CBCS SCHEME

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15ME63

Sixth Semester B.E. Degree Examination, June/July 2023
Heat Transfer

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. State the laws governing three basic modes of heat transfer. **(06 Marks)**

b. Derive the general three-dimensional conduction equation in Cartesian coordinates and state the assumptions made. **(10 Marks)**

OR

2 a. Derive an expression for the temperature distribution through the plane wall with uniform thermal conductivity. **(06 Marks)**

b. A metal [K = 45 W/m°C] steam pipe of 5 cm inside diameter and 6.5 cm outside diameter is lagged with 2.75 cm thickness of high temperature high insulation having thermal conductivity 1.1 W/m°C. convective heat transfer coefficients on the inside and outside surfaces are 4650 W/m^{2}K and 11.5 W/m^{2}K respectively. If the steam temperature is 200°c and the ambient temperature is 25°C. Calculate:

i) Heat loss per metre length of pipe
ii) Temperature at the interfaces
iii) Overall heat transfer coefficient to inside and outside surfaces. **(10 Marks)**

Module-2

3 a. Derive an expression for the temperature distribution and heat flow for a pinfin, when the tip of the fin is insulated. **(08 Marks)**

b. A thin rod of copper K = 100 W/m°C, 12.5 mm in diameter spans between two parallel plates 150 mm apart. Air flows over the rod providing a heat transfer co-efficient of 50 W/m^2°C. The surface temperature of the plate exceeds the air by 40°C. Determine (i) The excess temperature at the centre of the rod over that of air and (ii) Heat lost from the rod in watts. **(08 Marks)**

OR

4 a. Show that the temperature distribution under lumped analysis is given by,

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-BiFo}$$

Where T_i = Initial temperature

T_∞ = Ambient temperature **(08 Marks)**

b. A 15mm diameter mild steel sphere (K = 42W/m°C) is exposed to coding air flow at 20°C resulting in the convective co-efficient h = 120W/m^2°C. Determine the following:

i) Time required to cool the sphere from 550°C to 90°C.
ii) Instantaneous heat transfer rate for 2 mins after start of cooling.
iii) Total energy transferred from the sphere during first 2 mins.

Take for mild steel S = 7850kg/m^3, C_p = 475J/kg°C, α = 0.045m^2/hr. **(08 Marks)**

Module-3

5 a. Explain formulation of differential equation 1-D steady heat conduction. **(06 Marks)**

b. Explain different solution method used in numerical analysis of heat conduction. **(06 Marks)**

c. Explain applications and computation error of numerical analysis heat conduction. **(04 Marks)**

OR

6 a. Define (i) Blackbody (ii) Planks law (iii) Wein displacement law (iv) Lamberts law. **(06 Marks)**

b. Prove that emissive power of the black body in hemispherical enclosures in π terms of intensity of radiation. **(06 Marks)**

c. The temperature of black surface of 0.2 m^2 area is 540°C. calculate (i) the total rate of energy emission (ii) the intensity of normal radiation (iii) the wavelength of maximum monochromatic emission power. **(04 Marks)**

Module-4

7 a. Explain the physical significance of:
(i) Prandtl number (ii) Reynolds number (iii) Nusselt number **(06 Marks)**

b. Air at 1 atm pressure and temperature 25°C flowing with a velocity 50 m/s crosses an industrial heater made of long solid rod of diameter 20 mm. The surface temperature of the heater is 457°C. Determine the allowable electrical power density (W/m^3) within the heater per meter length. **(10 Marks)**

OR

8 a. A circular plate of 25 cm diameter with both surfaces maintained at a uniform temperature of 100°C is suspended horizontally in atmospheric air at 20°C. Determine the heat transfer from the plate. **(10 Marks)**

b. Obtain the fundamental relationship between Nusselt, Prandtle and Reynolds number using Buckingham's π - theorem for forced convection heat transfer. **(06 Marks)**

Module-5

9 a. With assumptions, determine LMTD for counter flow heat exchanger. **(08 Marks)**

b. A parallel flow heat exchanger uses 1500 kg/hr of cold water entering at 25°C to cool 600 kg/hr of hot water entering at 70°C. The exit temperature on the hot side is required to be 50°C. Neglecting the effects of fouling make calculations for the area of heat exchanger. It may be assumed that the individual heat transform co-efficient on both sides are 1600 W/m^2K. Use LMTD and NTU approaches. **(08 Marks)**

OR

10 a. With a neat sketch, explain the different regimes of pool boiling. **(08 Marks)**

b. A vertical square plate 300m × 300m is exposed to steam at atmospheric pressure. The plate temperature is 98°C. Calculate the heat transfer and the mass of steam condensed per hour. **(08 Marks)**

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15ME64

Sixth Semester B.E. Degree Examination, June/July 2023
Design of Machine Element – II

Time: 3 hrs. Max. Marks: 80

Note: *1. Answer any FIVE full questions, choosing ONE full question from each module.*
2. Use of design data hand book permitted.
3. Missing data, if any, may be suitably assumed.

