EXAM/TEST FORM 01

PHYSICS 22000 – F16 Second Midterm Exam

PRINT NAME: _____

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Instructions

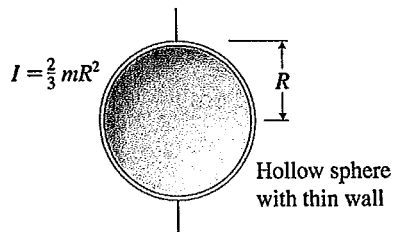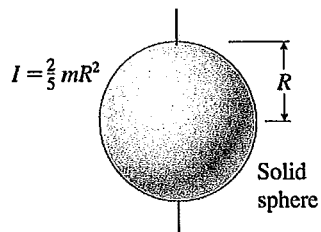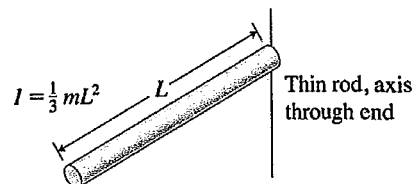1. Fill in your name and student number on the bubble sheet provided.
2. Fill in the bubbles that indicate whether you have exam/test form 01 or 02.
3. Clearly print your name and Purdue student number on this page.
4. Sign this page using your most elegant cursive hand writing.
5. Answer all 25 questions
6. Please hand in your bubble sheet and your exam when you are done.

Formulæ

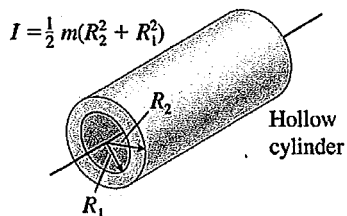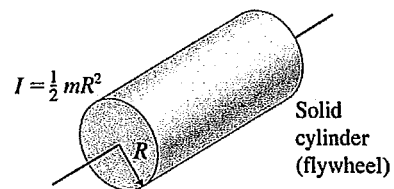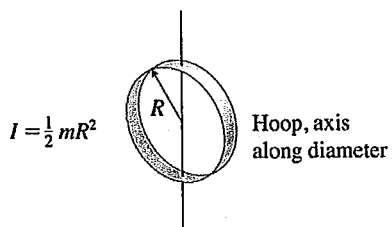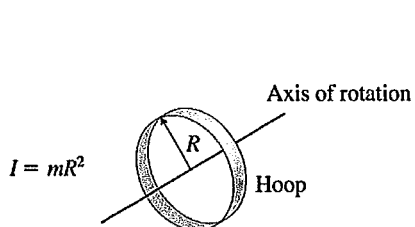$$\pi = 3.14159 \quad G = 6.673 \times 10^{-11} \text{ m}^3/(\text{kg} \cdot \text{s}^2) \quad 1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$$

$$g = 9.81 \text{ m/s}^2 = 32 \text{ ft/s}^2 \quad 1 \text{ lb} = 4.448 \text{ N} \quad 1 \text{ mile} = 1.609 \text{ km}$$

$$F_g = G \frac{m_1 m_2}{r^2} \quad F_{\text{friction}} = \mu N \quad \vec{p} = m \vec{v} \quad \vec{J} = \vec{F} \Delta t = \Delta \vec{p}$$

$$x = x_0 + \frac{1}{2}(v_0 + v_f)t \quad v = v_0 + at \quad a_c = \frac{v^2}{r} \quad T^2 \propto r^3$$

$$x = x_0 + v_0 t + \frac{1}{2} a t^2 \quad v_f^2 = v_0^2 + 2a(x - x_0)$$

$$\vec{F} = m\vec{a} \quad K = \frac{1}{2}mv^2 \quad U_g = mgy \quad U_s = \frac{1}{2}kx^2$$

$$N_A = 6.02 \times 10^{23} \quad k = 1.38 \times 10^{-23} \text{ J/K}$$

$$R = N_A k = 8.31 \text{ J/mol/K} \quad P_{atm} = 1.013 \times 10^5 \text{ Pa}$$

$$\overline{K} = \frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$$

$$\omega = \omega_0 + \alpha t \quad \theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \quad \omega_f^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

$$\tau = FL \sin \theta \quad \theta = s/r \quad \omega = \Delta\theta/\Delta t$$

$$PV = nkT = nN_A kT = nRT \quad T_C = T_K - 273°$$

2

Rotational Inertia

$I = mR^2$ Hoop — Axis of rotation, R

$I = \frac{1}{2} mR^2$ Hoop, axis along diameter, R

$I = \frac{1}{2} mR^2$ Solid cylinder (flywheel), R

$I = \frac{1}{2} m(R_2^2 + R_1^2)$ Hollow cylinder, R_2, R_1

$I = \frac{1}{12}mL^2$ Thin rod, axis through center, L

$I = \frac{1}{3} mL^2$ Thin rod, axis through end, L

$I = \frac{2}{5} mR^2$ Solid sphere, R

$I = \frac{2}{3} mR^2$ Hollow sphere with thin wall, R

3
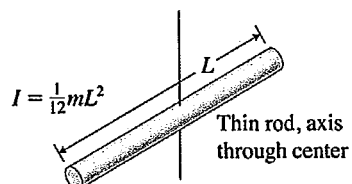
1. Which statement is true regarding inelastic collisions?
    (a) Momentum is not conserved
    (b) Energy is not conserved
    (c) Kinetic energy is not conserved
    (d) The objects always stick together
    (e) None of the above

