MULTIPLE CHOICE ANSWERS (FOR myCourses pdf):

1) #3
2) #4
3) #5
4) #1
5) #3
6) #1
7) #1
8) #1
9) #2
10) #1
11) #4
12) #3
13) #3

PHYS 211 2020/2021 Shared Area EXAM 2 SPRING 2021 DO NOT COPY YET

EXAM 2 SPRING 2021 DO NOT COPY YET Begin Date: 4/20/2021 6:30:00 PM -- **Due Date:** 4/20/2021 8:00:00 PM **End Date:** 4/20/2021 8:00:00 PM

Problem 1: A disk spins with a **non-constant** angular acceleration given by: $\alpha(t) = Bt$. It starts with an angular velocity of $+D$ at $t = 0$.

$$\omega = \int \alpha \, dt = \frac{Bt^2}{2} + D$$

What is the angular velocity as a function of time?
MultipleChoice :

1) $Bt^2 + D$
2) $2Bt + D$
3) $Bt^2/2 + D$
4) $2B + D$
5) $2Bt - D$

#3

Problem 2: A solid sphere and a hollow hoop have the same total mass and same radius. They both start from rest at the top of an incline of height H, and they roll down without slipping.

$U_{gi} = K_{R,f} + K_{T,f}$

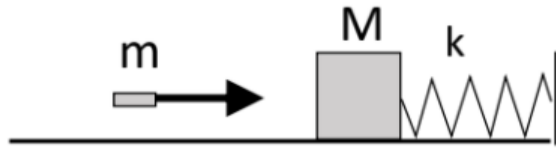
$I_{sphere} < I_{shell}$

Which reaches the bottom of the incline first, and why?
MultipleChoice :

#4

1) The solid sphere gets to the bottom first, because it has more rotational kinetic energy and less translational kinetic energy.
2) The hollow hoop gets to the bottom first, because it has more translational kinetic energy and less rotational kinetic energy.
3) They reach at the same time, because they started with the same gravitational potential energy.
4) The solid sphere gets to the bottom first, because it has more translational kinetic energy and less rotational kinetic energy.
5) The hollow hoop gets to the bottom first, because it has more rotational kinetic energy and less translational kinetic energy.

Problem 3: A bullet of mass m collides with a block of mass M. After the collision, the bullet/block combination compress a spring with spring constant k by a distance D.



CoLM for collision.

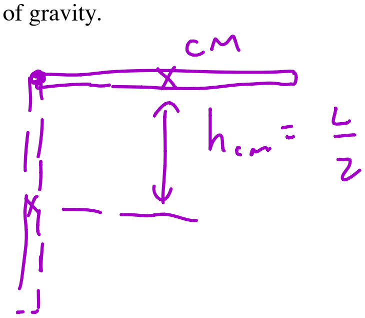
CoE for compressing spring

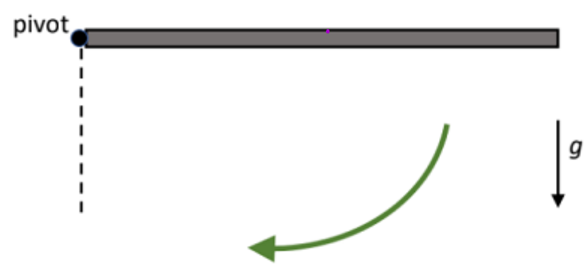
To calculate the initial speed of the bullet, you would need:
MultipleChoice :

#5

1) Only Newton's 2nd Law
2) Both conservation of energy and Newton's 2nd Law
3) Only conservation of energy
4) Only conservation of linear momentum
5) Both conservation of energy and conservation of linear momentum

Problem 4: A long uniform-density rod of length L is pivoted at one end as shown. It is released from rest in the horizontal position, and it swings downwards under the influence of gravity.





