

Instructor(s): *Field/Rinzler*PHYSICS DEPARTMENT  
Exam 2

April 4, 2012

Name (print, last first): \_\_\_\_\_

Signature: \_\_\_\_\_

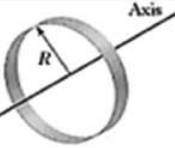
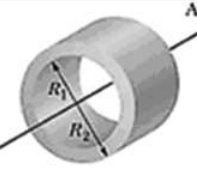
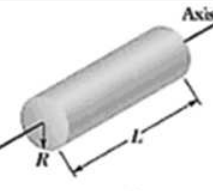
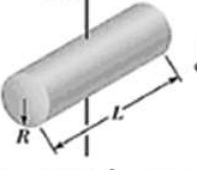

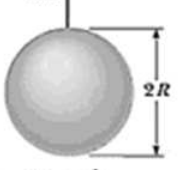
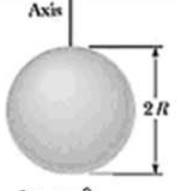


*On my honor, I have neither given nor received unauthorized aid on this examination.***YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.**

- (1) Code your test number on your answer sheet (use lines 76–80 on the answer sheet for the 5-digit number). Code your name on your answer sheet. **DARKEN CIRCLES COMPLETELY.** Code your UFID number on your answer sheet.
- (2) Print your name on this sheet and sign it also.
- (3) Do all scratch work anywhere on this exam that you like. **Circle your answers on the test form.** At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout.
- (4) **Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink.** Do not make any stray marks or some answers may be counted as incorrect.
- (5) **The answers are rounded off. Choose the closest to exact.** There is no penalty for guessing. **If you believe that no listed answer is correct, leave the form blank.**
- (6) Hand in the answer sheet separately.

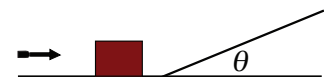
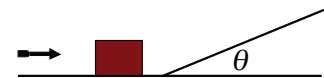
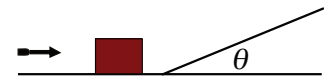
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 Use  $g = 9.80 \text{ m/s}^2$ 

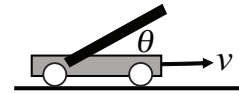

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 <p>Axis Hoop about central axis</p> <p><math>I = MR^2</math> (a)</p>	 <p>Axis Annular cylinder (or ring) about central axis</p> <p><math>I = \frac{1}{2}M(R_1^2 + R_2^2)</math> (b)</p>	 <p>Axis Solid cylinder (or disk) about central axis</p> <p><math>I = \frac{1}{2}MR^2</math> (c)</p>
 <p>Axis Solid cylinder (or disk) about central diameter</p> <p><math>I = \frac{1}{4}MR^2 + \frac{1}{12}ML^2</math> (d)</p>	 <p>Axis Thin rod about axis through center perpendicular to length</p> <p><math>I = \frac{1}{12}ML^2</math> (e)</p>	 <p>Axis Solid sphere about any diameter</p> <p><math>I = \frac{2}{5}MR^2</math> (f)</p>
 <p>Axis Thin spherical shell about any diameter</p> <p><math>I = \frac{2}{3}MR^2</math> (g)</p>	 <p>Axis Hoop about any diameter</p> <p><math>I = \frac{1}{2}MR^2</math> (h)</p>	 <p>Axis Slab about perpendicular axis through center</p> <p><math>I = \frac{1}{12}M(a^2 + b^2)</math> (i)</p>