2. A marble rolls down a ramp from an initial height of 20 cm and collides
    elastically with an identical marble that was initially stationary at the
    bottom. What is the maximum height reached by the first marble as it rolls
    back up the ramp after the collision?
    (a) 0 cm   (b) 10 cm   (c) 20 cm   (d) 30 cm
                        (e) not enough information

3. A marble with a mass of 10 grams rolls down a ramp and has a velocity of 3
    m/s at the bottom where it collides with a stationary block of putty which
    rests on a frictionless surface. If the putty has a mass of 20 grams, what is
    the final speed of the marble-putty system?
    (a) 0 m/s   (b) 1 m/s   (c) 2 m/s   (d) 3 m/s   (e) -3 m/s

4. An object that moves with constant rotational velocity undergoes
    acceleration because
    (a) Its speed is increasing
    (b) The direction of its velocity is changing
    (c) Its angular momentum is constant
    (d) It has a large rotational inertia
    (e) All of the above

5. What is the earth's rotational velocity in rad/s?
   (a) 7.3×10^{-5} rad/s
   (b) 7.3×10^{5} rad/s
   (c) 0.0017 rad/s
   (d) 0.26 rad/s
   (e) None of the above

6. An object of mass m=1 kg is tied to the end of a string and swung in a circle of radius r=2 m with an angular velocity of ω=2 rad/s. What is the tension in the string?
   (a) T=1 N
   (b) T=4 N
   (c) T=8 N
   (d) T=2 N
   (e) None of the above

7. A mass m=1 kg hangs from a string that is wrapped around a uniform cylinder with radius r=10 cm which itself has a mass of 1 kg. When the mass is released it falls and causes the cylinder to freely rotate as the string unwinds. What is the downward acceleration of the mass?
   (a) g
   (b) g/2
   (c) g/3
   (d) 2g/3
   (e) 2g

8. A globe can be treated as a hollow spherical shell with mass m=1 kg and radius r=20 cm. If the globe is initially at rest but is struck on the equator by a small blob of putty with mass m=10 g, moving with velocity v=5 m/s, what will its final rotational velocity be? Assume the putty is moving "east" and that it sticks to the globe on impact.

    (a) 1.85 rad/s
    (b) 0.27 rad/s
    (c) 0.17 rad/s
    (d) 0.37 rad/s
    (e) -0.17 rad/s

9. The radius of the wheels on a car is r=0.3 m and they rotate without slipping with an angular speed of 120 rpm. What is the linear speed of the car with respect to the fixed road?

    (a) 13.6 m/s
    (b) 3.77 m/s
    (c) 36 m/s
    (d) 2.82 m/s
    (e) None of the above

10. An Annual Cicada (if you don't know already, it's a large bug that is native to Indiana) has a mass of 50 grams and walks from the center to the outer radius, r=30 cm, of a freely spinning disk which has rotational inertia I_0=0.01 kg·m^2. If the disk was initially rotating with rotational velocity ω=5 rad/s and no external torques act on the disk, what will its final rotational velocity be when the bug reaches the outer radius?

    (a) 2.45 rad/s
    (b) 3.45 rad/s
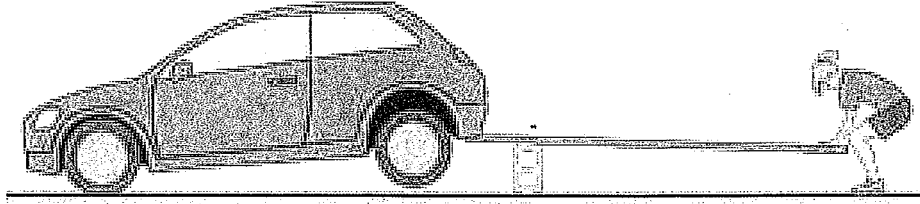   (c) 4.45 rad/s
    (d) 5.00 rad/s
    (e) None of the above
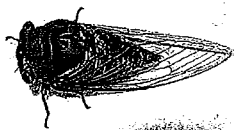
Annual Cicada   Cow (not to scale)

11. Without a car jack, Sarah Fisher is forced to use a long, thin rod to lift her Honda Civic so that she can change a tire:

The total length of the lever is 2 meters and the fulcrum is located 0.2 meters from one end. With how much force must she push down on the handle of the lever so that it exerts a 9000 N force to lift the back of the car?

(a) 800 N
(b) 900 N
(c) 1000 N
(d) 1800 N
(e) None of the above

12. How many oxygen atoms are there in one mole of O_2 molecules? (If you've forgotten your chemistry, let me remind you that there are two oxygen atoms in one molecule of O_2.)

