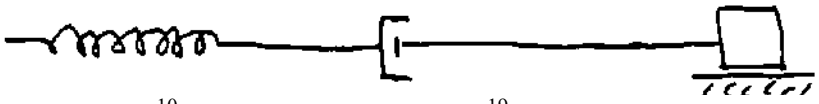
ESS 411/511 Geophysical Continuum Mechanics
Problem Set No. 1

1. (15) Consider a material represented by the following model.



$\mu = 4 \times 10^{10}$Pa $\quad\quad$ $\eta = 4 \times 10^{19}$Pa s, $\quad\quad$ $\sigma^* = 1$ MPa

Suppose at some initial time t=0, deformation e commences at a constant rate

$\dot{e} = c = constant \neq 0$ for $t > 0$.

a) Assuming $e(0) = 0$, find an expression for $\sigma(t)$.

b) Graph $e(t)$, $\dot{e}(t)$, and $\sigma(t)$, and explain in prose what is happening in the material in terms of the spring and dashpot elements as time proceeds.

c) Assuming failure at a stress of σ^*, find an expression for the minimum strain rate $\dot{e}_{min}$ needed to cause failure. Evaluate $\dot{e}_{min}$ for the parameters above.

d) Assuming that failure occurs and relaxes the stress to zero, find expressions for the change in elastic strain and the corresponding release in elastic strain energy/unit volume. Evaluate these expressions for the parameters above.

e) What properties of the material, and what parameters of the experiment do you think would affect the time until failure? Why? With the same assumptions as in d), and assuming the original strength is regained when the stress is relaxed, find an expression for the time until failure.

f) Based on tectonic rates of displacement of the lithosphere over the asthenosphere), reasonable assumptions about the length scale on which this happens (i.e., the thickness of the asthenosphere, and the above rheological parameters (which are estimates of asthenospheric properties), discuss the possibility of earthquake occurrence in the mantle. Hint: to understand the geometry, consider Figure 2.8 of the Raymond Notes.

2. (5) Design a real-world experiment to estimate the viscosity of silly putty. Describe
   - the measurements that you would carry out and why
   - limitations or restrictions on your results (range of validity).

   Tip : think about the "ingredients" of the definition of viscosity and how you could estimate them.