Santa Monica College - Physical Science Department

	Quiz No. 3	D. Farivar, Ph.D., P.E.
PHYSICS 21	**SOLUTIONS**	Date: ***Thurs. - May 17, 2018***

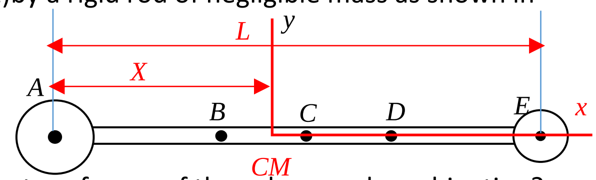
Notice: all problems:

A is used to denote vector $\vec{\mathbf{A}}$

NAME:

A 10 kg sphere (at A) is connected to a 5 kg sphere (at E)by a rigid rod of negligible mass as shown in the figure. Treat each sphere as a particle.

Use for problems 1, 2 and 3



1- Which of the five lettered points best represents the center of mass of the sphere-rod combination?

A. A

B. B

C. C

D. D

E. E

$X = \Sigma mx/\Sigma m = [-2mX + m(L - X)]/3m = (-3X + L)/3 = 0$

$X = L/3$ Therefore the answer is B

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2 - The sphere-rod combination can be pivoted about an axis that is perpendicular to the plane of the page and that passes through one of the five lettered points. Through which point should the axis pass for the moment of inertia of the sphere-rod combination about this axis to be greatest?

A. A

B. B

C. C

D. D

E. E

$I = m_A R^2 + m_B(L-R)^2$

$I = m(2R^2 + (L-R)^2)$

$I/(mL^2) = 2(R/L)^2 + (1 - R/L)^2$

R/L	$I/(mL^2)$
0.25	0.6875
0.5	0.75
0.75	1.1875
1	**2**

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3 - The sphere-rod combination can be pivoted about an axis that is perpendicular to the plane of the page and that passes through one of the five lettered points. Through which point should the axis pass for the moment of inertia of the sphere-rod combination about this axis to be smallest?

A. A

B. B

C. C

D. D

E. E

$I = m_A R^2 + m_B(L-R)^2$ $\quad I = m(2R^2 + (L-R)^2)$

$Y = I/(mL^2) = 2(R/L)^2 + (1 - R/L)^2$ $\quad R/L = x$

$Y = 2(x)^2 + (1 - x)^2$

$dY/dx = 4x - 2(1 - x) = 6x - 2 = 0$

$x = R/L = 1/3$ $\quad R = L/3$

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4 - Two homogeneous uniform selender rods each weighing 32.2 lb, are rigidly connected to form a single body. the coordinates of the center of mass is

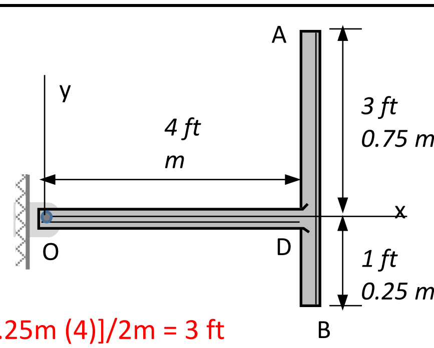
A. X = 0, Y = 0

B. X = 4 ft, Y = 0

C. X = 3 ft, Y = 0.5 ft

D. X = 4 ft, Y =1.0 ft

E. X = 2 ft, Y = -0.5 ft



$x_{CM} = [2\,m + 0.75\,m(4) + 0.25m\,(4)]/2m = 3$ ft

$Y_{CM} = [0 + 0.75\,m(1.5) - 0.25m\,(0.5)]/2m = 0.5$ ft

5 - Block **A** has mass *m* and block **B** has mass 3*m* . The blocks collide and stick together on a level, frictionless surface. After the collision, what is the kinetic energy of block A as compared to block B?

