



RN-6863

B. E. III (Sem. V) (Mechanical) Examination

May / June – 2010

Heat & Mass Transfer

Time : 3 Hours]

[Total Marks : 100

Instructions :

(1)

नीचे दृशवित्त निशानीवाणी विगतो उत्तरवडी पर अवश्य लभवी. Fillup strictly the details of signs on your answer book.	Seat No. :
Name of the Examination :	<input type="text"/>
<input type="text" value="B. E. 3 (Sem. 5) (Mechanical)"/>	<input type="text"/>
Name of the Subject :	<input type="text"/>
<input type="text" value="Heat & Mass Transfer"/>	<input type="text"/>
Subject Code No. : <input type="text" value="6"/> <input type="text" value="8"/> <input type="text" value="6"/> <input type="text" value="3"/>	<input type="text"/>
Section No. (1, 2,.....) : <input type="text" value="1&2"/>	<input type="text"/>
	Student's Signature

- (2) Attempt **all** questions.
- (3) Figures to the **right** indicate **full** marks of question.
- (4) Answers to **both** sections to be written in **separate** answer books.

SECTION - I

- 1 (a) Attempt the following question : 6
- (1) A perfect black body
 - (a) absorbs all the incident radiation.
 - (b) allows all the incident radiation to pass through it.
 - (c) reflects all the incident radiation.
 - (d) has its surface coated with lamp black.
 - (2) The roof of a house has been given a coating of shining metallic paint. Consequently the temperature inside the room will
 - (a) fall
 - (b) rise
 - (c) remain unaffected
 - (d) cannot be decided as it depends on factors other than the type of paint.

- (3) The energy emitted (of all wavelengths) in a particular direction per unit surface area and through a unit solid angle is called
- Total emissive power
 - Monochromatic emissive power
 - Radiant flux
 - Intensity of radiation
- (4) Which parameter should be highest for a radiation shield ?
- absorptivity
 - reflectivity
 - transmissivity
 - emissivity
- (5) Finned surfaces have improved rate of heat dissipation due to
- decrease in ambient temperature
 - increase in the surface area exposed to the surrounding
 - increase in the surface area exposed to the surrounding
 - all of the above
- (6) Upto the critical radius of insulation
- heat loss decreases with addition of insulation
 - heat loss increases with addition of insulation
 - there occurs a decrease in heat flux
 - conduction heat loss is more than convection heat loss
- (b) Match the following 4
- | | |
|--|--|
| <p>(a) Heat flow through a composite wall by conduction is</p> | <p>(1) Thermal conductivity</p> |
| <p>(b) The radial transfer of heat through a thick cylinder is</p> | <p>(2) $\frac{4\pi k r_1 r_2 (T_1 - T_2)}{r_2 - r_1}$</p> |

(c) Heat transfer by (3)
$$\frac{2\pi l k (T_1 - T_2)}{\log_e \left(\frac{r_2}{r_1} \right)}$$

conduction through
a thick sphere is

(d) Heat conducted in unit (4)
$$\frac{T_1 - T_2}{\sum \frac{x}{kA}}$$

time across unit area
through unit thickness
when a temperature
difference of unity
is maintained

- (c) Derive the governing equation for heat conduction in 8 cartesian co-ordinates.

2 Attempt any two : 16

- (a) A steel pipe with 50 mm OD is covered with a 6.4 mm asbestos insulation [$K=0.166$ W/mK] followed by a 25 mm layer of fiber-glass insulation [$k=0.0485$ W/mK]. The pipe wall temperature is 393 K and the outside insulation temperature is 311K. Calculate the interface temperature between the asbestos and fiber glass.
- (b) Derive an expression for critical thickness of insulation for cylinder.
- (c) Aluminium square fins (0.5 mm \times 0.5 mm) of 10 mm length are provided on a surface of semiconductor electronic device to carry 1W of energy generated by electronic device. The temperature at the surface of the device should not exceed 80°C when surrounding temperature is 40°C. Taking the following data, find the number of fins required to carry out above duty. Neglect the heat loss from the end of fins.

$$k(\text{aluminum}) = 200 \text{ W / m}^\circ\text{C}, h = 15 \text{ W / m}^2 \text{ }^\circ\text{C}$$

- 3 (a) Derive Stefan-Boltzmann law from Planck's law. **5**
- (b) Two concentric spheres 210 mm and 300 mm diameters with the space between them evaluated are to be used to store liquid air (-153°C) in a room at 27°C. The surface of the spheres are flushed with aluminum ($\epsilon=0.03$) and latent heat of vaporization of liquid air is 209.35 kJ/kg. Calculate the rate of evaporation of liquid air. **5**
- (c) Derive an expression for heat exchange between non-black bodies which are infinite parallel planes. **6**