What is the angular speed of the rod when it passes through the vertical position?
MultipleChoice :

1) $\sqrt{\frac{3g}{L}}$
2) $\sqrt{\frac{6g}{L}}$
3) 0
4) $\sqrt{\frac{3g}{2L}}$
5) $\sqrt{\frac{g}{L}}$

$$mgh_{cm} = \frac{1}{2} I \omega^2$$

$$mg\frac{L}{2} = \frac{1}{2}\left(\frac{1}{3}ML^2\right)\omega^2$$

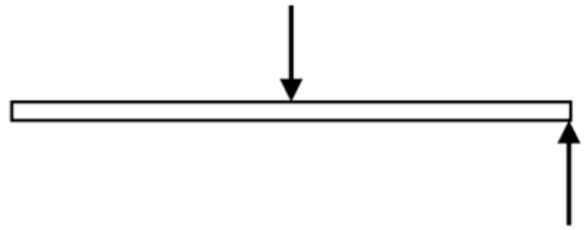
$$\omega = \sqrt{\frac{3g}{L}}$$

#1

Problem 5: A long uniform bar has only two forces acting on it. The two forces have equal magnitudes and act as shown.

$\Sigma F = 0$ but

$\Sigma \tau \neq 0$. would ↻



Which statement is true regarding the net force and net torque on the bar?

MultipleChoice :

1) The net force and the net torque are both zero
2) The net force and the net torque are both non-zero
3) The net force is zero but the net torque is not zero
4) The net torque is zero but the net force is not zero

#3

Problem 6: A **time-varying** force is applied to an object moving in one dimension. The force is given by $F(t) = At^4$, where A is a positive constant.

$\vec{J} = \int \vec{F}\, dt = \Delta \vec{p}$

so $\int At^4\, dt = \Delta p \Rightarrow \Delta p = \frac{At^5}{5}\Big|_0^2 = \frac{32A}{5}$

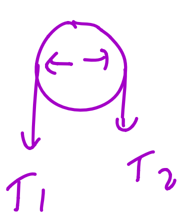
What is the change in momentum of the object from $t = 0$ to $t = 2$ seconds?

MultipleChoice :

1) $32A/5$
2) $16A$
3) $8A$
4) $16A/5$
5) $32A$

#1

Problem 7: Consider the pulley and mass configuration shown. The pulley can be modeled as a solid disk. Assume m_1 is accelerating downwards.

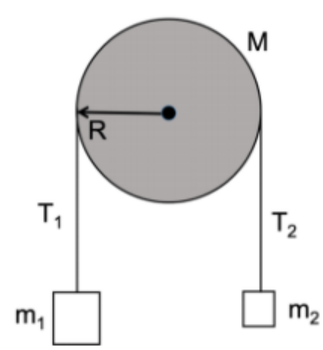


$\Sigma \tau = I\alpha$

get each $\vec{\tau}$ from $\vec{r} \times \vec{F}$

$\Rightarrow T_1 R \sin 90 - T_2 R \sin 90 = I\alpha$

and $I = \frac{1}{2} M R^2$



What is the correct equation of motion (N2L equation) for the pulley?

MultipleChoice :

1) $T_1R - T_2R = \frac{1}{2}MR^2\alpha$
2) $m_1gR - m_2gR = MR^2\alpha$
3) $m_1gR - m_2gR = \frac{1}{2}MR^2\alpha$
4) $T_1R + T_2R = \frac{1}{2}MR^2\alpha$
5) $m_1g - m_2g = MR^2\alpha$

#1

Problem 8: Consider the following integral: $\int_0^2 \left(3x^4 + 4x^2\right)dx$.

$$M_{TOT} = \int dm = \int \lambda dx$$

NOTE: $I = \int r^2 dm = \int x^2 \lambda dx$

Which of the following could be a correct physical interpretation of this integral?
MultipleSelect :

1) The total mass a bar with non-uniform linear mass density given by $\left(3x^4 + 4x^2\right)$, which is pivoted at one end.
2) The moment of inertia of a bar with non-uniform linear mass density given by $\left(3x^4 + 4x^2\right)$, which is pivoted at one end.
3) The moment of inertia of a bar with non-uniform linear mass density given by $\left(3x^4 + 4x^2\right)$, which is pivoted at the center.
4) None of the the answers listed are possible.
5) The total mass of a bar with non-uniform linear mass density given by $\left(3x^4 + 4x^2\right)$, which is pivoted at the center.