A. $K_A = 3K_B$

B. $K_A = K_B$

C. $K_A = 1/2\ K_B$

D. $K_A = 1/3\ K_B$

E. $K_A = 1/4K_B$

$K = 1/2\ mv^2$

$K_A = 1/2\ m_A\ v^2$

$K_B = 1/2\ m_B\ v^2$

$K_A = (m_A / m_B)\ K_B = (m\ /\ 3m)\ K_B$

$\mathbf{K_A = 1/3\ K_B}$

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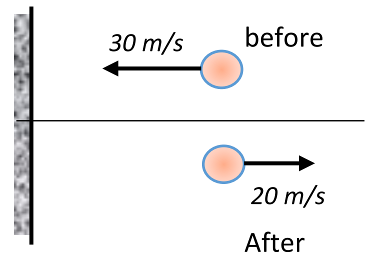
6 - A ball (mass 0.40 kg) is initially moving to the left at 30 m/s. After hitting the wall, the ball moves to the right at 20 m/s. What is the impulse of the net force on the ball during its collision with the wall?



A. 20 kg . m/s to the left

B. 20 kg . m/s to the right

C. 4.0 kg . m/s to the right

D. 4.0 kg . m/s to the left

E. none of the above

7- You are testing a new car using crash test dummies. Consider two ways to slow the car from 90 km/h to a complete stop:

(i) You let the car slam into a wall, bringing it to a sudden stop.

(ii) You let the car plow into a giant tub of gelatin so that it comes to a gradual halt.

In which case there is a greater *impulse* of the net force on the car?

A. In case (i).

B. In case (ii).

C. The impulse is the same in both cases.

D. The answer depends on how rigid the front of the car is.

E. The answer depends on how rigid the front of the car is and on the mass of the car.

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8 - In a system with external force, **always**

A. Momentum is conserved, energy is not conserved.

B. Momentum is not conserved, energy is conserved.

C. Both momentum and energy are conserved.

D. Neither momentum nor energy is conserved.

E. None of the above.

ΣF not Zero, momentum is not conserved, so not A or C
If the force is conservative
Energy is conserved
If force is not conservtive
Energy is not conserved

9 - Block *A* on the left has mass 1.00 kg. Block *B* on the right has mass 3.00 kg. The blocks are forced together, compressing the spring. Then the system is released from rest on a level, frictionless surface. After the blocks are released, how does p_A (the magnitude of momentum of block *A*) compare to p_B (the magnitude of momentum of block *B*)?

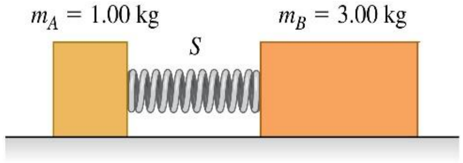
A. $p_A = p_B/9$

B. $p_A = p_B/3$

C. $p_A = p_B$

D. $p_A = 3p_B$

E. $p_A = 9p_B$



$m_A v_{A1} + m_B v_{B1} = m_A v_{A2} + m_B v_{B2}$

$v_{A1} = v_{B1} = 0$

$0 = m_A v_{A2} + m_B v_{B2}$

$|m_A v_{A2}| = |m_B v_{B2}|$

$p_A = p_B$

10 - An open cart is rolling to the left on a horizontal surface. A package slides down a chute and lands in the cart. Which quantity or quantities have the same value just *before* and just *after* the package lands in the cart?

A. the horizontal component of total momentum

B. the vertical component of total momentum

C. the total kinetic energy

D. None of the above

E. all of A, B, and C

11 - Block *A* on the left has mass 1.00 kg. Block *B* on the right has mass 3.00 kg. Block *A* is initially moving to the right at 6.00 m/s, while block *B* is initially at rest. The surface they move on is level and frictionless. What is the velocity of the center of mass of the two blocks *before* the blocks collide?

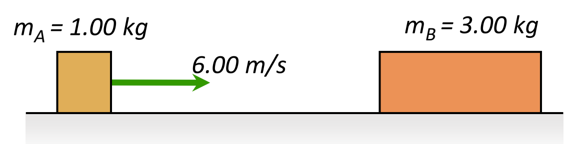
A. 6.00 m/s, to the right

B. 4.00 m/s, to the right

C. 3.00 m/s, to the right

D. 1.50 m/s, to the right

E. zero



12 - **Rank** the following objects in order of the *magnitude of the momentum* of the object, from largest to smallest.

