

**SAMPLE EXAM #3 - PH111, SPRING '13**  
**FRIDAY, APRIL 5** **CHAPTERS 9, 10 AND 11**

THE IN-CLASS EXAM WILL INCLUDE 20 QUESTIONS SIMILAR TO THESE AND TO HOMEWORK/CLASS EXERCISES. ALL 20 QUESTIONS WILL HAVE MULTIPLE-CHOICE ANSWERS; SOME ANSWERS MAY BE WORTH PARTIAL CREDIT; DO NOT LEAVE ANY QUESTION BLANK! **NOTE:** THERE MAY BE ONE PROBLEM WITH TWO CORRECT ANSWERS; CIRCLE BOTH FOR BONUS.

EXAM BEGINS PROMPTLY AT **2:20 AND ENDS AT 3:45**. MAKE ARRANGEMENTS WITH OTHER INSTRUCTORS IF YOU THINK YOU'LL BE LATE TO THEIR CLASS.

**EQUATIONS BELOW WILL BE ON YOUR IN-CLASS EXAM:**

**General equations:**

$$W = \Delta K = -\Delta U$$

$$\Delta E = \Delta K + \Delta U = -f_k d$$

$$U = mgh \text{ or } \frac{1}{2} kx^2$$

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

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + \cdots + m_n x_n}{M}$$

$$\sum \vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$$

**Elastic collision:**

$$v_{1f} = \frac{m_1 - m_2}{m_1 + m_2} v_{1i} + \frac{2m_2}{m_1 + m_2} v_{2i}$$

$$v_{2f} = \frac{2m_1}{m_1 + m_2} v_{1i} + \frac{m_1 - m_2}{m_1 + m_2} v_{2i}$$

**Rotational variables:**

$$s = r\theta, \quad v = r\omega, \quad a_t = r\alpha$$

$$\omega = \omega_0 + \alpha t$$

$$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$\theta = \frac{1}{2}(\omega_0 + \omega)t$$

$$\theta = \omega t - \frac{1}{2} \alpha t^2$$

$$K = \frac{1}{2} m v_{cm}^2 + \frac{1}{2} I \omega^2$$

$$\vec{l} = \vec{r} \times \vec{p}, \quad L = I\omega$$

$$\vec{\tau} = \vec{r} \times \vec{F}, \quad \sum \vec{\tau} = I\alpha = \frac{d\vec{l}}{dt}$$

**Rotational Inertia: (if any other rotational inertia equations are necessary, I will provide them)**

$$I = \sum_{i=1}^n m_i r_i^2 = \int r^2 dm$$

$$I = I_{cm} + Mh^2 \text{ (Parallel axis theorem)}$$

$$I_{\text{cylinder}} = \frac{1}{2} MR^2, \text{ about central axis}$$

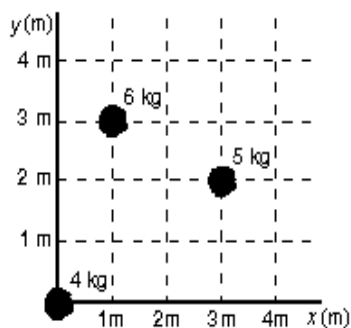
$$I_{\text{solid sphere}} = \frac{2}{5} MR^2, \text{ about center}$$

