Physics 124 – Common Hour Exam 1
Monday, February 15, 2016, 9:50 PM - 11:10 PM
ARC-103 (A-J), PLH (K-M),
SEC 111 (N-R), Hill 114 (S-Z)

Your name sticker ⇒
with exam code
SIGN HERE

1. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labeled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit RUID Number.
4. Under CODE enter the exam code given above.
5. Enter 124 under COURSE. You do not need to write anything else on the answer sheet. You should continue to read the instructions.
6. During the exam, you are allowed one 8.5 x 11 inch sheet of paper handwritten, both sides.
7. The exam consists of 15 multiple-choice questions. For each multiple-choice question mark only one answer. There is no deduction of points for an incorrect answer; if you cannot work out the answer to a question, you should make an educated guess.
8. If you have questions or problems during the exam, you may raise your hand and a proctor will assist you. We will provide the value of physical constants that are needed. It is your responsibility to know the relevant equations.
9. A proctor will check your name sticker and your student ID sometime during the exam. Please have them ready.
10. You are not allowed to help any other student, ask for help from anyone but a proctor, change your seat without permission from a proctor or use any electronic device other than a scientific calculator. Doing so will result in a zero score for the exam.
11. When you are done with the exam, hand in only this cover sheet and your answer sheet.
12. Please sign above by the name sticker to indicate that you have read and understood these instructions.
Possibly useful constants:

\[ G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2 \]
\[ g = 9.8 \text{ m/s}^2 \]

Radius of Earth = \(6.4 \times 10^6\) m, mass of Earth = \(6.0 \times 10^{24}\) kg

Moments of inertia for uniform density objects:

\[ I_{\text{disk}} = I_{\text{solid cylinder}} = \frac{1}{2}MR^2 \]
\[ I_{\text{thin walled hollow cylinder}} = I_{\text{ring}} = MR^2 \]
\[ I_{\text{solid sphere}} = \frac{2}{5}MR^2, \quad I_{\text{thin walled hollow sphere}} = \frac{2}{3}MR^2 \]
\[ I_{\text{slender rod, axis through center}} = \frac{1}{12}ML^2 \]
\[ I_{\text{slender rod, axis through one end}} = \frac{1}{3}ML^2 \]

Circumference of a circle = \(2\pi r\); area of a circle = \(\pi r^2\)

Surface area of a sphere = \(4\pi r^2\); Volume of a sphere = \(\frac{4}{3}\pi r^3\)

Surface area of a cylinder = \(2\pi rh + 2\pi r^2\); Volume of cylinder = \(\pi r^2h\)

\[ \sin(0^\circ) = \cos(90^\circ) = 0 \]
\[ \sin(90^\circ) = \cos(0^\circ) = 1 \]
\[ \sin(30^\circ) = \cos(60^\circ) = 1/2 \]
\[ \sin(60^\circ) = \cos(30^\circ) = \sqrt{3}/2 \]
\[ \sin(45^\circ) = \cos(45^\circ) = \sqrt{2}/2 \]

Some metric prefixes:

f = femto = \(10^{-15}\)
p = pico = \(10^{-12}\)
n = nano = \(10^{-9}\)
\(\mu\) = micro = \(10^{-6}\)
m = milli = \(10^{-3}\)
k = kilo = \(10^3\)
M = mega = \(10^6\)
G = giga = \(10^9\)
1. Three disks are spinning independently on the same axle without friction. Their respective rotational inertias and angular speeds are $I$, $\omega$ (clockwise); $3I$, $2\omega$ (counterclockwise); and $I/2$, $4\omega$ (clockwise). The disks then slide together and stick together, forming one piece with a single angular velocity $\omega_f$. What are the direction and rate of rotation $\omega_f$ of the single piece?

   a) $\omega_f = 2\omega$, Clockwise
   b) $\omega_f = 2\omega$, Counter-clockwise
   c) $\omega_f = (2/3)\omega$, Counter-clockwise
   d) $\omega_f = (2/3)\omega$, Clockwise
   e) $\omega_f = (1/3)\omega$, Counter-clockwise

2. A long mechanical arm of length $L$ is free to pivot about one end. A force $F_1 = 3.0 \text{ N}$ acts at a distance $L/3$ from the arm’s pivot point to rotate the arm in a counter-clockwise fashion. A force $F_2 = 6.0 \text{ N}$ acts at a distance $L/2$ from the pivot point to rotate the arm in a clockwise fashion. Both $F_1$ and $F_2$ are perpendicular to the arm. Find the magnitude and direction of the force $F_3$ you would need to apply to the end of the mechanical arm in order for the angular momentum of the arm to remain constant.

   a) $F_3 = 2.0 \text{ N}$ in the same direction as $F_2$.
   b) $F_3 = 2.0 \text{ N}$ in the same direction as $F_1$.
   c) $F_3 = 3.0 \text{ N}$ in the same direction as $F_2$.
   d) $F_3 = 3.0 \text{ N}$ in the same direction as $F_1$.
   e) $F_3 = 2.5 \text{ N}$ in the same direction as $F_2$.

