

Mechanical Engineering

Paper-II

Time Allowed: Three Hours

Maximum Marks: 300

- Note:* 1. The figures in the margin indicate full marks for the questions.
2. Candidate should answer questions No. 1 and 5 which are compulsory and any **three** of the remaining questions, selecting at least **one** from each section.
3. Assume suitable value for any missing data if necessary.

SECTION - A

1. Answer any **three** of the following: 20×3=60
- (a) (i) Describe scavenging process and valve timing diagram of two and four stroke S.I Engine. 10
- (ii) A vehicle having four stroke petrol engine delivers 60 kW at full load and it needs 10 kW to keep it running at same speed without load. Find the mechanical efficiency and fuel consumption at 25%, 50%, 75% and full load. Also, calculate indicated thermal efficiency at full load condition. Take calorific value of fuel as 42 MJ/kg and brake thermal efficiency as 30%. What inference do you draw from the results? 10
- (b) (i) Define COP and show that the COP of the heat pump is greater than COP of refrigerator by unity. Also draw relevant diagram. 10
- (ii) With help of diagram discuss the psychometric processes: 1) cooling & dehumidification and 2) heating and humidification. 10
- (c) (i) Explain surging and stalling phenomenon in compressors. 10
- (ii) Power plant A of 250 MW capacity consumes coal at the rate of 250 T/h and Plant B of the same capacity consumes oil at a rate of 50 T/h. Assuming calorific value of coal and oil as 10 MJ and 42

MJ respectively, determine the heat rate of both the plants. What inference do you draw about performance of the two plants? 10

- (d) In a furnace chamber 750 kW of heat is released at a temperature of 2500 K by burning of fuel. Find the first and second law efficiency in the following cases
- (i) The above heat is utilised in a metallurgical furnace at a rate of 600 kW at 1200 K.
 - (ii) The heat is utilised for steam generation at a rate of 500 kW at 550 K.
 - (iii) The heat is utilised in a chemical process at a rate of 400 kW at 400K.
 - (iv) Also calculate second law efficiency in all the above cases if heat absorption is 500 kW for all the above cases.
- Assume ambient temperature 300 K. Also discuss the results. 20
2. (a) With the help of diagram, describe circulation ratio in the modern high pressure boiler. Discuss the higher and lower limit of circulation ratio in case of boiler having natural circulation. What is the importance of circulation ratio in case of boiler with assisted / forced circulation? 30
- (b) Describe draft system in the boiler. Discuss merits and demerits of different draft systems used in the boiler. 20
- (c) Discuss working and advantages of electrostatic precipitator (ESP) dust collection system used in power plants. 10
3. (a) With the help of proper figure discuss use of solar energy through solar thermal and photovoltaic route for solar refrigeration. 30
- (b) A rectangular fin 4 mm thick and 10 mm long is attached to a walls maintained at temperature of 500°C. Ambient temperature and convective heat transfer coefficient are 30°C and 20 W/m² °C respectively. Determine the heat loss from per unit depth of fin. 30
4. (a) With the help of velocity triangles at entry and exit of impellor, discuss features of centrifugal compressor having backward swept, radial swept and forward swept blade. 30

- (b) In a 2-row velocity compounded axial turbine, steam comes out from the first row nozzle at a velocity of 550 m/s and at nozzle angle of 15° . It travels through the turbine with the following parameters:

Mean peripheral blade velocity : 110 m/s

Steam flow rate : 8 kg/s

Blade (fixed & moving) friction coefficient : 0.9

Exit angles: first row moving blade : 20°

first row guide blade : 24°

second row moving blade : 36°

Determine tangential thrust, axial thrust power developed and diagram efficiency.

30

SECTION - B

5. Answer any **three** of the following: 20×3=60
- (a) Describe the need of alternate fuels for I.C engines. Discuss advantages of using bio-diesel in terms of performance and emission.
 - (b) Explain the term critical thickness of insulation. Derive expression of critical thickness of insulation over a steam pipe.
 - (c) With the help of velocity triangles, explain the flow through the impulse and reaction blades of axial turbine. Write the expression of efficiency for the both.
 - (d) Determine the air required for combustion of fuel having carbon, hydrogen sulphur and oxygen. What is the need of excess air for complete combustion?
6. (a) Describe different stages of combustion in CI engine and discuss the methods to reduce knock in CI engine. Also draw pressure and time/crank angle diagram. 30
- (b) What are the different pollutants coming out with exhaust emission of IC engines? Describe different methods to control the emission. 30

7. (a) A refrigeration system using Ammonia is working between condenser temperature of 35°C and evaporator temperature of -15°C . Calculate theoretical horse power and piston displacement per ton of refrigeration and COP each for dry and wet compression separately. Draw P-H diagram for both the cases. Use the following thermodynamic properties of ammonia at different locations. 30

Compression Condition	Enthalpies (kJ/kg) at:			Specific Volume (m ³ /kg) at:
	Compressor inlet	Compressor outlet	Evaporator outlet	Compressor inlet
Dry	1443.9	1703	366.1	0.509
Wet	1286.1	1488.6	366.1	0.448

- (b) Air at a temperature of 70°C is flowing inside the steel pipe of diameter 12 cm. The pipe is covered with two layers of insulating materials of thicknesses 5 and 3 cm and thermal conductivities 0.3 and 0.4 W/mK respectively. Convective heat transfer coefficients at inside and outside the pipe are 60 and 15 W/m²K. Assuming ambient temperature 30°C and neglecting the steel pipe thickness, calculate heat loss from a 100 m of pipe. 30
8. (a) Derive Euler's equation of turbo-machinery and discuss its application for turbines and compressor. 30
- (b) Describe profile and secondary loss in a turbine cascade. 30