Module-1

1 a. Differentiate curved beam and straight beam with suitable diagram. **(04 Marks)**

b. Compute the combined stresses at the inner and outer surfaces of the crane hook. The cross section of the crane hook is trapezium of height 90mm and two parallel sides 30mm and 60mm. The inner radius of the crane hook is 100mm. The load line is nearer to the inner surface of the hook by 25mm than the centre of curvature at the critical section .The crane hook is used to lift a load of 25kN. **(12 Marks)**

OR

2 a. A cast iron cylindrical pipe of outside diameter 300mm and inside diameter 200mm is subjected to an internal fluid pressure of $20N/mm^2$ and external fluid pressure of $5N/mm^2$. Determine the tangential and radial stresses at the inner, middle and outer surface. Also sketch the tangential stress and radial stress distribution across its thickness. **(08 Marks)**

b. A 100mm inside and 150mm outside sleeve is press fitted on to a shaft of 100mm diameter? The modulus of elasticity of material is 210GPa and Poisson's ratio is 0.28. The contact pressure is not to exceed 60MPa. Determine :
i) Tangential stress at inner and outer surface of the sleeve ad outside diameter of the shaft
ii) Radial stress in the sleeve and shaft
iii) Original diameter of the shaft and hub before press fit
iv) Total interference. **(08 Marks)**

Module-2

3 a. A flat best is required to transmit 30KW from a pulley of 1500mm effective diameter running at 300rpm. The angle of contact is spread over $\frac{11}{24}$ of the circumference. The coefficient of friction between the belt and pulley surface is 0.3. Determine taking centrifugal tension into account, width of the belt required. IT is given that the best thickness is 9.5mm, density of its material is $1100kg/m^3$ and the related permissible working stress is 2.5MPa. **(10 Marks)**

b. A rope drive transmits 600KW from a pulley of effective diameter 4m, which runs at a speed of 90rpm. The angle of lap is 160°, the angle of groove 45°, the coefficient of friction 0.28, the mass of rope 1.5kg/m and the allowable tension in each rope 2400N. Find the number of ropes required. **(06 Marks)**

OR

4 a. The following data refers to the helical compression spring for the safety valve.

Maximum pressure	= 1.1MPa
Minimum pressure	= 1.0MPa
Diameter of the valve	= 100mm
Lift of the valve for this pressure range	= 6mm
Allowable shear stress	= 400MPa
Modulus of rigidity	= 80GPa
Spring index	= 5.5

Determine :

i) Maximum deflection
ii) Wire diameter
iii) Active number of coils. **(08 Marks)**

b. A truck spring has 12 number of leaves, tow of which are full length leaves. The spring supports are 1m apart and the central band is 70mm wide. The central load is to be 6kN with a permissible stress of 200MPa. Determine the thickness, width and deflection of steel spring leaves, if the ratio of total depth to width of the spring is 3. Take E = 206.8GPa. **(08 Marks)**

Module-3

5 Design a pair of spur gear 20° full depth inviolate to transmit 30KW of power at 600 rpm of pinion. Number of teeth on pinion is 15. Transmission ratio is 5. The pinion is made of cast steel untreated with allowable stress 137MPa and gear made of high grade cast iron with allowable stress 103MPa. Take service factor as 1.5. **(16 Marks)**

OR

6 Design a pair of helical gear to transmit 15KW of power at 4000rpm of pinion with a transmission ratio of 5. The material for pinion is 0.4% carbon steel with allowable stress 69MPa and the material for gear is cast iron with allowable stress 31MPa. Take service factor and fluctuation factors as 1.5 and 1.25 respectively. The profile of the gear is 20° FDI. **(16 Marks)**

Module-4

7 Complete the design and determine the input capacity of a worm gear speed reduces unit which consists of a hardened steel worm and a phosphor bronze gear having gear having 20° stub involute teeth. The centre distance is to be 200mm and transmission ratio is 10 and the worm speed is 2000rpm. **(16 Marks)**

OR

8 a. A motor clutch is required to transmit 60KW power at 2000rpm, from a single plate clutch, coefficient of friction is 0.25, allowable pressure is 0.75MPa. External diameter of the disc is 1.5 times the internal diameter. Assume uniform pressure circulation. Determine the dimensions of the plate and axial force required to engage the clutch. **(06 Marks)**

b. A simple band brake operates on 600mm diameter brake drum running at 200rpm, contact angle is 270°, $\mu = 0.25$. One end of the band is connected to a pin and other end 125mm from the pin and 625mm from the free end of the leaver, where the operating force is applied (effort). Find maximum pull required if 50KW power is absorbed. If the maximum tensile stress in the band is limited to a 50MPa, find width and thickness of the band and design the lever of rectangular cross section. Take depth =2 width material of the lever is having yield stress of 328.6MPa and take FOS = 2.5. **(10 Marks)**

Module-5

9 a. Derive Petroff's equation for co-efficient of friction. **(06 Marks)**

b. A full journal bearing 50mm in diameter and 50mm long operates at 1000rpm and carries a load of 5kN. The radial clearance is 0.025mm. The bearing is lubricated with SAE 40 oil and the operating temperature of oil is 80°C. Determine :

i) Bearing pressure
ii) Somerfield number
iii) Attitude and minimum film thickness
iv) Heat generated
v) Heat dissipitated if the ambient temperature is 20°C
vi) Amount of artificial cooling if necessary **(10 Marks)**

OR

10 a. With a neat diagram, explain the hydrodynamic theory of lubrication. **(06 Marks)**

b. Write short notes on Somerfield number. **(04 Marks)**

c. A single row deep groove ball bearing has a specific dynamic capacity of 46.3kN. The actual radial load $F_r = 9$kN. The speed of rotation is 1800rpm. What is the life in :

i) Cycles of operation
ii) In hours
iii) What is the average life? **(06 Marks)**

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