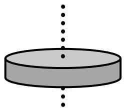
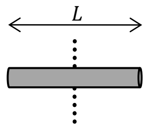
161 Spring 2024 Test 3A Once the exam has officially started, remove the top sheet. The remaining sheets comprise your exam. It is each student's individual responsibility to ensure the instructor has received her or his completed exam. Any exams not received by the instructor earn zero points. Smart watches, phones, or other devices (except scientific calculators) are not permitted during the exam.

$V_{sphere} = \frac{4}{3}\pi R^3$	$V_{box} = LWH$	$V_{cyl} = \pi R^2 H$	$\rho = \frac{M}{V}$
$A_{sphere} = 4\pi R^2$	$V = (A_{base}) \times (height)$	$A_{circle} = \pi R^2$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$C = 2\pi R$	$A_{rect} = LW$	$A_{CylSide} = 2\pi RH$	
$160\underline{9}\text{ m} = 1\text{ mi}$	$12\text{ in} = 1\text{ ft}$	$60\text{ s} = 1\text{ min}$	$1000\text{ g} = 1\text{ kg}$
$2.54\text{ cm} = 1\text{ in}$	$1\text{ cc} = 1\text{ cm}^3 = 1\text{ mL}$	$60\text{ min} = 1\text{ hr}$	$100\text{ cm} = 1\text{ m}$
$1\text{ cm} = 10\text{ mm}$	$1\text{ yard} = 3\text{ ft}$	$3600\text{ s} = 1\text{ hr}$	$1\text{ km} = 1000\text{ m}$
$1\text{ furlong} = 220\text{ yards}$	$528\underline{0}\text{ ft} = 1\text{ mi}$	$24\text{ hrs} = 1\text{ day}$	$1\text{ rev} = 2\pi\text{ rad} = 360°$
$g = 9.8\ \frac{\text{m}}{\text{s}^2}$	$G = 6.67 \times 10^{-11}\ \frac{\text{N}\cdot\text{m}^2}{\text{kg}^2}$	$P_0 = 1.0 \times 10^5\text{ Pa}$	$1\text{ eV} = 1.60\underline{2} \times 10^{-19}\text{ J}$
$1\text{ N} = 1\ \frac{\text{kg}\cdot\text{m}}{\text{s}^2}$	$1\text{ J} = 1\text{ N}\cdot\text{m}$	$1\text{ Pa} = 1\ \frac{\text{N}}{\text{m}^2}$	$m_e = 9.11 \times 10^{-31}\text{ kg}$
$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$	$v_{fx}^2 = v_{ix}^2 + 2a_x(\Delta x)$	$v_{fx} = v_{ix} + a_x t$	$r = \sqrt{x^2 + y^2}$
$\vec{A}\cdot\vec{B} = AB\cos\theta_{AB}$	$\lVert\vec{A}\times\vec{B}\rVert = AB\sin\theta_{AB}$	$\sin(A \pm B)$ $= \sin A\cos B \pm \cos A \sin B$	$\cos(A \pm B)$ $= \cos A\cos B \mp \sin A\sin B$
$\vec{v}_{ae} + \vec{v}_{eb} = \vec{v}_{ab}$	$\hat{r} = \cos\theta\,\hat{\imath} + \sin\theta\,\hat{\jmath}$	$\hat{\theta} = -\sin\theta\,\hat{\imath} + \cos\theta\,\hat{\jmath}$	
$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$	$\vec{a} = a_r\hat{r} + a_{tan}\hat{\theta}$	$\vec{a} = a_c(-\hat{r}) + a_{tan}\hat{\theta}$
$\Sigma\vec{F} = m\vec{a}$	$f \le \mu n$	$F_G = \frac{GmM}{r^2}(-\hat{r})$	$U_G = -\frac{GmM}{r}$
$TKE = \frac{1}{2}mv^2$	$RKE = \frac{1}{2}I\omega^2$	$U_S = SPE = \frac{1}{2}kx^2$	$U_G = GPE = mgh$
$E_i + W_{\substack{non-con \\ or\ ext}} = E_f$	$\Delta KE = W_{ext.\&\,non-con}$	$W = Fd\cos\theta = F_{\parallel}d$	$W = \int F_x dx$
$\Delta U = -W = -\int_i^f \vec{F}\cdot d\vec{s}$	$F_x = -\frac{d}{dx}U(x)$	$\mathcal{P}_{inst} = \frac{dE}{dt} = \vec{F}\cdot\vec{v}$	$\mathcal{P}_{avg} = \frac{\Delta E}{\Delta t} = \frac{Work}{time}$
$\vec{J} = \Delta\vec{p} = \vec{F}\Delta t$	$\vec{p} = m\vec{v}$	$x_{\text{CM}} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$	$x_{\text{CM}} = \frac{\int x\,dm}{\int dm}$
$\vec{\tau} = \vec{r}\times\vec{F}$	$\Sigma\vec{\tau} = I\vec{\alpha}$	$L = I\omega = mvr_{\perp}$	$\mathcal{P}_{inst} = \vec{\tau}\cdot\vec{\omega}$
$s = r\Delta\theta$	$v = r\omega$	$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$
$I_{\parallel axis} = I_{\text{CM}} + md^2$	$I_{zz} = I_{xx} + I_{yy}$	$I = \int r^2 dm$	$\frac{F}{A} = E\frac{\Delta L}{L_0}$
$P = \frac{F}{A}$	$P_{gauge} = P_{abs} - P_{ambient}$	$B = \rho_f V_{disp} g$	$A_1v_1 = A_2v_2$
$P(h) = P_0 + \rho gh$	$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$	$R = \frac{\pi r^4 \Delta P}{8\eta L}$	$F = \eta A\frac{\Delta v_x}{\Delta y}$