#1

Problem 9: A disk rotates with a constant angular acceleration given by 20.4 rad/s^2.

$\alpha = 20.4 \text{ rad/s}^2$

$t = 3.0$ sec

$\omega_0 = 0$

$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2 = \frac{1}{2}(20.4)(3^2) = 91.8$ RADians.

in radians

How many **revolutions** has it gone through in 3.0 seconds? Assume the disk starts from rest.
MultipleChoice :

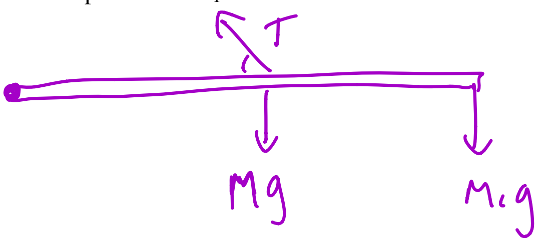
1) 29.2 revolutions
2) 14.6 revolutions
3) 45.9 revolutions
4) 91.8 revolutions

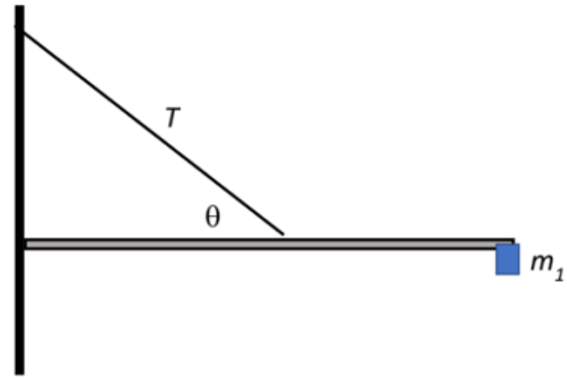
#2

$$\frac{91.8 \text{ rad}}{} \Big| \frac{1 \text{ revolution}}{2\pi \text{ rad}} = 14.6 \text{ revs}$$

5) 578 revolutions

Problem 10: A long uniform-density beam has a mass M and a length L. It is hinged to a wall at its left end. A cable is attached to the middle of the rod as shown. A point mass m_1 is attached to the far end.





$\Sigma \tau = T \sin\theta \frac{L}{2} - Mg\frac{L}{2} - M_1 g L$

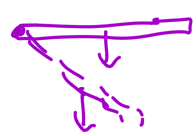
What is the correct N2L torque equation for this configuration?

MultipleChoice :

1) $T \sin\theta \frac{L}{2} - m_1 g L - Mg\frac{L}{2} = 0$
2) $T \sin\theta - m_1 g L - Mg = 0$
3) $T \cos\theta \frac{L}{2} - m_1 g L - Mg\frac{L}{2} = 0$
4) $T \cos\theta \frac{L}{2} + m_1 g L + Mg\frac{L}{2} = 0$
5) $T \sin\theta \frac{L}{2} + m_1 g L + MgL = 0$

#1

Problem 11: A bar is pivoted at one end. It is initially held in the horizontal position and it swings downwards under the influence of gravity.



No: Angle changes so τ changes

Which of the following statement(s) is(are) TRUE? Ignore air resistance.

1. The torque on the bar due to gravity is constant as the bar swings downwards.
2. As the bar swings, the sum of the gravitational potential energy and the rotational kinetic energy is a constant.
3. The angular momentum of the bar is constant as it swings.

Yes. CoE applies

No. $|\vec{\omega}|$ changes so $\vec{L}$ changes

MultipleChoice :

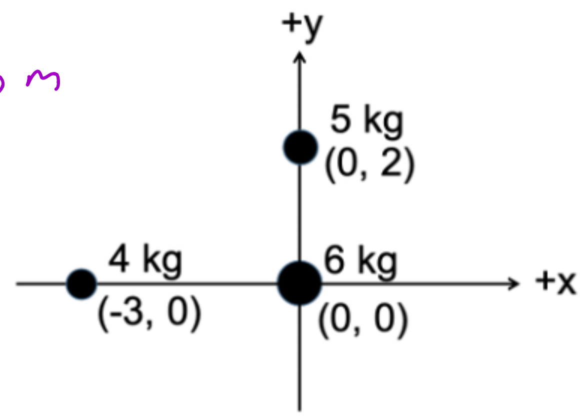
1) Only 1 is true
2) Both 1 and 2 are true
3) None are true
4) Only 2 is true
5) Only 3 is true

