PHYSICS-2101 Spring Semester 2013
Instructor and section (circle yours)
Examination 2
Mar. 12, 2013

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Name (print) ____________________________ LSU ID __________

Signature ___________________________________________________________________

TURN OFF AND PUT AWAY ALL CELL PHONES, PAGERS, IPODS, MP3s, OR ANY OTHER COMMUNICATIONS, AUDIO, OR VIDEO DEVICES

Have your LSU ID ready when you turn in your paper.

You may not use cell phone or smart phone application as your calculator.

You may use an ordinary scientific or even graphing type calculator, as long as it is not of the "full keyboard" sort.

Examine your paper to be sure it is complete and legible. There should be 3 problems and 2 questions, totaling 100 points. Examine your formula sheet as well.

For the multiple choice questions, clearly indicate your selected answer(s) for each of the part(s) of the question, circle the correct answers! For some questions there may be more than one correct response. If so, be sure mark each one. There is room on the paper for scratch work or calculations, but that work will not be checked or graded. There is no partial credit awarded for multiple choice questions.

For the problems, show your work in the space provided. Even a correct answer, without supporting work, will receive little or no credit. Partial credit may be awarded for problems if warranted.

Be sure that numerical answers appear with appropriate SI units. Points will be deducted for missing, incorrect, or "silly" units.

If the final answer is, in fact, a dimensionless quantity, please write the numerical result followed by the word "dimensionless."

If you need more room for your problem solution you may write on the back of the page, but be sure to add a note to look on the back. Otherwise anything on the back of the paper will be regarded as scratch work and will not be checked or graded.

You will have approximately 60 minutes to complete this examination.

Solutions will be posted to the course web page within a few days.
Question 1 (10 points) Billions of years from now our sun will reach a stage in its development when it grows in radius, ultimately engulfing the inner planets. The present angular speed of the sun is \( \omega = 2.97 \times 10^{-6} \text{ rad/s} \) and its radius is \( r = 6.96 \times 10^8 \text{ m} \). Consider a process during its development in which it grows to \( r' = 1.24 \times 10^9 \text{ m} \) without changing its mass \( M = 1.99 \times 10^{30} \text{ kg} \). Assume that the sun is a solid ball throughout this process.

(i) (5 points) Which of the following quantities is conserved in the process described?

(A) Linear Momentum.
(B) Angular Velocity.
(C) Angular Momentum.
(D) Potential Energy.
(E) Kinetic Energy.

(ii) (5 points) What is \( 10^7 \) times the new angular speed \( \omega' \)?

(A) 6.27 rad/s  (B) 5.82 rad/s  (C) 9.36 rad/s  (D) 4.45 rad/s  (E) 7.92 rad/s

Question 2 (10 points) A solid disk of mass \( M = 3 \text{ kg} \) and radius \( R = 0.05 \text{ m} \) rotates around an axis which is perpendicular to the plane of the disk and passes through its center. It has a kinetic energy of \( K = 0.2 \text{ J} \).

(i) (5 points) What is the kinetic energy of the disk if it rotates about a parallel axis through its perimeter at the same angular velocity?

(A) 0.74 J  (B) 0.29 J  (C) 0.93 J  (D) 0.51 J  (E) 0.60 J

(ii) (5 points) What is the angular momentum of the disk if it rotates about a parallel axis through its perimeter at the same angular velocity?

(A) 0.213 J s  (B) 0.116 J s  (C) 0.087 J s  (D) 0.159 J s  (E) 0.247 J s
Problem 1 (20 points) The figure below shows a uniform beam of mass $M = 6$ kg and length $L = 2$ m which makes an angle $\theta = 40^\circ$ with respect to a frictionless floor and rests against a frictionless wall. A horizontal wire extends from the wall and attaches a distance $d = 0.4$ m from the bottom end of the beam.

