AUG 1 9 2018

KATHMANDU UNIVERSITY
End Semester Examination
August, 2018

Marks scored:

Level : B.Tech.
Year : III

Course : MEEG 306
Semester: II

Exam Roll No. : Time: 30 mins. F. M. : 20

Registration No.: Date :

SECTION "A"
[20 Q × 1 = 20 marks]

Cross [×] mark the most appropriate answer.

1. The difference in slab two end temperatures maintained at 100° C and 50° C. The temperature profile obtained when the heat transfer takes place is
 [ ] linear
 [ ] parabolic
 [ ] exponential
 [ ] at first increase reaches a maximum at mid and then decreases

2. Fluid with velocity of $10\,{}^{m}/_{s}$ flows over a circular cylinder. It is observed that the flow separates and the flow reversal takes place behind the cylinder. This observation is true for which of the following conditions.
 [ ] $\frac{dP}{dx} = 0$ [ ] $\frac{dP}{dx} < 0$ [ ] $\frac{dP}{dx} > 0$ [ ] $\frac{dP}{dx} \leq 0$

3. The unit of thermal conductivity k and heat transfer coefficient h are ______ respectively.
 [ ] $\frac{W}{mK}$ and $\frac{W}{m^2K}$ [ ] $\frac{W}{m^2K}$ and $\frac{W}{mK}$ [ ] $\frac{W}{K}$ and $\frac{W}{m^2K}$ [ ] $\frac{W}{mK}$ and $\frac{W}{K}$

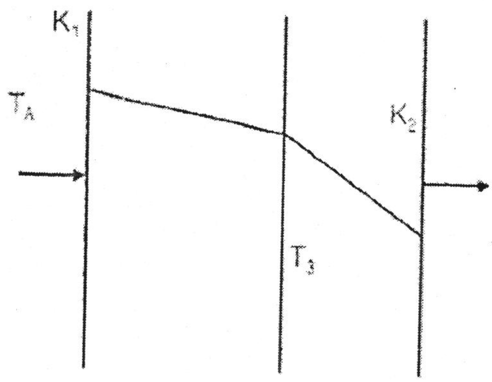
4. Critical insulation radius for a cylinder is
 [ ] $r_{o,c} = \frac{k}{h}$ [ ] $r_{o,c} = \frac{2k}{h}$ [ ] $r_{o,c} = \frac{h}{k}$ [ ] $r_{o,c} = \frac{2h}{k}$

5. The temperature of the fin in case of long fin varies
 [ ] linearly   [ ] hyperbolically   [ ] exponentially   [ ] parallel

6. Two layers of fluid are arranged one over another. The fluid at the top which is at temperature of 60 °C moves with a velocity of $2\,m/s$, while the fluid at bottom maintained at a temperature of 20 °C has also a velocity of $2\,m/s$. The movement of one fluid over another is parallel. The exchange of heat in this set up takes place by
 [ ] conduction   [ ] convection
 [ ] both conduction and convection   [ ] neither conduction nor convection

7. The ratio of actual heat transfer rate to that maximum heat transfer rate when the entire fin is at base temperature is called
 [ ] fin efficiency   [ ] fin effectiveness
 [ ] fin surface area   [ ] optimum fin heat transfer

8. The temperature variation under steady heat conduction along a composite slab of two materials with thermal conductivity of K_1 and K_2 as shown in figure. Which of the following conditions hold true?



[ ] $K_1 = K_2$ [ ] $K_1 > K_2$ [ ] $K_1 < K_2$ [ ] $K_1 = 0$

9. Heat transfer takes place according to
[ ] zeroth law of thermodynamics
[ ] first law of thermodynamics
[ ] second law of thermodynamics
[ ] third law of thermodynamics

10. Navier Stokes equation signifies
[ ] mass conservation
[ ] momentum conservation
[ ] energy conservation
[ ] both mass and momentum conservation

11. In which of the pool boiling regime, the heat flux decreases with increase in excess temperature $T_w - T_{sat}$
[ ] natural convection
[ ] nucleate boiling
[ ] transition boiling
[ ] film boiling

