Student ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part D, August 2012, 14:00–17:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may **NOT** use programmable calculators to store formulae.
2. All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.
3. For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.
4. Your assigned student **ID Number**, the **Problem Number**, and the **Page Number** should appear in the upper right hand corner of each sheet. Do **NOT** use your name anywhere on the Exam.
5. All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.
6. Each problem is worth 10 points.
7. Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

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D1. Some theorists speculate of a possibility of extra "curled" ("compactified") spatial dimensions. In a peculiar scenario when some of the extra dimensions are accessible to gravity only and the radius of the curvature for these extra dimensions is relatively large, creation of tiny black holes might become possible at the Large Hadron Collider (LHC). In 2012, LHC provides proton-proton collisions with the center of mass energy of 8 TeV. The rate of collisions is about 10^9 Hz. Theorists argue that such tiny black holes would evaporate well before having any remote chance of growing and swallowing the Earth; however, some worry if they should trust theorists on this.

At this point, an experimentalist notes that some of the cosmic rays (assume protons) have very large energies. When such highly energetic rays collide with hydrogen of the Sun, the collision's center-of-mass energy can be by far larger than those available at LHC. Therefore, from the fact that the Sun exists for more than 5 billion years, the experimentalist concludes that, if such exotic mini black holes, indeed, could be produced at the LHC, they could not possibly impose any danger. Substantiate experimentalist's conclusion with numerical calculations of how many collisions between cosmic rays and Sun's protons with a center of mass energy in excess of 8 TeV has occurred over 5 billion years and compare the result to the number of proton-proton collisions in one year of LHC operation. You may assume that each cosmic ray that enters the Sun will collide with a proton in the Sun.

The experimentalist knows:

1) The empiric formula for the flux of the high energy primary cosmic rays:

$$\frac{dN}{dE} = \frac{a}{E^3},$$

where $a = 10^{2}4\ \mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{sr}^{-1}\mathrm{eV}^{2}$ (sr stands for stereo radians);

2) Sun's radius is 7×10^8 m;

3) mass of a proton is 1.67×10^{-27} kg;

4) speed of light is 3×10^8 m/s.

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D2. A body is composed of a cylinder of radius R and length L and a hemisphere also of radius R. Assume both are of the same density. The circular cross-section of the hemisphere is attached to one circular end of the cylinder. The body is balanced on the hemisphere with the cylinder section being vertical.

(a) [points]
Find the center of mass of the whole system.

(b) [points] For what value of L is the center of mass at the center of the hemisphere (*i.e.,* at the cylinder-hemisphere interface).

(c) [points] If L is larger than this, what will happen to the body if it is tipped slightly away from equilibrium?

(d) [points] Explain why this does **not** happen if L is smaller than the value you found in part (b).

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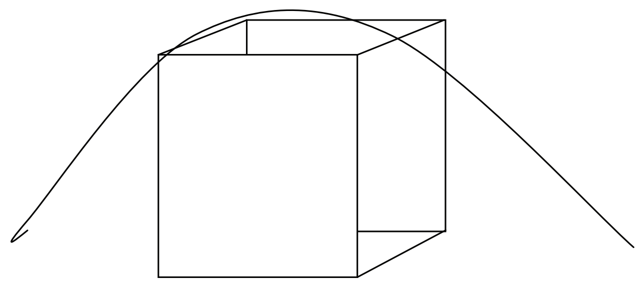
D3. Ethel is standing on the ground in front of a cube-shaped building with side length (and height) L. She wants to throw a ball that will just clear the building and land on the ground on the opposite side. She wants to do this with minimum kinetic energy for the ball.



(a) [2 points] If the ball reaches a height of H above the ground, show that $H/L = 1.25$?

(b) [3 points] Show that the launch angle with respect to the horizon must be 66°.

(c) [3 points] How fast (in terms of $(gL)^{1/2}$ should the ball be moving?

(d) [2 points] Show that Ethel needs to stand at a distance of $0.62L$ from the nearest edge of the building?