

KATHMANDU UNIVERSITY  
End Semester Examination  
February/March, 2018

Marks scored:

Level : B. E.  
Year : III

Course : MEEG 306  
Semester: I

Exam Roll No.:

Time: 30 mins.

F.M. : 20

Registration No.:

Date **MAR 13 2018**

SECTION "A"  
[20 Q.×1=20 marks]

Cross [×] mark the most appropriate answer. Candidates are **not allowed to use data book and/or formula sheets during objective examination.**

1. The thermal conductivity of a material varies with \_\_\_\_\_  
[ ] area [ ] thickness [ ] temperature [ ] specific Heat
2. The radiation heat transfer rate per unit area between two black bodies at temperature 900 °C and 40 °C is \_\_\_\_\_  
[ ] 37.2 W/m<sup>2</sup> [ ] 10.7 W/m<sup>2</sup> [ ] 107 W/m<sup>2</sup> [ ] 1070 W/m<sup>2</sup>
3. The temperature distribution for a plane wall whose thermal conductivity is constant is \_\_\_\_\_  
[ ] parabolic [ ] linear [ ] logarithmic [ ] indeterminate
4. With increase in convective heat transfer coefficient, the fin effectiveness \_\_\_\_\_  
[ ] increases [ ] decreases [ ] remains constant [ ] is unpredictable
5. A composite wall made of materials whose conductivities are 2 K and K and maintained at 200 °C and 100 °C. If the junction temperature is not to exceed 150 °C, the ratio of thickness should be \_\_\_\_\_  
[ ] 1:2 [ ] 1:3 [ ] 1:1 [ ] 2:3
6. Dropwise condensation occurs on a/an \_\_\_\_\_ surface.  
[ ] oily [ ] glazed [ ] coated [ ] smooth
7. The natural convection heat transfer is associated with a non-dimensional number known as \_\_\_\_\_  
[ ] Weber [ ] Prandtl [ ] Nusselt [ ] Grashoff
8. The Prandtl number for gases lies between \_\_\_\_\_  
[ ] 0.65 to 1 [ ] 5 to 50 [ ] 60 to 100 [ ] 110 to 150
9. The heat transfer coefficient on a horizontal tube surrounded with water is represented by  $Nu = 0.52(Gr.Pr)^{0.25}$ . A tube of 4 cm diameter gives heat transfer coefficient of 1500 W/m<sup>2</sup> °C. If the tube of 4 cm diameter is replaced by 16 cm diameter, then the heat transfer coefficient becomes \_\_\_\_\_  
[ ] 750 [ ] 3000 [ ] 2140 [ ] 1070



KATHMANDU UNIVERSITY  
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Level : B. E.  
Year : III  
Time : 2 hrs. 30 mins.

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

SECTION "B"

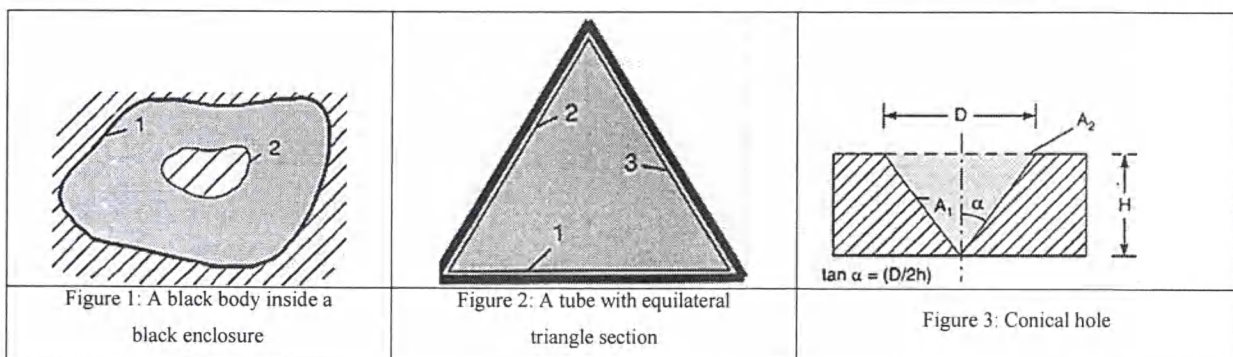
Attempt **ALL** questions. Use of **Data book and steam table is allowed in this exam.**

**Q.No.1**

- a. Calculate the surface area required for a cross flow heat exchanger with one tube pass and one shell pass and shell side fluid mixed, which has to cool  $60 \times 10^3$  kg/hr of alcohol ( $C_p = 4$  kJ/kgK) from  $66^\circ\text{C}$  to  $40^\circ\text{C}$  using  $50 \times 10^3$  kg/hr of water entering at  $10^\circ\text{C}$ . Assume that the overall heat transfer coefficient based on the water tube area is  $580$  W/m<sup>2</sup>K. [4]
- b. A counter flow heat exchanger operates under the following conditions: Fluid A, inlet and outlet temperatures  $80^\circ\text{C}$  and  $40^\circ\text{C}$  and Fluid B, inlet and outlet temperatures  $20^\circ\text{C}$  and  $40^\circ\text{C}$ . The exchanger is cleaned, causing an increase in overall heat transfer coefficient by 10% and the inlet temperature of fluid B is changed to  $30^\circ\text{C}$ , what would be the new outlet temperatures of fluid A & B? Assume heat transfer coefficient and capacity rates are unchanged by temperature changes. [5]
- c. Explain the significance of burnout phenomenon based on engineering design with representative Figure(s). [2]

