Problem 160B
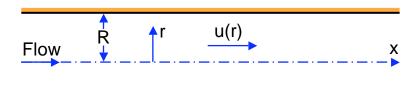
Consider the fully developed laminar pipe flow of an incompressible, non-Newtonian fluid :

This fluid is such that the normal stress in the x direction is equal to $-p$ where p is the pressure and the shear stress, σ, is related to the velocity gradient by

$$\sigma = C \left(-\frac{du}{dr} \right)^2$$

where C is a known constant. Find the friction factor, f, for this pipe flow in terms of C, ρ (the fluid density) and R (the radius of the pipe).

[Note: Remember the definition of the friction factor, f, namely

$$f = \frac{4R}{\rho V^2} \left(-\frac{dp}{dx} \right)$$

where V is the volumetric average velocity of flow in the pipe (the volume flow rate divided by the cross-sectional area).]