Manufacturing Technology.	CO6
LSO 15.1. Identify various features of CNC lathe and/or CNC milling machine *LSO 15.2.* Interpret the CNC part program	15.	Demonstrate working of CNC Lathe and/or CNC Milling Machine.	CO6

L) Suggested Term Work and Self Learning: S2433405 Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Perform a casting process by using different types of patterns and estimate the cost.
2. Manufacture auto parts using appropriate metal forming process.
3. Weld two pieces of the same components using gas welding and arc welding and compare their strength, surface roughness, weight, and cost.
4. Use appropriate cutting fluids and lubricants in given situations for better machining.

c. Other Activities:

1. Seminar Topics:
   - Usage of different forging tools and different forging methods.
   - Metal casting processes and their industrial application
   - Analysis of casting defects for quality improvement of sand casting.
   - Recent development in welding process.
   - Forging hammers, press and dies.
   - Selection of cutting tool for machining of given material for better surface finish.
   - Modern manufacturing processes (CNC and VMC)
   - Additive manufacturing
   - Automation in Auto component manufacturing technology
2. Visits: Visit nearby automobile Industry /Tool-room/plant which having casting, forming, welding, and machining facilities. Prepare report of visit of components produce by casting, forming, welding, machining, technique used, material used, single component/batch production/mass production and cost of component.
3. Self-Learning Topics:
   - Prepare Display Board such as gas cutting kit, welding kit etc.
   - Meal forming defects causes and its remedies.
   - Explore advanced welding techniques and their applicable in automobile Industries.
   - Identify advanced manufacturing processes used in making the main component of auto engine assemblies
   - Industrial application of surface finishing operation such as honing, buffing & lapping
   - Application of latest machining process such as Electrical Discharge Machining (EDM), Ultrasonic Machining (USM), Abrasive Jet Machining (AJM), Laser Beam Machining (LBM), Electron Beam Machining (EBM)

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	10%	10%	10%	-	-	10%	10%
CO-2	20%	20%	20%	25%	-	15%	15%
CO-3	20%	20%	20%	25%	30%	20%	20%
CO-4	20%	20%	20%	20%	30%	20%	20%
CO-5	15%	15%	15%	15%	15%	20%	20%
CO-6	15%	15%	15%	15%	25%	15%	15%
Total Marks	**30**	**70**	**20**	**20**	**10**	**20**	**30**
			50				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

Unit Title and Number	Total Classroom Instruction (CI) Hours	Relevant COs Number(s)	Total Marks	ETA (Marks)		
				Remember (R)	Understanding (U)	Application & above (A)
Unit-1.0 Basics of Manufacturing Processes	6	CO1	8	2	4	2
Unit-2.0 Metal Casting Processes	10	CO2	14	4	6	4
Unit-3.0 Metal Working Processes	10	CO1, CO3	14	4	6	4
Unit-4.0 Metal Joining Processes	10	CO4	14	4	6	4
Unit 5.0 Surface Treatment Processes	6	CO5	10	2	4	4
Unit-6.0 Modern Manufacturing Processes	6	CO6	10	4	2	4
Total	**48**	**-**	**70**	**20**	**28**	**22**

Note: Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

O) Suggested Assessment Table for Laboratory (Practical):