#4

Problem 12: Refer to the figure. Note that all coordinates are given in meters.

$$x_{cm} = \frac{(4\,kg)(-3)}{4+5+6} = \frac{-12}{15} = -0.8\,m$$

$$y_{cm} = \frac{(5\,kg)(2)}{4+5+6} = \frac{10}{15} = 0.67\,m$$



What is the location of the center of mass of the configuration shown?
MultipleChoice :

1) (-1.0, 1.3) m
2) (-1.3, 0.67) m
3) (-0.8, 0.67) m
4) (-1.3, 1.0) m
5) (-0.8, 1.0) m

#3

Problem 13: A force $F = (3\hat{i} + 2\hat{j})$ N acts on an object at a displacement $r = (4\hat{i} + 1\hat{j})$ m from the pivot.

$$\vec{\tau} = \vec{r} \times \vec{F} = ((4)(2) - (1)(3))\hat{k} = +5\hat{k}$$

put $\vec{r}$ first

What is the torque on the object?
MultipleChoice :

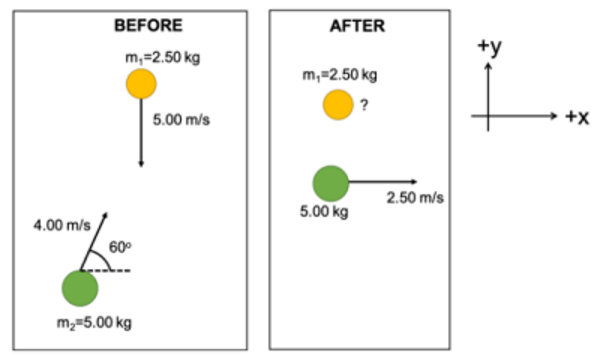
1) 0 N·m
2) 14 N·m
3) $+5\hat{k}$ N·m
4) $+12\hat{k}$ N·m
5) $-11\hat{k}$ N·m

#3

Problem 14: Long Problem 1 Long problem solutions on last page.

Two objects collide on a level frictionless surface. One object has a mass of 2.50

kg and is initially traveling in the negative y direction with a speed of 5.00 m/s. A second object has a mass of 5.00 kg and is traveling with a speed of 4.00 m/s, making an angle of 60.0° with the negative x axis, as shown in the diagram. After the collision, the 5.00 kg mass travels with a speed of 2.50 m/s in the positive x direction. The objects do not stick together.



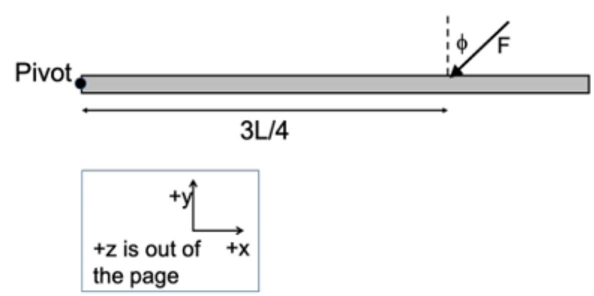
(a) What is the velocity of the 2.50 kg mass immediately after the collision? Express your velocity in unit vector (component) form, using the axes shown. Give each component to three significant digits, and include units.

(b) Say that the collision lasted for 0.0280 seconds. Determine the average force on the 5.00 kg object during the collision. Express the average force in unit vector (component) form, using the axes shown. Give each component to three significant digits, and include units.

