UNIVERSITY OF MARYLAND

Department of Physics

University of Maryland — M. Laurenzi

Physics 161 — Section number____________________

12-17-05 — Name____________________

Exam IV, final exam — Student ID#____________________

Chapters: 1-13 minus chapter 12.

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…..

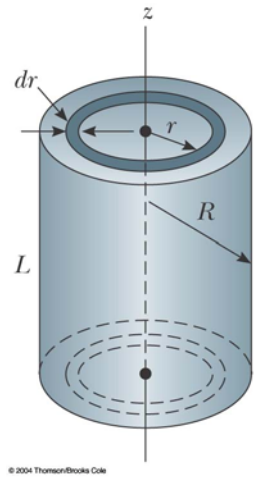
At the end of the exam, write and sign the honor pledge in the space below: "I pledge to my honor that I have not given nor received any unauthorized assistance on this examination."

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

1. In an inertial reference frame a proton initially at rest experiences a glancing collision with another proton that has a velocity V_0 in x-direction. After the collision the proton initially moving goes off at an angle of θ and the mass initially at rest goes off at an angle φ. Assume that both particles have the same mass.

   a.) Show that if the magnitudes of the final velocities of the protons are the same that it is necessary that the angles be equal and opposite relative to the positive x-axis. (Hint: use the equation with conserves momentum in the y-direction to prove this.)
   b.) Find the relationship between the initial velocity and the final velocities of the protons in the x-direction. (Hint: use the equation that conserves momentum in the x-direction to find this relationship.)
   c.) If the initial velocity of the proton that is moving before the collision is 4x10^6m/s what is the velocity of each proton in the x-direction.

2. Find the total moment of inertia for a **Solid** cylinder.



Keep in mind this a **SOLID** cylinder with mass M uniformly distributed throughout its volume. $I = \int r^2 dm$.

3. 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) $\vec{v} \otimes \vec{j} = ?$

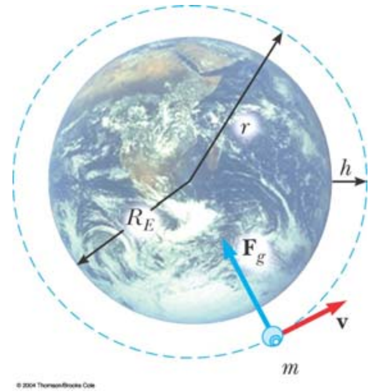
e) $\vec{j} \otimes \vec{v} = ?$

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?

4. 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?

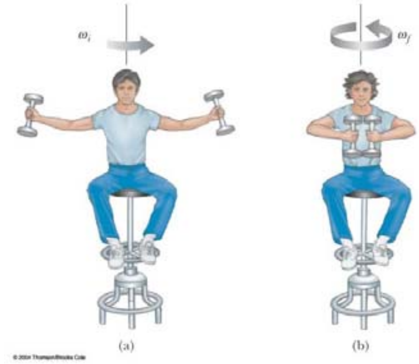
(c) What is the minimum energy $\Delta E_{\min}$ needed to place this satellite in orbit a distance h above the Earth's surface?

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)



5. A student sits on a freely rotating stool holding two weights, each of mass 3.00 kg. When his arms are extended horizontally, the weights are 1.00 m from the axis of rotation and he rotates with an angular speed of 0.750 rad/s. The moment of inertia of the student plus stool is 3.00 kg·m^2 and is assumed to be constant. The student pulls the weights inward horizontally to a position 0.300 m from the rotation axis.

(a) Find the new angular velocity of the student after the inward movement of the student's arms.

(b) Find the change in mechanical energy of the student-stool-weights system.

(c) In problem you just solved angular momentum was conserved. Start with $\frac{d\vec{L}}{dt} = \vec{\tau}$ and reason your way to the result that produces $L_f = L_i$.

Possibly useful information

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

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

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

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

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

$a_c = v_t^2 / r$

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

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

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

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

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

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

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

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