ME 331 Homework Assignment #1
Due Monday April 3, by 5 pm in MEB main office

1. An ice chest whose outer dimensions are 30 cm x 40 cm x 40 cm is made of 3.0 cm thick Styrofoam (k = 0.033 W/m-K) Initially, the chest is filled with 40 kg of ice at 0.0°C, and the inner surface temperature of the ice chest can be taken to be 0.0°C at all times. The heat of fusion of ice at 0°C is 333.7 kJ/kg, and the surrounding ambient air is at 30°C. Disregarding any heat transfer from the 40 cm x 40 cm base of the ice chest, determine how long it will take for the ice in the chest to melt completely if the outer surfaces of the ice chest are at 8°C.

2. A 50 cm long, 800 W electric resistance heating element with diameter 0.50 cm and surface temperature 120°C is immersed in 40 kg of water initially at 20°C. Determine how long it will take for this heater to raise the water temperature to 80°C. Also, determine the convection heat transfer coefficients at the beginning and at the end of the heating process.

3. Consider a person standing in a room at 23°C. Determine the total rate of heat transfer from this person if the exposed surface area and the skin temperature of the person are 1.7 m^2 and 32°C, respectively, and the convection heat transfer coefficient is 5.0 W/m^2-K. Take the emissivity of the skin and clothes to be 0.90, and assume the temperatures of the inner surfaces of the room to be the same as the air temperature.

4. Consider a medium in which the heat conduction equation is given in its simplest form as

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

   (a) Is the heat transfer steady or transient?
   (b) Is the heat transfer one-, two-, or three-dimensional?
   (c) Is there heat generation in the medium?
   (d) Is the thermal conductivity of the medium constant or variable?

5. Consider a steel pan used to boil water on top of an electric range. The bottom section of the pan is L = 0.30 cm thick and has a diameter of D = 20 cm. The electric heating unit on the range top consumes 1000 W of power during cooking, and 85 percent of the heat generated in the heating element is transferred uniformly to the pan. Heat transfer from the top surface of the pan bottom to the water is by convection with a heat transfer coefficient of h. Assuming constant thermal conductivity and one-dimensional heat transfer through the pan bottom, express the mathematical formulation (differential equation and boundary conditions) of this heat conduction process during steady state. Solve for the steady state temperature distribution through the thickness of the pan bottom for h = 3400 W/m^2K. Now express the mathematical formulation for the transient heat conduction process (differential equation and boundary conditions – do not solve) with variable heat transfer coefficient h and variable water temperature T_∞.