PHY2053

PHYSICS
EXAM 2

Name (print, last first): _____ Signature: _____

*On my honor, I have neither given nor received unauthorized aid on this examination.*

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Given Information:

$g = 9.8$ m/s$^2$ 1 m = 100 cm 1 kg = 1000 g

$G = 6.67 \times 10^{-11}$ Nm$^2$/kg$^2$

1 inch $= 2.54 \times 10^{-2}$ m 1 foot = 12 inches

1 day = 24 hours 1 hour = 60 minutes 1 minute = 60 seconds

$A = \pi r^2$ $C = 2\pi r$ 1 rev $= 2\pi$ radians $\pi$ radians $= 180°$

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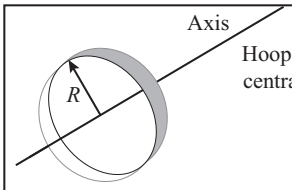
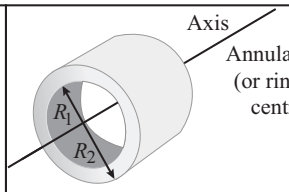
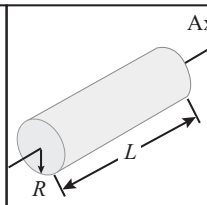
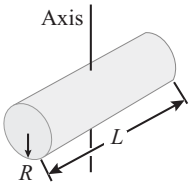
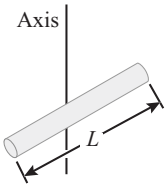
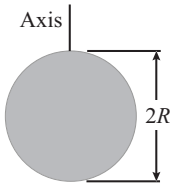
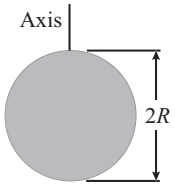
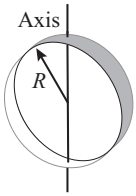
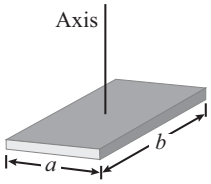
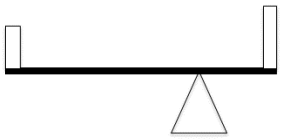
|---|---|---|
|  Hoop about central axis<br>$I = MR^2$ |  Annular cylinder (or ring) about central axis<br>$I = \frac{1}{2} M(R_1^2 + R_2^2)$ |  Solid cylinder (or disk) about central axis<br>$I = \frac{1}{2} MR^2$ |
|  Solid cylinder (or disk) about central diameter<br>$I = \frac{1}{4} MR^2 + \frac{1}{12} ML^2$ |  Thin rod about axis through center perpendicular to length<br>$I = \frac{1}{12} ML^2$ |  Solid sphere about any diameter<br>$I = \frac{2}{5} MR^2$ |
|  Thin spherical shell about any diameter<br>$I = \frac{2}{3} MR^2$ |  Hoop about any diameter<br>$I = \frac{1}{2} MR^2$ |  Slab about perpendicular axis through center<br>$I = \frac{1}{12} M(a^2 + b^2)$ |

1. A ball dropped from height $h$ hts the ground with velocity $v$. A what height is the velocity $v/3$?

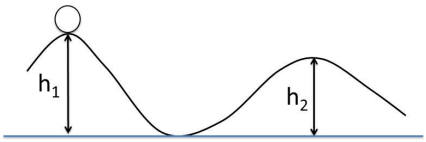
(1) $8h/9$ (2) $2h/3$ (3) $h/3$ (4) $5h/6$ (5) None of these.

2. An adult and a child are on a see-saw. The child (mass $m$) is sitting on the far left end of the plank. The adult (mass $5m$) is seated at the far right end. The plank of the see-saw has length $l$ and mass $m_{pl}$. Where should the fulcrum, or support, of the see-saw be placed, such that the adult and child are perfectly balanced? Assume x = 0 is the center of the plank.



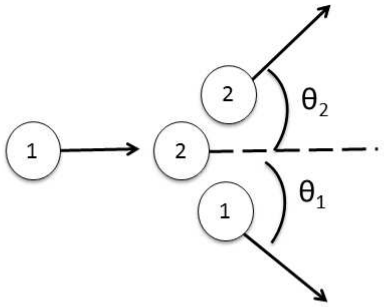
(1) $\frac{4lm}{2[6m+m_{pl}]}$ (2) $\frac{6lm}{2[6m+m_{pl}]}$ (3) $\frac{6lm}{2[4m+m_{pl}]}$ (4) $\frac{5lm}{2[4m+m_{pl}]}$ (5) $\frac{l}{2}+\frac{6lm}{2[4m+m_{pl}]}$

3. A solid sphere starts from rest at the top of a hill of height $h_1$. The object rolls down the hill and to the top of the next hill. If the speed of the object at the top of the second hill is $v$, what is the height of the second hill?