1. What is the mass (in kg) of a particle with a momentum of 4 kg·m/s and kinetic energy equal to 5 J?  
 (1) 1.6                      (2) 3.6                      (3) 6.4                      (4) 0.8                      (5) 7.2
2. What is the mass (in kg) of a particle with a momentum of 6 kg·m/s and kinetic energy equal to 5 J?  
 (1) 3.6                      (2) 1.6                      (3) 6.4                      (4) 0.8                      (5) 7.2
3. What is the mass (in kg) of a particle with a momentum of 8 kg·m/s and kinetic energy equal to 5 J?  
 (1) 6.4                      (2) 1.6                      (3) 3.6                      (4) 0.8                      (5) 7.2
4. A lump of clay of mass 0.30 kg is thrown straight at a brick wall with a speed of 22 m/s. The time taken from when the clay first touches the wall until it has stopped deforming is 6 ms, after which the lump sticks to the wall. What is the average force on the wall (in N) during this collision?  
 (1) 1100                      (2) 1650                      (3) 2200                      (4) 800                      (5) 700
5. A lump of clay of mass 0.45 kg is thrown straight at a brick wall with a speed of 22 m/s. The time taken from when the clay first touches the wall until it has stopped deforming is 6 ms, after which the lump sticks to the wall. What is the average force on the wall (in N) during this collision?  
 (1) 1650                      (2) 1100                      (3) 2200                      (4) 800                      (5) 700
6. A lump of clay of mass 0.60 kg is thrown straight at a brick wall with a speed of 22 m/s. The time taken from when the clay first touches the wall until it has stopped deforming is 6 ms, after which the lump sticks to the wall. What is the average force on the wall (in N) during this collision?  
 (1) 2200                      (2) 1650                      (3) 1100                      (4) 800                      (5) 700
7. A block of wood of mass 1.0 kg is initially at rest on a frictionless horizontal surface as shown in the figure. A bullet of mass 50 g traveling at 100 m/s strikes the block and becomes embedded in it. The block-bullet system slides along the surface and up a frictionless incline. What is the maximum height above the surface (in m) the block-bullet system reaches before sliding back down the incline?  
 (1) 1.16                      (2) 2.60                      (3) 4.63                      (4) 0.76                      (5) 5.32
8. A block of wood of mass 1.0 kg is initially at rest on a frictionless horizontal surface as shown in the figure. A bullet of mass 50 g traveling at 150 m/s strikes the block and becomes embedded in it. The block-bullet system slides along the surface and up a frictionless incline. What is the maximum height above the surface (in m) the block-bullet system reaches before sliding back down the incline?  
 (1) 2.60                      (2) 1.16                      (3) 4.63                      (4) 0.76                      (5) 5.32
9. A block of wood of mass 1.0 kg is initially at rest on a frictionless horizontal surface as shown in the figure. A bullet of mass 50 g traveling at 200 m/s strikes the block and becomes embedded in it. The block-bullet system slides along the surface and up a frictionless incline. What is the maximum height above the surface (in m) the block-bullet system reaches before sliding back down the incline?  
 (1) 4.63                      (2) 1.16                      (3) 2.60                      (4) 0.76                      (5) 5.32

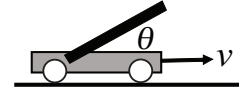


10. A cannon on a railroad car is facing in a direction parallel to the tracks as shown in the figure. The cannon can fire a 100-kg cannonball at a muzzle speed of 150 m/s at an angle of  $\theta$  above the horizontal as shown in the figure. The cannon plus railway car have a mass of 5,000 kg. If the cannon and one cannon ball are travelling to the right on the railway car a speed of  $v = 2$  m/s, at what angle  $\theta$  must the cannon be fired in order to bring the railway car to rest? Assume that the track is horizontal and there is no friction.



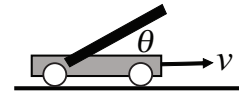
- (1)  $48.2^\circ$                       (2)  $60.0^\circ$                       (3)  $36.9^\circ$                       (4)  $45.0^\circ$                       (5)  $28.5^\circ$

11. A cannon on a railroad car is facing in a direction parallel to the tracks as shown in the figure. The cannon can fire a 100-kg cannonball at a muzzle speed of 200 m/s at an angle of  $\theta$  above the horizontal as shown in the figure. The cannon plus railway car have a mass of 5,000 kg. If the cannon and one cannon ball are travelling to the right on the railway car a speed of  $v = 2$  m/s, at what angle  $\theta$  must the cannon be fired in order to bring the railway car to rest? Assume that the track is horizontal and there is no friction.



- (1)  $60.0^\circ$                       (2)  $48.2^\circ$                       (3)  $36.9^\circ$                       (4)  $45.0^\circ$                       (5)  $28.5^\circ$

12. A cannon on a railroad car is facing in a direction parallel to the tracks as shown in the figure. The cannon can fire a 100-kg cannonball at a muzzle speed of 125 m/s at an angle of  $\theta$  above the horizontal as shown in the figure. The cannon plus railway car have a mass of 5,000 kg. If the cannon and one cannon ball are travelling to the right on the railway car a speed of  $v = 2$  m/s, at what angle  $\theta$  must the cannon be fired in order to bring the railway car to rest? Assume that the track is horizontal and there is no friction.