12. Hydro dynamic boundary layer is thick than the thermal boundary layer, in which of the following cases?
[ ] Pr = 1 [ ] Pr < 1 [ ] Pr > 1 [ ] Pr ≤ 1

13. Which of the following condition is true for mixed convection?
[ ] $\frac{Gr_L}{Re^2{}_L} \ll 1$ [ ] $\frac{Gr_L}{Re^2{}_L} \gg 1$ [ ] $\frac{Gr_L}{Re^2{}_L} = 1$ [ ] $\frac{Gr_L}{Re^2{}_L} \geq 1$

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

15. The dimensionless number that determines whether the flow is laminar or turbulent in natural convection is.
[ ] Reynolds number
[ ] Rayleigh number
[ ] Prandtl number
[ ] Nusselt number

AUG 1 9 2018

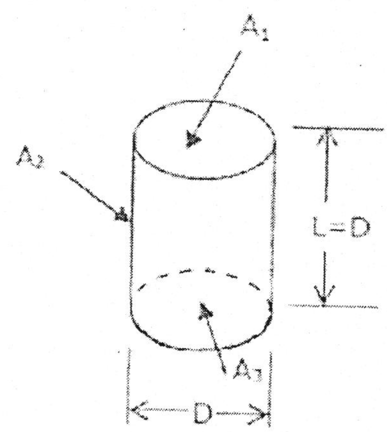
16. For black body, which of the following conditions is/are true?
[ ] $\propto = 1;\ \tau = 0; \rho = 0$
[ ] $\propto = 0;\ \tau = 1; \rho = 0$
[ ] $\propto = 0;\ \tau = 0; \rho = 1$
[ ] $\propto = 1;\ \tau = 1; \rho = 0$

17. Gray surface is one which
[ ] appears gray in color
[ ] properties are independent of wavelength
[ ] properties are dependent of wavelength
[ ] properties resemble to that of black surface

18. One face of a copper plate 3 cm thick is maintained at 400° C and the other face is maintained at 100° C. How much heat is transferred through the plate? Assume thermal conductivity value as 370 W/m.^{0}C.
[ ] 3.7 $MW/_{m^2}$ [ ] 2.7 $MW/_{m^2}$ [ ] 3.0 $MW/_{m^2}$ [ ] 4.7 $MW/_{m^2}$

19. Air at 20 °C blows over a hot plate 50 by 70 cm maintained at 250 °C. The convective heat transfer coefficient is 25 $W/_{m^2.\,°C}$. Calculate the heat transfer.
[ ] 2.012 kW [ ] 20.12 kW [ ] 0.2012 kW [ ] 2.5 kW

20. For the circular tube of equal length and diameter shown below, the view factor $F_{13} = 0.17$. The view factor F_{12} in this case will be



[ ] 0.17 [ ] 0.21 [ ] 0.79 [ ] 0.83

KATHMANDU UNIVERISTY
End Semester Examination
August, 2018

AUG 1 9 2018

Level : B.Tech.
Year : III
Time : 2 hrs. 30 mins.

Course : MEEG 306
Semester: II
F.M. : 55

SECTION "B"

Attempt *ALL* questions. Assume suitable data if missing.

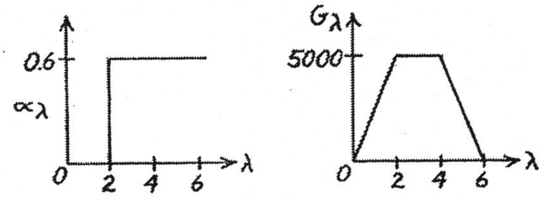
Q. No. 1

a. Heat flows over a flat plate of thickness 10 cm whose hot end temperature is 60° C. The quantity of heat flow from high temperature to low temperature is 100 Watts. If the thermal conductivity of the flat plate material is 50 W/m. K, Find the temperature gradient that exists in the plate. [2]

