Physics 595CL – Homework 6

1) Use the Classius-Clapeyron equation to estimate how much pressure is needed to melt ice at a temperature ΔT below $0°C$. The Latent heat of water is $L = 3.34 \times 10^5$ J/kg, and the change in volume from ice to liquid water is $\Delta v = -9.05 \times 10^{-5}$ m^3/kg. Obtain a numerical estimate for the pressure needed at $-1°C$.

2) Refer to class notes for the context for this problem.

(a) Verify the product rule for the material derivative, i.e.,

$$\frac{D(FG)}{Dt} = F\frac{DG}{Dt} + G\frac{DF}{Dt}$$

(b) Let $f(x, y, z, t)$ be a smooth function with units of the form, unit/mass, i.e., some quantity per unit mass. Show that,

$$\frac{d}{dt}\int_{V(t)} \rho f dV = \int_{V(t)} \rho \frac{Df}{Dt} dV.$$

Hint: Use the Transport theorem and the Continuity equation

(c) For the stress tensor τ, assume that $\tau_{11} = \tau_{22} = \tau_{33} = -p$, where p is pressure. Show that

$$\nabla \cdot \tau = -\nabla p + \vec{F}_{\text{visc}},$$

where part of the problem is to find $\vec{F}_{\text{visc}}$, the viscous (drag) force in terms of τ.

3) Andrews, problem 4.4

4) Andrews, problem 4.5

5) Derive Andrews' Eq. (4.37)

6) Andrews, problem 5.1