KATHMANDU UNIVERSITY
End Semester Examination
February, 2025

Marks Scored:

Level : B.E.
Year : III

Course : MEEG 306
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date 27 FEB 2025

Data books, steam tables & formula sheets are permitted during **SUBJECTIVE EXAMINATION ONLY**.

SECTION "A"

[20 Q. × 1 = 20 marks]

Choose and mark in [X] the most appropriate option from each set of choices

1. Studies show that error involved in 1 D fin analysis is negligible when $h\delta/k$ is _____
   [ ] 0 [ ] < 0.1 [ ] < 0.2 [ ] < 0.3

2. The value of _____ Constant is 6.62×10^{-34} J.s.
   [ ] Boltzmann's [ ] Planck's [ ] Wein's [ ] Kirchoff's

3. Thermal diffusivity is
   [ ] A dimensionless parameter [ ] A function of temperature
   [ ] Used as a mathematical model [ ] A physical property of materials

4. The radiation heat transfer rate per unit area between two black bodies at temperature 900 °C and 40 °C is _____ kW/m^2 °C
   [ ] 37.2 [ ] 10.7 [ ] 107 [ ] 1070

5. When the heated milk in an open container spill out, the boiling is known as _____ boiling.
   [ ] Sub-cooled [ ] Pool [ ] Nucleated [ ] Film

6. In practice, the efficiency of most fins are above _____ percent.
   [ ] 45 [ ] 60 [ ] 75 [ ] 90

7. A hot water stream of flow rate m_h = 1kg/s is to be cooled from 90 °C to 60 °C in a heat exchanger by contact with large stream of cold mater m_c= 2 kg/s. The inlet temperature of cold stream is 40°C. Consider counter flow arrangement and find by what amount the arithmetic and mean temperature difference overestimates the log mean temperature difference between two fluids.
   [ ] 27.5 °C [ ] 0.70 °C [ ] 1.0 °C [ ] 26.8 °C

8. Effectiveness of a fin is not a direct function of _____
   [ ] thermal conductivity [ ] cross section area
   [ ] temperature difference [ ] convective heat transfer coefficient

9. For the circular tube of equal length and diameter, the view factor $F_{1\text{-}3}$ = 0.17. The view factor $F_{1\text{-}2}$ in this case will be
   [ ] 0.17 [ ] 0.1 [ ] 0.79 [ ] 0.83

10. The ratio of surface convection resistance to internal conduction resistance is known as _____ number.
[ ] Biot [ ] Grashoff [ ] Stanton [ ] Prandtl

11. The 700 m^2 ceiling of a building has a thermal resistance of 0.2 m^2K/W. The rate at which heat is lost through the ceiling on a cold winter day when the ambient temperature is -10 °C and the interior is at 20 °C is _____ MW.
[ ] 150 [ ] 118 [ ] 105 [ ] 87

12. Solar radiation is incident on a semi-transparent body at a rate of 500 W/m^2. If 150 W/m^2 of this incident radiation is reflected back and 225 W/m^2 is transmitted across the body, the absorptivity of the body is _____
[ ] 0 [ ] 0.25 [ ] 0.3 [ ] 0.45

13. The relationship between the conduction shape factor and the thermal resistance is given by _____
[ ] $S = k \times R$ [ ] $S = \frac{1}{k \times R}$ [ ] $S = (k \times R)^{\frac{1}{2}}$ [ ] $\frac{1}{2}(k \times R)$

14. Eggs with mass of 0.15 kg per egg and a specific heat of 3.32 kJ/kg°C are cooled from 32 °C to 10 °C at a rate of 300 eggs per minute. The rate of heat removal from the eggs is ___ kW.
[ ] 11 [ ] 80 [ ] 25 [ ] 55

15. Three metal walls of same wall thickness and cross-sectional area have thermal conductivities k, 2k and 3k respectively. For the same heat transfers, the temperature drops across the wall will be in the ratio
[ ] Insufficient data [ ] 3:2:1 [ ] 1:1:1 [ ] 1:2:3

16. A hot metal piece kept in air cools from 80 °C to 70 °C in t_1 seconds, from 70 °C to 60 °C in t_2 seconds and from 60 °C to 50 °C in t_3 seconds. Then
[ ] Insufficient data [ ] $t_1 = t_2 = t_3$ [ ] $t_1 < t_2 < t_3$ [ ] $t_1 > t_2 > t_3$

17. The Nusselt number of convective heat transfer between a horizontal tube and water surrounding it is prescribed by the relation: $Nu = 0.52(Gr\ \mathrm{Pr})^{0.25}$
For a 4 cm diameter tube, the heat transfer coefficient is stated to be 1412 kcal/m^2 hr °C. Subsequently the tube is replaced by one with 16 cm diameter tube. If temperature and surface of the fluid remains same, the heat transfer coefficient will change to ____ kcal/m^2 hr °C.
[ ] 1000 [ ] 2824 [ ] 5648 [ ] 11296

18. In a counter flow heat exchanger, the hot fluid is cooled from 140 °C to 80 °C and cold fluid is heated from 20 °C to 80 °C. The value of LMTD is
[ ] 110 [ ] 80 [ ] 60 [ ] 50

19. The NTU of a heat exchanger is given by
[ ] $\frac{AC_{min}}{U}$ [ ] $\frac{U}{AC_{min}}$ [ ] $\frac{AU}{C_{min}}$ [ ] $\frac{C_{min}}{AU}$

20. The ratio of the thickness of thermal boundary layer to the thickness of hydrodynamic boundary layer is equal to (Prandtl number)^n, where n is equal to
[ ] -1/3 [ ] -2/3 [ ] 1 [ ] -1

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F. M. : 55

Students are permitted to use data books and formula sets during subjective examination ONLY.

