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2.	/20
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Name:____________________________.

Exam 2

CM 4650 Polymer Rheology
3 April 2018

- ✓ Please be neat.
- ✓ Please write on only one side of each piece of paper in your solution.
- ✓ This exam is closed book, closed notes.
- ✓ No internet-capable devices are permitted.
- ✓ Submit only your own work.
- ✓ A calculator is permitted.

1. (20 points)
   a. For a typical long-chain polymer, how does steady shear viscosity vary as a function of shear rate $\dot{\gamma}$? Sketch your answer; be sure to label the axes.
   b. For a typical long-chain polymer, how does steady shear first normal stress coefficient Ψ_1 vary as a function of shear rate $\dot{\gamma}$? On the same axes as part a, sketch your answer.
   c. For a typical long-chain polymer, how does steady elongational viscosity $\bar{\eta}$ vary as a function of elongation rate $\dot{\varepsilon}_0$? Sketch your answer; be sure to label the axes.
   d. For long chain polymers at low deformation rates, what is the relationship between steady shear viscosity η_0 and steady elongational viscosity $\bar{\eta}_0$? Be quantitative.

2. (20 points) What is the magnitude of the rate of deformation tensor given below (show your work)? This flow is called steady planar elongation; $\dot{\varepsilon}_0$ is a constant.

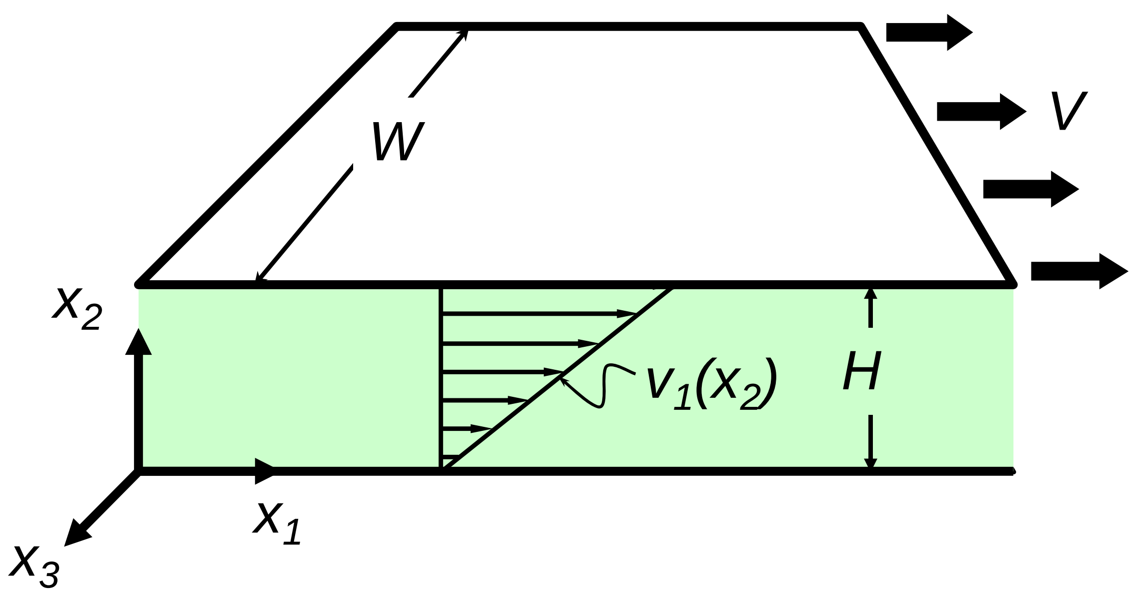
$$\underline{\underline{\dot{\gamma}}} = \begin{pmatrix} -\dot{\varepsilon}_0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \dot{\varepsilon}_0 \end{pmatrix}_{123}$$

3. (20 points) For a power-law generalized Newtonian fluid, what are the predictions of all three material functions of cessation of steady shear? Show your work.

4. (20 points) In Homework 5 you calculated the steady state velocity profile for the steady drag flow of an incompressible power-law Generalized Newtonian fluid confined in the flow set-up shown below. The results were:

$$\underline{v} = \begin{pmatrix} \frac{V}{H} x_2 \\ 0 \\ 0 \end{pmatrix}_{123}$$

From this answer for $\underline{v}$, calculate the stress tensor $\underline{\underline{\tau}}$ for the power-law Generalized Newtonian fluid in the flow. Does the stress vary with position?



5. (20 points)A steady flow of an incompressible, power-law, Generalized Newtonian fluid is created between two very wide, parallel plates as shown in the figure. The bottom plate is stationary and the top plate is pulled to the right at a speed V. There is a slight opposing pressure gradient applied to the flow such that at the left edge (upstream) the pressure is low (P_0) and downstream a distance L the pressure is high (P_L). This can happen when there is a constriction downstream. Answer the questions below. Please show your work and indicate your assumptions. You may neglect gravity.

   a. What is the differential equation for the velocity?
   b. What are the boundary conditions on velocity and pressure? (express the boundary conditions mathematically)
   c. What is the steady state velocity profile? You may leave your final answer in terms of the integration constants and equations for the integration constants (that is you may omit the final algebra needed to determine the integration constants).