Q-1 For each of the following, multiple choices are provided that reasonably answer the question. Read the following questions carefully and check [X] against the appropriate choice or choices providing the best possible answer.

a. A solid body is occupying a space between 0 to \( \infty \) is at initial temperature of \( T_1 \). If at time \( t=0 \), a sinusoidal heat flux is imposed at distance \( \sim 0 \) and if \( q_0 \) is the heat flux of oscillations and \( w \) is circular frequency, then the temperature distribution for unsteady state heat conduction is given by-

i. \[ T - T_1 = \frac{q_o}{k} \sqrt{\frac{\alpha}{w}} e^{-(\sqrt{w/2}\alpha y)} \cos(-0.785\pi + wt - \sqrt{\frac{w}{2\alpha}} y) \]

ii. \[ T - T_1 = \frac{q_o}{k} \sqrt{\frac{\alpha}{w}} e^{-(\sqrt{w/2}\alpha y)} \cos(wt - \sqrt{\frac{w}{2\alpha}} y) \]

iii. \[ T - T_1 = \frac{q_o}{k} \sqrt{\frac{\alpha}{w}} e^{-(\sqrt{w/2}\alpha y)} \cos(22/28 + wt - \sqrt{\frac{w}{2\alpha}} y) \]

iv. \[ T - T_1 = \frac{q_o}{k} \sqrt{\frac{\alpha}{w}} e^{-(\sqrt{w/2}\alpha y)} \cos(-0.785 + wt - \sqrt{\frac{w}{2\alpha}} y) \]

v. \[ \text{None of the above.} \]

b. A metallic ball of 1 ft diameter is at initial temperature of 30\(^\circ\)C and its thermal conductivity, specific heat, and density are 30 Btu/hr ft F, 0.5 Btu/lbm.F and 500 lbm/ft\(^3\), respectively. If it is plunged in into a fluid at 306 F, the time requires for the center of a ball to attain temperature of 150 F will be ……

i. \[ 0.208 \text{ sec} \]

ii. \[ 0.208 \text{ hrs} \]

iii. \[ 12.5 \text{ hrs} \]

iv. \[ 12.5 \text{ min} \]

V. \[ 12 \text{ sec} \]

iv. \[ \text{None of the above.} \]

Q-2 A viscous fluid at a mean temperature of 636\(^\circ\)R and a mean velocity of 0.1 m/s flows through a metallic tube with an ID of 1 inch. The outer surface of the tube dissipates heat by free convection into surrounding air at 528\(^\circ\)R. Calculate the temperature of a tube wall, overall heat transfer coefficient and the heat loss.

Q-3 A spherical tank of 20 cm diameter contains liquid N\(_2\) at about -196\(^\circ\)C. It is insulated with a thick porous inorganic coating of about 10 cm thickness to slow down the evaporation losses. A
small space of 0.02 cm is left between the spherical tank and porous insulator coating as shown below-

![Diagram of spherical tank with temperature differences](image)

If the thermal conductivity of the insulating material, heat of evaporation of N\textsubscript{2}, and average specific heat of N\textsubscript{2} flowing through the insulation are 117 W/m °C, 85.7 Btu/lbm, and 0.5 Btu/lbm °F, respectively, calculate the heat gain with and without the transpiration. Neglect the thermal resistance of the liquid N\textsubscript{2}, tank wall, and heat losses through the stopper.

**Q-4** A solid lump occupying the space between (−a, 0) to (+a, ∞) is initially at temperature of T\textsubscript{i,0}. At time t=0, the surfaces at x = −a, x = +a are instantaneously raised to a temperature T\textsubscript{1} and maintained there. Derive expression for temperature distribution as a function of distance and time.

If the expression for the temperature distribution is an infinite series, then show that for the higher values of dimensionless time, the series converges very fast.

**Points distribution:** Q-1: 10 points, Q-2: 10 points, Q-3: 40 points and Q-4: 40 points