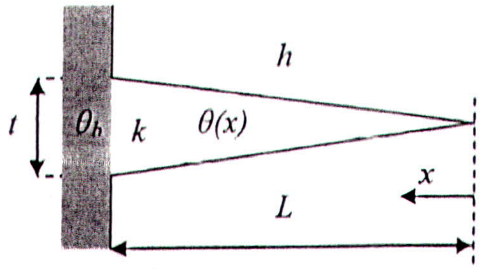
Indian Institute of Technology, Kharagpur
Mechanical Engineering Department

Heat Transfer (ME 30005) – Autumn Semester 2016
Mid-Semester Exam

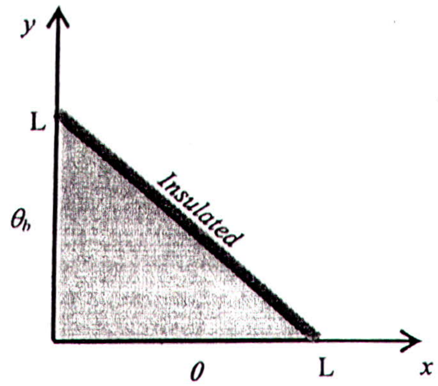
1. Consider longitudinal conduction through a fin with triangular profile. The width of the fin is W (not shown). Show that the temperature distribution along the fin, $\theta(x)$, must satisfy the differential equation

$$x\frac{d^2\theta}{dx^2}+\frac{d\theta}{dx}-a\theta=0$$



Determine the expression for a. Outline a method to solve this equation (*you do NOT have to solve it*). 5

2. The figure shows the triangular cross-section of a long bar with a temperature difference of θ_b maintained between two sides that are perpendicular to each other. The hypotenuse is perfectly insulated. Outline a method for analytical solution of the temperature field along with governing equations and boundary conditions. *You do NOT need to get the solution.* 5



3. A person is found dead at 5 pm in a room at 20°C. The temperature of the body is measured to be 25°C and h is estimated to be 4 W/m^2-K. Estimate the time of the person's death by modeling the corpse as a 20-cm diameter and 1.7-m long (significantly larger compared to lateral dimension) cylinder with k = 0.8W/m-K. Assume a healthy body temperature to be 37°C. 5

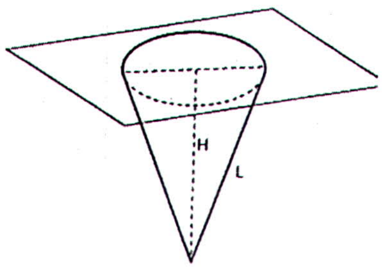
4. Temperature of sun's surface is 5779 K and it may be assumed be black. Calculate
   a. the maximum value of monochromatic emissive power $e_{b\lambda}$ (max) in the radiation emitted from the surface of the sun and the wavelength λ_m corresponding to it
   b. emissive power of the sun's surface
   c. e_b and $e_{b\lambda}$ at λ_m as received at the earth's surface

   The mean distance between the sun and earth can be assumed to be 1.5 x 10^8 km and radius of the sun is 6.95 x 10^5 km.

   2+1+2 = 5

5. (a) Assume a diffuse grey surface at 800K with emissivity of 0.8. Calculate its radiation intensity in the normal direction (i_n) and the radiant flux emitted within a cone with zenith angle of 50°.

   (b) Calculate the shape factor for the inner surface of a conical cavity with respect to itself.



