SUBJECT: Basic Mechanical Engineering

Part-I

Q1 Answer the following questions: (2 x 10)

a) What are thermodynamic properties? Differentiate between intensive and extensive properties.

b) State the Zeroth Law of Thermodynamics and explain its significance.

c) Define entropy and explain its physical significance.

d) Differentiate between a 2-stroke and a 4-stroke internal combustion engine.

e) Define the term “specific gravity” of a fluid.

f) How does the viscosity of fluid vary with temperature?

g) What is thermal conductivity? How does it vary for solids and gases?

h) Mention the advantages of metal forming process over other manufacturing processes.

i) Mention the key principles of a robot.

j) Differentiate between shaft and axle in power transmission devices.

Part-II

Q2 Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve) (6 x 8)

a) Using the First Law of Thermodynamics, derive the energy balance equation for a closed

system undergoing a cyclic process.

b) Discuss the importance of the Second Law of Thermodynamics in determining the direction of spontaneous processes.

c) What is a polytropic process? Derive an expression for the work done during a polytropic process in terms of pressure and volume.

d) Illustrate the working cycle of a 4-stroke internal combustion engine with a schematic diagram. Explain each stroke in detail.

e) Differentiate between (I) Laminar vs Turbulent Flow, (II) Uniform vs Non-uniform Flow, (III) Steady vs Unsteady Flow, and (iv) Compressible vs Incompressible Flow.

f) Name the fluid properties responsible for the following actions in fluid mechanics:

(I) transport of water from root to the leaves of a plant, (II) spherical form of water bubbles,

(III) small insects being able to walk on water surface, (IV) cavitation, (V) no-slip condition,

and (VI) boiling of water below 100 0C temperature.

g) Explain the classification of heat transfer processes, and discuss how convection heat transfer is influenced by fluid motion.

h) Classify engineering materials and describe their characteristics with examples. Discuss the advantages and limitations of composite materials.

i) Highlight the requirements of a good gating system in the casting process.

j) Discuss the commonly encountered defects in sand casting process.

k) Discuss the advantages and disadvantages of spur gears and helical gears used for power transmission between two shafts.

l) Highlight different industrial applications of robots.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four)

Q3 a) Air at 12 0C and 85 kPa enters the diffuser of jet engine steadily with a velocity of 220 m/s. The inlet area of the diffuser is 0.38 m2. The air leaves the diffuser at a negligible velocity compared to inlet velocity. Calculate (i) mass flow rate of air (ii) the temperature of air leaving the diffuser. (8+8)

b) A heat pump is used to heat the house in the winter. A house requires 50 kJ/s heat for heating in winter which is delivered by heat pump from outside air. Work required to operate the heat pump is 8 kW. Calculate COP of heat pump and heat abstracted from the outside.

Q4 a) Two parallel plates are separated by a fluid layer of thickness 0.01 m. The lower plate is stationary, and the upper plate is subjected to a force of 10 N over an area of 0.2 m2. The fluid has a dynamic viscosity of 0.8 Pa. Determine the velocity of the upper plate. (8+8)

b) What is the vapor pressure of a liquid? How is it related to cavitation? Explain the factors that influence the vapor pressure of a liquid.

Q5 a) The velocity vector in a fluid flow is given as: 3 2 ˆ ˆ ˆ V x i x y j t k = − + 4 10 2 Find the velocity and acceleration of a fluid particle at (2, 1, 3) at time t = 1. (8+8)

b) A plane wall of 10 cm thickness and 3 m2 area is made of a material whose conductivity is 8.5 W/mK.

The temperatures of the wall surfaces are steady at 100 0C and 30 0C respectively. Find the temperature gradient and heat flow across the wall.

Q6 a) Define and explain the following mechanical properties: elasticity, plasticity, toughness, and hardness. Provide examples where these properties are critical in material selection. (8+8)

b) Explain the types of joints commonly used in robots, such as prismatic, revolute, and spherical joints. Provide examples of where each type is used.