- (1)  $36.9^\circ$                       (2)  $48.2^\circ$                       (3)  $60.0^\circ$                       (4)  $45.0^\circ$                       (5)  $28.5^\circ$

13. A point particle with mass  $2M$  is traveling to the right along the x-axis at speed  $V$  and another point particle with mass  $M$  is traveling the left along the x-axis at the same speed  $V$ . If  $V = 12$  m/s, what is the speed (in m/s) of the center-of-mass of the two-particle system? (Remember that the total momentum of the system can be written as  $\vec{P}_{tot} = M_{tot}\vec{V}_{COM}$ , where  $M_{tot}$  is the total mass of the system.)

- (1) 4                                  (2) 5                                  (3) 6                                  (4) 3                                  (5) 10

14. A point particle with mass  $2M$  is traveling to the right along the x-axis at speed  $V$  and another point particle with mass  $M$  is traveling the left along the x-axis at the same speed  $V$ . If  $V = 15$  m/s, what is the speed (in m/s) of the center-of-mass of the two-particle system? (Remember that the total momentum of the system can be written as  $\vec{P}_{tot} = M_{tot}\vec{V}_{COM}$ , where  $M_{tot}$  is the total mass of the system.)

- (1) 5                                  (2) 4                                  (3) 6                                  (4) 3                                  (5) 10

15. A point particle with mass  $2M$  is traveling to the right along the x-axis at speed  $V$  and another point particle with mass  $M$  is traveling the left along the x-axis at the same speed  $V$ . If  $V = 18$  m/s, what is the speed (in m/s) of the center-of-mass of the two-particle system? (Remember that the total momentum of the system can be written as  $\vec{P}_{tot} = M_{tot}\vec{V}_{COM}$ , where  $M_{tot}$  is the total mass of the system.)

- (1) 6                                  (2) 4                                  (3) 5                                  (4) 3                                  (5) 10

16. Hercules (mass 130 kg) and his wife Deianeira (mass 60 kg) stand on (frictionless) ice separated by 12 meters, with a light rope stretched between them. They both pull on the rope. At what distance (in m) from Hercules' original position do they meet?

- (1) 3.8                                  (2) 4.7                                  (3) 6.3                                  (4) 2.5                                  (5) 0