3. A ruler marked in centimeters, balanced at its center point, has two coins placed on it, as shown in the figure. One coin, of mass $M_1 = 10 \text{ g}$, is placed at the zero mark. The other of unknown mass $M_2$, is placed at the 4.7 cm mark. The ruler is perfectly balanced. What is the mass $M_2$?

   a) $M_2 = 1.8 \text{ g}$
   b) $M_2 = 6.3 \text{ g}$
   c) $M_2 = 18 \text{ g}$
   d) $M_2 = 63 \text{ g}$
   e) $M_2 = 10 \text{ g}$
4. Two people are carrying a uniform wooden board with length \( L = 3.0 \) m with mass \( M = 16 \) kg. If one person applies an upward force \( F_1 = 60 \) N at one end, at what point \( X \) from that end does the other person lift? The forces exerted by both people are perpendicular to the board and the board is horizontal. Assume \( g = 10 \text{ m/s}^2 \).

a) You need to know the magnitude of the force that the other person exerts.

b) \( X = 3.0 \) m

c) \( X = 2.0 \) m

d) \( X = 2.4 \) m

e) \( X = 2.8 \) m

5. The abstract sculpture shown in the figure can be placed on a horizontal surface without tipping over. Different parts of the sculpture may be hollow or solid, or made of different materials. The artist is not providing such information. Five locations labeled \( A \) through \( E \) are indicated on the diagram. Which one of these points is a possible location of the object’s center of mass?

a) Point \( C \)
b) Point \( E \)
c) Point \( D \)
d) Point \( A \)
e) Point \( B \)
6. Three objects each with a mass $M$ exert gravitational forces on each other. Let each unit on the graph represent a distance $x$. What is the magnitude of the net force $F$ acting on object $B$ in terms of $G$, $M$, and $x$?

- $F = \frac{(M^2G)}{(2x^2)}$
- $F = \frac{(M^2G)}{(4x^2)}$
- $F = \frac{(M^2G\sqrt{2})}{(2x^2)}$
- $F = \frac{(M^2G)}{(x^2)}$
- $F = \frac{(M^2G\sqrt{2})}{(4x^2)}$

7. The weight of an object on the earth is $W_E = 500$ N. On an unknown planet its weight is $W_p = 400$ N. The diameter of the planet is $D_p = D_E/2$, where $D_E$ is the diameter of the earth. What is the mass $M_p$ of the planet in terms of $M_E$, the mass of the earth?

- $M_p = M_E$
- $M_p = M_E/2$
- $M_p = M_E/4$
- $M_p = M_E/5$
- $M_p = 2M_E/5$

8. A merry-go-round of radius $R$ is rotating at a constant angular speed. The friction in its bearings is so small that it can be ignored. A sandbag of mass $m$ is dropped onto the merry-go-round at a position designated by $r$. The sandbag does not slip or roll on contact with the merry-go-round. These are the combinations of mass $m$ and radius $r$.

$m_1 = 20$ kg, $r_1 = 0.25 R$
$m_2 = 10$ kg, $r_2 = 0.50 R$
$m_3 = 40$ kg, $r_3 = 0.25 R$
$m_4 = 30$ kg, $r_4 = 0.50 R$

Rank the final angular velocities $\omega$ after the sandbag sticks to the merry-go-round.

- $\omega_3 > \omega_4 > \omega_1 > \omega_2$
- $\omega_2 = \omega_4 > \omega_1 = \omega_2$
- $\omega_4 > \omega_2 = \omega_3 > \omega_1$
- $\omega_1 > \omega_2 = \omega_3 > \omega_4$
- $\omega_2 > \omega_1 > \omega_4 > \omega_3$
9. A weight is tied to a rope that is wrapped around a pulley. The pulley is initially rotating counter-clockwise and is pulling the weight up. The tension in the rope creates a torque on the pulley that opposes this rotation. At the instant the pulley stops rotating counter-clockwise, which of the following statements is TRUE?

a) The torque is constant, but not zero, and the angular momentum is constant, but not zero.

b) The torque is constant, but not zero, and the angular momentum is zero.

c) The torque is zero and the angular momentum is constant, but not zero.

d) The torque is changing and the angular momentum is changing.

e) The torque is zero and the angular momentum is constant, but not zero.