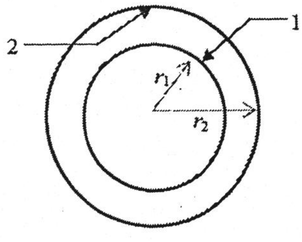
b. Consider the wall with thickness L whose hot side and cold side temperatures are maintained at T_h and T_c respectively. Show that for the problem stated the temperature profile is linear. Also write an expression to find the temperature at mid of the wall. Assume the problem as one dimensional steady state heat conduction with no internal heat generation. [4]

Q.No.2

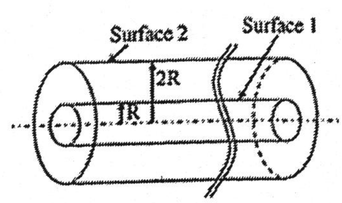
a. State Krichoff's laws of radiation. Spectral distribution of the absorptivity and irradiation of a surface at 1000 K is shown in the Figure below. Find the total absorptivity ($\propto$) and emissivity (ϵ). [1+ 4]



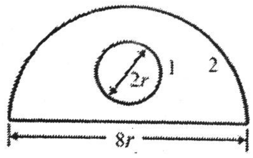
b. Write the view factors for the following cases mentioned below. [3]



Case: 1



Case: 2



Case 3

c. Two parallel black plates 0.5 m by 1.0 m are spaced 0.5 m apart. One plate is maintained at 1000 ^{0}C and other is maintained at 500 ^{0}C. What is net radiant heat exchange between the two plates? [3]

Q. No. 3

Air at 27 ^{0}C and 1 atm flows over a flat plate at a speed of 2 m/s. Calculate the boundary layer thickness at distances of 20 cm and 40 cm from the leading edge of the plate. Calculate the mass flow which enters the boundary layer between $x = 20\ cm$ and $x = 40\ cm$. Assume unit depth in the z direction. [4]

$$\frac{u}{u_\infty} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

Q. No. 4

Draw the pool boiling regime and label it. A cylindrical heating element with a diameter of 1 cm and length of 30 cm is immersed horizontally in a pool of saturated water at atmospheric pressure. The cylindrical surface plated with nickel. Calculate the heat flux q_w'' and the total heat transfer rate from the cylinder to the water poolq_w, when the surface temperature is T_w = 108 ^{0} C. Calculate also the critical heat flux q''_{max}. Justify the values obtained with boiling regime curve. [2+4]

Data given:

$$h_{fg} = 2257\frac{KJ}{kg} \rho_v = 0.6\frac{kg}{m^3}$$

Q. No. 5

The counter flow heat exchanger has a heat transfer area A = 10 m^2 and a corresponding overall heat transfer coefficient $U = 500\ {}^{W}/_{m^2K}$. It is used to cool 1.5 kg/s of hot oil initially at 100 ^{0}C, by contact with 0.5 kg/s stream of cold water whose inlet temperature is 15 ^{0}C. The respective c_p values of oil and water are 2.25 kJ/kg. K and 4.18 kJ/kg. K respectively. Find the heat transfer rate and outlet temperatures. [4]

Q. No. 6

a. An electric current is passed through a wire 1 mm in diameter and 10 cm long. The wire is submerged in liquid water at atmospheric pressure and the current is increased until the water boils. For this situation $h = 5000\ {}^{W}/_{m^2}$ °C. And the water temperature will be 100 °C. How much electric power must be supplied to the wire to maintain the wire surface at 114 °C? [2]

b. The non-dimensional fluid temperature profile near the surface of a convectively cooled flat plate is given by $\frac{T_w - T}{T_w - T_\infty} = a + b\frac{y}{L} + c\left(\frac{y}{L}\right)^2$ where y is measured perpendicular to the plate, L is the length, and a, b, c are arbitrary constants. T_w and T_∞ are wall and ambient

AUG 19 2018

temperatures respectively. If the thermal conductivity of the fluid is k and wall heat flux is q'' . Find the value of Nusselt number $Nu = \frac{q''}{T_W - T_\infty}\frac{L}{k}$. [3]