SECTION "B"

Attempt ALL questions. Assume any missing values (if and only if needed).

1. Electrical resistance of the mattress type is inserted between two slabs of different materials. One side, *Asbestos mill board set @ 25°C* is used and is 1.25 cm thick. On the other side, *Kapak insulation material set @ 25°C* is used and is 5 cm thick. The heat transfer coefficients from outer surfaces of the thinner and thicker slabs are 30 and 16 W/m^2K respectively. Ambient temperature may be taken as 15°C. If the energy loss from each m^2 of the mattress is 5.4 kW, calculate: [5]
   a. The temperatures of the outer surfaces of both slabs
   b. The temperature of the mattress assuming it to be the same as that of the contact surface of the slab

2. An electrical wire of 4 mm in diameter is designed to bear the maximum temperature of 200°C when exposed to surrounding air temperature of 30°C and surface heat transfer coefficient of 20 $W/m^{2o}C$. The wire is insulated with 4 mm thick plastic insulation (K = 0.16 W/m°C) and wire surface temperature is maintained constant. Find out: [6]
   a. Percentage increase in current carrying capacity of the wire.
   b. What is maximum current carrying capacity of the wire if its surface temperature should remain same as original?
   c. What is maximum possible insulation thickness when the current carrying capacity is same as bare wire, which is considered most safe from electrical point of view?
   d. If the wire is insulated with 7 mm thick insulation, what is the effect of the current carrying capacity of the wire?

3. An electronic equipment has to dissipate 1.72 kJ/min of heat by providing pin fins of 1 mm diameter and 5 cm height of stainless steel whose conductivity is 65 W/m°C. The maximum temperature at the base is 200°C when surrounding air temperature is 30°C. If the heat transfer coefficient is 20 $W/m^{2o}C$. [6]
   a. Find out the number of fins required.
   b. If the fins of isosceles triangle base are to be used with the same height and with the same area of material, find out the percentage change in heat transfer rate.
   c. If the amount of heat to be dissipated is same, then what is the percentage change in the number of fins required.

4. One end of the long rod is inserted into a furnace with the other end projecting into the outside air. After steady state is reached, the temperature of the rod is measured at two points 10 cm apart and found to be 125 °C and 91 °C when then ambient temperature is 28 °C. If the rod is 2 cm in diameter and h = 15 W/m^2K, what is the thermal conductivity of the rod? [5]

P.T.O.

5. Air is flowing with 1590 km/hour on a plate which is maintained at 100 °C. If the temperature of the air is 20 °C, find the heat lost per hour from the plate assuming the plate is 50 cm long along the flow and 30 cm wide. [5]

6. The local atmospheric pressure in Chandragiri Hills is 83.4 kPa. Air at this pressure and 20 °C flows with a velocity of 8 m/s over a 1.5 m x 6 m flat plate whose temperature is 140 °C. Determine the rate of heat transfer from the plate if the air flows parallel to the: [6]

   a. 6 m long side
   b. 1.5 m side

7. In a heat exchanger, hot fluid enters at 180°C and leaves at 118°C. The cold water enters at 99°C and leaves at 119°C. Find the LMTD, and effectiveness in the following cases of heat exchanger: [8]
   a. Counter flow
   b. One shell pass and multiple tube passes
   c. Two shell passes and multiple tube passes
   d. Cross flow both fluids unmixed, and

8. Sketch a typical pool boiling curve for water at 1 atm indicating all the salient points. [3]

9. The furnace of boiler is laid from fire clay brick with outside lagging from plate steel; the distance between the two is quite small compared with the size of the furnace. The brick setting is at an average temperature of 365 K whilst the steel lagging is at 290 K. [7]
   a. Calculate the radiant heat flux. Assume the following emissivity values:
   $$\epsilon_{brick} = 0.85 \; and \; \epsilon_{steel} = 0.65$$
   b. What will be the reduction in heat loss if a steel screen having an emissivity value of 0.6 on both sides is placed between the brick and steel setting? Also calculate the desired emissivity of screen if the radiation loss is to be limited to 100 W/m^2.

10. Consider a thin hollow cylinder of 8 cm diameter and 10 cm length. If the radiant shape factor of the circular surface of this cylinder is 0.172, make calculations for the shape factor of the curved surface of the cylinder with respect to itself. [4]