17. Hercules (mass 130 kg) and his wife Deianeira (mass 60 kg) stand on (frictionless) ice separated by 15 meters, with a light rope stretched between them. They both pull on the rope. At what distance (in m) from Hercules' original position do they meet?
- (1) 4.7                      (2) 3.8                      (3) 6.3                      (4) 2.5                      (5) 0
18. Hercules (mass 130 kg) and his wife Deianeira (mass 60 kg) stand on (frictionless) ice separated by 20 meters, with a light rope stretched between them. They both pull on the rope. At what distance (in m) from Hercules' original position do they meet?
- (1) 6.3                      (2) 3.8                      (3) 4.7                      (4) 2.5                      (5) 0
19. A 1000 kg piece of space debris has velocity  $(10m/s)\hat{y}$  when it collides with a second piece of space debris of mass 2500 kg and moving with velocity  $(5m/s)\hat{x}$ , where  $\hat{x}$  and  $\hat{y}$  are unit vectors in the x and y-direction, respectively. If after the collision the two pieces are locked together, what is their speed (in m/s)?
- (1) 4.6                      (2) 6.7                      (3) 9.3                      (4) 2.5                      (5) 10.2
20. A 1000 kg piece of space debris has velocity  $(20m/s)\hat{y}$  when it collides with a second piece of space debris of mass 2500 kg and moving with velocity  $(5m/s)\hat{x}$ , where  $\hat{x}$  and  $\hat{y}$  are unit vectors in the x and y-direction, respectively. If after the collision the two pieces are locked together, what is their speed (in m/s)?
- (1) 6.7                      (2) 4.6                      (3) 9.3                      (4) 2.5                      (5) 10.2
21. A 1000 kg piece of space debris has velocity  $(30m/s)\hat{y}$  when it collides with a second piece of space debris of mass 2500 kg and moving with velocity  $(5m/s)\hat{x}$ , where  $\hat{x}$  and  $\hat{y}$  are unit vectors in the x and y-direction, respectively. If after the collision the two pieces are locked together, what is their speed (in m/s)?
- (1) 9.3                      (2) 4.6                      (3) 6.7                      (4) 2.5                      (5) 10.2
22. At time  $t = 0$  a 2 kg particle is located at  $\vec{r} = (2m)\hat{x} + (4m)\hat{y}$ , and its velocity is  $\vec{v} = -(6m/s)\hat{y}$ , and it is subject to the force  $\vec{F} = (8N)\hat{x}$ , where  $\hat{x}$  and  $\hat{y}$  are unit vectors in the x and y-direction, respectively. What is the magnitude of the angular momentum of the particle about the origin at  $t = 0$ ?
- (1) 24 kg·m<sup>2</sup>/s              (2) 32 kg·m<sup>2</sup>/s              (3) 36 kg·m<sup>2</sup>/s              (4) 12 kg·m<sup>2</sup>/s              (5) 16 kg·m<sup>2</sup>/s
23. At time  $t = 0$  a 2 kg particle is located at  $\vec{r} = (2m)\hat{x} + (4m)\hat{y}$ , and its velocity is  $\vec{v} = -(8m/s)\hat{y}$ , and it is subject to the force  $\vec{F} = (8N)\hat{x}$ , where  $\hat{x}$  and  $\hat{y}$  are unit vectors in the x and y-direction, respectively. What is the magnitude of the angular momentum of the particle about the origin at  $t = 0$ ?
- (1) 32 kg·m<sup>2</sup>/s              (2) 24 kg·m<sup>2</sup>/s              (3) 36 kg·m<sup>2</sup>/s              (4) 12 kg·m<sup>2</sup>/s              (5) 16 kg·m<sup>2</sup>/s
24. At time  $t = 0$  a 2 kg particle is located at  $\vec{r} = (2m)\hat{x} + (4m)\hat{y}$ , and its velocity is  $\vec{v} = -(9m/s)\hat{y}$ , and it is subject to the force  $\vec{F} = (8N)\hat{x}$ , where  $\hat{x}$  and  $\hat{y}$  are unit vectors in the x and y-direction, respectively. What is the magnitude of the angular momentum of the particle about the origin at  $t = 0$ ?
- (1) 36 kg·m<sup>2</sup>/s              (2) 24 kg·m<sup>2</sup>/s              (3) 32 kg·m<sup>2</sup>/s              (4) 12 kg·m<sup>2</sup>/s              (5) 16 kg·m<sup>2</sup>/s



32. A turntable must spin at 33.3 rpm to play an old-fashioned vinyl record. The turntable is a uniform disk of radius 15 cm and mass 0.16 kg. How much constant torque (in N·m) must the motor deliver if the turntable is to reach its final angular speed in 2.5 revolutions, starting from rest?

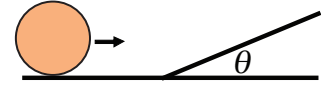
- (1)  $6.97 \times 10^{-4}$       (2)  $1.16 \times 10^{-3}$       (3)  $8.71 \times 10^{-4}$       (4)  $2.37 \times 10^{-3}$       (5)  $4.65 \times 10^{-4}$

33. In the previous problem, how much work (in mJ) must the motor do if the turntable is to reach its final angular speed in 2.5 revolutions, starting from rest?

- (1) 10.9      (2) 8.5      (3) 5.4      (4) 21.8      (5) 2.9

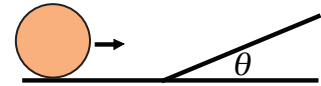
34. A solid sphere of mass  $M$  and moment of inertia  $2MR^2/5$  rolls without slipping along a horizontal surface with a translational speed of 5 m/s as shown in the figure. It comes to an incline that makes an angle of  $20^\circ$  with the horizontal surface. Ignoring energy losses due to friction, how far does the sphere travel along the incline (in m) before coming to rest and rolling back down?

- (1) 5.22      (2) 3.57      (3) 2.78      (4) 6.42      (5) 1.80



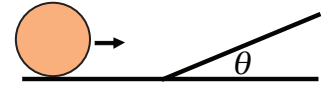
35. A solid sphere of mass  $M$  and moment of inertia  $2MR^2/5$  rolls without slipping along a horizontal surface with a translational speed of 5 m/s as shown in the figure. It comes to an incline that makes an angle of  $30^\circ$  with the horizontal surface. Ignoring energy losses due to friction, how far does the sphere travel along the incline (in m) before coming to rest and rolling back down?

