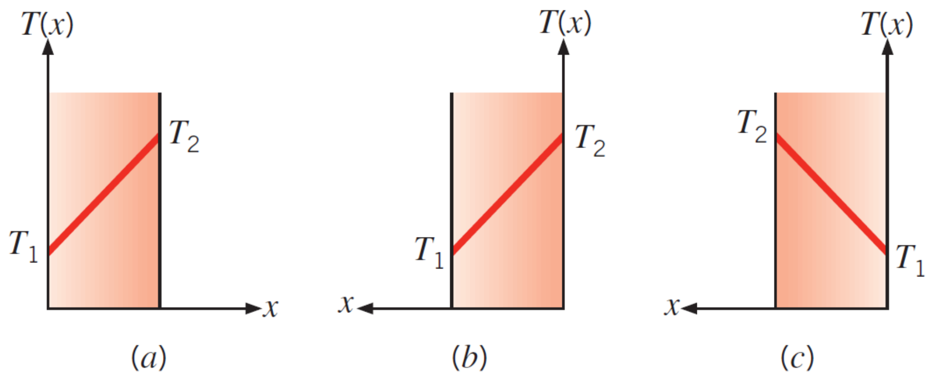
Heat Transfer Ch En 3453 | Homework 2 | Due Friday Sept. 10 at 5 PM

Scan as pdf and submit through Canvas

Note: Approximate solutions are the actual solution, but rounded to only 1 significant figure.

Problem 1

Consider a plane wall 100 mm thick and of thermal conductivity k = 100 W/m*K. Steady-state conditions are known to exist with T_1 = 400 K and T_2 = 600 K. Determine the heat flux (q_x'') and the temperature gradient dT/dx for the coordinate systems shown.



Problem 2

A cylindrical rod of thermal conductivity k = 2.0 W/m*K and radius r = 0.3 m has a temperature distribution given by T(r) = 120 + 5.5*ln(r) where T is in °C.

a. At r = 0.2 m, what is the conductive heat flux (q_r'')?
b. At r = 0.2 m, what is the rate of heat transfer (q_r) for a 1 m long section of the rod?
c. Plot T(r), q_r'', and q_r from r=0.02 m to r=0.3 m
d. In which direction is heat flowing (with respect to r)?

Approximate solutions: (a) -60 W/m^2, (b) -70 W

Problem 3

A sphere of radius r_1 = 30 cm has non-uniform generation, giving it a temperature profile at steady state of T(r) = 500 – 100*r^2 – 275*r, where r is expressed in meters and T is in K. The sphere has a thermal conductivity of k = 5 W/m*K.

At steady state, how much energy (in W) leaves the sphere's outer surface?

Approximate solution: 2000 W

Problem 4

Consider a 300 mm x 300 mm window in an aircraft. For a temperature difference of 80°C from the inner to the outer surface of the window, calculate the heat loss through *L* _ 10-mm-thick polycarbonate, soda lime glass, and aerogel windows, respectively. The thermal conductivities of the aerogel and polycarbonate are k_{ag} = 0.014W/m*K and k_{pc} = 0.21W/m*K, respectively. Evaluate the thermal conductivity of the soda lime glass at 300 K (use book Appendix A-3). If the aircraft has 130 windows and the cost to heat the cabin air is $1/kWh, compare the costs associated with the heat loss through the windows for an 8-hour intercontinental flight.

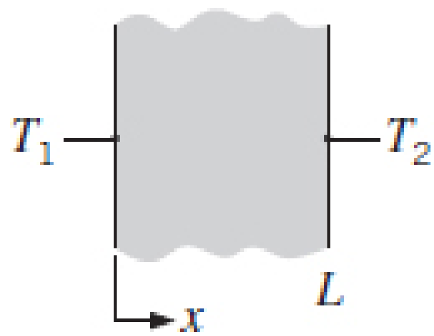
Approximate solutions: $1000 (glass), $200 (polycarbonate, $10 (aerogel)

Problem 5

Consider steady-state conditions for one-dimensional conduction in a plane wall having a thermal conductivity *k* = 50 W/m · K and a thickness *L* = 0.25 m, with no internal heat generation.

Determine the heat flux and the unknown quantity for each case and sketch the temperature distribution, indicating the direction of the heat flux.

Case	T_1(°C)	T_2(°C)	*dT/dx* (K/m)
1	50	−20	
2	−30	−10	
3	70		160
4		40	−80
5		30	200



Problem 6

In a pipe wall (a cylindrical, one-dimensional system), the temperature distribution has been determined to be:

$$T(r) = \frac{T_{s,1} - T_{s,2}}{ln\left(\frac{r_1}{r_2}\right)} ln\left(\frac{r}{r_2}\right) + T_{s,2}$$

where $T_{s,1} = 200$°C (temperature at inner wall), $T_{s,2} = 50$°C (temperature at outer wall), $r_1 = 0.1m$ (radius at inner wall), $r_2 = 0.5m$ (radius at outer wall), and $k = 2.4\frac{W}{m*K}$.

a. Plot the temperature distribution $T(r)$ from r_1 to r_2.
b. Derive an equation for the flux: $q_r''(r)$.
c. Plot $q_r''(r)$.
d. Derive an equation for the heat rate for a 10 m long pipe: $q_r\ (r)$.
e. Plot $q_r\ (r)$.

Use Excel, Python, Matlab, or other software for the plots.