A. Mass = 4.0 kg, kinetic energy = 2.5 J

B. Mass = 2.0 kg, kinetic energy = 2.0 J

C. Mass = 2.0 kg, kinetic energy = 4.0 J

D. Mass = 4.0 kg, kinetic energy = 4.0 J

$KE = ½mv^2$

$v = (2KE/m)^{1/2}$

$mv = (2mKE)^{1/2}$

A. DACB

B. DBCA

C. ADCB

D. ABCD

E. DCAB

m	KE	mv		
4	2.5	4.47	2	A
2	2	2.83	4	B
2	4	4.00	3	C
4	4	5.66	1	D

13 - To warm up for a match, a tennis player hits the 57.0-g ball vertically with her racket. If the ball is stationary just before it is hit and goes 5.50 m high, what impulse did she impart?

A. 0.28 kg.m/s $v_2^2 = v_1^2 + 2a\ (y_2 - y_1)$ ⇨ $0 = v_1^2 - 2 \times 9.8\ m/s^2 \times 5.5\ m$

B. 0.59 kg.m/s $v_1 = 10.4\ m/s$

C. 1.15 kg.m/s $mv_o + F\Delta t = mv_1$

D. 6.14 kg.m/s $0 + F\Delta t = 0.057\ kg \times 10.4\ m/s$

E. 60.5 kg.m/s **$J = F\Delta t = 0.59$ kg.m/s**

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14 - In a completely inelastic collision (also called plastic collision) between two objects, where the objects stick together after the collision, the final kinetic energy of the system

A. can be zero if only they have same velocity in opposite direction

B. can be zero if only they have same mass $K_2 = \frac{1}{2}(m_1 + m_2)v'^2 = 0$

C. can be zero if the thay have equal momentum in opposite dorections. $v' = 0$

D. can never be zero $m_1v_1 + m_2v_2 = (m_1 + m_2)v' = 0$

E. is always zero $m_1v_1 = - m_2v_2$

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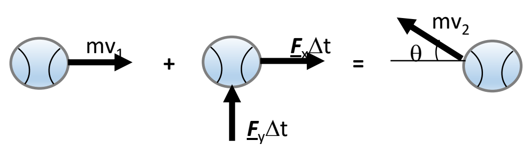
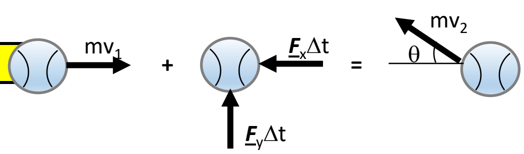
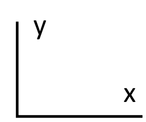
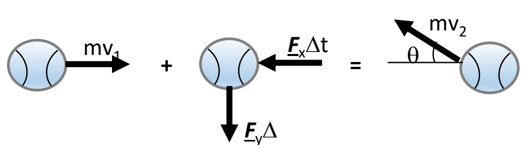
15 - A baseball is pitched with a velocity v_1 toward a batter. After the ball is hit by the bat B, it has a velocity of v_2 in the direction θ above horizontal.
Which of the following diagram shows the correct impulse momentum diagram.
and correct directions for the impulse.

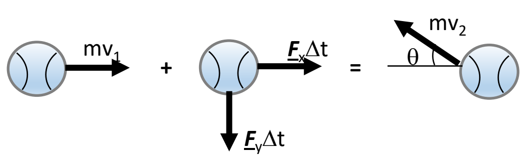
A.


B.




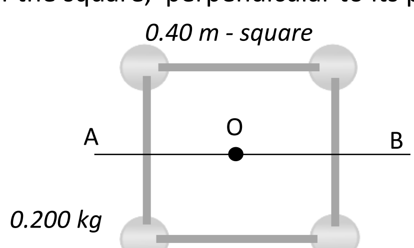
Common coordiante system

C.


D.


