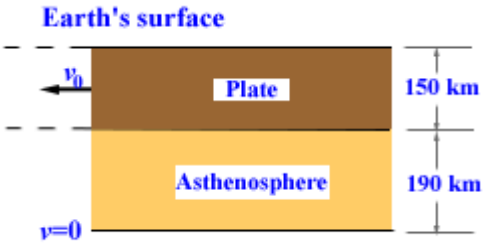
82.

Problem 18.37 (RHK)

In the diagram a cross-section of the upper layers of the Earth has been shown. The surface of the Earth is broken into several rigid blocks, called plates that slide (slowly) *over a slushy layer called asthenosphere. Suppose that the speed of the rigid plate shown is* $v_0 = 48$ mm y^{-1}, *and that the base of the asthenosphere does not move. We have to calculate the sheer stress on the plate. The viscosity of the asthenosphere material is* 4.0×10^{19} Pa s^{-1}. *We may ignore the curvature of the Earth.*



Solution:

We will use the definition of viscosity of a fluid for solving this problem.

The ratio between stress and strain in a fluid is called the *coefficient of viscosity* η of the fluid. For fluids stress is the shearing stress and strain is the velocity gradient, $\frac{dv}{dy}$.

That is

$$\eta = \frac{\text{shearing stres}}{\text{strain}} = \frac{F/A}{dv/dy} = \frac{F/A}{v/D}.$$

Velocity gradient of the asthenosphere is

$$\frac{v}{D} = \frac{48\times10^{-3}}{3.156\times10^{7}\times190\times10^{3}}\ \text{s}^{-1} = 8.0\times10^{-15}\ \text{s}^{-1}.$$

Therefore, the stress on the base of the plate

$$= \eta\times\frac{v}{D} = 4.0\times10^{19}\times8.0\times10^{-15}\ \text{Pa}=320\ \text{kPa}.$$