- (1) 3.57      (2) 5.22      (3) 2.78      (4) 6.42      (5) 1.80



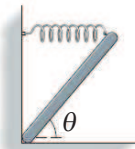
36. A solid sphere of mass  $M$  and moment of inertia  $2MR^2/5$  rolls without slipping along a horizontal surface with a translational speed of 5 m/s as shown in the figure. It comes to an incline that makes an angle of  $40^\circ$  with the horizontal surface. Ignoring energy losses due to friction, how far does the sphere travel along the incline (in m) before coming to rest and rolling back down?

- (1) 2.78      (2) 5.22      (3) 3.57      (4) 6.42      (5) 1.80



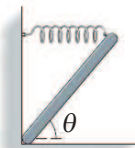
37. A modern sculpture has a large horizontal spring, that is attached to a 60-kg piece of uniform metal at its end and holds the metal at rest at an angle of  $\theta = 40^\circ$  above the horizontal direction as shown in the figure. The other end of the metal is wedged into a corner and is free to rotate. If the spring is stretched 0.2 m, what is the spring constant  $k$  (in N/m)?

- (1) 1752      (2) 1233      (3) 849      (4) 1470      (5) 785



38. A modern sculpture has a large horizontal spring, that is attached to a 60-kg piece of uniform metal at its end and holds the metal at rest at an angle of  $\theta = 50^\circ$  above the horizontal direction as shown in the figure. The other end of the metal is wedged into a corner and is free to rotate. If the spring is stretched 0.2 m, what is the spring constant  $k$  (in N/m)?

- (1) 1233      (2) 1752      (3) 849      (4) 1470      (5) 785









56. A 2,000 kg wrecking ball is to be lifted by a crane with a steel cable that has a diameter of 1.0 cm and an unstretched length of 30 m. The Young's modulus of steel is  $2.0 \times 10^{11}$  Pa. Ignoring the weight of the cable itself, when the ball is lifted and held at rest, how much does the cable stretch (in cm)?
- (1) 3.74                      (2) 0.94                      (3) 1.66                      (4) 0.24                      (5) 4.25
57. A 2,000 kg wrecking ball is to be lifted by a crane with a steel cable that has a diameter of 1.5 cm and an unstretched length of 30 m. The Young's modulus of steel is  $2.0 \times 10^{11}$  Pa. Ignoring the weight of the cable itself, when the ball is lifted and held at rest, how much does the cable stretch (in cm)?
- (1) 1.66                      (2) 3.74                      (3) 0.94                      (4) 0.24                      (5) 4.25
58. A simple harmonic oscillator consists of a block of mass 2 kg attached to an ideal spring with spring constant  $k$ . If the speed of the block is 40 m/s when the displacement from equilibrium is 3 m and the amplitude of the oscillations is 5 m, what is the spring constant  $k$  (in N/m)?
- (1) 200                      (2) 50                      (3) 450                      (4) 800                      (5) 600
59. A simple harmonic oscillator consists of a block of mass 2 kg attached to an ideal spring with spring constant  $k$ . If the speed of the block is 20 m/s when the displacement from equilibrium is 3 m and the amplitude of the oscillations is 5 m, what is the spring constant  $k$  (in N/m)?
- (1) 50                      (2) 200                      (3) 450                      (4) 800                      (5) 600
60. A simple harmonic oscillator consists of a block of mass 2 kg attached to an ideal spring with spring constant  $k$ . If the speed of the block is 60 m/s when the displacement from equilibrium is 3 m and the amplitude of the oscillations is 5 m, what is the spring constant  $k$  (in N/m)?
- (1) 450                      (2) 200                      (3) 50                      (4) 800                      (5) 600

THE FOLLOWING QUESTIONS, NUMBERED IN THE ORDER OF THEIR APPEARANCE ON THE ABOVE LIST, HAVE BEEN FLAGGED AS CONTINUATION QUESTIONS: 29 31 33 FOLLOWING GROUPS OF QUESTIONS WILL BE SELECTED AS ONE GROUP FROM EACH TYPE

TYPE 1

Q# S 1

Q# S 2

Q# S 3

TYPE 2

Q# S 4

Q# S 5

Q# S 6

TYPE 3

Q# S 7

Q# S 8

Q# S 9

TYPE 4

Q# S 10

Q# S 11

Q# S 12

TYPE 5

Q# S 13

Q# S 14

Q# S 15

TYPE 6

Q# S 16

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TYPE 7

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Q# S 58  
Q# S 59  
Q# S 60