#15

Name: SOLUTION

Seat Assignment: _____

Specify your **EXAM ID** on the right. Use 000 if you do not know your exam ID.

[000]

0 ●	0 ●	0 ●
1 ○	1 ○	1 ○
2 ○	2 ○	2 ○
3 ○	3 ○	3 ○
4 ○	4 ○	4 ○
5 ○	5 ○	5 ○
6 ○	6 ○	6 ○
7 ○	7 ○	7 ○
8 ○	8 ○	8 ○
9 ○	9 ○	9 ○

Circle your **LAB SECTION**

	102	212	216	217	218
8:10	A102 Jackson	A212 Adam	A216 Min	A217 Siavash	A218 Erik
9:40	B102 Jackson	B212 Dhruv	B216 Min	B217 Siavash	B218 Erik
11:10	C102 Savannah	C212 Adam	C216 Will	C217 Siavash	C218 Erik
12:40	D102 Savannah	D212 Min	D216 Will	D217 Teague	D218 Eric
2:10	E102 Savannah	E212 Adam	E216 Dhruv	E217 Teague	E218 Eric
3;40	F102 Jackson	F212 Will	F216 Dhruv	F217 Teague	F218 Eric

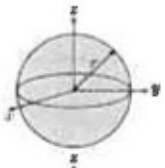
Instructions

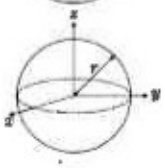
- Sit in your assigned seat.
- Do not open the exam until instructed to do so.
- Completely color in the dot for your chosen answers on multiple choice.
- Do not leave if there is less than 5 minutes to go in the exam.
- When time is called, immediately stop writing, remain seated, and pass your exam to the center aisle.
- Working after time is called results in an automatic deduction.

Guidelines

- Assume 3 significant figures for all given numbers unless otherwise stated
- Show all of your work – no work, no credit
- Write your final answer in the box provided
- Include units for all answers and directions for all vectors

Moment of Inertia:

Solid sphere  $I = \frac{2}{5}mr^2$

Hollow sphere  $I = \frac{2}{3}mr^2$

Solid cylinder  $I_c = \frac{1}{2}mr^2$

Thin-walled hollow cylinder  $I = mr^2$

1. (2 pts) A wheel is rotating in a counter-clockwise direction at a constant angular speed of 40 rev/min. Which of the following is true about the net torque acting on the wheel?

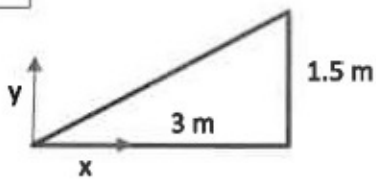
#1 1.2/2 (60%)

orque is zero	Net torque is positive	Net torque is zero
○ 2	○	● 2

2. (2 pts) What is the x coordinate of the center of mass of this object:

#2 1.6/2 (80%)

	1.5 m	2 m	3 m
○	○	● 2	○



3. (2 pts) A figure skater is rotating at 2.5 rev/s with her arms extended. She pulls her arms in and her angular speed increases to 4 rev/s. What quantity is conserved?

#3 1.8/2 (90%)

l kinetic energy	Angular acceleration	Angular momentum
○	○	● 2

4. (2 pts) A 2.0 m diameter wheel starts from rest and speeds up at a constant rate reaching an angular velocity of 10 rev/s in 6 seconds. How many revolutions has it made after 6 seconds?

#4 1.4/2 (70%)

30 rev	60 rev	120 rev
● 2	○	○

5. (2 pts) When a rigid body rotates about a fixed axis, all points on the body have the same:

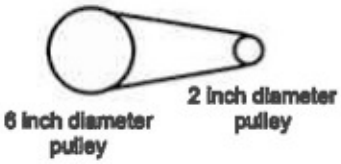
#5 1.4/2 (70%)

ntial speed	Centripetal Acceleration	Angular Acceleration	Linear displacement
○	○	● 2	○

6. (2 pts) The angular velocity of the 6 inch diameter pulley is 2.5 rad/s. What is the angular velocity of the 2 inch diameter pulley?

#6 1.9/2 (95%)

rad/s	7.5 rad/s	16 rad/s
○	● 2	○



7. (2 pts) A wheel starts at rests and speeds up at a constant rate. If it makes 6 revolutions in the first 2 seconds, how many revolutions has it made after 4 seconds?

#7 0.8/2 (40%)

12 rev	18 rev	24 rev
○	○	● 2

8. (2 pts) A solid cylinder and a hollow cylinder roll down identical inclines. Which reaches the bottom first?