Q. No. 7

The thin plate is swiped by laminar flow. The length of plate in the flow direction is 20 times greater than the plate thickness (0.5 mm). The plate is isothermal $T_w = 35$ °C and water stream is somewhat colder $T_\infty = 25$ °C. Calculate the local heat flux at the trailing edge of the plate, plate averaged heat flux and heat transfer coefficient, and the total heat transfer rate between plate and water stream. [4]

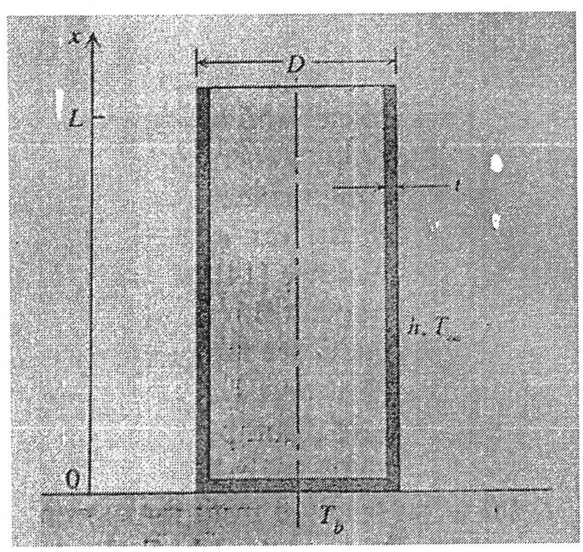
Q. No. 8

Steam at $T_{\infty 1} = 320$ °C flows in a cast iron pipe (k = 80 W/m·K) whose inner and outer diameters are D_1 = 5cm and D_2 = 5.5 cm, respectively. The pipe is covered with 3 cm thick glass wool insulation with k = 0.05 W/m.K. Heat is lost to the surroundings at $T_{\infty 2} = 5$ °C by natural convection with a combined heat transfer coefficient of h_2 = 18 W/m^2·K. Taking the heat transfer coefficient inside the pipe to be h_1 = 60 W/m^2·K, determine the rate of heat loss from the steam per unit length of the pipe. Also determine the temperature at all interfaces. [5]

Q. No. 9

During the investigation of the effect of temperature on the life of a battery, the battery is positioned on a plate heater of temperature T_b = 50 °C. The battery is cylindrical with a diameter D = 3 cm and a height L = 6 cm. The ambient temperature is T_∞ = 20 °C and the heat transfer coefficient at the outer cylindrical surface is $h = 5\ \frac{W}{m^2K}$. The outer skin of the battery is made out of stainless steel with a thickness t = 0.5 mm. The interior of a battery is such a poor conductor that a heat transfer between it and stainless steel shell can be neglected. [2+2]

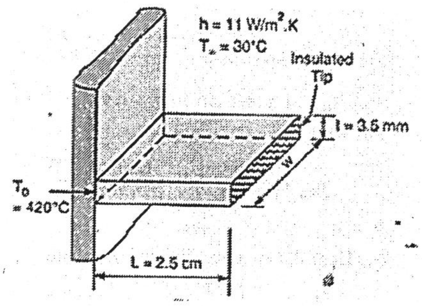
(a) Determine whether the stainless steel shell can be treated as long fin
(b) Calculate the temperature at the top edge of the shell i.e. at x = L in the Figure.



Q. No. 10

a. An aluminum alloy fin (k = 200 W/mK), 3.5 mm thick and 2.5 cm long protrudes from a wall. The base is at 420 ^{0}C and ambient air temperature is 30 ^{0}C. The heat transfer coefficient may be taken as 11 W/m^2K. Find the heat loss and fin efficiency, if the heat loss from the fin tip is negligible.

[4]



b. Consider heat conduction equation as [2]

a. $\frac{d^2T}{dx^2} + \frac{d^2T}{dy^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$

(i) Is heat transfer steady or transient?

(*ii*) Is heat transfer one, two, or three-dimensional?

(*iii*) Is there heat generation in the medium?

(*iv*) Is the thermal conductivity of the medium constant or variable?