Question #1

Two semi-infinite solids have initial uniform temperatures of T_h (density ρ_h, specific heat c_h, and thermal conductivity k_h), and T_c (density ρ_c, specific heat c_c, and thermal conductivity k_c) respectively, where $T_h>T_c$. They are suddenly brought in contact at time t=0 and maintained in intimate contact thereafter.

1. Find out the interface temperature and its variation with time for t>0, assuming no thermal resistance at the interface. Explicitly write down the boundary conditions that apply at the interface **(30%).**
2. Sketch the temperature profiles in the two solids at three time instants, all such that t>0 **(20%).**
3. Use the above analysis to explain why a ceramic floor feels colder than a wood floor on a winter day **(15%).**
4. Show how you would set up a one-dimensional numerical calculation to determine the transient temperature field in the two solids **(20%).**
5. Sketch the temperature profiles in Part 2 for a finite thermal resistance at the interface **(15%).**

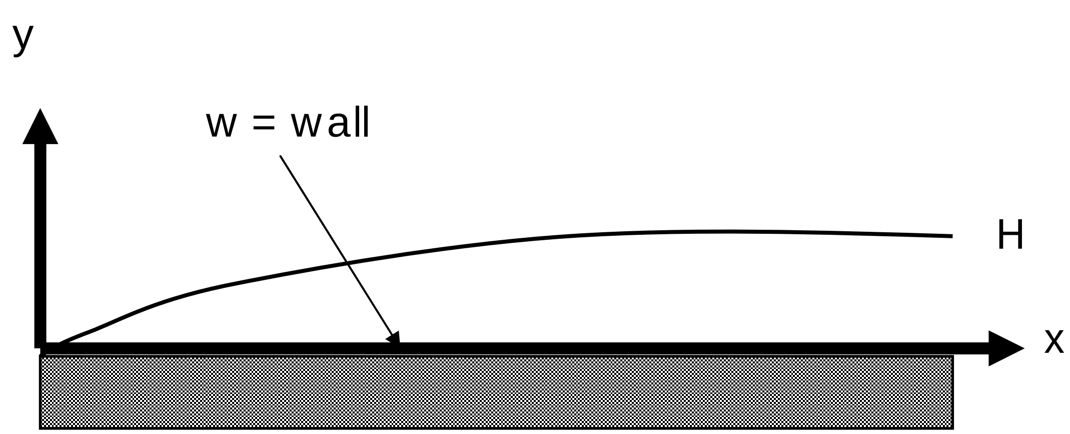
Question #2

Using the integral form of the energy equation, given below, determine an expression for the Nusselt number for laminar slug flow over a horizontal flat plate held at a constant temperature. Assume that the horizontal component of velocity, u, is constant in the direction perpendicular to the direction of flow, and where the temperature profile is linear with respect to a direction perpendicular to the direction of flow.

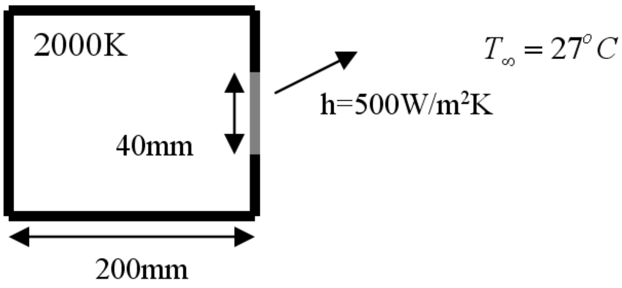
$$\frac{d}{dx}\left[\int_0^H (T_\infty - T)u\,dy\right] + \frac{\mu}{\rho C_p}\left[\int_0^H \left(\frac{du}{dy}\right)^2 dy\right] = \alpha\left[\frac{\partial T}{\partial y}\right]_w$$

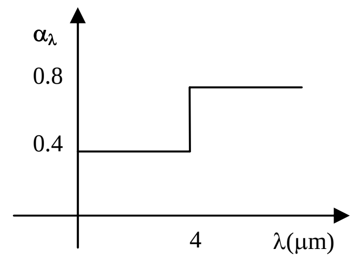
where :

H is defined such that $T(x,H) \approx T_\infty$



Question #3





A cubic furnace (200mm x 200mm x 200mm) at a temperature of 2000 K has a thin ceramic plate 40mmx40mm positioned over the open side, as shown above. The plate has spectral hemispherical absorptivity of 0.4 for wavelengths shorter than 4μm, and 0.8 for wavelengths longer than 4μm. Assume convection on the interior can be neglected and at the heat transfer coefficient to the exterior of the plate is 500W/m^{2}K.

(1) State and justify your assumptions (**20%**);
(2) Formulate governing equations (**30%**);
(3) Develop expressions and compute values of required properties (**30%**);
(4) Solve the problem to find the plate temperature and comment on the results (**20%**).

Fractional Emissive Power of Blackbody Radiation

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