UNIVERSITY OF MARYLAND

Department of Physics

University of Maryland
Physics 161
12-15-05
Exam IV, final exam
Chapters: 1-13 minus chapter 12.

M. Laurenzi
Section number____________________
Name____________________________
Student ID#_______________________

In general, I do not curve individual exams however, more likely than not your final grade in this course may potentially be adjusted in the direction of your favor.

Each question is worth a total of 100 pts. The points will be distributed evenly by dividing 100 by the number of sub-questions. The grade you receive will be a percent grade. ***For problems which involve numbers use only one significant figure.***

Solve the following problems completely for full credit. **Please do your work under the problem on the exam page NEATLY. Please make a box around your final answer.** The test is closed books, notes and classmates. Do the questions that you find less challenging first. Then follow up with those that seem to be more difficult. Best of Luck…..

At the end of the exam, write and sign the honor pledge in the space below: "I pledge to my honor that I have not given nor received any unauthorized assistance on this examination."

Please leave your pages stapled together unless you have a stapler to re-staple the pages….

1. A bowling ball with mass M, radius R, and a moment of inertia of $\frac{2}{5}MR^2$ is released from the top of an inclined plane of height H. A cylindrical ring with the same mass M, radius R, and with a moment of inertia MR^2 is also released at the same time. Both roll without slipping.

   a. Use energy methods to find the center of mass velocity (V_{CM}) of each object when it reaches the bottom of the incline. Express your result in terms of R, H and the acceleration due to gravity, g.

   b. Which object reaches the bottom first?

2. In a snowball fight it is possible to distract your opponent by throwing a snowball at a high angle (θ) relative to the horizontal. While your opponent is watching the first snowball you immediately throw a second snowball at a low angle (φ) relative to the horizontal aimed more directly. Set the origin so that the guy throwing the snowball is at the origin of your coordinate system. Assume that both snowballs start and end at $y = 0$, are thrown with an initial velocity of 30m/s and the first snowball is thrown at $\theta = 70°$ relative to the horizontal.

a) Find the time t_1 that it takes the first snowball to land.

b) Find the displacement in the $\hat{x}$ direction of the first snowball.

c) Find the time t_2 it will take the second snowball to land as a function of φ.

d) Using the results from part b) solve the equation $x_f - x_i = v_{0x} t_2$.

e) Using the trigonometric identity $\sin(2\varphi) = 2\sin(\varphi)\cos(\varphi)$ and your results from d) find the angle φ that the second snowball must be thrown at in order to make it land in the same position as the first snowball.

3. At constant velocity, a 10kg block is pushed from the ground up a wall that has a coefficient of kinetic friction $\mu_k = 0.3$ by a force of magnitude F applied to the left side of the block at an angle of 30° relative to the horizontal. After the block travels 4m up the wall *the force vanishes*.

- c. *Draw a free body diagram and find the net force in the x and y directions.*
- d. *What is the force of gravity?*
- e. *What is the magnitude of the normal force between the block and the wall?*
- f. *Determine the work done by the force in moving the block 4m up the wall.*
- g. *How much potential energy is transferred to the block after being pushed up the wall?*
- h. *When the force vanishes will the block remain touching the wall? (yes or no)*
- i. *When the force vanishes assume that that block is in a state of free fall. Find the velocity of the block after it has fallen 4m (hits the mathematical ground at y = 0).*

4. For the following vectors: $\vec{v} = 1\hat{x} + 2\hat{y} + 3\hat{z}$ and $\vec{j} = 2\hat{x} + 1\hat{y} + 3\hat{z}$ find:

a) $\vec{v} \bullet \vec{j} = ?$

b) $\vec{j} \bullet \vec{v} = ?$

c) Is the result from part a) equal to part b)?

d) $\vec{v} \otimes \vec{j} = ?$

e) $\vec{j} \otimes \vec{v} = ?$

f) Is the result from d) equal part e)?

g) What is the result of performing the dot product vector operation?

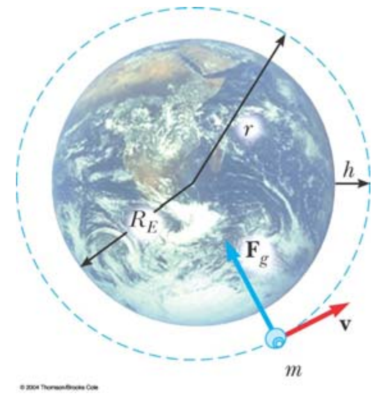
h) What is the result of performing the cross product vector operation?

5. A satellite of mass *m,* originally on the surface of the Earth, is placed into Earth orbit at an altitude *h*. Ignore air resistance but include the effect of the planet's daily rotation. Leave your answers in terms of the G, M, m, R_E, and h.

(a) What is the velocity of the satellite in orbit a distance h above the earth's surface?

(b) What is the orbital period? Or the time that it takes to make one complete trip around the Earth?

(c) What is the minimum energy $\Delta E_{\min}$ needed to place this satellite in orbit a distance h above the Earth's surface?



Hint: $\Delta E_{\min} = (KE + PE)_f - (KE + PE)_i$

$$F = -\frac{GMm}{r^2} \qquad U_g = -\frac{GMm}{r} \qquad T = \frac{2\pi R}{v}$$

(d) At what location on the Earth's surface and in what direction should the satellite be launched to minimize the required energy and Why?

(e) What is the escape velocity of an object with mass m trying to release itself from the Earths gravitational field? (This problem is separate)

Possibly useful information

$\Delta x \equiv x_f - x_i$ $\Delta t \equiv t_f - t_i$ $\Delta v_x \equiv v_{xf} - v_{xi}$

$v_x = dx/dt$ $a_x = dv_x/dt$ $v_{xf} = v_{xi} + a_x t$

$x_f = x_i + \frac{1}{2}(v_{xi} + v_{xf})t$ $x_f = x_i + v_{xi}t + \frac{1}{2}a_x t^2$

$v_{xf}^2 = v_{xi}^2 + 2a_x(x_f - x_i)$

$x = r\cos(\theta)$ $y = r\sin(\theta)$ $r = \sqrt{x^2 + y^2}$

$a_c = {v_t^2}/{r}$

$\vec{A} \bullet \vec{B} = A_x B_x + A_y B_y + A_z B_z$ $W = \int \vec{F} \bullet d\vec{r}$

$U_g = mgy$ $U_s \equiv \frac{1}{2}kx^2$ $W_g = -(U_f - U_i)$

$\vec{p} = m\vec{v}$ $\vec{I} \equiv \int_{t_i}^{t_f} \vec{F}dt$ $\vec{I} = \Delta\vec{p} = m\vec{v}_f - m\vec{v}_i$

$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$ $\vec{r}_{cm} = \frac{1}{M}\sum_i m_i \vec{r}_i$ $\vec{r}_{cm} = \frac{1}{M}\int \vec{r}dm$

$\theta = s/r$ $\omega = d\theta/dt$ $\alpha = d\omega/dt$

$\omega_f = \omega_i + \alpha t$ $\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$ $\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$

$v_t = r\omega$ $a_t = r\alpha$ $a_c = {v_t^2}/{r} = r\omega^2$

$\theta_f = \theta_i + \frac{1}{2}(\omega_i + \omega_f)t$ $I = \int r^2 dm$ $K = \frac{1}{2}I\omega^2$