#8 1.6/2 (80%)

solid cylinder	The hollow cylinder	They reach the bottom at the same time
● 2	○	○

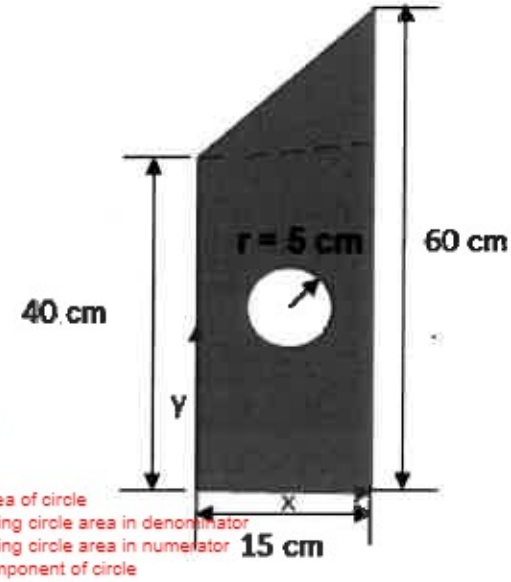
12.2/14 (87.1%)

9. (14 pts) The object shown has a uniform thickness and density. The center of the hole is located at (7.5 cm, 20 cm). Using a coordinate system with the origin at the lower left corner of the object, what is the x coordinate of the center of mass?

8.06cm

Shape	Area	$\bar{x}$	$A\bar{x}$
Rectangle	40(15) = 600	7.5	4500
Triangle	$\frac{1}{2}(15)(20) = 150$	10	1500
Circle	$-\pi(5)^2 = -78.54$	7.5	-589
Total	671.46		5411

$$\bar{x} = \frac{5411}{671.5} = 8.058\ cm$$



-1 math error
-1 units
-1 sig figs
-2 Incorrect area of circle
-2 not subtracting circle area in denominator
-2 not subtracting circle area in numerator
-2 wrong x-component of circle
-2 wrong rectangle area
-2 incorrect area of triangle
-2 wrong x-component of rectangle
-4 not subtracting circle from entire shape
-4 did not include areas in numerator
-4 used x-distances in denominator
-6 Incorrect equation to solve for x-bar
-2 wrong x-coordinate of triangle

#10

12.0/14 (85.7%)

10. (14 pts) A uniform solid ~~disk~~ cylinder (r = 1.60 m and m = 2.30 kg) starts from rest and rolls without slipping to the bottom of an inclined plane. If the angular velocity of the disk is 5.35 rad/s at the bottom, what is the height of the inclined plane?

5.60 m

Conservation of Energy:

$$I = \frac{1}{2}mr^2 = \frac{1}{2}(2.30\,kg)(1.60\,m)^2 = 2.944\ kg\cdot m^2$$

$$v = \omega r = 5.35\ rad/s\ (1.60\,m) = 8.56\ m/s$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$2.30\,kg(9.81\,m/s^2)\,h = \frac{1}{2}(2.30\,kg)(8.56\,m/s)^2 + \frac{1}{2}(2.944\,kg\cdot m^2)(5.35\,rad/s)^2$$

$$22.56h = 84.26\,J + 42.13\,J$$

$$h = 5.602\ m$$

-1 math
-1 units
-1 sig figs
-2 wrong I
-1 wrong w is used
-2 V=r*w
-4 missing linear kinetic energy
-4 missing rotational kinetic energy
-4 final velocity is not zero

#11
10.6/14 (75.7%)

11. (14 pts) A potter's wheel ($I = 64$ slug-ft^2) is spinning at 40 rev/min. The potter drops a lump of clay onto the wheel, where it lands and sticks 1.2 ft from the rotational axis. After this happens, the angular speed of the wheel and clay is 38 rev/min. What is the mass of the clay?

40 rpm = 4.189 rad/s
38 rpm = 3.979 rad/s

2.34 slug

Conservation of Angular Momentum

$$I_1\omega_1 = I_2\omega_2$$

$$64\ \text{slug-ft}^2\left(40\ \tfrac{\text{rev}}{\text{min}}\right) = \left(64\ \text{slug-ft}^2 + m(1.2\ \text{ft})^2\right)38\ \tfrac{\text{rev}}{\text{min}}$$