E. None of te above.

16- Four small spheres, each of which can be regarded as a point mass 0.20 kg, are arranged in a square 0.400 m on a side and connected by extremely light cords. The moment of inertia of the system about an axis through the center of the square, perpendicular to its plane (an axis through point O) is



A. 0.080 kg.m^2 $I = \Sigma (m_i r_i^2)$

B. 0.016 kg.m^2 $r = (0.2^2 + 0.2^2)^{1/2} = 0.283$ m

C. 0.032 kg.m^2 $I = \Sigma (m_i r_i^2) =$

D. 0.064 kg.m^2 $4\ (0.200 \times 0.283^2) = 0.064$ kg.m^2

E. 0.128 kg.m^2

17- A thin uniform rod of mass M and length L is bent at its center so that the two segments are now perpendicular to each other. The moment of inertia about an axis perpendicular to its plane and passing throughthe point where the two segments meet (point O)is

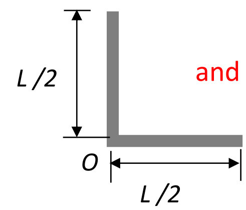
A. $(1/24)\ ML^2$

B. $(1/12)\ ML^2$

C. $(1/6)\ ML^2$

D. $(1/3)\ ML^2$

E. ML^2



I for a thin bar, length 'a' about its midpoint: $I = (1/12)Ma^2$

I of inertia of each segment about its mid point is then

$I = (1/12)(M/2)(L/2)^2 = (1/96)\ ML^2$

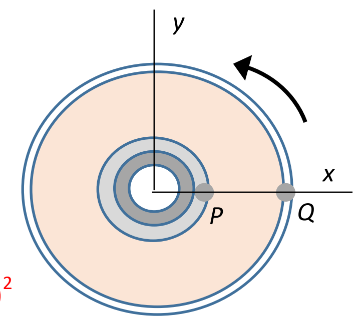
and moment of inertia about O for each one is:

$I_P = (1/96)\ ML^2 + (M/2)(L/4)^2 = (1/24)\ ML^2$

Then for both segments:

$I_O = 2I_P = 2 \times (1/24)\ ML^2$ $\qquad I_O = (1/12)\ ML^2$

18- A DVD is initially at rest so that the line PQ on the disc's surface is along the +x-axis. The disc begins to run with a constant $\alpha_z = 5.0\ \text{rad/s}^2$. At t=0.40 s, what is the angle between the line PQ and the +x-axis?



A. 0.4 rad

B. 0.8 rad

C. 1.0 rad

D. 1.6 rad

E. 2.0 rad

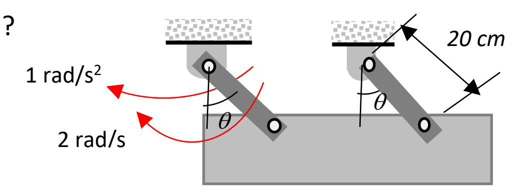
$\omega_o = 0$

$\theta = \theta_0 + \omega_{0z}\, t + \frac{1}{2}\alpha_z t^2$

$\theta = 0 + 0 + \frac{1}{2} + \omega_{0z}\, t + \frac{1}{2} \times (5.0\ \text{rad/s}^2) \times (0.4\ \text{s})^2$

$\boldsymbol{\theta = 0.4\ \text{rad}}$ $= 0.4\ \text{rad} \times 180/\pi = \mathbf{22.9^o}$

19- A rectangular plate swings from arms of equal length as shown. What is the magnitude of the angular velocity of the plate at t= 2.0 S.?



A. $\omega = 4$ rad/s

B. $\omega = 2$ rad/s

C. $\omega = 1.$ rad/s

D. $\omega = 0.5$ rad/s

E. $\omega = 0$

$\omega = 0$

This is a curvilinear motion and not rotation therefore:

20- The design of a 60.0 cm industrial turntable requires that it has a kinetic energy of 0.250 j when turning at 45.0 rpm. What must be the moment of inertia of the turntable about the rotation axis?