OR

- 3 (a) Explain Kirchoff's law of radiation. **5**
- (b) State and prove reciprocity theorem. **5**
- (c) The effective temperature of a body having an area of 0.12 m² is 527°C. Calculate the following : **6**
- (i) Total rate of energy emission
- (ii) Intensity of normal radiation and
- (iii) Wavelength of maximum monochromatic emissive power

SECTION - II

- 1 (a) Attempt any **ten** : **10**
- (1) The value of Prandtl number for air is
- (a) 0.1
- (b) 0.4
- (c) 0.7
- (d) 1.1
- (2) The value of LMTD in counter flow heat exchanger as compared to parallel flow heat exchanger is
- (a) more
- (b) less
- (c) same
- (d) none of the above
- (3) Automobile radiator is a heat exchanger of
- (a) Counter flow type
- (b) Parallel flow type
- (c) Cross flow type
- (d) Regenerator type

- (4) Baffles are provided in heat exchangers to
- (a) Increase pressure drop
 - (b) Decrease pressure drop
 - (c) Increase rate of heat transfer
 - (d) Decrease vibrations
- (5) A 1-2 heat exchanger means
- (a) 1 tube pass 2 shell pass
 - (b) 2 tubes pass 1 shell pass
 - (c) 2 tubes of cold fluid 1 tube hot fluid
 - (d) 1 tube of cold fluid 2 tubes hot fluid
- (6) A dimensionless number generally associated with mass transfer is
- (a) Stanton number
 - (b) Peclet number
 - (c) Mach number
 - (d) Biot number
- (7) For evaporator and condenser, the LMTD for parallel flow is _____ that for counter flow
- (a) Equal to
 - (b) Greater than
 - (c) Smaller than
 - (d) Any one of the above
- (8) Free convection heat flow depends on all of the following, except
- (a) Density
 - (b) Coefficient of viscosity
 - (c) Gravitational force
 - (d) Viscosity
- (9) Which dimensionless number has significant role in forced convection heat transfer ?
- (a) Stanton number
 - (b) Peclet number
 - (c) Mach number
 - (d) Reynolds number
- (10) A dimensionless number generally associated with mass transfer is
- (a) Stanton number
 - (b) Peclet number
 - (c) Mach number
 - (d) Biot number

- (11) The steam condenser in a thermal power plant is a heat exchanger of the type
- Direct contact
 - Regenerator
 - Recuperator
 - None of the above
- (12) In a free convection heat transfer, the limit for transition from laminar to turbulent flow is given by
- $Gr Pr > 10^8$
 - $Gr Pr > 10^9$
 - $Gr Pr > 10^7$
 - $Gr Pr > 10^6$
- (b) Compare the Fick's law of diffusion with Fourier's law of conduction and Newton's law of viscosity. 4
- (c) An open pan 20 cm in diameter and 20 mm deep is filled with water to a level of 10 mm and is exposed to air at 25°C. Assuming mass diffusivity of $0.25 \times 10^{-4} \text{ m}^2/\text{s}$, calculate time required for all the water to evaporate. 6
- 2 (a) What do you understand by local and average value of heat transfer coefficient ? 5
- (b) Air at 65°C flows over a heated flat plate at 121°C with a velocity of 0.915 m/s. Determine local heat transfer coefficient at a distance 0.61m from the leading edge and heat transfer rate for 0.61m length of the plate, taking width of the plate as 1 m. 10

OR

- (b) A straight tube having a diameter of 40 mm carries water with velocity of 10 m/s. The temperature of the tube surface is 50°C and flowing water is heated from 15°C to 25°C. Determine the length of the tube required. 10

- 3 (a) What do you mean by fouling factor ? State the causes of fouling. 4
- (b) What is natural convection ? How does it differ from forced convection ? 4
- (c) A thin walled concentric tube heat exchanger is used to cool engine oil from 160°C to 60°C using water as coolant which is available at 25°C. The oil and water flow rates are each 2 kg/s. The overall heat transfer coefficient 250 W/m²K. Determine the exit temperature of water and the heat exchanger area required for counter flow arrangement. Take $C_{water} = 4.187 \text{ kJ/kg.K}$ and $C_{oil} = 2.035 \text{ kJ/kg.K}$. 7

OR

- (a) A vertical plate 0.5 m high and 1 m wide is maintained at uniform temperature of 124°C. It is exposed to ambient air at 30°C. Calculate the heat transfer rate from the plate. 7