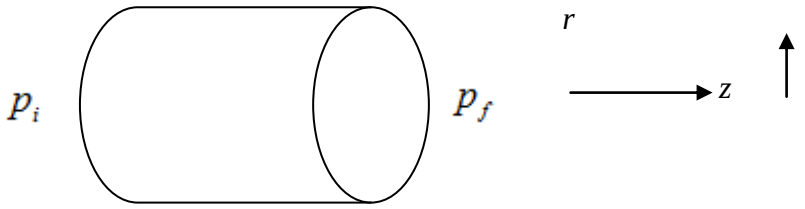
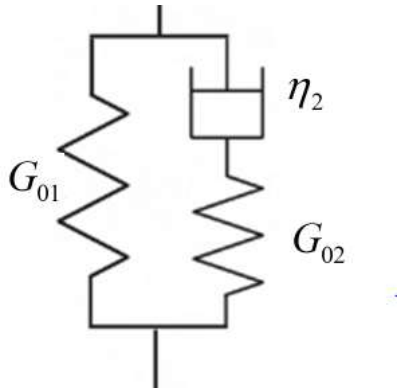
Assignment-1

1. Consider a pressure driven flow (linear pressure gradient, $\frac{-dp}{dz} = \frac{p_i - p_f}{L}$) through a cylindrical pipe of length L and radius r. Find out the steady state velocity profile $\left(V_z(r)\right)$ for Newtonian as well as Power law fluid. (Assume fully developed flow).



Hint: Use Cauchy Momentum Balance in cylindrical coordinate system (given below). The constitutive equation for Newtonain fluid: $\tau_{rz} = \eta \frac{\partial V_z}{\partial r}$, and for Power law fluid: $\tau_{rz} = \eta \left(\frac{\partial V_z}{\partial r} \right)^n$.

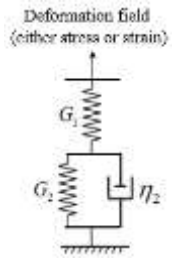
2. Consider a mechanistic rheological model shown in the figure below.



a) Obtain the constitutive equation for the abovementioned mechanistic model. The constitutive equation is defined as the relationship betweenstress (σ), strain (γ) and their time derivatives ($\dot{\sigma}, \dot{\gamma}$).The model parameters are: G_{01}, G_{02}, and η_2.

b) The model undergoes a stress relaxation test, wherein a constant strain field, $\gamma = \gamma_0$ is imposed on the above system for $t \geq 0$. Solve the constitutive equation obtained in part (a) for step strain test and obtain stress (σ) as a function of time, plot $\sigma(t)$ as a function of t also.

3. Consider a mechanistic rheological model shown in the figure below.



The above model has been sujcted to the constant stress (within linear regime) up tp time G_1, after which stress has been removed, and the strain starts getting recovered. Find out the exoression of strain rate as a function of time during recovery step.

The constitutive
equation is defined as the relationship between
stress (σ), strain (γ) and their time derivatives ($\dot{\sigma}, \dot{\gamma}$).

The model parameters are: G_1, G_2, and η_2.

a) The model undergoes a step strain test, wherein a constant strain field, $\gamma = \gamma_0$ is imposed on the above system for $t \geq 0$. Solve the constitutive equation obtained in part (a) for step strain test and obtain stress (σ) as a function of time, plot $\sigma(t)$ as a function of t also.