ta3220 Re-Examination
Summer 2012
4 July 2012

Write your solutions *on your answer sheet*, not here. In all cases ***show your work***.
To avoid any possible confusion,
state the equation numbers and figure numbers of equations and figures you use.
Beware of unnecessary information in the problem statement.

1. A common way to measure the rheology of fluids is to measure shear stress in a Fann viscometer at 600 and 300 rev/min. A unit of "rev/min" (revolution/minute) is proportional to $(-dv_x/dy)$. Suppose for a given drilling fluid one measures the following data:

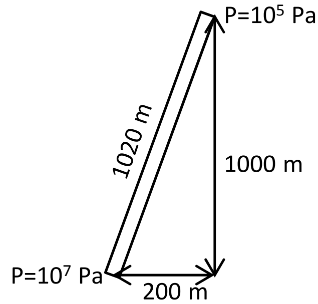
rev/min, proportional to $(-dv_x/dy)$	shear stress τ_{yx}, Pa
600	50
300	40

Don't worry about converting from "rev/min" to units of s^{-1}; you don't need to do so for this problem.
a. If this fluid were a Bingham plastic, what would be the value of yield stress τ_o?
b. If this fluid were a power-law fluid, what would be the value of the exponent n?
(15 pts)

2. A fluid flows in highly turbulent flow through a slit of width D_o. The potential gradient driving the flow is $(\Delta\mathscr{P}/L)_o$. Suppose the flow rate Q (m^3/s) is held fixed as the gap width of the slit is doubled to $D_1=2D_o$. What is the new potential gradient $(\Delta\mathscr{P}/L)_1$ for the slit in terms of the original potential gradient $(\Delta\mathscr{P}/L)_o$? For simplicity, assume the roughness factor does not change as the gap width changes.
(10 pts)

3. A fluid flows in highly turbulent flow through a slit of width D_o. The heat-transfer coefficient between the liquid and the slit walls is h_o. Suppose the flow rate Q (m^3/s) is held fixed as the gap width of the slit is doubled to $D_1=2D_o$. What is the new heat-transfer coefficient h_1 in terms of h_o?
(10 pts)

4. A well is drilled into an oil field at an angle to the vertical as shown below. The oil at the bottom of the well is at a pressure of 10^7 Pa and pressure at the top of the well is 1 atmosphere (~10^5 Pa). The oil has density 850 kg/m^3 and viscosity 0.01 Pa s (10 cp). What is the gradient of flow potential $(\Delta\mathscr{P}/L)$ driving flow up the well?
(10 pts)



5. A narrow metal cylinder of radius R and length L has thermal conductivity k, density ρ, and heat capacity C_p. It is maintained at T_0 on the flat surface on one end (z = L). The flat surface on the opposite end is perfectly insulated. Along its length, the cylinder is in contact with fluid at temperature T_1; the heat-transfer coefficient along the radial surface is h. The cylinder is so thin that difference is temperature in the radial direction can be assumed to be negligible; in other words, T varies with z within the cylinder but not with r.
   a. Starting with a shell balance, derive a second-order ordinary differential equation for steady-state temperature T as a function of z for this problem.
   b. State two boundary conditions on T for this problem.

   (20 pts)

6. An electrically heated pot maintains water inside at 60°C. The surroundings are at 20°C. The pot is cylindrical, 10 cm in diameter and 10 cm tall. About 1 minute out of every 15 minutes the heater comes on (power = 650 W) to make up for heat loss from the pot.
   a. What is the average rate of heat input needed to maintain the water at 60°C?
   b. Assuming that the only heat transfer is through the walls, estimate the overall heat-transfer coefficient U_o (in W/m^2K) for the surfaces of the pot.
   c. In reality, there are other processes going on; most important is evaporation of water from the pot. Therefore, is the estimate you give in part (b) likely to be larger or smaller than the true value of U_o for the surfaces of the pot? Briefly justify your answer.

   (20 pts)

7. A solid cube of aluminum, 0.1 m on a side, is perfectly insulated on three surfaces: top, bottom and back. The solid is initially at 0°C. On the three other surfaces (front, left and right), starting at time t=0, the temperature is suddenly raised to, and maintained at, 100°C. What is the temperature at the coldest spot in the cube after 10 seconds?

   (15 pts)

<u>Properties of aluminum</u>

ρ = 2700 kg/m^3 k = 230 W/(m K) C_p = 938 J/(kg K)