PHYS-3202 Homework 1 Due 11 Sept 2019

This homework is due in the dropbox outside 2L26 by 10:59PM on the due date. You may alternately email a PDF (typed or black-and-white scanned) or give a hardcopy to Dr. Frey.

1. **Conservation of Momentum** *inspired by Kibble & Berkshire 1.1 and 1.2*

   (a) Object A moves initially with nonzero velocity $\vec{v}$ and collides with initially stationary object B. After the collision, A moves with velocity $\vec{v}/3$ and B moves with velocity $\vec{v}/2$. What is the ratio of masses?

   (b) The two stars of a double star system have concentric circular orbits of radii r_1 and r_2. What is the ratio of their masses? *Hint:* The orbital speed v in a circular orbit of radius r is $v = r\omega$, where ω is the angular velocity.

2. **Force From Velocity** *inspired by Fowles & Cassiday*

   An object of mass m moves in one dimension with velocity given by $v = \alpha/x$ for α a positive constant. Find the force on the object as a function of position and the position as a function of time. To find the force, you may use either Newton's 2nd law or energy conservation. Assume that the object is initially at the origin.

3. **Yield of Explosion** *from the 2018 CAP Lloyd G. Elliott University Prize Exam*

   An explosion releases an energy E into the atmosphere at time $t = 0$. Use dimensional analysis to find the radius R of the resulting fireball as a function of time t. Relevant information is E and atmospheric density ρ. Note that the air pressure is related to ρ by the ideal gas law, so it is not a separate variable. (The formula you will find is valid at early times after the explosion.)

4. **Turbulent Air Resistance**

   Consider an object falling in a uniform gravitational acceleration g against a drag force of magnitude λv^2. In this problem, you will want to recall the hyperbolic trig functions and the relationships $\cosh^2\theta - \sinh^2\theta = 1$, $d\cosh\theta/d\theta = \sinh\theta$, and $d\sinh\theta/d\theta = \cosh\theta$.

   (a) Show that the speed of the object as a function of time is

   $$v(t) = \sqrt{\frac{mg}{\lambda}}\tanh\left(\sqrt{\frac{\lambda g}{m}}\,t\right) \ , \tag{1}$$

   where m is the object's mass. Assume that $v = 0$ at $t = 0$. Does this formula agree with the terminal velocity from the lecture notes? *Hint:* You can directly integrate Newton's 2nd law.

   (b) Now find the distance traveled as a function of time. Check that your answer has the correct units.