A. 0.092kg.m^2

B. 0.046kg.m^2

C. $0.023\ \text{kg.m}^2$

D. $0.002\ \text{kg.m}^2$

E. Not enough information

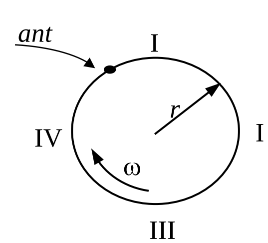
$\omega = 45.0\ \text{rev/min} = 45.0\ \text{rev/min} \times 2\pi\ \text{rad}/ 1\ \text{rev} \times 1\text{min} / 60\ \text{s} = 4.71\ \text{rad/s}$

$K = (1/2)\, I\, \omega^2$

$I = 2K/\omega^2 = 2 \times 0.250\ \text{N.m} / (4.70\ \text{rad/s})^2 = \mathbf{0.023\ kg.m^2}$

Problems 21 and 22

An ant of mass m clings to the rim of a flywheel of radius r, as shown at the right. The flywheel rotates clockwise on a vertical plane with constant angular velocity ω. As the wheel rotates, the ant revolves past the stationary point I, II, III, and IV. The ant never slips from the surface (that is, the ant remains at rest relative to the flywheel).



21- At which point will it be most difficult for the ant to adhere to the wheel (and not slip off) as it revolves?

A. I
B. II
C. III
D. IV
E. It will be equally difficult for the ant to adhere to the wheel at all points.

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22 - What is the magnitude of the adhesion force necessary for the ant to stay on the flywheel at point III?

A. mg
B. $m\omega^2 r$
C. $m\omega^2 r + mg$
D. $m\omega^2 r - mg$
E. m sym$^2/r + mg$

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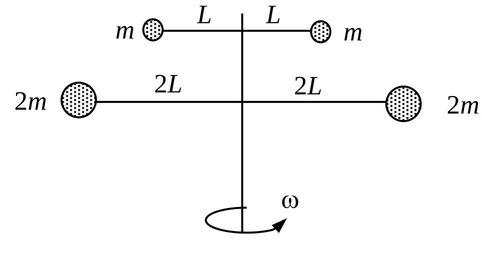
23 - The rigid body shown in the diagram consists of four spheres mounted on rods of negligible mass. The masses of the spheres and lengths of the rods are shown in the diagram. If the rigid body rotates with angular speed ω what is the ratio of the angular momentum of the two upper spheres to that of the two lower spheres?



A. 2/1
B. 1/1
C. 1/2
D. 1/4
E. 1/8

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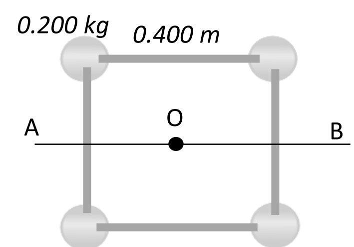
24 - Four small spheres, each of which can be regarded as a point mass 0.200 kg, are arranged in a square 0.400 m on a side and connected by extremely light rods. The moment of inertia of the system about an axis through the center of the square, perpendicular to its plane (an axis through point O) is



A. 0.080 kg.m^2
B. 0.016 kg.m^2
C. 0.032 kg.m^2
D. 0.064 kg.m^2
E. 0.128 kg.m^2

$I = \Sigma (m_i r_i^2)$

$r = (0.2^2 + 0.2^2)^{1/2} = 0.283$ m

$I = \Sigma (m_i r_i^2) = 4\,(0.200 \times 0.283^2) = 0.064$ kg.m^2

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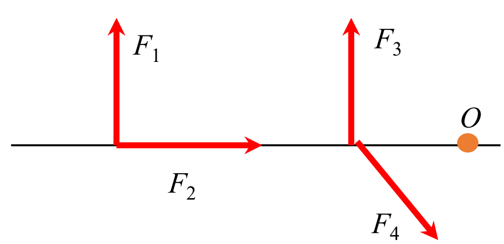
25 - The four forces shown all have the same magnitude:

$F_1 = F_2 = F_3 = F_4$.

Which force produces the *greatest torque* about the point *O*



A. F_1
B. F_2
C. F_3
D. F_4
E. Not enough information is given to decide.

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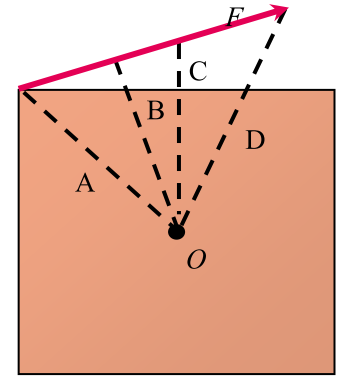
26 - A force *F* acts at one corner of a thin, square metal plate.
Which dashed line represents the lever arm for the force about point *O* at the center of the plate?



