Phys 331 Practice Test: Ch 1-4

1. Physics sometimes turns up in unexpected places. The following is a quotation from C.S. Forester's *Admiral Hornblower in the West Indies*:

   > *"There's all the difference in the world between six knots, which she's making now closed-hauled, and twelve knots, which she'll make when she puts up her helm," he [Hornblower] said. "Mr. Spendlove here will tell you that the water resistance is a function of the square of the speed. Isn't that so, Mr. Spendlove?" "Perhaps a function of the cube or even one of the higher powers, my lord."*

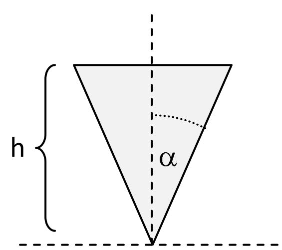
   What if the dependence were exponential? $f = -ke^{cv}$. Also, assume that the ship moves in just one dimension. (20 pts.)

   (a) Suppose the wind provide a constant forward force F_w. What is the terminal speed of the ship in turbulent water?

   (b) At time $t = 0$, the ship is at position $x(0) = 0$ and has a velocity of $v(0) = v_o$. If the only force after this time is the drag force (the wind has stopped blowing) and mass of the ship is *m*, how long will it take the ship's velocity to decrease to one half of its initial value?

   (c) For the conditions given in part (b), how far will the ship travel by the time its velocity has decreased to one half of its initial value? (note: $\int xe^{ax}dx = \frac{e^{ax}}{a^2}(ax-1)$)

2. Suppose a thin sheet of metal is cut into the triangle shown below, with mass M. (20 pts.)



   (a) Find the center of mass using the corner at the bottom as the origin.

   (b) Find the moment of inertia about an axis perpendicular to this page that passes through that corner.

The space shuttle launches (from rest) with a mass around m_o=2×10^{6}kg, and after two minutes it's burnt half that in fuel, so it's down to m = 1×10^{6}kg. If its exhaust speed is 3000 m/s…

a) How fast would it be going at the end of this period if it started from rest and there were *no gravity?*

b) How fast would it be going at the end of this period if it *were* subject to a uniform gravitational field, so $F_{external}$ = -mg? (15 pts.)

3. Consider the force: (13 pts.)

$$\vec{F} = (x^3)\hat{x} + (y^2 \cdot z)\hat{y} + (z \cdot y^3)\hat{z}.$$

(a) Find the value of c so that the force is conservative.

(b) By performing a line integral along the path of choice, from the origin to location (x,y,z), find the potential energy associated with the force using the origin as the reference point.

4. Suppose two particles repel each other if too close or too far, but attract if somewhere in between (for example, like two protons do). Say the potential is given by $U(r) = \frac{6}{r} - \frac{18}{r^2} + \frac{10}{r^3} - 15$, where the energy is in MeV's and the separations are in 10^{-15} meters. (13 pts.)

(a) Find the position of all equilibrium points.

(b) Determine whether each equilibrium point found in part (a) is stable or unstable.

5. The ball is constrained to slide up and down on the rod. (4 pts.)
Find an expression for the potential energy for the situation illustrated below in terms of the string length, l, the vertical separation of pulley and rod, b, and the variable angle θ. The distances H and h are offered for your use in reasoning it out, but they should not appear in your final equation.