S. No.	Laboratory Practical Titles	Relevant COs Number(s)	PLA/ELA		
			Performance		Viva-Voce (%)
			PRA* (%)	PDA** (%)	
1.	Identify various manufacturing processes & its applications in Automobile industry.	CO1	30	60	10
2.	Demonstrate operation of conventional machine tools such as lathe, milling, drilling, shaper, planer and grinding machine.	CO1	30	60	10
3.	Prepare a pattern for the given components/drawings, considering pattern allowance.	CO2	30	60	10
4.	Prepare a mould using a prepared pattern, and molding sand. Also pour molten metal and get the casting. (Use wax in place of molten metal for the purpose of demonstration.	CO2	30	60	10
5.	Observe and Check casting defects of given casting parts	CO3	30	60	10
6.	Prepare a simple job using hot/cold forging/hot smithy process.	CO4	30	60	10
7.	Observe and check defects of given hot/cold metal working process	CO4	30	60	10
8.	Prepare a job using arc welding. This includes cutting of raw material and edge preparation.	CO5	30	60	10
9.	Prepare a job using gas welding. This includes cutting of raw material and preparation of pre-weld parts.	CO5	30	60	10
10.	Prepare a job using special welding processes	CO5	30	60	10
11.	Prepare two jobs, one using soldering and another using brazing.	CO4	30	60	10
12.	Demonstrate any one surface finishing operation (honing, buffing, lapping & polishing).	CO4	40	50	10
13.	Make a chart on, any two modern manufacturing process. (EDM, USM, AJM, LBM and EBM.)	CO6	40	50	10
14.	Make a report on Automation in Manufacturing Technology.	CO6	40	50	10
15.	Demonstrate working of CNC Lathe and/or CNC Milling Machine.	CO6	30	60	10

Legend:

PRA*: Process Assessment
PDA**: Product Assessment
Note: This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software:

S. No.	Name of Equipment, Tools, and Software	Broad Specifications	Relevant Experiment/ Practical Number
1.	Pattern materials, moulding sand,	Standard pattern materials Commonly used moulding sand	3 & 4
2.	moulding boxes, moulding equipment's, and tools	Size varies from 200mm to 600mm square by 75mm to 1000mm deep, screw motor drive, reciprocating crew and barrel, heaters, thermocouple, ring plunger, mould, tie bar, shovel, trowel, mallet, bellows, clamps, sand rammer, bellow lifter, vent wiredraw spike	3 & 4
3.	Forging equipment's and tools	Anvil (WEIGHT-167 lbs, horn-73/4", face length-10", rear-71/2"), hammer (double face sledge hammer10 kg), scaling hammer, chipping hammer, tongs (500g, flat nose size 15 inch) open hearth, air blower (60 hp capacity 40000 m3/hr.), swage block (14X14X5 inch material iron)	6
4.	Forging press	Capacity 16 MN, die height 900 mm, stroke length 320 mm, stroke rate 60 RPM, slide adjustment 10 mm,press height 6300mm	4
5.	Extrusion tools	Extruder screws, barrels and tips, extrusion dies sets	5
6.	Gas welding machine and hand tools	Welding torch, welding tip, pressure regulator, oxygen and acetylene gas cylinder and cutting kit with cylinder and regulator, spark lighter	9
7.	Arc welding machine	20 KV, 400 A Welding current, welding cable 400 amp, with all accessories	8
	Spot/Resistance Welding machine	Spot/Resistance welding machine includes: Plier cutter, Hammer, Steel rule, Anvil	
8	Soldering and brazing tools	Solder. Soldering iron (35 W) soldering wick, magnifying glass, wire cutters, brazing torch, aluminum brazing rod,	11
9	Sheet metal and hand tools	Snip, shears sheet gauge, straight edge, L/T square scriber, divider trammel, punches, pliers, stakes, groovers, limit set	6
10	Lathe machines	Capacity Light Duty Heavy Duty Height of center 165 mm 254 mm Swing Over Bed 325 mm 490 mm Swing Over Cross Slide 175 mm 290 mm Movement of Cross Slide 225 mm 300 mm Swing in gap 500 mm 800 mm With suitable motor drive with all accessories.	2
11	Milling machines	Working surface mm 1050 X250, width of T-slots 15mm, maximum distance from spindle Centre to underside of over support 15mm, longitudinal movement of the table by lever/ screw600 mm, spindle bore 17mm, range of spindle speed 50 -525 RPM, main drive electric motor 2HP	2
12	Drilling machines	Up to 15 mm drill cap with 1 HP motor 1000mm height	All
13	Grinding machine	No load speed 2840 RPM, wheel diameter 5-inch, voltage 220V, frequency 50Hz, rated input power 120 watts, wheel size 125X16X12.7 mm	2
14	CNC lathe(turning centre)	CNC lathe (turning centre) Oi-mate TD. 02. CAPACITY	15
15	VMC Machine	1200M. Table size, mm, 1200 x 510, 1500 x 630. Traverses X, Y & Z axes, mm, 1000 x 500 x 500l), 1200 x 600 x 600. Rapid rate, m/min, 12 (standard), 20/32 (optional),	2 &15
16	Electric discharge machine / Ultrasonic cutting machine / Abrasive jet machine	Specifications to be decided by the concerned Institutes	13