A. line A
B. line B
C. line C
D. line D
E. any of the lines depending on circumstances

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27 - A force $\underline{\boldsymbol{F}}$ = (4 N)$\underline{\boldsymbol{i}}$ + (3N)$\underline{\boldsymbol{j}}$ acts on an object at a point located at the position $\underline{\boldsymbol{r}}$ = (6m)$\underline{\boldsymbol{k}}$.
What is the torque that this force applies about the origin?

A. zero
B. (24 N.m)$\underline{\boldsymbol{i}}$ + (18 N.m) $\underline{\boldsymbol{j}}$
C. (-24 N.m)$\underline{\boldsymbol{i}}$ - (18 N.m) $\underline{\boldsymbol{j}}$
D. (-18 N.m)$\underline{\boldsymbol{i}}$ + (24 N.m) $\underline{\boldsymbol{j}}$
E. (-18N.m)$\underline{\boldsymbol{i}}$ - (24 N.m) $\underline{\boldsymbol{j}}$

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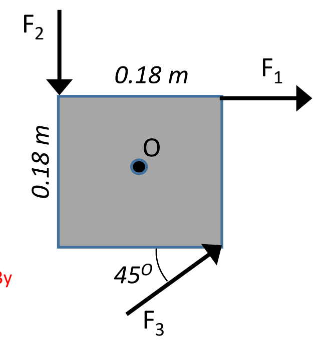
28 - A square metal plate 0.180 m on each side is pivoted about an axis through point O at its center and perpendicular to the plate. Calculate the net torque about this axis due to the three forces shown if the magnititude of the forces are: F_1 = 18.0 N, F_2 = 26.0 N, F_3 = 14.0 N. The plate and all forces are in the plane of the page.



A. 5.22 N.m ↺
B. 5.22 N.m ↻
C. 2.50 N.m ↺
D. 2.50 N.m ↻
E. Zero

F_{3x} = 14.0 x cos (45) = 9.9 N

F_{3y} = 14.0 x sin(45) = 9.9 N

τ_O = 0.09 x F2 - 0.09 x F1 + 0.09 x F_{3x} + 0.09 x F_{3y}

τ_O = 0.09 (26.0 -18.0 + 9.9 + 9.9)

τ_O = 2.5 N.m ↺

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29 - Calculate the magnitude of the angular momentum of the earth in a circular orbit around the sun.
Data for Earth:

m_E = 5.97 x 10^{24} kg

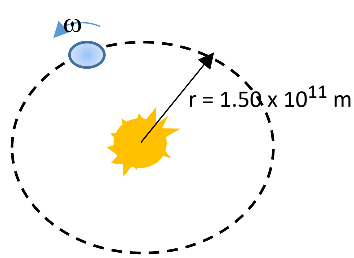
r = 1.50 x 10^{11} m

1 year = 365.25 days

Model earth as a particle.

R_E = 6.38 x 10˘ m

L = I ω



A. 2.67 x 10^{50} kg.m^2/s
B. 2.67 x 10^{45} kg.m^2/s
C. 2.67 x 10^{40} kg.m^2/s
D. 2.67 x 10^{29} kg.m^2/s
E. 2.67 x 10^{20} kg.m^2/s

1 yr = 1yr x (365.25 days/1year) x (24 hr/1day) x (3660 s/ 1hr)