Reminder: *After completing the three long problems, you will upload a pdf of your written work to the myCourses "Exam 2 Long Problems" dropbox. What is uploaded there is what is graded for those problems. There is nothing that needs to be entered on ExpertTA for this problem.*
Essay :
= ____

Problem 15: Long Problem 2

Consider a long rod pivoted at one end, laying on a horizontal frictionless table, as shown in the diagram. The bar has a **non-uniform** linear mass density given by:
$\lambda(x) = Ax^2 + B$,
where A and B are positive constants and $x = 0$ at the pivot. The total length of the bar is L.



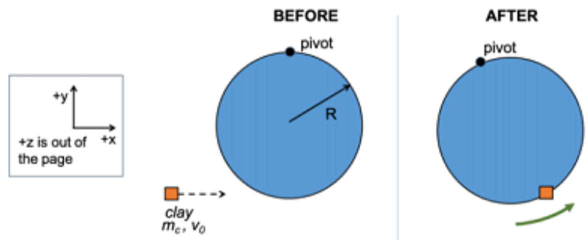
(a) What is the moment of inertia of the bar? State your answer in terms of L, A, and B.

(b) Say that a constant force F is applied at a distance $3L/4$ from the pivot, at the direction shown in the diagram. What is the angular acceleration of the bar while this force acts? Give both the magnitude and the vector direction of the angular acceleration as this torque acts. Express your answer in terms of L, A, B, F, and ϕ, and use the axes shown for stating the vector direction.

Reminder: *After completing the three long problems, you will upload a pdf of your written work to the myCourses "Exam 2 Long Problems" dropbox. What is uploaded there is what is graded for those problems. There is nothing that needs to be entered on ExpertTA for this problem.*
Essay :
= ____

Problem 16: Long Problem 3

A solid uniform-density disk of radius R and mass M_d is pivoted at the edge, as shown in the diagram. It is initially at rest. A piece of clay of mass m_c is traveling in the positive x direction with a speed v_o. The clay strikes the edge of the disk directly opposite the pivot. It sticks to the disk, and the disk and clay combination rotates as shown. The clay can be modeled as a point mass.



Determine the angular velocity of the disk and clay combination immediately after the collision. State **both** the magnitude **and** the vector direction of the angular velocity. Give your answer in terms of R, M_d, m_c, and v_o. Use the axes shown for stating the vector direction.

Reminder: *After completing the three long problems, you will upload a pdf of your written work to the myCourses "Exam 2 Long Problems" dropbox. What is uploaded there is what is graded for those problems. There is nothing that needs to be entered on ExpertTA for this problem.*
Essay :
= ____

$\boxed{\#14}$ (a) CoLM 12 PTS TOTAL

-1 : careless math error
-2 : switch sin/cos (one deduction)
-2 : wrong +/- sign
-1 : no units / wrong units
-9 : no components at all
(No deduction if took v_{xi} as negative)

	initial	final
$\hat{x}$	$(2.50)(0) + (5.00)(4\cos 60)$	$2.50\, v_{fx} + (5.00)(2.50)$
$\hat{y}$	$-(2.50)(5.00) + (5.00)(4\sin 60)$	$2.50\, v_{fy}$ $5.00\,(0)$

$$\hat{x}: (5\text{ kg})(4\cos 60) + (2.5\text{ kg})(0) = (5\text{ kg})(2.50) + (2.5\text{ kg})\, v_{fx}$$ 6 PTS

$$\hat{y}: -(2.5\text{ kg})(5) + (5\text{ kg})(4\sin 60) = (2.5\text{ kg})\, v_{fy} + (5\text{ kg})(0)$$ 6 PTS

result : $\boxed{\vec{v}_f = (-1.00\,\hat{i} + 1.93\,\hat{j})\,\frac{m}{s}}$

(b) IMPULSE-MOMENTUM 8 PTS TOTAL

$$\vec{F}_{ave}\, \Delta t = \Delta \vec{p}$$ ← 3 PTS FOR THIS EQN.