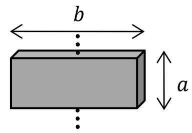
Prefix	**Abbreviation**	**$10^?$**		**Prefix**	**Abbreviation**	**$10^?$**
Giga	G	10^9		milli	m	10^{-3}
Mega	M	10^6		micro	µ	10^{-6}
kilo	k	10^3		nano	n	10^{-9}
centi	c	10^{-2}		pico	p	10^{-12}
				femto	f	10^{-15}



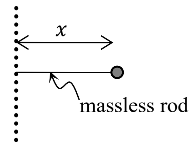
$I_{disk} = \frac{1}{2}mR^2$



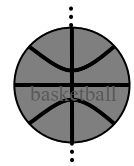
$I_{\substack{thin\\rod}} = \frac{1}{12}mL^2$



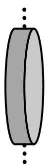
$I_{\substack{thin\\plate}} = \frac{1}{12}mb^2$



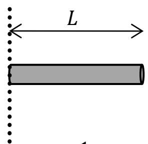
$I_{\substack{pnt\\mass}} = mx^2$



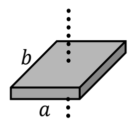
$I_{\substack{spherical\\shell}} = \frac{2}{3}mR^2$



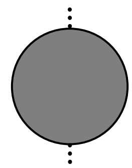
$I_{disk} = \frac{1}{4}mR^2$



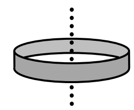
$I_{\substack{thin\\rod}} = \frac{1}{3}mL^2$



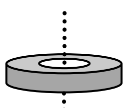
$I_{\substack{thin\\plate}} = \frac{1}{12}m(b^2 + a^2)$



$I_{\substack{solid\\sphere}} = \frac{2}{5}mR^2$



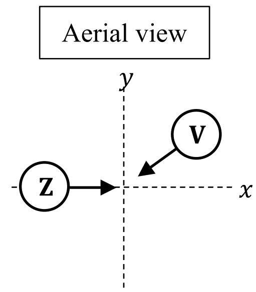
$I_{\substack{thin\\ring}} = mR^2$



$I_{\substack{thick\\ring}} = \frac{1}{2}m(R_{inner}^2 + R_{outer}^2)$

Name:____

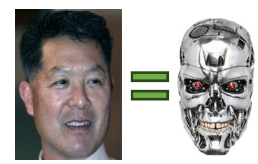
Zenobia and Vaida collide in mid-air. Assume the two have identical mass and speed. Collision time is extremely short. As seen from above, we can model the collision as 2D perfectly inelastic. They collide at the origin while both have negligible motion in the z-direction.



1) Which best describes Vaida's direction of motion after the collision? Circle the best answer.