$$I_{\text{thin rod}} = \frac{1}{3} ML^2, \text{ about end}$$

$$I_{\text{hoop}} = MR^2, \text{ about central axis}$$

$$= \frac{1}{12} ML^2, \text{ about midpoint}$$

1. The  $x, y$  coordinates, in meters, of the center of mass of the three-particle system shown below are:



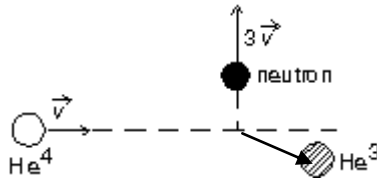
- A) 0, 0  
B) 1.3 m, 1.7 m  
C) 1.4 m, 1.9 m  
D) 1.9 m, 2.5 m  
E) 1.4 m, 2.5 m
2. The center of mass of a uniform disk of radius  $R$  is located:  
A) on the rim  
B) a distance  $R/2$  from the center  
C) a distance  $R/3$  from the center  
D) a distance  $2R/3$  from the center  
E) at the center
3. The center of mass of a system of particles remains at the same place if:  
A) it is initially at rest and the external forces sum to zero  
B) it is initially at rest and the internal forces sum to zero  
C) the sum of the external forces is less than the maximum force of static friction  
D) no friction acts internally  
E) none of the above
4. A 640-N hunter gets a rope around a 3200-N polar bear. They are stationary, 20 m apart, on frictionless level ice. When the hunter pulls the polar bear to him, the polar bear will move:  
A) 1.0 m  
B) 3.3 m  
C) 10 m  
D) 12 m  
E) 17 m

5. A 1.0 kg-ball moving at 2.0 m/s perpendicular to a wall rebounds from the wall at 1.5 m/s. The change in the momentum of the ball is:
- A) zero
  - B)  $0.5 \text{ kg} \cdot \text{m/s}$  away from wall
  - C)  $0.5 \text{ kg} \cdot \text{m/s}$  toward wall
  - D)  $3.5 \text{ kg} \cdot \text{m/s}$  away from wall
  - E)  $3.5 \text{ kg} \cdot \text{m/s}$  toward wall
6. A 64-kg woman stands on frictionless level ice. She kicks a 0.10-kg stone backwards with her foot so that the stone acquires a velocity of 1.1 m/s. The velocity (in m/s) acquired by the woman is:
- A) 1.1 forward
  - B) 0.0017 backward
  - C) 0.0017 forward
  - D) 1.1 backward
  - E) none of these
7. A man is marooned at rest on level frictionless ice. In desperation, he hurls his shoe to the right at 15 m/s. If the man weighs 720 N and the shoe weighs 4.0 N, the man moves to the left at approximately:
- A) 0
  - B)  $2.1 \times 10^{-2} \text{ m/s}$
  - C)  $8.3 \times 10^{-2} \text{ m/s}$
  - D) 15 m/s
  - E)  $2.7 \times 10^{-3} \text{ m/s}$
8. A 3.00-g bullet traveling horizontally at 400 m/s hits a 3.00-kg wooden block, which is initially at rest on a smooth horizontal table. The bullet buries itself in the block without passing through. The speed of the block/bullet after the collision is:
- A) 1.33 m/s
  - B) 0.40 m/s
  - C) 12.0 m/s
  - D) 40.0 m/s
  - E) 160 m/s
9. Bullets from two revolvers are fired with the same velocity. The bullet from gun #1 is twice as heavy as the bullet from gun #2. Gun #1 weighs three times as much as gun #2. The ratio of the momentum imparted to gun #1 to that imparted to gun #2 is:
- A) 2:3
  - B) 3:2
  - C) 2:1
  - D) 3:1
  - E) 6:1