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Manufacturing technology volume 1	P. N. Rao	McGraw Hill Education ,2017 ISBN: 978-1259062575
2.	Manufacturing technology volume 2	P. N. Rao	McGraw Hill Education ,2018 ISBN: 978-353160524,9789353160524
3.	A Textbook of manufacturing Technology-1 and 2	Dr. pc. SHARMA	S. Chand,2011 ISBN:9788211928212
4.	A Textbook of manufacturing Technology-2	Dr. pc. SHARMA	S. Chand,2013 ISBN:9788211928465
5	Production technology	R.K Jain	Khana publishers,2021 ISBN:978-8195207565
6	Manufacturing science	Amitabha Ghosh, Ashok Kumar Mallik	East-west Press Pvt-Ltd,2010 ISBN:8176710636

(b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/112/107/112107219/
2. https://swayam.gov.in
3. https://auto.howstuffworks.com
4. https://tinyurl.com/mpvhf2as for video link
5. https://tinyurl.com/ms4pe636 for web link
6. https://www.youtube.com/watch?v=Kmb5tivQ_bY
7. https://www.youtube.com/watch?v=h-c4_Ukqgx4
8. http://www.youtube.com/watch?v=Kmb5tivQ_bY
9. https://www.youtube.com/watch?v=jk0Kap7afMc
10. https://www.youtube.com/watch?v=OOyAaWT6WQU
11. https://www.youtube.com/watch?v=BBqzca2gmNI
12. http://www.youtube.com/watch?v=U99asuDT97I
13. http://www.youtube.com/watch?v=RIbdYmmhPDI
14. https://www.youtube.com/watch?v=CoNw_faThgQ

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Automation, Production Systems, and Computer- integrated Manufacturing; Prentice Hall
2. Production Technology; Khanna Publication
3. Lab Manuals

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A) Course Code : **2400108(T2400108)**

B) Course Title : Essence of Indian Knowledge System and Tradition
(Common for all Programmes)

C) Pre- requisite Course(s) :

D) Rationale :

This course will survey the basic structure and operative dimensions of Indian knowledge system. With the new education policy-NEP 2020 focusing on Indian Knowledge Systems (IKS) and Traditions of India. This course introduces the learners to the rich and varied knowledge traditions of India from antiquity to the present. This also helps the learner to know and understand their own systems and traditions which are imperative for any real development and progress. Also, it helps the learner to think independently and originally adopting Indian frameworks and models for solving the problems related to world of work where the student is supposed to perform.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course out comes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

CO-1 Identify the rich heritage and legacy residing in our Indian Knowledge systems.

CO-2 Correlate the technological & philosophical concepts of IKS with engineering domain specific problems and local problems for finding out possible solutions.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	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**
CO-1	2	-	-	-	1	1	1		
CO-2	1	2	2	-	3	1	1		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (TW+ SL)	Total Hours (CI+LI+TW+SL)	Total Credits (C)
		L	T				
2400108	Essence of Indian Knowledge System and Tradition	01	-	-	-	01	01

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture(L), Tutorial(T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits= (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Assessment Scheme:

Course Code	Course Title	Assessment Scheme (Marks)						Total Marks (TA+TWA+LA)
		Theory Assessment (TA)		Term Work& Self-Learning Assessment (TWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Internal	External	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2400108	Essence of Indian Knowledge System and Tradition	25	-	-	-	-	-	25