5 PTS FOR DOING IT IN COMPONENTS

$$\hat{x}: \vec{F}_x = \frac{m(v_{fx} - v_{ix})}{t} = \frac{(5\text{ kg})(2.50 - 4\cos 60)}{0.028} = +89.3\text{ N}$$

$$\hat{y}: \vec{F}_y = \frac{m(v_{fy} - v_{iy})}{t} = \frac{(5\text{ kg})(0 - 4\sin 60)}{0.028} = -619\text{ N}$$

result : $\boxed{\vec{F}_{ave} = (+89.3\,\hat{i} - 619\,\hat{j})\,\text{N}}$

-3 : IF leave out Δt
-1 : wrong/no units
-5 : no components
-4 : using M_{TOTAL} anywhere
-2 : using 2.5 kg instead of 5 kg.
-1 : careless math

-2 : opposite $\vec{F}$
-2 : $(v_i - v_f)$

#15

(a) MOI integration — 12 PTS TOTAL

$$I = \underbrace{\int r^2\,dm}_{\text{1 PT eqn.}} = \int_0^L x^2 \lambda\,dx = \int_0^L (Ax^4 + Bx^2)\,dx$$

1 PT eqn. 2 PTS Limits 4 PTS $r^2 = x^2$ 4 PTS $dm = \lambda dx$) all or nothing points

result:

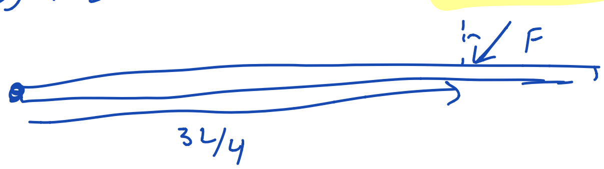
$$\boxed{I = \frac{AL^5}{5} + \frac{BL^3}{3}}$$

1 PT Math

−5 : Find M_{TOT} not I

−10 : use ∥ axis or uniform bar

(b) N2L For ROTATION — 8 PTS TOTAL



(No deduction if try to include Mg.)

$$\Sigma \vec{\tau} = I\vec{\alpha}$$

4 PTS 2 PTS

$$\left(\frac{3L}{4}\right)(F\cos\phi) = I|\vec{\alpha}|$$

−2 : using $\sin\phi$

−2 : wrong r but have something

−1 : wrong math

−6 : if don't use $\Sigma\tau = I\alpha$ (wrong concept)

Result :

$$\boxed{|\vec{\alpha}| = \frac{\frac{3L}{4}F\cos\phi}{\left(\frac{AL^5}{5} + \frac{BL^3}{3}\right)}}$$

Direction : $\boxed{-\hat{z}\text{, into page}}$

2 PTS, all or nothing. CW or CCW doesn't count.

#16 CoAM w/ || axis

20 PTS TOTAL

$\sum L_i = \sum L_f \leftarrow 2$ PTS.

4 PTS, TOTAL (−2 PTS IF USE R NOT 2R)

- $L_{i,\text{clay}} = \vec{r} \times \vec{p} = (2R)\underbrace{(M_c v_0)\sin 90}_{2\text{ PT}}$

- $L_{f,\text{TOTAL}} = I_{TOT}\,\omega_f$

6 PTS TOTAL (2 PTS I_{cm}, 4 PTS $M_d R^2$)

3 PTS TOTAL

- $I_{TOT} = I_{disk} + I_{clay}$

I_{clay}: $M_c (2R)^2 = 4 M_c R^2$

I_{disk}: $(I_{cm} + Md^2) = \frac{1}{2} M_d R^2 + M_d R^2 = \frac{3}{2} M_d R^2$

$\Rightarrow I_{TOT} = \frac{3}{2} M_d R^2 + 4 m_c R^2$

−8 : Try to write $p_i = L_f$

−2 : IF use R not 2R for clay, each time.

−9 : IF use CoL But Have I_{TOT} and Direction right

RESULT: $2R\, m_c v_0 = \left(\frac{3}{2} M_d R^2 + 4 m_c R^2\right)\omega_f$

$$\Rightarrow \boxed{|\vec{\omega}_f| = \frac{2R\, m_c v_0}{\frac{3}{2} M_d R^2 + 4 m_c R^2}} \leftarrow 1 \text{ PT result.}$$

$\boxed{\text{Direction: } +\hat{z}, \text{ OUT OF Page}}$ ← 2 PTS, all or nothing