$+\hat{\imath}$	$+\hat{\jmath}$	Into 1st quadrant	Into 3rd quadrant	Impossible to determine without an exact value for angle
$-\hat{\imath}$	$-\hat{\jmath}$	Into 2nd quadrant	Into 4th quadrant	Impossible to determine even if one had the exact value for angle.

In an apocalyptic near-future, Allan Hancock College Human Resources discovers Len Miyahara is actually a terminator T-800. To most of his friends and family, all of the strange things Len has put us through suddenly make sense. Len (mass 182.7 kg) is sliding across a level sheet of ice while holding a 20.0 kg mass. Assume Len travels to the right with constant speed $5.00\ \frac{\text{m}}{\text{s}}$ (negligible friction). Len wants to throw the mass in such a way that he is at rest after the throw. Side note: the district tries to retroactively discredit all the sick days Len took out of spite…



2a) Which quantities are conserved (in the Len-mass system) while Len throws the mass?

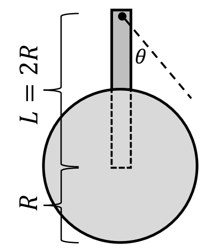
Energy	Linear Momentum	Both	Neither	Impossible to determine without more info

***2b) With what *speed* must Len throw the mass?

**2c) What is the percent change in kinetic energy during this process?
To be clear, if energy is *lost* I am expecting a *negative* % change for your answer.
If no energy is gained/lost, I'm expecting 0% for your answer.

2b	
2c	

A pendulum (shown at right) is made from a *spherical shell* of radius R and mass M and a rod of length $L = 2R$ and mass $2M$. Notice the pivot at the top of the pendulum (black dot). Assume the distance between the pivot and the end of the rod is negligible. Figure not to scale. As the pendulums swings it reaches max angle $\theta = 36.87°$. Assume axle friction and drag forces are negligible. The magnitude of freefall acceleration near earth's surface is g.



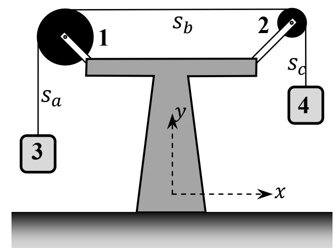
**3a) Determine distance between the pivot (black dot) and the center of mass.
Answer as a simplified fraction (or decimal number with 3 sig figs) times R.

3b) Determine moment of inertia of the pendulum about the pivot point. Do <u>not</u> assume the spherical shell is a point mass! **Answer as a simplified fraction (or decimal number with 3 sig figs) times MR^2.

***3c) Determine rotation rate at the bottom of the swing.
Since you have a number for the angle, plug in that number to make it easier for me to grade your work. Answer with an expression involving the other given parameters times a decimal number with 3 sig figs.

3a	
3b	
3c	

One day I was setting up some pulleys to do an experiment.
I ran out of equal size pulleys and had to set up the experiment as shown at right.
Assume the pulleys are both uniform disks with equal density and thickness.
Pulley 1 has twice the radius of pulley 2.
Assume the pulleys have negligible axle friction.
Do not assume the pulleys are massless.
A single massless inextensible string is used to connect two masses labeled $m_3 > m_4$.
The system is released from rest.
The segments of the string are labeled $s_a, s_b, \& \, s_c$ for ease of communication.



4a) After release, which best describes the rotation direction of pulley 1?

$+\hat{\imath}$	$+\hat{\jmath}$	$+\hat{k}$	$-\hat{\imath}$	$-\hat{\jmath}$	$-\hat{k}$	No rotation	Impossible to determine without more info

4b) Which line segment has greatest tension?

s_a	s_b	s_c	All have same tension	None of the other answers is correct	Impossible to determine without more info

4c) Which best relates the *translational* accelerations (magnitudes) of the two blocks.

$a_3 = \frac{a_2}{8}$	$a_3 = \frac{a_4}{4}$	$a_3 = \frac{a_4}{2}$	$a_3 = a_4$	$a_3 = 2a_4$	$a_3 = 4a_4$	$a_3 = 8a_4$	None of the other answers is correct	Impossible to determine without more info

4d) Which best relates the *angular* acceleration (magnitudes) of the pulleys.

