HW Jan 23, Johannes Byle

2.4 (a) The amount of mass that is directly in contact with the projectile is the area of the projectile times the density of the fluid ρA. Since the mass density of the fluid is constant in any direction the amount of mass encountered of a period of time is $\rho A v$.

(b) In this example $\frac{\Delta E}{\Delta x} = F$. The amount of energy change per unit time is is $\frac{1}{2}\rho A v^3$. To get the force we divide by x, making the drag force per unit time $F = \frac{1}{2}\frac{\rho A v^2}{t}$.

(c) $f_{quad} = \gamma D^2 v^2 = k\rho\frac{\pi D^2}{4}v^2$ thus $\gamma = k\rho\frac{\pi}{4} \approx 0.25$

2.6 (a) We know $v_y(t) = v_{ter}(1 - e^{-t/\tau})$, we also know $v_{ter} = g\tau$. Thus if Taylor approximations are good at low values of x then $v_y(t) = g\tau(1 - (1 + (-t/\tau))) = gt$.

(b) We know $y(t) = v_{ter}t + (v_{y0} - v_{ter})\tau(1 - e^{-t/\tau})$, from part (a) we can reduce this to $y(t) = g\tau t + (v_{y0} - g\tau)\tau(1 - (1 + (-t/\tau)))$ which is $\frac{1}{2}gt^2$.

2.11 (a) $v_y(t) = v_0 - v_{ter}(1 - e^{-t/\tau}) - gt$

(b) The highest point would be where $v_0 = v_{ter}(1 - e^{-t/\tau}) + gt$. The position at this point would be $y_{max}(t) = v_0 - v_{ter}t + (v_{y0} - v_{ter})\tau(1 - e^{-t/\tau}) - \frac{1}{2}gt^2$

2.31 (a) $v_{ter} = \frac{mg}{b}$ and $b = \beta D$, thus $v_{ter} = 20.2\frac{m}{s}$.

(b) In vacuum it would take $\sqrt{\frac{60}{9}}$.