Midterm 1 for General Physics I

Date: Oct 14, 2014

(1) Please do not flip the sheet until instructed.
(2) Please try to be as neat as possible so that I can understand your answers without ambiguity.
(3) While it is certainly your rights to make wild guesses or memorize irrelevant details, I would truly appreciate if you try to make your answers logical.
(4) Good luck for all hard-working students!

Lecturer: Hsiu-Hau Lin

Midterm for General Physics I (Fall, 2014)

Lecturer: Hsiu-Hau Lin

(Dated: Oct 14, 2014)

1. Energy-momentum vector (20%) Consider two inertia frames, Jack and Jill, with relative velocity v as discussed in class. In special relativity, energy E and momentum $\boldsymbol{p} = (p_x, p_y, p_z)$ can be cast into the 4-vector form, $(E/c, p_x, p_y, p_z)$, following Lorentz transformation. The energy-momentum vector of a particle at rest with respect to Jack's frame is

$$(p_0, p_x, p_y, p_z) = (m_0 c, 0, 0, 0),$$

where $E = m_0 c^2$ is used and m_0 is the rest mass of the particle. Find out the energy-momentum vector $(E'/c, p'_x, p'_y, p'_z)$ of the particle in Jill's frame.

2. Planet motion (20%) In a strange universe X, the gravitational law takes the linear form,

$$\boldsymbol{F} = -\mathcal{G} M m \boldsymbol{r},$$

where M is the mass of the sun, $m \ll M$ is the mass of the planet and $\mathcal{G}$ is the universal constant for gravity. The vector $\boldsymbol{r} = (x, y)$ describes the trajectory of the planet on the two-dimensional orbital plane. At $t = 0$, the initial displacement of the planet is $\boldsymbol{r}(t = 0) = (r_0, 0)$ and its initial velocity is $\boldsymbol{v}(t = 0) = (0, v_0)$. Find the trajectory $\boldsymbol{r}(t)$ of the planet.

3. Equations of motion (20%) A block of mass m slides up and down a triangular block of mass M as shown in the figure. To describe the horizontal and the vertical motions of the blocks, one can choose three dynamical variables, $x(t)$, $y(t)$ and $X(t)$. We assume that the triangular block remains on the surface without any vertical displacement. Write down the equations of motion for these dynamical variables.

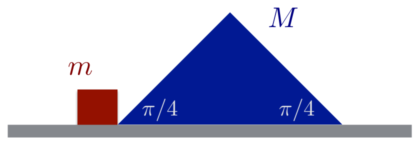

FIG. 1: A block sliding up and down another block.

4. Center of mass (20%) Consider a hemisphere of radius R and mass M with uniform density. Find the location of its center of mass by integration.

5. Inertia frames (20%) Write a short essay (less than two pages of your answer booklet) on *"Distinction between inertia and non-inertia frames"*. Try to arrange all your personal understanding in logical order and cook up a readable essay on the subject. Just copying down pieces from hedgehog notes or the textbook won't earn you any point.