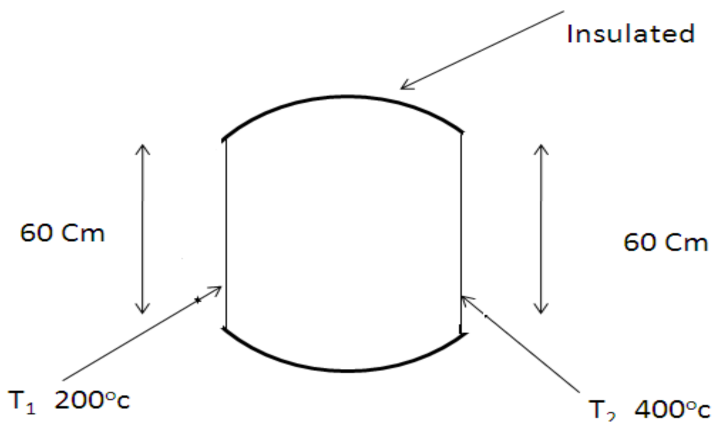
CLL 110 Major Time: Max 2 hrs Max Marks: 40

After you finish answering all questions, you are required to submit the scanned copy of your answers in a single pdf file before 12 noon. Once you have created a single pdf file of your answers, please upload this file to the folder 'Major' on Moodle. No submissions will be accepted after 12 noon.

Q 1. A Newtonian fluid is flowing under laminar flow conditions inside a circular inclined tube of radius R. The tube is inclined at an angle ‘θ’ from the vertical axis. At the entrance of the tube, at z =0, pressure is p_0, while at the exit of the tube, at z =L, pressure is p_L. Assuming constant physical properties, determine the velocity and shear stress profiles. Finally, determine the friction factor.

(8)

Q2. A copper spherical ball of radius 50 cm is cut at two ends as shown below



The temperature T_1 at one end is maintained at 200°C while the temperature T_2 at the other end is maintained at 400°C. The remaining surface of the sphere is insulated. Determine the rate of heat transfer if the thermal conductivity of the copper is 3 cal/(cm-sec-°c). **It is important that you place your coordinate system at the center of the sphere.** **(8)**

Q3. Consider flow a highly viscous liquid between two parallel plates. The plates are separated by a distance *b*. The lower plate (at x=0) is stationary and the upper plate (at x=b) is moving with a velocity of V_0 in z-direction. Due to the friction between fluid layers, some of the mechanical energy is converted into heat energy (“viscous dissipation”). The lower plate is at maintained at constant temperature of T_0 and while the upper plate is insulated such that the heat does not leave the upper plate in x-direction. First, determine the velocity profile and then using the equation of thermal energy, derive an expression for fully developed temperature profile between the two plates. Assume the fluid to be Newtonian, incompressible and having all physical properties as constants.

(8)

Q4. A power law fluid is placed between two concentric cylinders. The inner cylinder at r = kR is rotated by applying a torque, T, while the outer cylinder at r = R is held stationary. Determine the relation between the torque, T and the angular velocity, Ω, achieved by the inner cylinder under steady conditions. Write your assumption clearly. **(8)**

Q5. A cylindrical tank of diameter 20 cm and height 40 cm is half filled with methanol at 27^{o}C. The methanol is lost to air surrounding the tank by evaporation. Determine the rate of loss of methanol in gm/sec for the following data

P = pressure = 760 mm Hg
Diffusion coefficient of methanol in air = 0.15 cm^2/sec and
Vapor pressure of methanol at 27^{o}C = 160 mm Hg

You may assume that negligible methanol is present in the air outside the tank and that methanol behaves like an ideal gas.

Finally, determine approximately the time taken for the liquid level in the tank to fall by 1 cm. **(8)**