Homework 5
CM4650
Spring 2018

Due:
5A: due Wednesday 21March 2018, in class
5B: due Wednesday 28March 2018, to Pratik in class at 4pm (There will be no class, however)

Please do not write on the back side of the pages. Please write legibly and large. Thank you. ***Note: Part B (3 long problems) is much longer than Part A (2 problems).***

Part 5A

1. (20 points) Text problem 6.7
2. (20 points) Choose two of the following materials. Choose one of the following material functions. Find in the literature (give full citation) a graph of the material function for each of the materials. Compare the two.
   Materials:
   a. Polyethylene
   b. Polystyrene
   c. Filled elastomer (meaning polybutadiene or polyisoprene or natural rubber with carbon black or chalk or some other powder)
   d. Polypropylene
   e. Branched polymer
   f. Motor oil
   Material functions:
   a. Steady shear viscosity
   b. Steady shear first normal stress coefficient
   c. Steady elongational viscosity
   d. Step strain
   e. Small amplitude oscillatory shear
   f. Small amplitude oscillatory elongation

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Part 5B

3. (20 points) The Carreau-Yasuda model (p231) is given below:

$$\underline{\underline{\tau}}(t) = -\dot{\underline{\underline{\gamma}}}(t)\left[\eta_\infty + (\eta_0 - \eta_\infty)[1 + (\lambda\dot{\gamma})^a]^{\frac{n-1}{a}}\right]$$

where η_∞, η_0, λ, n and $a=2$ are constant parameters of the model and $\dot{\gamma} = \left|\dot{\underline{\underline{\gamma}}}\right|$ is the magnitude of the rate of deformation tensor. :

   a. What does the model predict in steady shearing? Sketch the result for plausible values of the parameters.
   b. Find the values of the four general parameters of the Carreau-Yasuda for the data given in Table 1 (seebelow). Produce a plot that shows the model and the fit. (Fitting instructions: http://www.chem.mtu.edu/~fmorriso/cm4650/Using_Solver_in_Excel.pdf)
   c. Plot the start-up of steady shearing traces for the data given in Table 1 (see reverse) as predicted by your model fit. Show traces for the following values of $\dot{\gamma}_0$: $0.01, 0.1, 10, 50 s^{-1}$.

Table 1: Data for problem number 4; Menzes and Graessley, concentrated polybutadiene solution; 350 kg/mol

shear rate $\dot{\gamma} = \dot{\gamma}_0$ s^{-1}	viscosity η Poise
1.61E-02	1.78E+04
3.63E-02	1.78E+04
5.34E-02	1.78E+04
1.09E-01	1.71E+04
1.77E-01	1.66E+04
2.87E-01	1.55E+04
3.53E-01	1.44E+04
7.04E-01	1.21E+04
1.17E+00	1.02E+04
3.53E+00	5.11E+03
5.48E+00	3.15E+03
1.11E+01	2.08E+03
1.92E+01	1.38E+03
2.94E+01	1.03E+03
4.39E+01	7.19E+02

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4. (20 points) Text problem 7.30 ***THIS IS A LONG PROBLEM***

5. (20 points) Calculate the steady state velocity profile for the steady drag flow of an incompressible power-law fluid confined in the geometry shown below. The upper plate is made to move at a constant velocity V. Do not use tables for tensor/vector quantities.