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. The position of a particle is given by: $\vec{x}(t) = \{(t-2)\}\hat{x} + \{(t^2 + 3t - 2)\}\hat{y}$ in the units of meters.

   a. Find the instantaneous velocity in vector component form.
   b. Find the magnitude of the instantaneous velocity at t = 2sec.
   c. Find the instantaneous acceleration in vector component form.
   d. Find the magnitude of the instantaneous acceleration at t =2sec.

3. A 5.0g bullet moving with an initial velocity of 400m/s is shot into and passes through a 1.0kg block that is attached to spring and continues on its original path. The other side of the spring is attached to a wall. The wooden block is initially at rest on a frictionless, horizontal surface with spring possessing a spring constant of 900N/m. At maximum compression of the spring the block has moved 5cm to the right. (Hint: the bullet does not stay in the block)

a. Use energy considerations to find the velocity of the Block after the bullet has passed through it. Keep in mind that energy is not conserved during the time interval when the bullet is passing through the block.

b. Use conservation of Linear momentum to find the velocity of the bullet after it has passes through the wooden block and continues on its path.

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?

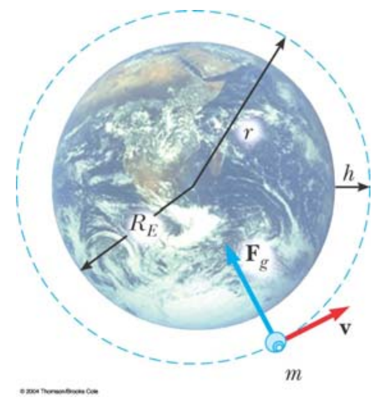
h) What is the result of performing the cross product vector operation?

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

$\Delta x \equiv x_f - x_i$

$\Delta t \equiv t_f - t_i$

$\Delta v_x \equiv v_{xf} - v_{xi}$

$v_x = dx/dt$

$a_x = dv_x/dt$

$v_{xf} = v_{xi} + a_x t$

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

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

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

$x = r\cos(\theta)$

$y = r\sin(\theta)$

$r = \sqrt{x^2 + y^2}$

$a_c = v_t^2 / r$

$\vec{A} \bullet \vec{B} = A_x B_x + A_y B_y + A_z B_z$

$W = \int \vec{F} \bullet d\vec{r}$

$U_g = mgy$

$U_s \equiv \frac{1}{2}kx^2$

$W_g = -(U_f - U_i)$

$\vec{p} = m\vec{v}$

$\vec{I} \equiv \int_{t_i}^{t_f} \vec{F}dt$

$\vec{I} = \Delta\vec{p} = m\vec{v}_f - m\vec{v}_i$

$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$

$\vec{r}_{cm} = \frac{1}{M}\sum_i m_i \vec{r}_i$

$\vec{r}_{cm} = \frac{1}{M}\int \vec{r}dm$

$\theta = s/r$

$\omega = d\theta/dt$

$\alpha = d\omega/dt$

$\omega_f = \omega_i + \alpha t$

$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$

$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$

$v_t = r\omega$

$a_t = r\alpha$

$a_c = v_t^2 / r = r\omega^2$

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

$I = \int r^2 dm$

$K = \frac{1}{2}I\omega^2$