1 year = 3.156 x 10^7 s

I = $m_E r^2$

I = (5.97 x 10^{24} kg) x (1.5 x 10^{11} m)^2 =1.34 x 10^{47} kg.m^2

ω = (2π rad) /(3.156 x 10^7 s) = 1.99 x 10^{-11} rad/s

L =1.34x10^{47} kg.m2) x (1.99 x 10^{-11}) = **2.67 x 10^{40} kg.m^2/s**

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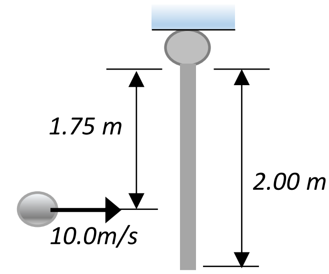
30 - A thin, uniform metal bar, 2.00 m long and weighing 90.0 N, is hanging vertically from the ceiling by a frictionless pivot. Suddenly it is struck 1.5 m below the ceiling by a small 3.00 kg ball, initially traveling horizontally at 10.0 m/s. The ball rebounds in opposite direction with a speed of 6.00 m/s. During the collision



A. Linear momentum is conserved
B. Angular momentum is conserved
C. Both angular and linear momenta are conserved
D. Neither angular and linear momenta are conserved
E. Neither angular and linear momenta are conserved, but Energy is conseved

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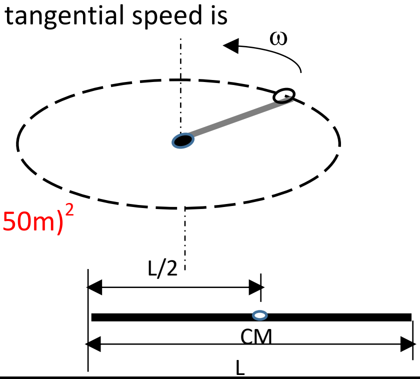
31- A thin uniform rod has a length of 0.50 m and is rotating in a circle on a frictionless table. The axis of rotation is perpendicular to the length of the rod at one end and is stationary. The rod has an angular vlocity of 0.40 rad/s and a moment of inertia about the axis of 3.00x 10^{-3} kg.m^2. A bug initially standing on the rod at the axis of rotation decides to crawl out to the other end of the rod. When the bug has reached the end of the rod and sits there, its tangential speed is 0.160 m/s. The bug can be treated as a point mass.
What is the mass of the rod?



A. 0.012 kg

B. 0.024 kg

C. 0.036 kg

D. 0.048 kg

E. 0.060 kg

$I_{rod} = (1/3)\ ML^2$

$M = 3I_{rod}/L^2 = 3 \times (3.00 \times 10^{-3}\ \text{kg.m}^{2)}) / (0.50\text{m})^2$

M = 0.036 kg

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32 - The Hubble Space Telescope is stablized to within an angle of about 2-millionths of a degree by means of a series of gyroscopes that spin at 19,200 rpm. Although the structure of these gyroscopes is actually quite complex, we can model each of the gyroscopes as a thin-walled cylinders on mass 2.0 kg and diameter of 5.0 cm, spinning about its central axis.
How large a torque would it take to causethese gyroscopes to precess through an angle of 1.0 x 10-6 degree during a 5.0-hour exposure of galaxy?

A. 2.75 x 10^{-16} N.m

B. 2.64 x 10^{-14} N.m

C. 2.00 x 10^{-13} N.m

D. 2.43 x 10^{-12} N.m

E. 2.20 x 10^{-10} N.m

$\Omega = wr/I\omega = \tau / I\ \omega$

$\tau = \Omega\ I\ \omega$

$I = MR^2 \quad I = (2.0\ \text{kg}) \times (0.05/2\ \text{m})^2 = 1.25 \times 10^{-3}\ \text{kg.m}^2$

$\omega = 19{,}200\ \text{rpm} \times (2\pi\ \text{rad}/ 1\ \text{rev}) \times (1\ \text{min}/ 60\ \text{s}) = 2010.6\ \text{rad/s}$

$\Omega = 1.0 \times 10^{-6}\ \text{deg} / 5.0\ \text{hr} \times (\pi\ \text{rad} / 180\ \text{deg}) \times (1\ \text{hr} / (3600\ \text{s}) =$

$= 9.7 \times 10^{-13}\ \text{rad/s}$

$\tau = (9.7 \times 10^{-13}\ \text{rad/s}) \times (1.25 \times 10\text{-}3\ \text{kg.m}^2) \times (2010.6\ \text{rad/s}) =$

$\tau = 2.43 \times 10^{-12}\ \text{N.m}$