10. To crack a nut a force of magnitude $F_n$ (or greater) must be applied to both sides, as shown in the figure. The nut is placed in the nutcracker as shown at a distance $d$ from the pivot. Equal forces of magnitude $F$ are applied to each end of the nutcracker, directed perpendicular to the handle, at a distance $D$ from the pivot. What is the magnitude of the force $F$ that should be applied to each side of the nutcracker to crack the nut?

a) $F = F_n$

b) $F = F_n d$

c) $F = F_n/2$

d) $F = (2F_n d)/D$

e) $F = (F_n d)/D$
11. You are given 4 planets.
   Planet 1: Has radius $R$ and mass $M$.
   Planet 2: Has radius $2R$ and mass $4M$.
   Planet 3: Has radius $R/2$ and mass $2M$.
   Planet 4: Has radius $2R$ and mass $6M$.
   Rank the escape speeds $v$ for a spacecraft from the surface of each of these planets.
   a) $v_4 > v_2 > v_3 > v_1$
   b) $v_4 = v_2 > v_1 > v_3$
   c) $v_4 > v_2 > v_1 > v_3$
   d) $v_3 > v_4 > v_2 > v_1$
   e) None of the other answers is correct. Need to know the mass of the spacecraft to be launched.

12. A planet twice the mass of the earth orbits a distant star with twice the mass of the sun. The nearly circular orbital radius of that planet is the same as that of the earth. What is the length of a year $T_p$ on the distant planet in units of earth years?
   a) $T_p = 1/\sqrt{2}$ years
   b) $T_p = 1/2$ years
   c) $T_p = 1$ years
   d) $T_p = \sqrt{2}$ years
   e) $T_p = 2$ years

13. A satellite with mass $m = 100$ kg orbits a planet with mass $M = 1 \times 10^{22}$ kg with a circular orbit of radius $r = 2000$ km measured from the center of the planet. The radius of the planet is $R = 1000$ km. What is the magnitude of the angular momentum $L$ of the satellite with respect to the center of the planet? Note: $G = 6.67 \times 10^{-11}$ N·m$^2$/kg$^2$.
   a) $L = 1.2 \times 10^{11}$ kg·m/s$^2$
   b) $L = 1.2 \times 10^{11}$ kg·m$^2$/s
   c) $L = 1.6 \times 10^{11}$ kg·m$^2$/s$^2$
   d) $L = 1.6 \times 10^{11}$ kg·m$^2$/s
   e) $L = 1.4 \times 10^{11}$ kg·m$^2$/s$^2$
14. A rock with mass \( m = 3.00 \text{ kg} \) has a horizontal velocity of magnitude \( v = 12.0 \text{ m/s} \) when it is at point \( P \) in the figure. At this instant, what are the magnitude and direction of its angular momentum \( L \) relative to the point \( O \)?

- \( a) \ \ L = 144 \text{ kg}\cdot\text{m/s}, \text{ into the page.} \)
- \( b) \ \ L = 144 \text{ kg}\cdot\text{m/s}, \text{ out of the page.} \)
- \( c) \ \ L = 288 \text{ kg}\cdot\text{m/s}, \text{ into the page.} \)
- \( d) \ \ L = 288 \text{ kg}\cdot\text{m/s}, \text{ out of the page.} \)
- \( e) \ \ L = 36.0 \text{ kg}\cdot\text{m/s}, \text{ out of the page.} \)

15. Sir Lancelot rides slowly out of the castle at Camelot and onto the 12.0-m-long drawbridge that passes over the moat. Unbeknownst to him, his enemies have partially severed the vertical cable holding up the front end of the bridge so that it will break under a tension \( T = 6.0 \times 10^3 \text{ N} \). The bridge has a weight of \( W_1 = 2000 \text{ N} \) and its center of gravity is at its center. Lancelot, his lance, his armor, and his horse together have a combined weight of \( W_2 = 6000 \text{ N} \). At what distance \( X \) from the castle end of the bridge will the center of gravity of the horse plus rider be when the cable breaks?

- \( a) \ \ \text{Lancelot will be able to get safely to the far side of the moat, because the cable will not break.} \)
- \( b) \ \ X = 11 \text{ m} \)
- \( c) \ \ X = 8 \text{ m} \)
- \( d) \ \ X = 6 \text{ m} \)
- \( e) \ \ X = 10 \text{ m} \)