ME 3117 Heat Transfer
Tutorial 1 – Introduction to Heat Transfer

(1) A heat rate of 3 kW is conducted through a section of an insulating material of cross-sectional area 10 m^2 and thickness 2.5 cm. If the inner (hot) surface temperature is 415ºC and the thermal conductivity of the material is 0.2 W/m.K, what is the outer surface temperature? ***(Answer: 378 ºC)***

(2) The inner and outer surface temperatures of a glass window 5 mm thick are 15 and 5C. What is the heat loss thorough a window that is 1 m and 3 m on a side. The thermal conductivity of glass is 1.4 W/m.K. ***(Answer: 8400 W)***

(3) A freezer compartment consists of a cubical cavity that is 2 m on a side. Assume the bottom to be perfectly insulated. What is the minimum thickness of styrofoam insulation (k = 0.030 W/m.K) that must be applies to the top and side walls to ensure a heat load of less than 500 W, when the inner and outer surface are -10ºC and 35 ºC? ***(Answer: 54 mm)***

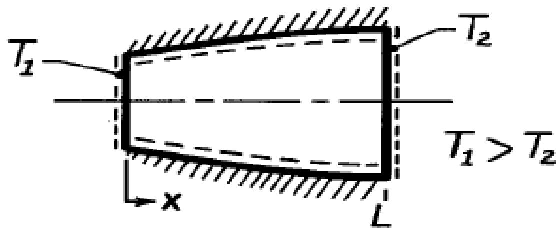
(4) An electric resistance heater is embedded in a long cylinder of diameter 30 mm. When water with a temperature of 25 ºC and velocity of 1 m/s flows crosswise over the cylinder, the power per unit length required to maintain the surface at a uniform temperature of 90ºC is 28 kW/m. When air, also at 25ºC, but velocity of 10 m/s is flowing, the power per unit length required to maintain the same surface temperature is 400 W/m. Calculate and compare the convection coefficients for the flows of water and air. ***(Answer: 4570 W/m^2.K, 65 W/m^2.K)***

(5) A square isothermal chip is of width w = 5mm on a side and is mounted in a substrate such that its side and back surfaces are well insulated, while the front surface is exposed to the flow of a coolant at T_∞ =15ºC. From reliability considerations, the chip temperature must not exceed T = 85ºC. If the coolant is air and the corresponding coefficient is h = 200 W/m^2.K, what is the maximum allowable chip power? If the coolant is a dielectric liquid for which h = 3000 W/m2.K, what is the maximum allowable power? ***(Answer: 0.35W, 5.25 W)***

(6) A surface of area 0.5 m^2, emissivity 0.8, and temperature 150ºC is place in a large, evacuated chamber whose walls are maintained at 25ºC. What is the rate at which radiation is emitted by the surface? What is the net rate at which radiation is exchanged between the surface and the chamber walls? ***(Answer: 726 W, 547 W)***

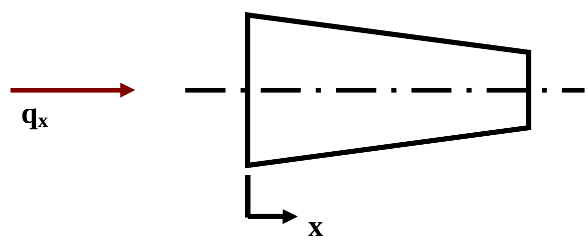
ME 3117 Heat Transfer
Tutorial 2a – Conduction

(1) Assume steady-state, one-dimensional heat conduction through the axisymmetric shape shown on the right. Assume constant properties and no internal heat generation, sketch the temperature distribution on T-x coordinates.

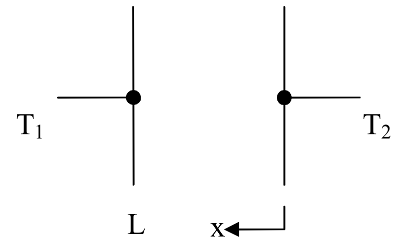


(2) A hot water pipe with outside radius r_1 has a temperature T_1. A thick insulation applied to reduce the heat loss has an outer radius r_2 and temperature T_2. On T-r coordinates, sketch the temperature distribution in the insulation for one-dimentional, steady-state heat transfer with constant properties.

(3) Assume steady-state, one-dimensional heat conduction through the symmetric shape shown. Assuming that there is no internal heat generation, derive an expression for the thermal conductivity k(x) for these conditions: A(x) = (1-x), $T(x) = 300(1 - 2x - x^3)$, and q = 6000 W, where A is in square meters, T in Kelvin, and x in meters.

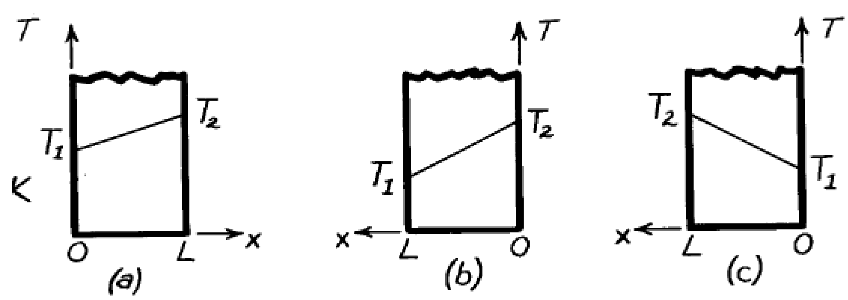


(4) One dimensional, steady-state conduction without heat generation occurs in the system shown. The thermal conductivity is 25 W/m.K and the thickness L is 0.5m. Determine the unknown quantities for each case in the accompanying table and sketch the temperature distribution, indicating the direction of the heat flux.



Case	T_1	T_2	dT/dx (K/m)	q''_x (W/m^2)
1	400 K	300 K		
2	100 ºC		-250	
3	80 ºC		200	
4		-5 ºC		
5	30 ºC			

(5) Consider a plane wall 100 mm thick and of thermal conductivity 100 W/m.K. Steady-state conditions are known to exist with T1 = 400 K and T2 = 600 K. Determine the heat flux and the temperature gradient for the coordinate systems shown.



(6) A cylinder of radius r_0, length L, and thermal conductivity k is immersed in a fluid of convection coefficient *h* and unknown temperature T_∞. At a certain instant the temperature distribution in the cylinder is $T(r) = a + br^2$, where *a* and *b* are constants. Obtain expressions for the heat transfer rate at the fluid temperature.