(1) $h_1-\frac{7v^2}{10g}$ (2) $h_1-\frac{5v^2}{6g}$ (3) $h_1-\frac{3v^2}{4g}$ (4) $h_1+\frac{7v^2}{10g}$ (5) $h_1-\frac{2v^2}{5g}$

4. A ball of mass m kg is moving in the positive x direction. It strikes a stationary ball of mass m kg. The balls move off at angles as shown in the picture. If the final velocity of the first ball is $v_{1f}$, what was the initial velocity of ball 1?




(1) $v_{1f}*\frac{sin\theta_1}{tan\theta_2}+v_{1f}*cos\theta_1$

(2) $\frac{v_{1f}}{v_{2f}}*\frac{sin\theta_1}{tan\theta_2}-v_{1f}*cos\theta_1$

(3) $\frac{v_{1f}}{v_{2f}}*\frac{sin\theta_1}{tan\theta_2}+v_{1f}*m*cos\theta_1$

(4) $\frac{v_{1f}}{v_{2f}}*\frac{sin\theta_1}{cotan\theta_2}-v_{1f}*m*cos\theta_1$

(5) $v_{2f}*\frac{tan\theta_2}{sin\theta_1}+v_{1f}*cos\theta_1$

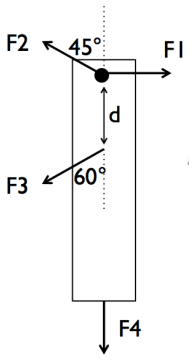
5. A car traveling at 15.6 m/s must come to a very quick stop in order to avoid an accident. To do this, it decelerates at a constant rate of 3.63 m/s$^2$ without skidding on the pavement. If the tires have a radius of 0.27 m, how many complete turns do they make as the car comes to a stop?

(1) 19 (2) 17 (3) 22 (4) 26 (5) 31

6. An intergalactic spaceship arrives at a distant planet that rotates on its axis with a period of $T$ seconds. If the planet has a mass of $M$ kg, at what distance $R$ in meters from the center of the planet must the ship position itself so that it can travel in a geosynchronous orbit about the planet?

(1) $\sqrt[3]{\frac{G\,M\,T^2}{4\,\pi^2}}$ (2) $\sqrt{\frac{G\,M\,T^2}{4\,\pi^2}}$ (3) $\frac{G\,M\,T^2}{4\,\pi^2}$ (4) $\sqrt[3]{4\,\pi^2\,G\,M\,T^2}$ (5) $\sqrt{4\,\pi^2\,G\,M\,T^2}$

7. A uniform beam of 2.30 kg and 0.900 m length rotates about an axle through one end with an angular acceleration of -14.1 rad/s$^2$. The beam is thin enough to be treated as a long thin rod. Four forces are acting on it as shown in the figure. Their magnitudes are each 5.00 N. $F_3$ acts at some distance from the point of rotation. What is this distance? Answer in meters.

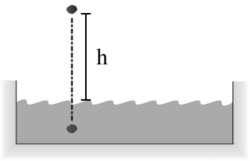



(1) 2.02
(2) 0.49
(3) −2.02
(4) 6.74
(5) 6.07

8. A tranquilizer gun fires a 125 g dart which experiences a force of 200 N over the 1.20 m length of the barrel. The muzzle velocity of the dart is (in m/s):

(1) 62.0 (2) 31.0 (3) 93.0 (4) 124 (5) 155

9. A stone of mass 1.35 kg is dropped from rest into water from a height h = 2.50 m above the water surface. As the stone drops through the water it experiences an average force of 4.80 N over the time of 1.49 s. The stone's velocity at the end of that time (in m/s) is:




(1) 1.70 (2) 7.00 (3) 5.30 (4) 4.10 (5) 2.90

10. In summer training for the winter Olympics Shaun White would catch a thrown medicine ball while moving on his skateboard. Shaun and his skateboard weigh 695 N and are traveling forward at 4.40 m/s. The 11 kg medicine ball has a speed of 3.0 m/s in a direction 33° below the horizontal, backwards when it hits Shaun in the chest as he catches it. Shaun's forward speed after the catch (in m/s) is:

(1) 3.47 (2) 3.41 (3) 3.35 (4) 3.29 (5) 3.23

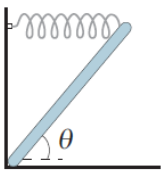
11. A car with mass of 1000 kg accelerates from 10 m/s to 40 m/s in 10 s. Ignore air resistance. The engine has 22% efficiency, which means that 22% of the energy released by the burning gasoline is converted into mechanical energy. What is the average mechanical power output of the engine?