5+5 = 10

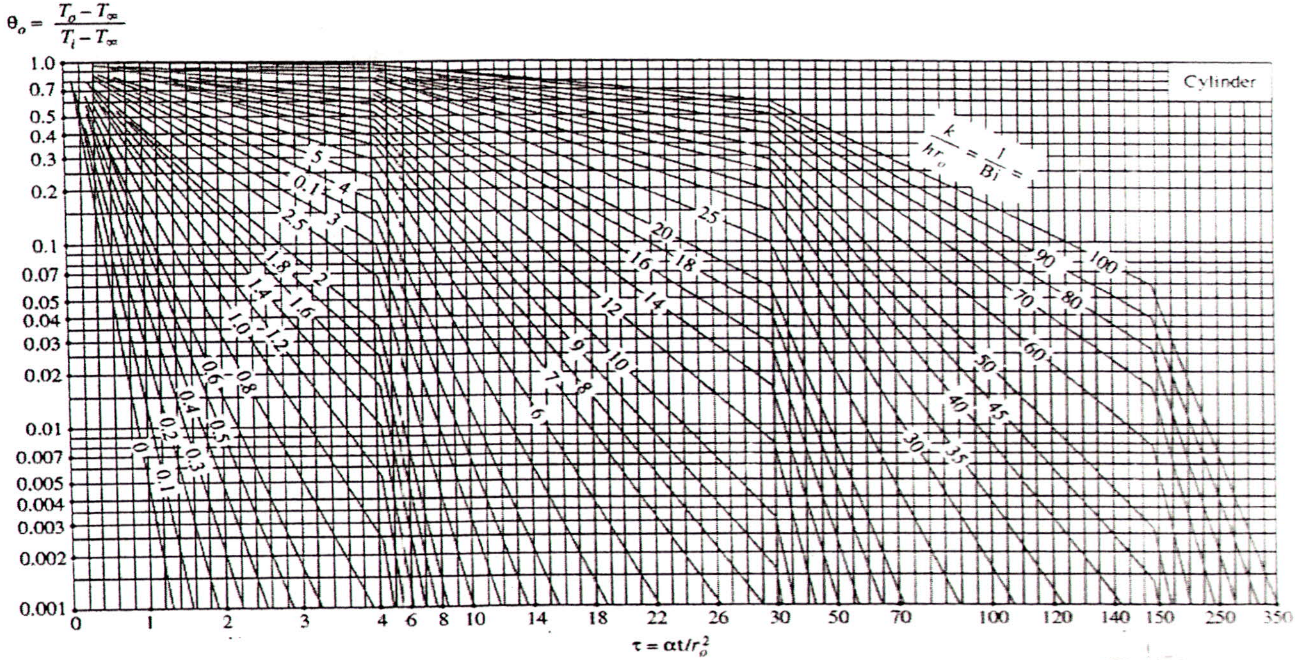
Useful data

Stefan Boltzmann constant: 5.667 x 10^{-8} W/m^2-K^4

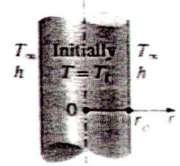
Coefficient of Wien's law: 0.00290 m-K

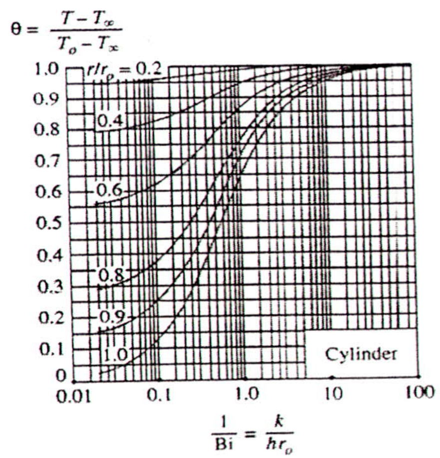
Planck's Law: $$e_{b\lambda}=\frac{2\pi C_1}{\lambda^5\left[e^{C_2/\lambda T}-1\right]}$$ C_1 = 5.96 x 10^{-17} W-m^2, C_2= 0.014387 m-K

Heisler Chart for Cylinder

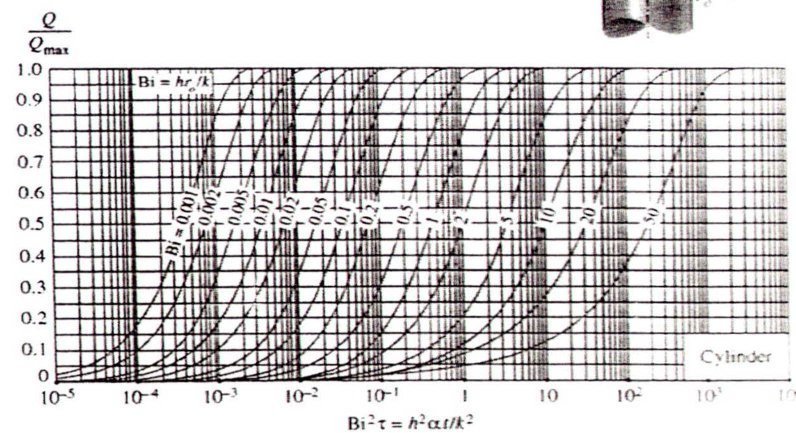


(*a*) Centerline temperature (from M. P. Heisler)





(*b*) Temperature distribution (from M. P. Heisler)



(*c*) Heat transfer (from H. Gröber et al.)