

2021

MECHANICAL ENGINEERING

PAPER-II

Time Allowed — 3 Hours *Full Marks — 200*

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

*Answers may be given either in **English** or in **Bengali** but all answers must be in one and same language.*

Any data if needed may be assumed, but it must be clearly mentioned.

Answer *any five* questions.

1. (a) A vertical gate supports water on one side to a depth of 7·2 meters. Horizontal load on the gate is taken by three beams placed parallel to the water surface. Determine the position of the beams such that each beam carries one-third of the total load. 20

   (b) Water flows out through an opening, 20 cm in diameter, in the bottom of a constant level tank. Obtain an equation for the profile of the jet expressing 'V' in term of Z/H when the radius of the jet is 'V' at a depth 'Z' below the tank bottom and 'H' is the depth of water in the tank. 20

2. (a) A constant speed test of a centrifugal pump resulted in the following relationship:

   $$H = 43{\cdot}8 + 251Q - 3760Q^2$$

   where, H is the total head in metre and Q the discharge in m^3/s.

   The pump is to be used to deliver water through a pipeline 1 km long and 35 cm diameter, the static lift being 25·8 m. Calculate the operating head and the pump discharge taking the friction factor as 0·03 and neglecting the velocity heads. For the particular H vs. Q point at which the pump operates, determine the power required to drive the pump if the overall efficiency is 72%. 25

   (b) Oil of specific gravity 0·85 issues from a 5 cm diameter orifice under a pressure of 1·2 kg/cm^2 (gauge). The diameter of the jet at the vena contracta is 4·0 cm and the discharge is 1·2 m^3/ minute. What is the coefficient of velocity? 15

3. (a) Air at 227°C and 800 kPa expands to 200 kPa in a quasi-equilibrium process following the law $PV^{1\cdot3} = C$, where C is a constant. Determine the work done and heat transfer per kg of air. Specific heats of air are given as $C_P = 1{\cdot}0$ kJ/kg-K and $C_v = 0{\cdot}714$ kJ/kg-K. 15

(b) Two reversible heat engines are arranged in series in such a way that the heat rejected by the first engine is absorbed by the second engine. The first engine receives 400 kJ of heat from a reservoir maintained at temperature 600°C while the second engine rejects heat to a reservoir having temperature 0°C. If the work output of the first engine is twice that of the second, determine

(i) efficiency of both the engines,

(ii) heat rejected by the second engine,

(iii) intermediate temperature. 25

4. (a) Calculate the entropy change of 1kg of water at 27°C, when it is converted to ice at – 20°C. Specific heat of ice and water are 2·18 kJ/kg-K and 4·18 kJ/kg-K respectively. The latent heat of fusion of ice at 0°C is 335 kJ/kg. 15

(b) Two bodies, each of equal mass 'm' and heat capacity 'C_p' are at temperatures T_1 and T_2 respectively ($T_1 > T_2$). The first body is used as a source of heat for reversible engine and the second body as the sink. Show that the maximum work obtainable from such an arrangement is $mC_p \left(\sqrt{T_1} - \sqrt{T_2}\right)^2$. 25

5. (a) For the same maximum pressure and temperature of the cycle and the same heat rejection, which cycle is more efficient—Otto or Diesel? Explain with the help of P–V and T–S diagram. 20

(b) In an air standard Diesel Cycle, the pressure and temperature at the intake are 100 kPa and 27°C respectively. The maximum pressure in the cycle is 4 MPa and heat supplied during the cycle is 1000 kJ/kg. Determine

(i) the compression ratio,

(ii) the temperature at the end of the compression,

(iii) the temperature at the end of combustion,

(iv) the cut-off ratio,

(v) the air standard efficiency.

Assume : $\gamma = 1{\cdot}4$ and $C_p = 1{\cdot}005$ kJ/kg-K for air. 20

6. (a) Draw the nature of P–V and T–S plots for a Rankine Cycle with saturated steam at turbine inlet.

Why is a Carnot Cycle not practicable for a steam power plant? 10

(b) A steam power plant is designed to operate on Rankine Cycle. Steam enters into the turbine at 2 MPa, 400°C and leaves as saturated liquid in the condenser at 10 kPa. The mass flow rate of steam is 1 kg/s. Find out the power developed by the turbine and the efficiency of the cycle. Assume the efficiencies of the turbine and the pump as 0·85 and 0·8 respectively. 30