NAME: ________________________ STUDENT #___________

AESB2320, 2015-16

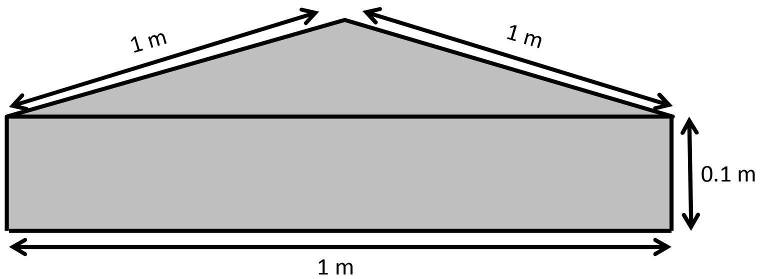
Part 2 Examination - 13 April, 2016

Turn in this exam with your answer sheet.
Write your solutions *on your answer sheet*, not here.
In all cases ***show your work***.
Beware of unnecessary information in the problem statement.

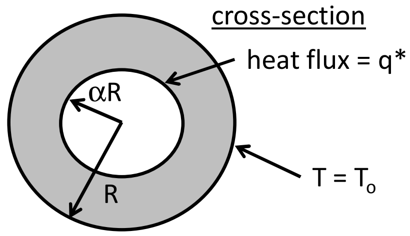
To avoid any possible confusion,
state the equation numbers and figure numbers of equations and figures you use along with the text you are using (BSL2 or BSLK).

1. Rocky has a uniform solid with a horizontal cross-section of an equilateral triangle (1 m long on a side), but two opposing flat surfaces (0.1 m apart), as shown. This solid is the orthogonal intersection of an equilateral triangle and a finite-width slab. The solid is initially at temperature of 100°C, and at time zero all the surfaces are cooled to, and maintained at, 0°C. Rocky doesn't have chart for unsteady heat conduction in a triangle, but based on the chart for a finite-width slab alone he calculates that the temperature at the center of the slab is 50°C after 5 minutes.
   a. Is the true T at the center of the slab after 5 minutes higher or lower than what Rocky computed? (Assume he did the calculation for the finite-width slab correctly.) Briefly justify your answer.
   b. Would you expect the true answer to differ significantly from the answer Rocky computed, or not; or is it impossible to tell? Again, briefly justify your answer.

   (*Just to be clear: You don't have a chart for heat conduction in a triangle, but you should still be able to answer those two questions.*)
   (15 points)



2. A hollow sphere, of radius R (radius of cavity αR, with $\alpha < 1$), has a fixed (positive) heat flux at the inner surface q*. Within the sphere, heat is released at a rate S (in W/m^3), given by
   $S = (A/r)$
   where A is a constant. The outer surface is maintained at temperature T_o.



   a. Derive a formula for the heat flux $q_r(r)$ for $\alpha R \le r \le R$.
   b. Derive a formula for the steady-state temperature T(r) for $\alpha R \le r \le R$.
   b. Derive a formula for the total rate of heat transfer from the sphere, Q (in J/s).
   (33 points)

3. Water, with properties below, flows through a tube 20 m long, 0.1 m in diameter, with velocity 0.2 m/s. The tube wall is maintained at a uniform and constant temperature T_o. The water enters the tube with temperature 100°C. It leaves the tube with temperature 50°C. What is the wall temperature T_o?

   If you can't solve for T_o, give an equation which T_o must satisfy.

   (30 points)

<u>properties of water</u>

ρ= 1000 kg/m^3 μ = 0.001 Pa s k = 0.680 W/(m K) C_p = 4190 J/(kgK)

4. Bubba is concerned about chemical A diffusing into a plastic (polypropylene) solid. The plastic is a very (for our purposes, infinitely) thick solid, with one flat surface exposed to the chemical. Because of this exposure, starting at time zero the concentration c_A of chemical A in the plastic at the exposed surface is 10 kg/m^3. The diffusion coefficient of chemical A in plastic, $\mathcal{D}_{AP}$, is 10^{-8} m^2/s.
   a. Estimate how far into the plastic the chemical has reached a concentration of 1 kg/m^3 after 1 hour. (15 pts.)
   b. Suppose the slab has 1 m^2 of surface exposed to the chemical. Estimate how much chemical A (in kg) is inside the plastic after 1 hr. A rough estimate is OK (i.e., you don't need an exact number), but justify how you reach this estimate. Don't spend too long on this if you can't figure it out. (7 pts)

   (22 points total)