10. A 3-gram bullet is fired horizontally into a 10-kg block of wood suspended by a rope from the ceiling. The block swings in an arc, rising 3 mm above its lowest position. The velocity of the bullet was:
- A) 0.24 m/s
  - B)  $8.0 \times 10^2$  m/s
  - C) 24.0 m/s
  - D) 8.0 m/s
  - E)  $2.4 \times 10^4$  m/s
11. Blocks A and B are moving toward each other. Block A has a mass of 2.0 kg and a velocity of 50 m/s, while B has a mass of 4.0 kg and a velocity of  $-25$  m/s. They suffer a completely inelastic collision. The kinetic energy dissipated during the collision is:
- A) 0
  - B) 1250 J
  - C) 3750 J
  - D) 5000 J
  - E) 5600 J
12. Two spacemen are floating together with zero speed in a gravity-free region of space. The mass of spaceman A is 120 kg and that of spaceman B is 90 kg. Spaceman A pushes B away from him with B attaining a final speed of 0.5 m/s. The final recoil speed of Spaceman A is:
- A) zero
  - B) 0.38 m/s
  - C) 0.50 m/s
  - D) 0.67 m/s
  - E) 1.0 m/s
13. Block A, with a mass of 2.0 kg, moves along the  $x$  axis with a velocity of 5.0 m/s in the positive  $x$  direction. It suffers an elastic collision with block B, which initially has a velocity of  $-2.0$  m/s (in the negative  $x$  direction). The blocks leave the collision along the  $x$  axis. If B is much more massive than A, the velocity of A after the collision is:
- A) 0
  - B)  $-3.0$  m/s
  - C)  $-5.0$  m/s
  - D)  $-7.0$  m/s
  - E)  $-9.0$  m/s

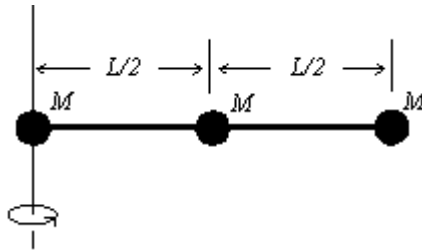
14. A 5.0-g ball is moving downward at 100 cm/s. It undergoes an elastic collision with a heavy horizontal plate, which is fixed to the Earth. The change in momentum of the ball due to this collision is:
- A)  $500 \text{ g} \cdot \text{cm/s}$ , up
  - B)  $1000 \text{ g} \cdot \text{cm/s}$ , up
  - C) zero
  - D)  $500 \text{ g} \cdot \text{cm/s}$ , down
  - E)  $1000 \text{ g} \cdot \text{cm/s}$ , down

15. A  $\text{He}^4$  nucleus (atomic weight 4) moving with speed  $v$  breaks up into a neutron (atomic weight 1) and a  $\text{He}^3$  nucleus (atomic weight 3). The neutron moves off at right angles to the original  $\text{He}^4$  as shown. If the neutron speed is  $3v$ , the final speed of the  $\text{He}^3$  nucleus is:



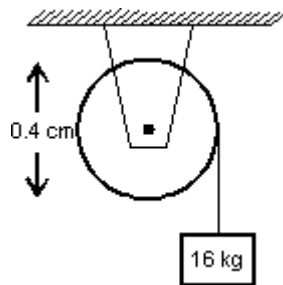
- A) zero
  - B)  $v$
  - C)  $4v/3$
  - D)  $5v/3$
  - E) none of these
16. The angular speed in rad/s of the second hand of a watch is:
- A)  $\pi/1800$
  - B)  $\pi/60$
  - C)  $\pi/30$
  - D)  $2\pi$
  - E) 60
17. A phonograph turntable, rotating at 0.75 rev/s, slows down and stops in 30 s. The magnitude of its angular acceleration in  $\text{rad/s}^2$  for this process is:
- A) 1.5
  - B)  $1.5\pi$
  - C)  $\pi/40$
  - D)  $\pi/20$
  - E) 0.75

18. A wheel initially has an angular velocity of  $18 \text{ rad/s}$  but it is slowing at a rate of  $2.0 \text{ rad/s}^2$ . By the time it stops it will have turned through:
- A) 13 rev
  - B) 26 rev
  - C) 39 rev
  - D) 52 rev
  - E) 65 rev
19. A wheel starts from rest and has an angular acceleration of  $4.0 \text{ rad/s}^2$ . When it has made 10 rev its angular velocity is:
- A) 16 rad/s
  - B) 22 rad/s
  - C) 32 rad/s
  - D) 250 rad/s
  - E) 500 rad/s
20. Three identical objects, each of mass  $M$ , are fastened to a massless rod of length  $L$  as shown. The rotational inertia about one end of the rod of this array is:



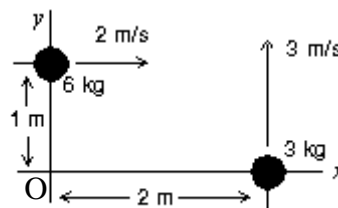
- A)  $ML^2/2$
  - B)  $ML^2$
  - C)  $3ML^2/2$
  - D)  $5ML^2/4$
  - E)  $3ML^2$
21. The rotational inertia of a solid uniform sphere about a diameter is  $(2/5)MR^2$ , where  $M$  is its mass and  $R$  is its radius. If the sphere is pivoted about an axis that is tangent to its surface, its rotational inertia is:
- A)  $MR^2$
  - B)  $(2/5)MR^2$
  - C)  $(3/5)MR^2$
  - D)  $(5/2)MR^2$
  - E)  $(7/5)MR^2$

22. A solid uniform sphere of radius  $R$  and mass  $M$  has a rotational inertia about a diameter that is given by  $(2/5)MR^2$ . A light string of length  $2R$  is attached to the surface and used to suspend the sphere from the ceiling. Its rotational inertia about the point of attachment at the ceiling is:
- A)  $(2/5)MR^2$   
 B)  $4MR^2$   
 C)  $(7/5)MR^2$   
 D)  $(22/5)MR^2$   
 E)  $(47/5)MR^2$
23. A thin circular hoop of mass  $1.0 \text{ kg}$  and radius  $2.0 \text{ m}$  is rotating about an axis through its center and perpendicular to its plane. It is slowing down at the rate of  $7.0 \text{ rad/s}^2$ . The net torque acting on it is:
- A)  $7.0 \text{ N} \cdot \text{m}$   
 B)  $14.0 \text{ N} \cdot \text{m}$   
 C)  $28.0 \text{ N} \cdot \text{m}$   
 D)  $44.0 \text{ N} \cdot \text{m}$   
 E) none of these
24. A certain wheel has a rotational inertia of  $12 \text{ kg} \cdot \text{m}^2$ . As it turns through  $5.0 \text{ rev}$  its angular velocity increases from  $5.0 \text{ rad/s}$  to  $6.0 \text{ rad/s}$ . If the net torque is constant, its value is:
- A)  $0.016 \text{ N} \cdot \text{m}$   
 B)  $0.18 \text{ N} \cdot \text{m}$   
 C)  $0.57 \text{ N} \cdot \text{m}$   
 D)  $2.1 \text{ N} \cdot \text{m}$   
 E)  $3.6 \text{ N} \cdot \text{m}$
25. A  $16 \text{ kg}$  block is attached to a cord that is wrapped around the rim of a flywheel of diameter  $0.40 \text{ m}$  and hangs vertically, as shown. The rotational inertia of the flywheel is  $0.50 \text{ kg} \cdot \text{m}^2$ . When the block is released and the cord unwinds, the acceleration of the block is:



- A)  $0.15 \text{ g}$   
 B)  $0.56 \text{ g}$   
 C)  $0.84 \text{ g}$   
 D)  $g$   
 E)  $1.3 \text{ g}$