(1) $7.5 \times 10^4$ W (2) $7.5 \times 10^5$ W (3) $8.0 \times 10^4$ W (4) $1.65 \times 10^4$ W (5) None of these.

12. A cylindrical cable has a weight suspended from it. The cable has an unstretched length of 4.5 m and diameter 0.04 m. The weight has a mass of 35 kg. When the cable is pulled down a distance $d$ meters from its equilibrium position and released it acts like a spring with spring constant 490.7 N/m. What is the Young's Modulus of this cable? Answer in N/m$^2$.

(1) $1.76 \times 10^6$ (2) $4.40 \times 10^5$ (3) $8.80 \times 10^5$ (4) $7.03 \times 10^4$ (5) $1.10 \times 10^5$

13. 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 $\theta$ 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 and is the spring constant $k = 1,752$ N/m, what is the angle $\theta$?




(1) 40° (2) 50° (3) 60° (4) 45° (5) 30°

14. A turntable must spin at 33.3 rpm to play an old-fashioned vinyl record. How much constant torque (in N·m) must the motor deliver if the turntable is to reach its final angular speed in 2 revolutions, starting from rest? The turntable is a uniform disk of radius 15 cm and mass 0.16 kg.

(1) $8.71 \times 10^{-4}$ (2) $5.81 \times 10^{-4}$ (3) $4.35 \times 10^{-4}$ (4) $2.37 \times 10^{-3}$ (5) $1.16 \times 10^{-3}$

15. 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 revolutions, starting from rest?

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

16. You sand a block of wood by pushing it against a rotating electric sander. The sander is a solid cylinder with diameter of 35 cm. It spins with an intial speed of 200.0 rpm and has a mass of 26 kg. If you are pressing the wood against the sander with a force of 2.4 N, what will the final speed of the sander be after 10 s have elapsed? Assume the coefficient of kinetic friction between the wood and sander is 0.20. Answer in SI units for angular speed.

(1) 18.83 (2) 197.54 (3) 22.17 (4) 198.77 (5) 19.71

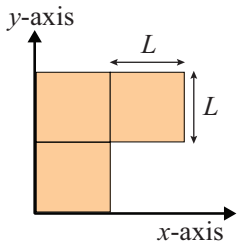
17. What is the angular momentum of Mars around the Sun? The mass of Mars is $6.36 \times 10^{23}$ kg and it orbits $228 \times 10^6$ km from the Sun with a period of 687 days.

(1) $3.50 \times 10^{39}$ kg m$^2$/s
(2) $1.53 \times 10^{28}$ kg m$^2$/s
(3) $3.50 \times 10^{33}$ kg m$^2$/s
(4) $1.53 \times 10^{25}$ kg m$^2$/s
(5) $3.50 \times 10^{40}$ kg m$^2$/s

18. A tennis ball of mass 0.30 kg strikes a brick wall and bounces straight back along the incoming direction. The collision is neither completely elastic nor inelastic. The ball's incident speed is 40 m/s and the ball's return speed is 35 m/s. If the time over which the ball is in contact with the wall is 6 ms, what is the average force on the wall (in N) during the collision?

(1) 3750 (2) 5625 (3) 7500 (4) 250 (5) 375

19. Three uniform square slabs are arranged in the xy-plane as shown in the figure. Each of the three squares have mass $M$ and sides of length $L$. If $L = 6$ m, what are the $x$ and $y$ components of the center-of-mass of the three slab system?




(1) $x_{cm} = 5$ m, $y_{cm} = 7$ m
(2) $x_{cm} = 7$ m, $y_{cm} = 5$ m
(3) $x_{cm} = 5$ m, $y_{cm} = 5$ m
(4) $x_{cm} = 7$ m, $y_{cm} = 7$ m
(5) $x_{cm} = 4$ m, $y_{cm} = 7$ m

20. Bart uses a spring gun ($k = 28$ N/m) to shoot a 56 g ball horizontally. Initially the spring is compressed by 18 cm. The ball loses contact with the spring and leaves the gun when the spring is still compressed by 12 cm. What is the speed of the ball when it leaves the gun?

(1) 3.0 m/s
(2) 4.0 m/s
(3) 2.7 m/s
(4) 5.1 m/s
(5) None of these.