(i) (10 points) Draw a free-body diagram for the beam, clearly labeling the locations of each force and the chosen pivot point. Write down the algebraic equations of Newton’s second law for the horizontal, vertical, and angular directions in terms of the above variables, the tension $T$, the normal force of the wall $N_w$, and the normal force of the floor $N_f$.

\begin{align*}
N_w - T &= 0 \\
N_f - Mg &= 0 \\
dT \sin \theta + Mg \frac{L}{2} \cos \theta - N_w L \sin \theta &= 0
\end{align*}

(ii) (10 points) Solve for $T$, $N_w$ and $N_f$.

\begin{align*}
N_f &= Mg = 58.8 \text{ N} \\
Mg \frac{L}{2} \cos \theta &= (L-d) T \sin \theta \\
N_w &= T = \frac{Mg \frac{L}{2}}{(L-d) \tan \theta} = 43.80 \text{ N}
\end{align*}
Question 3 (20 points) The figure below shows two masses \( m_1 = 3 \text{ kg} \) and \( m_2 = 2 \text{ kg} \) which are connected by a string on a frictionless surface. Forces internal to the two masses are shortening the string, causing the masses to move toward each other. Initially the two masses are at rest \( (v_1 = v_2 = 0) \) at positions \( x_1 = 0 \) and \( x_2 = d = 1.0 \text{ m} \).

(i) (6 points) Which of the following statements is false?

(A) The position of the center of mass is constant in this problem.
(B) The kinetic energy of the system is conserved.
(C) The total momentum of the system is conserved.
(D) The string does not cause a change in the total momentum of the system.
(E) The total momentum of the system is zero.

(ii) (6 points) If at some later time \( x_1' = 0.1 \text{ m} \), what is \( x_2' \)?

(A) 0.78 m (B) 0.96 m (C) 0.85 m (D) 0.92 m (E) 0.81 m

(iii) (8 points) If at some later time \( v_1' = 2.3 \text{ m/s} \), what is \( v_2' \)?

(A) -3.07 m/s (B) -3.45 m/s (C) -2.89 m/s (D) -4.15 m/s (E) -3.88 m/s
Problem 2 (20 points) The figure below shows a solid ball of mass $M = 3\text{ kg}$ and radius $R = 0.1\text{ m}$ which, starting from rest, rolls without slipping down the hill at left from an initial height $h_1 = 2\text{ m}$. At the bottom of the hill the ball has acquired the speed $v_b$. Once it passes the point $P$, it experiences no friction with the surface and slides up the hill at right to a height $h_2$.

(i) (12 points) Find the speed $v_b$.

$$I = \frac{3}{5}MR^2$$

$$Mg h_1 = \frac{1}{2} (M + \frac{I}{R^2}) v_b^2$$

$$g h_1 = \frac{1}{2} \left(\frac{3}{5}\right) V_b^2$$

$$V_b = \frac{10}{7} g h_1$$

$$v_b = 5.29 \text{ m/s}$$

(ii) (8 points) Find the height $h_2$.

$$\frac{1}{2} M V_b^2 = Mg h_2$$

$$V_b^2 = 2 g h_2 = \frac{10}{7} g h_1$$

$$h_2 = \frac{5}{7} h_1 = 1.43\text{ m}$$
Question 4 (20 points)

The figure below shows a beam of mass $M = 7 \text{ kg}$ and length $L = 1 \text{ m}$ which is free to rotate in a vertical plane around an axis which passes though the end of the beam ($I = \frac{1}{3}ML^2$). The beam is initially taken to be in the upright ($\theta = 90^\circ$) position and then swings down under the influence of gravity in the clockwise direction.

(i) (6 points) Which of the following statements is false?
(A) The angular momentum of the beam is conserved.
(B) Only gravity exerts a torque on the beam.
(C) The total momentum of the system is not conserved.
(D) The mechanical energy of the system is conserved.
(E) The torque exerted by the axis force is zero.

(ii) (6 points) What is the angular acceleration $\alpha$ of the beam when $\theta = 0^\circ$?
(A) $14.7 \text{ rad/s}^2$ (B) $12.2 \text{ rad/s}^2$ (C) $9.4 \text{ rad/s}^2$ (D) $16.8 \text{ rad/s}^2$ (E) $5.7 \text{ rad/s}^2$

(iii) (8 points) What is the angular velocity $\omega$ of the beam when $\theta = -90^\circ$?
(A) $5.21 \text{ rad/s}$ (B) $3.87 \text{ rad/s}$ (C) $7.67 \text{ rad/s}$ (D) $9.52 \text{ rad/s}$ (E) $6.45 \text{ rad/s}$