PHYS-3202 Homework 1 Due 16 Sept 2020

This homework is due to `https://uwcloud.uwinnipeg.ca/s/LLijRqSDKdXgMDA` by 10:59PM on the due date. You may submit a Word doc/docx document (with an equation editor for mathematics) or a PDF (typed or black-and-white scanned).

1. **"Composite" Object** *based on a problem by Kibble & Berkshire*

   Consider three particles interacting with each other but with no external forces. The particles have masses m_1, m_2, m_3 respectively. Suppose we pretend that particles 2 and 3 are a single particle A of mass $M = m_2 + m_3$. We define the force on A from 1 as the sum of the forces on 2 and 3 from 1.

   (a) In the case that $m_2 = m_3 \equiv m$, show that the equations of motion (ie, Newton's 2nd law) for particles 1 and A can be written as Newton's 2nd law for those particles with particle A at the average location of the particles 2 and 3 ($\vec{r}_A = (\vec{r}_2 + \vec{r}_3)/2$).

   (b) Now suppose that $m_2 \neq m_3$. What must be the location of the imaginary particle A if we still have $M\vec{a}_A = \vec{F}_{A1}$?

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. **Planck Units** *general physics; see also Idema 1.2*

   The speed of light c, Newton's constant G, and (the reduced) Planck's constant $\hbar$ are all usually considered constants of nature.

   (a) List the dimensions of the three physical constants $c, G, \hbar$. You may start from any formula you know involving them.

   (b) Find a combination l_P of $c, G, \hbar$ with units of length; this is the "Planck length." Give the value of l_P in meters (to 2 significant digits). (You can find the physical constants in appendix B of Idema.)

   (c) Because they are dimensionful, we can work in units where $c = G = \hbar = 1$ and therefore $l_P = 1$. These are called Planck units. Can you think of any other physical constants that you can set equal to 1 in Planck units?

4. **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.)