Type: DES

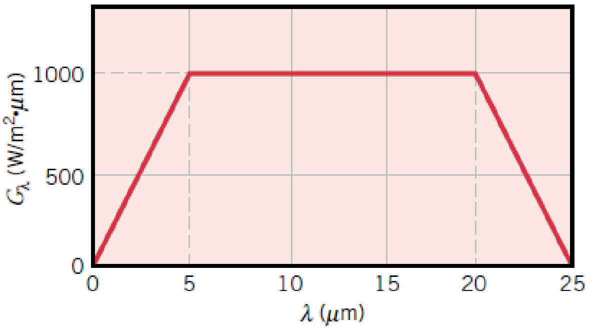
Q1. Explain extraterrestrial solar irradiation, Rayleigh, and Mie scattering for environmental radiation. (2)

Q2. Define thermal diffusivity. Derive the heat diffusion equation for cartesian coordinates. (4)

Q3. The temperature distribution across a wall 1m thick at a certain instant of time is given as $T(x)=a+bx+cx^2$ where T is in degrees Celsius and x is in meters, while $a=$ 900°C, b=-300°C/m, and c= -50°C/m^2. A uniform heat generation, 1000W/m^3 is present in the wall of area 10m^2 having the properties ρ= 1600 kg/m^3, k= 40 W/m.K, and cp=4 kJ/kg.K. **1.** Determine the rate of heat transfer entering the wall (x= 0) and leaving the wall (x= 1 m). **2.** Determine the rate of change of energy storage in the wall. Determine the time rate of temperature change at x=0, 0.25, and 0.5 m. (4)

Q4. Air at a pressure of 6 kN/m^2 and a temperature of 300°C flows with a velocity of 10 m/s over a flat plate 0.5 m long. Estimate the cooling rate per unit width of the plate needed to maintain it at a surface temperature of 27°C. Pr=0.687, υ=5.21X10^{-4} m^2/s, k=36.4X10^{-3}W/m.K. explain the concept of evaporative cooling. (4)

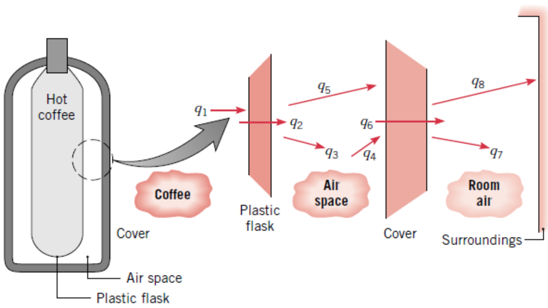
Q5. What are three important concepts of a black body? The spectral distribution of surface irradiation is as follows:



What is the total irradiation? (3)

Q6. Derive the temperature distribution for a plane wall. (3)

Q7. A closed container filled with hot coffee is in a room whose air and walls are at a fixed temperature.

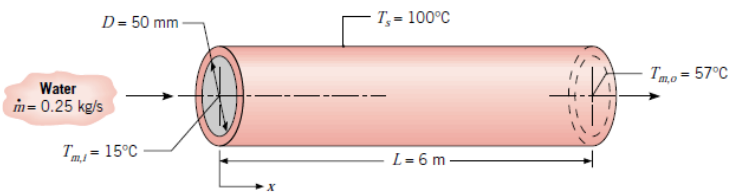


Identify all heat transfer processes that contribute to the cooling of the coffee. (4)

Q8. The concrete slab of a basement is 11 m long, 8 m wide, and 0.20 m thick. During the winter, temperatures are nominally 17°C and 10°C at the top and bottom surfaces, respectively. If the concrete has a thermal conductivity of 1.4 W/m.K, what is the rate of heat loss through the slab? If the basement is heated by a gas furnace operating at an efficiency of η_f = 0.90 and natural gas is priced at C_g= \$0.01/MJ, what is the daily cost of natural gas that must be combusted to compensate for the heat loss? (2)

Q9. Consider a plane composite wall that is composed of two materials of thermal conductivities k_A= 0.1 W/m. K and k_B = 0.04 W/m. K and thicknesses L_A= 10 mm and L_B= 20 mm. The contact resistance at the interface between the two materials is known to be 0.30 m^2. K/W. Material A adjoins a fluid at 200°C for which h=10 W/m^2.K and material B adjoins a fluid at 40°C for which h= 20 W/m^2. K. What is the rate of heat transfer through a wall that is 2 m high by 2.5 m wide? Draw the thermal circuit for the system. (4)

Q10. Steam condensing on the outer surface of a thin-walled circular tube of diameter D=50mm and length L=6m maintains a uniform outer surface temperature of 100°C. water flows through the tube at a rate of 0.25Kg/s and its inlet and outlet temperatures are 15 and 57 °C respectively. What is the average convection coefficient associated with the water flow? Consider Cp=4178 J/Kg.k.



(3)

Q11. Experiments have been conducted on a metallic cylinder 12.7 mm in diameter and 94 mm long. The cylinder is heated internally by an electrical heater and is subjected to a cross-flow of air in a low-speed wind tunnel. Under a specific set of operating conditions for which the upstream air velocity and temperature were maintained at V=10 m/s and 26.2°C, respectively, the heater power dissipation was measured to be P= 46 W, while the average cylinder surface temperature was determined to be T_s= 128.4°C. It is estimated that 15% of the power dissipation is lost through the cumulative effect of surface radiation and conduction through the endpieces. for Hilpert correlation, C= 0.193 and m= 0.618 and for Zukauskas relation, C= 0.26 and m= 0.6

Properties: Table A.4, air (T_∞ = 26.2°C ≈ 300 K): $\nu = 15.89 \times 10^{-6}$ m^2/s, $k = 26.3 \times 10^{-3}$ W/m·K, Pr = 0.707. Table A.4, air ($T_f \approx$ 350 K): $\nu = 20.92 \times 10^{-6}$ m^2/s, $k = 30 \times 10^{-3}$ W/m·K, Pr = 0.700. Table A.4, air (T_s = 128.4°C = 401 K): Pr = 0.690.

a) Determine the convection heat transfer coefficient from the experimental observations.**b)** Compare the experimental result with the convection coefficient computed from any 2 appropriate correlations. (5)

Q12. What is Wein's displacement law? Define radiosity and write the expression for spectral radiosity (2)

Q13. With the help of a nest diagram clearly explain various modes of pool boiling. (3)

Q14. Explain with a help of a neat diagram various types of heat exchangers. (3)

Q15. The bottom of a copper pan, 150 mm in diameter, is maintained at 115°C by the heating element of an electric range. Estimate the power required to boil the water in this pan. Determine the evaporation rate. Consider $C_{s,f}$=0.0128 amd n=1 for a copper pan.

PROPERTIES: *Table A-6*, Water (1 atm): $T_{sat} = 100°C$, $\rho_\ell = 957.9\ kg/m^3$, $\rho_v = 0.5955\ kg/m^3$, $c_{p,\ell} = 4217\ J/kg\cdot K$, $\mu_\ell = 279 \times 10^{-6}\ N\cdot s/m^2$, $Pr_\ell = 1.76$, $h_{fg} = 2257\ kJ/kg$, $\sigma = 58.9 \times 10^{-3}\ N/m$.

What is the ratio of the surface heat flux to the critical heat flux if critical heat flux is given as 1.26MW/m^2? What pan temperature is required to achieve the critical heat flux? (4)