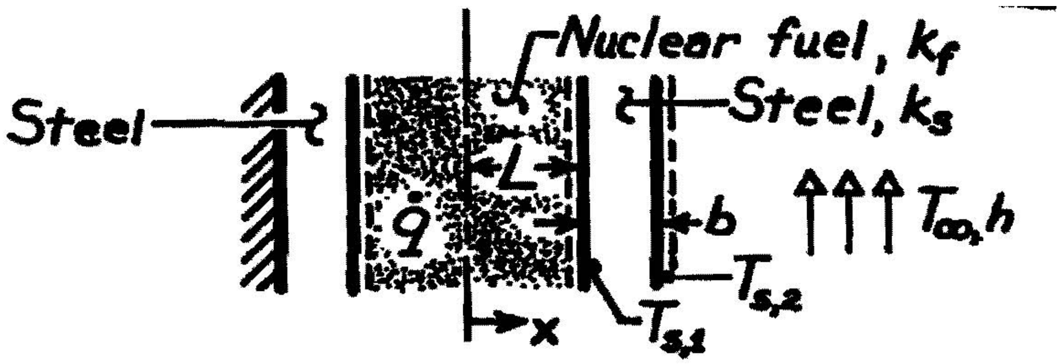
Problem #1

A nuclear fuel element of thickness ***2L*** is covered with a steel cladding of thickness ***b***. Heat is generated within the nuclear fuel element at a rate, $\dot{q}$, and is removed by a fluid at T_∞, which adjoins one surface and is characterized by a convection coefficient ***h***. The other surface is well-insulated, and the fuel and steel have thermal conductivities of k_f and k_s respectively.



(a) Obtain an equation for the temperature distribution T(x) in the nuclear fuel. Express your results in terms of $\dot{q}$, k_f, L, b, k_s, h, and T.

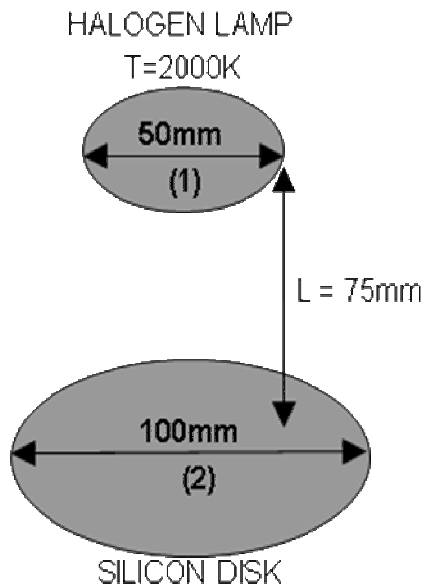
(b) Sketch the temperature distribution T(x) for the entire system.

(c) Assuming that L>>b, discuss (and sketch) the effect on the temperature distribution that increasing the convective heat transfer coefficient by an order of magnitude? Why would increasing h be a good thing to do?

Problem #2

A non-metallic fluid with constant physical properties flows steadily between two large parallel flat plates heated with a uniform heat flux. The inlet temperature is uniform and equal to T_0. Ignoring heat conduction in the flow direction and assuming plug flow (i.e. uniform velocity) show that the asymptotic Nusselt number based on the channel hydraulic diameter is 12.

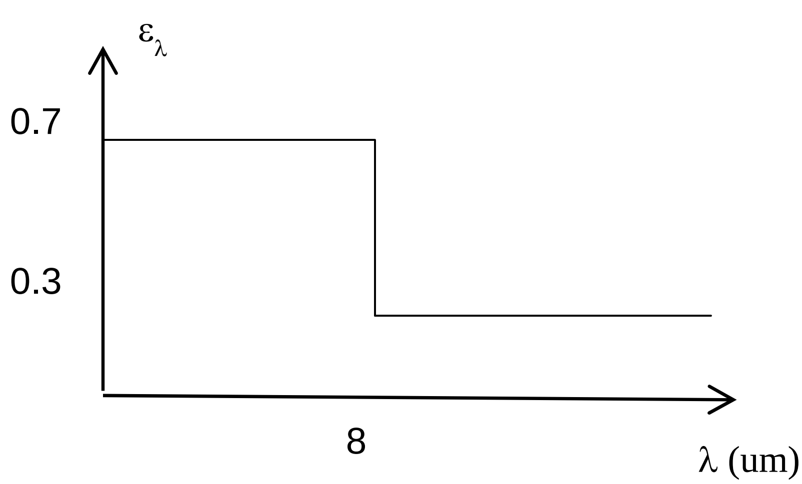
Problem #3:



A Halogen lamp of diameter 50mm is used to heat a silicon wafer 1mm thick and diameter 100mm inside a black enclosure. The spectral emissivity of the silicon is known (see below), the back surface of the silicon is able to radiatively exchange with the enclosure which is at room temperature of 27^{o}C. Please answer the following questions and list any assumptions that you make while doing so.

1. Determine the view factors: the silicon-to-lamp and the silicon-to-enclosure.
2. Determine the emissivity and absorptivity of the silicon wafer.
3. Set up an energy balance to determine the steady-state temperature of the wafer.
4. Calculate the temperature of the wafer, given the halogen lamp can be assumed a diffuse gray emitter with emissivity 0.9 and at a temperature of 2000K
5. Assuming that the lamp comes on at full power instantaneously, discuss how the silicon transient temperature profile may look when considering the radiation properties given below.

<u>Spectral hemispherical emissivity of silicon</u>



Angle (View) Factor for two coplanar disks:

$$F_{12} = 0.5\left[S - \sqrt{S^2 - 4\left(\frac{r_2}{r_1}\right)^2}\,\right] \quad \frac{\left[S = 1 + \left[1 + \left(\frac{r_2}{L}\right)\right]^2\right]}{\left(\frac{r_1}{L}\right)^2}$$

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
4000	0.48088
5000	0.63375
6000	0.73782
7000	0.80811
8000	0.85630
9000	0.89003
10000	0.91420
11000	0.93189
12000	0.94510
13000	0.95514
14000	0.96290
15000	0.97000