Legend:

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

Note:

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) Theory Session Outcomes (TSOs) and Units: T2400108

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the architecture of the Ancient Indian Knowledge Systems. *TSO 1b.* List the salient features of IKS. *TSO 1c.* Comprehend the given IKS model. *TSO 1d.* Identify the role and relevance of the given IKS model in contemporary society.	**Unit-1.0 Introduction to Indian Knowledge Systems** 1.1 Overview of IKS 1.2 Organization of IKS – चतुर्दश-विद्यास्थानं 1.3 Conception and Constitution of Knowledge in Indian Tradition 1.4 The Oral Tradition 1.5 Models and Strategies of IKS	**CO1**
TSO 2a. Enlist the importance of Veda, Vedanga, Visaya, Siksaka. *TSO 2b.* Describe the given IKS domain. *TSO 2c.* Identify elements of mentioned IKS domains that are relevant to Technical Education System. *TSO 2d.* Correlate the elements of mentioned IKS domains with given engineering domain.	**Unit-2.0 Overview of IKS Domains and Relevance in Current Technical Education System.** 2.1 The Vedas as the basis of IKS 2.2 Overview of all the six Vedāṅgas 2.3 Relevance of following IKS domains in present Technical Education System: • Arthashastra (Indian economics and political systems) • Ganita and Jyamiti (Indian Mathematics, Astronomy and Geometry • Rasayana (Indian Chemical Sciences) • Ayurveda (Indian Biological Sciences / Diet & Nutrition) • Jyotish Vidya (Observational astronomy and calendar systems) • Prakriti Vidya (Indian system of Terrestrial/ Material Sciences/ Ecology and Atmospheric Sciences) • Vastu Vidya (Indian system of Aesthetics-Iconography and built-environment /Architecture) • Nyaya Shastra (Indian systems of Social Ethics, Logic and Law) • Shilpa and Natya Shastra (Indian Classical Arts: Performing and Fine Arts) • Sankhya and Yoga Darshna (Indian psychology, Yoga and consciousness studies) • Vrikshayurveda (Plant Science / Sustainable agriculture/food preservation methods)	**CO1, CO2**

Note: One major TSO may require more than one Theory session/Period.

K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

L) Suggested Term Work and Self Learning: Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

b. Micro Projects:

1. Write a report on any IKS domain highlighting the correlation with one domain specific engineering course.

c. Other Activities:

1. Seminar Topics: discuss any one IKS domain in details a highlighting the eminent works in the area.
2. Visits:
   - Visit any nearby ancient temple and correlate the geometrical, Shilpa and Vaastu on IKS dimensions specified in each domain.
3. Self-Learning Topics:
   - Sustainable practices adopted in ancient India that can be applied for current engineering situations.

M) Suggested Course Evaluation Matrix: The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

COs	Course Evaluation Matrix						
	Theory Assessment (TA)**		Term Work Assessment (TWA)			Lab Assessment (LA)#	
	Progressive Theory Assessment (PTA) Class/Mid Sem Test	End Theory Assessment (ETA)	Term Work & Self Learning Assessment			Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)
			Assignments	Micro Projects	Other Activities*		
CO-1	50%	-	-	-	-	-	-
CO-2	50%	-	-	-	-	-	-
Total Marks	**25**	**-**	-	-	-	**-**	**-**
			-				

Legend:

*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

**: Mentioned under point- (N)

#: Mentioned under point-(O)

Note:

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

N) Suggested Specification Table for End Semester Theory Assessment: (Not Applicable)

O) Suggested AssessmentTable for Laboratory (Practical): (Not Applicable)

P) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

Q) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

R) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Introduction to Indian Knowledge System: Concepts and Applications	Archak, K.B. (2012).	Kaveri Books, New Delhi
2.	Introduction to Indian Knowledge System: Concepts and Applications	Mahadevan, B. Bhat, Vinayak Rajat Nagendra Pavana R.N.	PHI, ISBN: 9789391818203
3.	Glimpse into Kautilya's Arthashastra	Ramachandrudu P. (2010)	Sanskrit Academy, Hyderabad
4.	"Introduction" in Studies in Epics and Purāṇas, (Eds.)	KM Munshi and N Chandrashekara Aiyer	Bhartiya Vidya Bhavan

(b) Online Educational Resources:

1. http://bhavana.org.in
2. www.academia.edu/23254393/Science_in_Ancient_India_-_an_educational_module
3. www.academia.edu/23305766/Technology_in_Ancient_India_-_Michel_Danino
4. www.hamsi.org.nz/http://insaindia.res.in/journals/ijhs.php
5. www.niscair.res.in/sciencecommunication/ResearchJournals/rejour/ijtk/ijtk0.asp
6. www-history.mcs.st-andrews.ac.uk/Indexes/Indians.html

Note: Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

(c) Others:

1. Swami Harshananda. "A bird's eye view of vedas". R K Math. Bangalore.,http:// rkmathbangalore. org/Books/ABirdsEyeViewOfTheVedas.pdf.
2. Sanskrit Prosody, https://en.wikipedia.org/wiki/Sanskrit_prosody.
3. Vartak, P.V. (1995). "Veda and Jyotish," Part II, Chapter 2, in Issues in Veda and Astrology, H Pandya (Ed.), pp 65 – 73.
4. Sundaram, A.V. (1995). "Astrology: Its usefulness and Limitations in ModernTimes", Part II, Chapter 9, in Issues in Veda and Astrology, H Pandya (Ed.), pp 129 – 135.
5. Archak, K.B. (2012), "The Vedāṅga Literature", Chapter VIII in Essentials of Vedic Literature, Kaveri Books, New Delhi, pp 330 – 391.
6. Vasant Lad (1996), "Ayurveda: A Brief Introduction and Guide", (whole article).

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A) Course Code : **24001111(T2400111)**

B) Course Title : Principles of Management
(CE, AIML, AE, CHE, CSE, ME (Auto), FTS, MIE)

C) Pre- requisite Course(s) :

D) Rationale :

The course is designed to provide students with an overview of the management functions and its role in organizations and society. The course aims to provide students with the basic managerial knowledge necessary for engineering students in the world of work. The course focuses on providing students with analytical, developmental, managerial, and technical skills that relate to managerial positions in organizations. This course is an introduction to the critical management skills involved in planning, organizing, controlling, leading and decision making in an organization. It provides a framework for understanding issues involved in both managing and being managed, and it will help you to be a more effective contributor to organizations that you join.

E) Course Outcomes (COs): After the completion of the course, teachers are expected to ensure the accomplishment of following course out comes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

After completion of the course, the students will be able to-

CO-1 Design strategic plan for various types of organizations.
CO-2 Take decisions to handle world of work situations.
CO-3 Formulate organizational hierarchy for different situations.
CO-4 Identify various leadership styles.

F) Suggested Course Articulation Matrix (CAM):

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)	
	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**
CO-1	1	-	-	-	-	3	1		
CO-2	1	2	2	-	-	3	1		
CO-3	1	-	3	-	-	3	1		
CO-4	1	2	-	-	1	3	1		

Legend: High (3), Medium (2), Low (1) and No mapping (-)

***** PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

G) Teaching & Learning Scheme:

Course Code	Course Title	Scheme of Study (Hours/Week)				
		Classroom Instruction (CI)		Notional Hours (TW/ Activities+ SL)	Total Hours (CI+TW/ Activities)	Total Credits (C)
		L	T			
2400111	Principles of Management	01	-	-	01	01

Legend:

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture(L), Tutorial(T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits= (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

Note: TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

H) Course Curriculum Detailing: This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