**Q.No.2**

- a. At a wave length of  $4 \mu\text{m}$ , what is the temperature of the black body that will give an emissive power of  $1000$  W/m<sup>2</sup>  $\mu\text{m}$ . [3]
- b. Calculate the view factor  $F_{1-1}$ ,  $F_{1-2}$  and  $F_{2-1}$  for the following geometries: [2+2+1]



- c. The temperature of a filament of an incandescent light bulb (a black body) is maintained at  $2500$  K. Calculate the fraction of radiant energy emitted by the filament in the visible spectrum. Also calculate the wavelength at which the emission from the filament reaches maximum value. [3]

**Q.No.3**

- a. In a wind tunnel, 15 °C air at 5 m/s flows over a flat plate, 1 m × 0.8 m in size. The plate temperature is 35 °C. One of the side of the plate is arranged parallel to the flow direction, such that the heat transfer is lesser, estimate [3+1+3+1]
- Rate of heat transfer from one side of the plate (based on forced convection on length side).
  - Initial rate of cooling per hour of the plate, if mass of the plate is 5 kg and specific heat is 875 J/kgK.
  - If the flow is turned off, compute the heat flow rate from the upper surface of the plate in still air at 15 °C. (Take  $L_c = A_s/P$ )
  - What is the percentage change in heat flow rate?

Useful thermophysical properties of air and correlations:			
$\rho = 1.1707$ kg/m <sup>3</sup>	$C_{pf} = 1007$ J/kg.K	$\nu = 1.5712 \times 10^{-5}$ m <sup>2</sup> /s	$K_f = 0.02614$ W/m. K
$Pr = 0.7075$	$Nu = 0.664 Re_L^{1/2} Pr^{1/3}$ (Forced Convection)	$Nu = 0.27 (Gr_L Pr)^{1/3}$ (Natural Convection)	

- b. What are any three significances of using dimensionless number in convection heat transfer-based designs [3]

**Q.No.4**

- a. A nickel chrome (90 % Ni, 10 % Cr) fin having 8 mm diameter and 100 mm long is exposed to boiling water having convective heat transfer coefficient of 4000 W/m<sup>2</sup> K. T. Show by calculation how much heat dissipation is achieved and is it advisable to use the fin? How the heat dissipation performance change, if a non-metallic solid fin of aluminum oxide Sapphire at 27 °C is used? All other conditions are same. [5]
- b. A very long 25 mm diameter copper rod extends from a surface at 120 °C. The temperature of surrounding air is 25 °C and the heat transfer coefficient over the rod is 10 W/m<sup>2</sup>K. Calculate the heat loss from the rod and find out how long the rod should be in order to be considered infinite? [3]
- c. Three rods of pure copper, pure aluminum and chrome nickel steel (18 % Cr, 8 % Ni) are coated with wax all around and are dipped vertically in a water bath at 100 °C. The length of each rod projecting outside the bath is 300 mm. Diameter of each rod is 20 mm and length are 400 mm. Convective heat transfer coefficient at the surface of each rod is 11 W/m<sup>2</sup> K. Calculate the ratio of lengths of rod up to which wax melting occurs due to transfer of heat. [3]

**Q.No.5**

- a. Two large aluminum plates ( $k = 240$  W/m K), each 1 cm thick 10 μm surface roughness are placed in contact under pressure of 1 bar in air ( $k = 0.026$  W/m.K). The temperature at inside and outside surfaces are 400 °C and 150 °C. Calculate the heat flux, and the temperature drop due to contact resistance. [3]

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- b. To affect a bond between two metal plates, 2.5 cm and 15cm thick, heat is uniformly applied through the thinner plate by a radiant heat source. The bonding epoxy must be held at 320 K for a short time. When the heat source is adjusted to have a steady value of  $43.5 \text{ kW/m}^2$ , a thermocouple installed on the side of the thinner plate next to source indicates a temperature of 345 K. Calculate the temperature gradient for heat conduction through thinner plate and thermal conductivity of its material. [4]
- c. A square plate heater of 0.8 kW rating and measuring 15 cm by 15 cm is placed between two slabs A and B and the following data refers to these slabs:  
Slab A is 1.8 cm thick with  $k = 55 \text{ W/m}^\circ\text{C}$ .  
Slab B is 1 cm thick with  $k = 0.2 \text{ W/m}^\circ\text{C}$ .  
The outside heat transfer coefficients on the sides of plate A and B are  $200 \text{ W/m}^2^\circ\text{C}$  and  $45 \text{ W/m}^2^\circ\text{C}$  respectively. If the surrounding environment is at  $27^\circ\text{C}$  temperature, make calculations for the maximum temperature of the system and outside surface temperature of both slabs. [4]