$\alpha_1 = \frac{\alpha_2}{8}$	$\alpha_1 = \frac{\alpha_2}{4}$	$\alpha_1 = \frac{\alpha_2}{2}$	$\alpha_1 = \alpha_2$	$\alpha_1 = 2\alpha_2$	$\alpha_1 = 4\alpha_2$	$\alpha_1 = 8\alpha_2$	None of the other answers is correct	Impossible to determine without more info

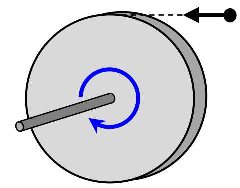
4e) Which best describes the relationship between the pulley masses?

$m_1 = \frac{m_2}{8}$	$m_1 = \frac{m_2}{4}$	$m_1 = \frac{m_2}{2}$	$m_1 = m_2$	$m_1 = 2m_2$	$m_1 = 4m_2$	$m_1 = 8m_2$	None of the other answers is correct	Impossible to determine without more info

4f) Which best describes the relationship between the moments of inertia of the two pulleys?

$I_1 = \frac{I_2}{8}$	$I_1 = \frac{I_2}{4}$	$I_1 = \frac{I_2}{2}$	$I_1 = I_2$	$I_1 = 2I_2$	$I_1 = 4I_2$	$I_1 = 8I_2$	None of the other answers is correct	Impossible to determine without more info

A uniform density, solid disk of radius R rotates with rate ω_0 about the axle shown. To be clear the axle is mounted securely in place by supports not shown in the figure. A point particle with 8 times less mass impacts the edge of the disk and sticks to it. After impact, the disk's rotation rate decreases by 27.5%. Again, to be clear, the axle and disk remain in place during this collision.



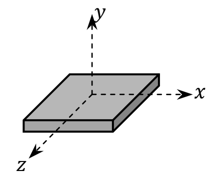
5a) Which quantities are conserved during this collision?

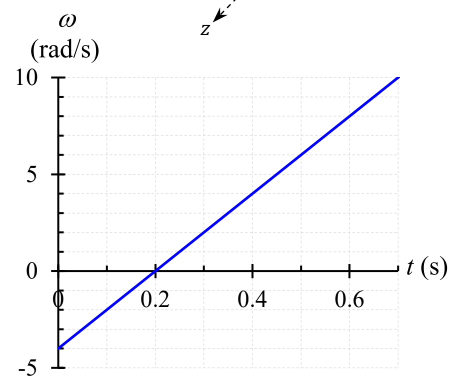
E	$\vec{p}$	$\vec{L}$	*None* of $E, \vec{p}, \& \vec{L}$	*All* of $E, \vec{p}, \& \vec{L}$	Impossible to determine without more info
E & $\vec{p}$	E & $\vec{L}$	$\vec{p}$ & $\vec{L}$			

******5b) Determine *speed* of the point particle *just before impact*. Simplify your work to a decimal number with 3 sig figs times an expression involving R & ω.

5b

A square plate of side length 34.5 cm and mass 678 g is rotated about an axis through its center (see figure at right). The plate rotates in the xz-plane about an axis through its center. The angular velocity of the plate as a function of time for the first 0.700 s of motion is shown at right.





6a) Which *direction* best describes the *initial* angular velocity vector?

$+\hat{\imath}$	$+\hat{\jmath}$	$+\hat{k}$	Impossible to determine without more info
$-\hat{\imath}$	$-\hat{\jmath}$	$-\hat{k}$	

6b) Determine *initial rotation speed* of the plate *in units of* RPM.

**6c) Determine *initial kinetic energy*.

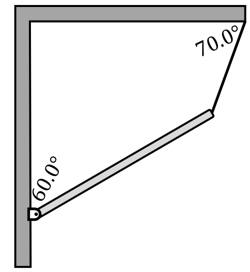
**6d) Determine *torque magnitude* exerted on the plate.

6e) Determine *angular displacement* (in units of *revolutions*) over the entire 0.700 s interval.

**6f) Determine *initial total acceleration* (magnitude) at *a corner* of the plate.

6b	
6c	
6d	
6e	
6f	

A uniform rod is attached to a wall using a frictionless pivot and supported at the other end using a light, inextensible cable (see figure). An engineer wants to support the rod using the angles shown. Cable tension cannot exceed 100.0 N. Rod length is 0.333 m.



***7a) Determine the maximum linear mass density of the rod.

****7b) Determine *magnitude* of the reaction force at the pivot.
Assume cable tension is maxed out at 100.0 N for this part.

7a	
7b	

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