

Name: _____.

Midterm Exam I

CM 4650 Polymer Rheology
12 February 2009

Note:

Please be neat.

Please write on one side of the paper only.

1. (15 points) What is $\underline{\underline{A}} \cdot \underline{\underline{g}}$ in Einstein notation?
2. (15 points) For the tensor $\underline{\underline{M}}$ given below, what is $\underline{\underline{M}} : \underline{\underline{M}}$? Show your solution method.

$$\underline{\underline{M}} = \begin{pmatrix} 1 & 2 & 0 \\ -1 & 1 & 3 \\ 2 & 0 & -2 \end{pmatrix}_{123}$$

3. (20 points) What is the 3-component of the vector $\nabla \cdot (\underline{\underline{a}} \underline{\underline{d}})$? Carry out the product rule of differentiation.
4. (20 points) In rheology, one of our standard flows is elongational or extensional flow. For this flow, the velocity vector is given by

$$\underline{\underline{v}} = \begin{pmatrix} -0.5\dot{\epsilon} x_1 \\ -0.5\dot{\epsilon} x_2 \\ \dot{\epsilon} x_3 \end{pmatrix}_{123}$$

where $\dot{\epsilon}$ is a scalar function of time.

- a. What is $\nabla \cdot \underline{\underline{v}}$ for elongational flow (the divergence of velocity)?
- b. What is $\nabla \underline{\underline{v}}$ for elongational flow (the gradient of velocity)?

OVER

5. (30 points) A Newtonian fluid flows over a piece of process equipment as shown below. The flow over the top of the apparatus drains into a thin slit (gap= H) that is very long in the flow direction; the apparatus extends very far in the neutral direction (into the plane of the paper)

The film on the top is very thin and therefore the pressure at the slit entrance is nearly atmospheric. The slit discharges to the atmosphere after a length of L . What is the steady state velocity profile in the slit? Use the coordinate system shown in the figure below. Bonus (5 points): What is the flow rate in the slit?