(a) 6.02×10^{23}
(b) 3.01×10^{23}
(c) 9.03×10^{23}
(d) 12.04×10^{23}
(e) None of the above

13. A vertical tube, closed at the top end, is lowered into water until half its volume is filled with water. What is the pressure of the air inside the tube?

    (a) 101 kPa

    (b) 151 kPa

    (c) 202 kPa

    (d) 68 kPa

    (e) None of the above

14. Temperature is related to which of the following properties of the particles out of which a gas is composed?

    (a) Their average velocity

    (b) The average of their squared velocity

    (c) The average of their velocity, squared

    (d) Their average density

    (e) All of the above

15. What is the resulting pressure (in atmospheres) when one mole of liquid H_2O, which occupies 18 cm^3, is vaporized at 100 °C in a closed container?

    (a) 1705 Atm

    (b) 1248 Atm

    (c) 1.72×10^8 Atm

    (d) 22.4 Atm

    (e) None of the above

16. The temperature of a volume of gas is raised from 273 K to 373 K. By how much does the average kinetic energy of gas particles increase?

    (a) 1.52×10^{-21} J

    (b) 1.54×10^{-20} J

    (c) 1.13×10^{-20} J

    (d) 4.14×10^{-21} J

    (e) None of the above

17. When a rigid object rotates about a fixed axis, what is true about all the points on the object?

    (a) The points closer to the axis have a smaller rotational velocity

    (b) All points have the same rotational velocity

    (c) All points have zero radial acceleration

    (d) They all have zero rotational acceleration

    (e) Both (b) and (c)

18. A uniform spherical ball is released from rest on a non-slippery surface as shown in the figure below. After reaching its lowest point, the ball begins to rise again, this time on a frictionless surface. When the ball reaches its maximum height on the frictionless surface, it is

No-slip   Frictionless
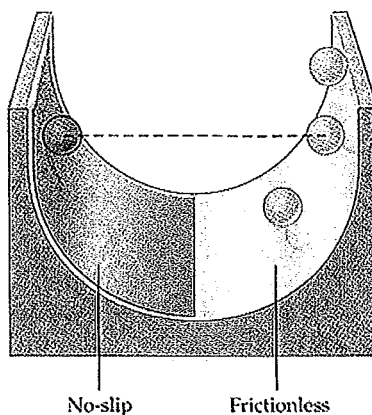
    (a) At the same height from which it was released

    (b) Lower than when it was released

    (c) Higher than it was when it was released

    (d) It is impossible to tell without knowing the mass of the ball

    (e) It is impossible to tell without knowing the rotational inertia of the ball

19. When is the rotational momentum of a system constant?

    (a) Only when the linear momentum and energy are constant

    (b) Only when its total kinetic energy is constant

    (c) Only when no net external torque is exerted on the system

    (d) Only when the rotational inertia is constant

    (e) Only when the rotational inertia is zero

20. Which two temperature changes are equivalent?

   (a) 1 °C = 1 K
   (b) 1 °F = 1 K
   (c) 1 °F = 1 °C
   (d) 5 °F = 9 °C
   (e) None of the above

21. Suppose your mass is 70 kg and your density is 970 kg/m^3. Given that the density of air is 1.29 kg/m^3, what is the buoyant force that the atmosphere exerts on you?

   (a) 0.5 N
   (b) 1.0 N
   (c) 1.5 N
   (d) 2.0 N
   (e) None of the above.

22. A circular disk that was initially at rest experiences a uniform rotational acceleration through 2 complete revolutions in 10 seconds. If the rotational velocity at the end of 10 seconds is 2.5 rad/s, what was the uniform rotational acceleration?

   (a) 0.1 rad/s^2
   (b) 2.5 rad/s^2
   (c) 0.8 rad/s^2
   (d) 0.1 rad/s
   (e) 0.25 rad/s^2

23. Two children, Nikolai and Ivan, ride on a merry-go-round. Ivan is at a greater distance from the axis of rotation than Nikolai.

   (a) Ivan has a greater tangential speed than Nikolai
   (b) Ivan and Nikolai have the same tangential speed
   (c) Nikolai and Ivan have zero rotational velocity
   (d) Ivan has a greater angular speed than Nikolai
   (e) Ivan has a smaller angular speed than Nikolai

24. Consider a uniform hoop of radius R and mass M rolling without slipping. Which is larger, its translational kinetic energy or its rotational kinetic energy?

     (a) Translational kinetic energy is larger
     (b) Rotational kinetic energy is larger
     (c) Both are equal
     (d) You need to know the speed of the hoop to tell
     (e) You need to know the potential energy of the hoop to tell

25. The air pressure in the tires of an 860 kg car is 3.2×10^5 N/m^2. Determine the average area of contact of each tire with the road.

     (a) 0.026 m^2
     (b) 0.066 m^2
     (c) 0.0027 m^2
     (d) 0.00067 m^2
     (e) None of the above