I) Theory Session Outcomes (TSOs) and Units: T2400111

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 1a. Explain the nature of management *TSO 1b.* List the steps of evolution of management. *TSO 1c.* Differentiate between different plans. *TSO 1d.* Design Strategic plan for the given world of work situation. *TSO 1e.* Take decisions in the given situation with justification.	**Unit-1.0 Introduction to Management and Planning** 1.1 Nature and Purpose. 1.2 Evolution of Management Thoughts. 1.3 System approach to Management Process. 1.4 Types of Plans: Missions or Purpose, Objective or Goals, Strategies, Policies, Procedures. 1.5 Decision Making.	**CO1, CO2**
TSO 2a. Differentiate formal and informal organizations. *TSO 2b.* Identify the levels of hierarchy in the given organization. *TSO 2c.* List the staffing principles.	**Unit-2.0 Organizing and Staffing** 2.1 Nature of Organizing 2.2 Formal and Informal Organization 2.3 Principles of Organizing, Organizational Hierarchy, Authority, and Power. 2.4 Staffing, Recruitment, Selection, Performance Appraisal.	**CO3**

Major Theory Session Outcomes (TSOs)	Units	Relevant COs Number(s)
TSO 3a. Explain the theories of motivation *TSO 3b.* Differentiate between leadership styles	**Unit-3.0 Motivation and Leadership** 3.1 Motivation 3.2 McGregor Theory of X and Y 3.3 Maslow Hierarchy of Needs Theory 3.4 Herzberg's Motivation- Hygiene Theory 3.5 Leadership: Definition, Ingredients, Styles, theories	**CO4**

Note: One major TSO may require more than one Theory session/Period.

J) Suggested Term Work and Self Learning: Some sample suggested assignments, micro project and other activities are mentioned here for reference.

a. Assignments: Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- Describe about adopting the systems approach in any organization.
- Write in brief about grapevine communication.
- Compare the traits Theory of X and Y as proposed by McGregor

b. **Micro** Projects:

- Apply Maslow's need hierarchy theory in workplace.

c. Other Activities:

1. Seminar Topics:
   - Importance of management theories in the corporates.
   - The hierarchy levels crate smoothness in functioning of any organization.
   - Leadership practices that are popular in current scenario.
2. Visits:
   - Visit nearby corporate setup and report
   - Interview leaders in the organization and identify leadership style'
3. Self-Learning Topics:
   - Herzberg's Motivation- Hygiene Theory
   - Leadership theories
   - Motivation for efficient productivity

K) Suggested Instructional/Implementation Strategies: Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

L) List of Major Laboratory Equipment, Tools and Software: (Not Applicable)

M) Suggested Learning Resources:

(a) Books:

S. No.	Titles	Author(s)	Publisher and Edition with ISBN
1.	Fundamentals of Management: Essential Concepts and Applications	Robbins S.P. and DeCenzo David A	Pearson Education
2.	Koontz Essentials of Management	Koontz	Tata McGraw Hill Latest Edition
4.	Principles and Practices of Management	Shejwalkar and Ghanekar	Tata McGraw Hill Latest Edition
5.	Fundamentals of Management	Robbins and Dinzo	2002, Pearson India.
6.	Organization Theory, Structure, Design and Application	Stephen P. Robbins	PHI, New Delhi, 2005

(b) Online Educational Resources:

1. https://www.coursera.org/learn/principles-of-management
2. https://alison.com/course/an-introduction-to-the-principles-of-management
3. https://www.udemy.com/course/principles-of-management-j/
4. https://lumenlearning.com/courses/principles-of-management/
5. https://www.mygreatlearning.com/academy/learn-for-free/courses/principles-of-management
6. https://onlineprogrammes.insead.edu/leadership-programme-for-senior-executives
7. implilearn.com/general-management-certification-training-course?utm_source=google&utm_medium=cpc&utm_term
8. https://discovery.ucl.ac.uk/id/eprint/10115948/1/Educational-Resource-Management.pdf
9. https://libraries.etsu.edu/research/guides/management/oer
10. https://www.cmu.edu/teaching/designteach/syllabus/checklist/learningresources.html

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(c) Others: -

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