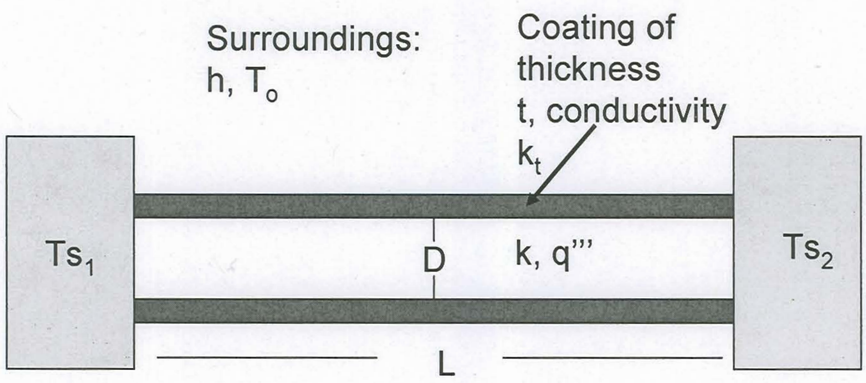
Conduction Question:



Consider a long copper rod of diameter D and Length L and conductivity k, which is used to enhance the heat transfer from a surface that is maintained at Ts_1. The opposite end of the rod is attached to a surface at Ts_2. The rod generates energy at a rate of q''' and has a thin coating of thickness t and thermal conductivity k_t. Assume that t is much smaller than the diameter of the rod and that $k_t < k$. The rod is also exposed to convective heat transfer from the ambient at To = Ts_2 and heat transfer coefficient, h.

1. Find a general expression for the temperature distribution in the rod.

2. Assume that the heat generation is negligible and the following parameters for the system:

a) the rod has a thermal conductivity of k = 400 W/mK, D= 4 mm, L = 25 mm.
b) the coating thickness is 250 μm and k_t = 0.1 W/mK.
c) Ts_1 = 100°C and Ts_2 = To = 0°C.
d) h = 200 W/m^2K.

Determine the rate of convective heat loss to the ambient environment.

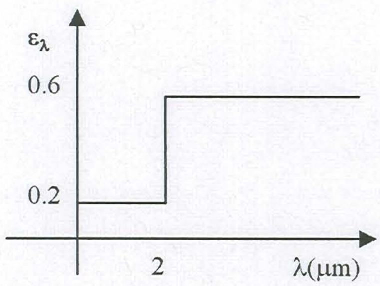
3) Develop the method to determine the rate of heat loss by convection from fin if q''' = 10^4 W/m^3 and all other parameters from part 2) remain. (You may set up symbolically. If you have time, please calculate the rate).

Radiation Question:

A simple method to estimate solar irradiation is to measure the temperature rise of a sphere of known emissivity. A sphere of diameter 1cm is positioned in direct sunlight.
(a) Given the data presented below, calculate the irradiation at each time of the day.
(b) Indicate the error due to an inaccurate estimate of the convection heat transfer coefficient of 10%.
(c) Indicate the error due to an inaccurate estimate of the emissivity of 10%.

Time	8am	Noon
Air temperature (°C)	12	25
Temperature of the sphere (°C)	18	32

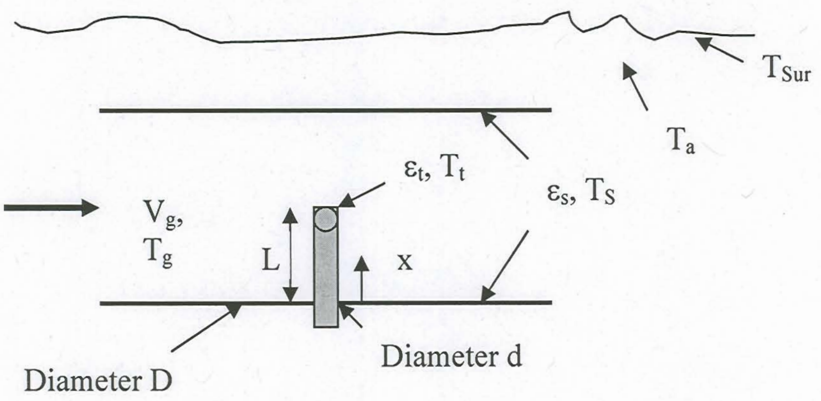
Convection heat transfer coefficient of $8 W/m^2K$
Spectral emissivity is given below with the blackbody radiation functions.



Blackbody Radiation Functions

λT (μmK)	F(0-λ)
1000	0.00032
1200	0.00213
1400	0.00779
1600	0.01972
1800	0.03934`
2000	0.06673
2200	0.10089
2400	0.14026
2600	0.18312
2800	0.22790
3000	0.27323
3200	0.31810
3400	0.36174
3600	0.40361
3800	0.44338

Convection Question:



Consider the steady flow of hot exhaust gases at mean velocity V_g and temperature T_g through a section of a thin-walled long pipe of circular cross-section with diameter D. The pipe wall may be assumed to be at a uniform temperature T_s, and the ambient air at temperature T_a. Both are unknowns. A thin wire thermocouple probe is routed within a solid metal rod and the junction resides at the end of the rod at a distance L from the pipe wall. The convection coefficients for the flow across the rod, and at the outer and inner surfaces of the pipe are available as h_{rod}, h_o, h_i respectively. The hemispherical total emissivity of ε_s may be assumed on both the inner and outer walls of the pipe, and ε_t on the surface of the metal rod. Extensive surroundings at a temperature of T_{sur} encase the pipe.

1. Find an expression for the error in the measurement of the gas temperature, $T_g - T_t$ assuming the rod to be isothermal within the duct and being perfectly insulated at the junction of the pipe and beyond. Clearly state your assumptions.
2. How will the analysis in Part 1 change if the rod temperature changes along the length, reaching the duct temperature at the connection point ? Clearly state your assumptions.