Cankaya University
Faculty of Engineering
Mechanical Engineering Department
ME 313 Heat Transfer

Chapter-5 Examples
Fall 2015

1) A solid copper sphere of 10-cm diameter [$\mathbf{\rho = 8954\,kg/m^3}$, $\mathbf{c = 383\,J/kg.^0C}$, $\mathbf{k = 386\,W/m.^0C}$] initially at a uniform temperature $\mathbf{T_i = 250\,^0C}$, is suddenly immersed in a well-stirred fluid which is maintained at a uniform temperature $\mathbf{T_\infty = 50\,^0C}$ .The heat transfer coefficient between the sphere and the fluid is $\mathbf{\bar{h} = 200\,W/m^2.^0C}$

(a) Check whether the lumped system analysis is suitable

(b) If it is suitable , determine the temperature of copper sphere at t=5,10 and 20 min after the immersion.

2) A solid rod [α= $2x10^{-5}$ m^2/s and k=60 W/(m.°C)] of diameter D=6 cm, initially at temperature T_i=800 °C, is suddenly dropped into an oil bath at T_∞=50. °C. The heat transfer coefficient between the fluid and the surface is h=400 W/(m^2.°C).

(a) Using the transient-temperature charts, determine the centerline temperature 10 min after immersion in the fluid.

(b) How long will it take the centerline temperature to reach 100 °C?

Answer: (a) 54.5 °C ; (b) 5 min 47 s

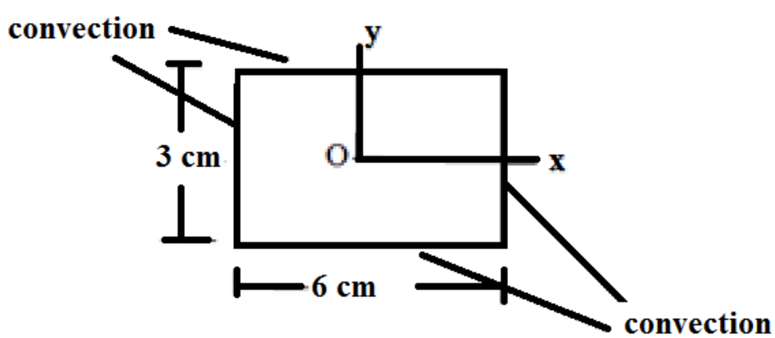
3) An orange of diameter 10 cm is initially at a uniform temperature of 30° C. It is placed in a refrigerator in which the air temperature is 2° C. If the transfer coefficient between the air and the surface of the orange is h=50 W/(m^2.°C), determine the time required for the center of the orange to reach 10 °C. Assume the thermal properties of the orange are the same as those of water at the same temperature. [α= $1.4x10^{-7}$ m^2/s and k=0.59 W/(m.°C)]
Answer: 1 h 32 min

4) A steel plate [α= $1.2x10^{-5}$ m^2/s and k=43 W/(m.°C)] of thickness 2L=10 cm, initially at a uniform temperature of 240 C, is suddenly immersed in an oil bath T_∞=40. °C. The convection heat transfer coefficient between the fluid and the surface is h=600 W/(m^2.°C). How long will it take for the center plane to cool to 100 °C? What fraction of the initial energy is removed during this time?

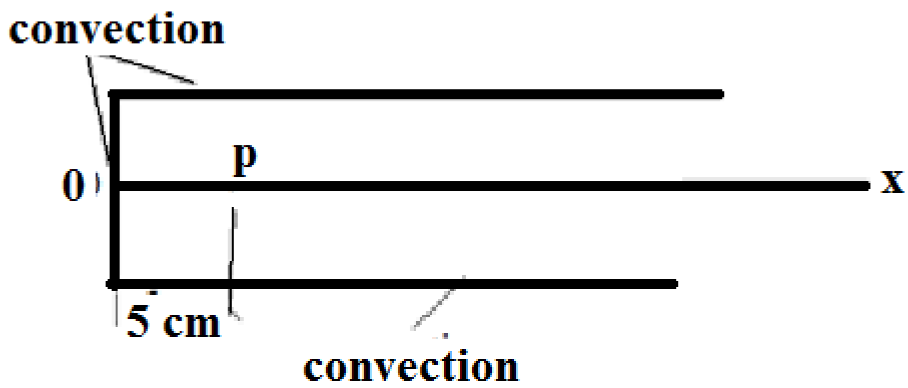
5) A thick concrete slab (α= $7x10^{-7}$ m^2/s) is initially at a uniform temperature T_i=60 °C. One of its surfaces is suddenly lowered to 10 °C. By treating this as a one-dimensional transient heat conduction problem in a semi-infinite medium, determine the temperatures at depths 5 and 10 cm from the surface 30 min after the surface temperature is lowered.

6) A thick bronze [x= $0.86x10^{-5}$ m^2/s and k= 26/W(m. °C)] is initially at a uniform temperature 250 °C. Suddenly the surface is exposed to a coolant 25 °C. Assuming that the heat transfer coefficient for convection between the fluid and the surface is 150 W/(m^2.°C), determine the temperature 5 cm from the surface 10 min after the exposure.
Answer: 205 °C

7) A rectangular aluminum bar 6 cm by 3 cm [k=200 W/(m.°C), c_p = 890 J/(kg.° C), ρ=2700 kg/m^3,and α= $8.4x10^{-5}$ m^2/s] is initially at a uniform temperature T_i=175 °C. Suddenly the surfaces are subjected to convective cooling with a heat transfer coefficient h=250 W/(m^2.°C) into an ambient at T_∞=25° C as shown in figure. Determine the center temperature T_o of the bar t=1 min after the start of the cooling.
Answer: 107.5 °C



8) A semi-infinite strip, 0<x<∞, 0<y<10 cm, of fireclay brick [k=1 W/(m.°C), and α= $5.4x10^{-5}$ m^2/s] is initially at a uniform temperature T_i= 340 °C. Suddenly all surfaces are subjected to convection, with a heat transfer coefficient h=100 W/(m^2.°C) into an ambient at T_∞ = 40 °C. Calculate the temperature T_o of a point P located along the midplane at a distance L= 5 cm from the surface as shown in figure, t= 2h after the start of the cooling.



Answer: 51.4 ̊C

9) A semi-infinite, cylindrical iron bar [$\alpha = 1.6 \times 10^{-5}$ m^2/s and k=60 W/(m. ̊C)] of diameter D=5 cm, confined to the region $0 \leq x \leq \infty$, is initially at a uniform temperature T_i=330 ̊C. Suddenly the surfaces are subjected to convection with a heat transfer coefficient h= 200 W/(m^2. ̊C) into an ambient at T_∞ = 30 ̊C. Determine the temperature T_o of a point P located along the axis L= 3 cm from the flat surface t= 2 min after the start of the cooling. See figure given below.