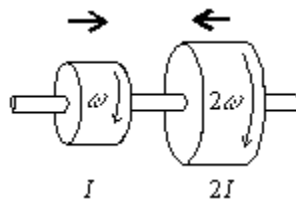
26. A hoop, a uniform disk, and a uniform sphere, all with the same mass and outer radius, start with the same speed and roll without slipping up identical inclines. Rank the objects according to how high they go, least to greatest.
- hoop, disk, sphere
  - disk, hoop, sphere
  - sphere, hoop, disk
  - sphere, disk, hoop
  - hoop, sphere, disk
27. A sphere rolls without slipping along level ground at 5 m/s. Its mass is 0.20 kg and its radius is 0.25 cm. The sphere encounters an incline. How high up the incline does the center of mass of the sphere rise?
- 0.36 m
  - 0.50 m
  - 1.3 m
  - 1.8 m
  - 5 m
28. Two identical disks, with rotational inertia  $I (= 1/2 MR^2)$ , roll without slipping across a horizontal floor and then up inclines. Disk A rolls up its incline without slipping. On the other hand, disk B rolls up a frictionless incline. Otherwise the inclines are identical. Disk A reaches a height 12 cm above the floor before rolling down again. Disk B reaches a height above the floor of:
- 24 cm
  - 18 cm
  - 12 cm
  - 8 cm
  - 6 cm
29. Two objects are moving in the  $x,y$  plane as shown. The magnitude of their total angular momentum about the origin O is:



- zero
- $6 \text{ kg}\cdot\text{m}^2/\text{s}$
- $12 \text{ kg}\cdot\text{m}^2/\text{s}$
- $30 \text{ kg}\cdot\text{m}^2/\text{s}$
- $78 \text{ kg}\cdot\text{m}^2/\text{s}$



30. A 15-g paper clip is attached to the rim of a phonograph record with a radius of 30 cm, spinning at 3.5 rad/s. The magnitude of its angular momentum is:
- $1.4 \times 10^{-3} \text{ kg} \cdot \text{m}^2/\text{s}$
  - $4.7 \times 10^{-3} \text{ kg} \cdot \text{m}^2/\text{s}$
  - $1.6 \times 10^{-2} \text{ kg} \cdot \text{m}^2/\text{s}$
  - $3.2 \times 10^{-1} \text{ kg} \cdot \text{m}^2/\text{s}$
  - $1.1 \text{ kg} \cdot \text{m}^2/\text{s}$
31. A man, with his arms at his sides, is spinning on a light frictionless turntable. When he extends his arms:
- his angular velocity increases
  - his angular velocity remains the same
  - his rotational inertia decreases
  - his rotational kinetic energy increases
  - his angular momentum remains the same
32. A uniform sphere of radius  $R$  rotates about a diameter with angular momentum  $L$ . Under the action of internal forces the sphere collapses to a uniform sphere of radius  $R/2$ . Its new angular momentum is:
- $L/4$
  - $L/2$
  - $L$
  - $2L$
  - $4L$
33. Two disks are mounted on low-friction bearings on a common shaft. The first disc has rotational inertia  $I$  and is spinning with angular velocity  $\omega$ . The second disc has rotational inertia  $2I$  and is spinning in the same direction as the first disc with angular velocity  $2\omega$  as shown. The two disks are slowly forced toward each other along the shaft until they couple and have a final common angular velocity of:



- $5\omega/3$
- $\omega\sqrt{3}$
- $\omega\sqrt{7/3}$
- $\omega$
- $3\omega$

34. A playground merry-go-round has a radius of 3.0 m and a rotational inertia of  $600 \text{ kg} \cdot \text{m}^2$ . It is initially spinning at 0.80 rad/s when a 20-kg child crawls from the center to the rim. When the child reaches the rim the angular velocity of the merry-go-round is:
- A) 0.62 rad/s
  - B) 0.73 rad/s
  - C) 0.80 rad/s
  - D) 0.89 rad/s
  - E) 1.1 rad/s

**Answer Key -- Sample Exam #3, Spring '13**

- 1. C
- 2. E
- 3. A
- 4. B
- 5. D
- 6. C
- 7. C
- 8. B
- 9. C
- 10. B
- 11. C
- 12. B
- 13. E
- 14. B
- 15. D
- 16. C
- 17. D
- 18. A
- 19. B
- 20. D
- 21. E
- 22. E
- 23. C
- 24. D
- 25. B
- 26. D
- 27. D
- 28. D
- 29. B
- 30. B
- 31. E
- 32. C
- 33. A
- 34. A