$$m = 2.339\ \text{slug}$$

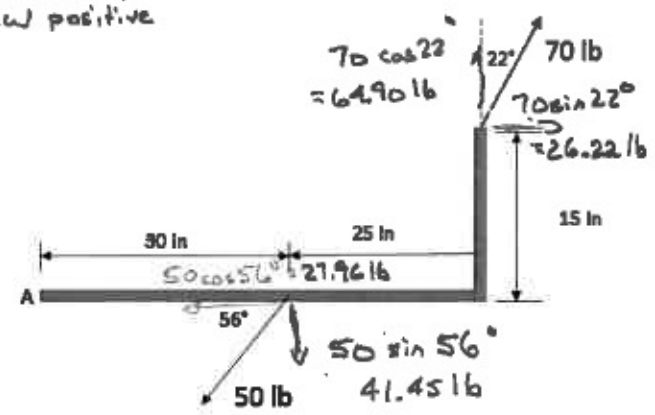
-1 math
-1 units
-1 sig figs
-5 I2 = (Icm + md^2)
-10 COM: Iw = (I + md^2)w'
-1 rounding error
-3 Icm + md^2
-3 +md^2
-5 forgot w
-3 Iw = (Icm + md^2)w'
-1 mixed rad/s and rev/min
-2 wrong d
-3 no mrv term

#12
10.1/14 (72.1%)

12. (14 pts) What is the net torque about point A (~~in-lb-inches~~)?

ccw positive

1933 in-lb



$$-50\text{lb}\sin(56°)(30\text{in}) + 70\text{lb}\cos(22°)(55\text{in}) - 70\text{lb}\sin(22°)(15\text{in})$$

$$-1244 + 3570 - 393$$

$$= 1933\ \text{in-lb}$$

-1 math
-1 units
-1 sig figs
-3 need perp distance
-3 no x-comp for 50 lb
-6 wrong method for T_2
-1 wrong sign
-2 wrong trig function
-4 missing 70 lb x-comp
-4 missing 70 lb y-comp
-2 wrong angle
-1 wrong distance

#13
10.7/14 (76.4%)

13. (14 pts) A force of <68, -32, -18> lbs is applied at point A <7, 0, 12> ft. What is the magnitude of the torque about the point <5, 2, 0>?

953 ft·lb

$\bar{r} = \bar{A} - \bar{O} = (7-5)\hat{i} + (0-2)\hat{j} + (12-0)\hat{k} = \langle 2, -2, 12 \rangle$ ft

$\tau = \bar{r} \times \bar{F}$

$\tau_x = r_y F_z - r_z F_y = -2(-18) - (12)(-32) = 420$ ft·lb

$\tau_y = r_z F_x - r_x F_z = 12(68) - 2(-18) = 852$ ft·lb

$\tau_z = r_x F_y - r_y F_x = 2(-32) - (-2)(68) = 72$ ft·lb

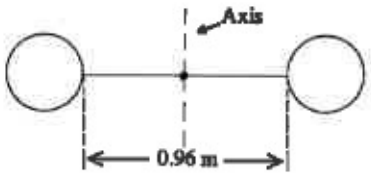
$|\bar{\tau}| = \sqrt{(420)^2 + (852)^2 + (72)^2} = 952.6$ ft·lb

-1 math
-1 units
-1 sig figs
-10 incorrect work
-7 incorrect r vector
-3 added components
-3 switched points for r vector
-2 incorrect torque i
-2 incorrect torque j
-2 incorrect torque k
-1 sign
-2 rxF
-2 incorrect torque magnitude
-7 incorrect cross product
+4 Found correct r vector

#14
9.9/14 (70.7%)

14. (14 pts) A barbell consists of 2 identical solid spheres each with a radius of 0.17 m and a mass of 50 kg. The two spheres are connected by a 0.96 m long uniform steel rod with a mass of 12 kg. What is the moment of inertia of the barbell about an axis through the center?

44.3 kg·m²



$I = I_{s,cm} + m_s d^2 + I_{r,cm}$

$= 2\left[\frac{2}{5}(50\text{kg})(0.17\text{m})^2 + 50\text{kg}\left(\frac{0.96\text{m}}{2} + 0.17\text{m}\right)^2\right] + \frac{1}{12}(12\text{kg})(0.96\text{m})^2$ (0.65 m)

$= 2\left[0.578\ \text{kg·m}^2 + 21.125\ \text{kg·m}^2\right] + 0.922\ \text{kg·m}^2$

$= 44.328\ \text{kg·m}^2$

-1 math
-1 units
-1 sig figs
-2 wrong I eqn
-2 didn't consider both spheres
-2 wrong length
-2 squared mass
-2 wrong mass
-2 wrong d
-2 length not squared
-4 Wrong Icm of sphere
-4 no Icm of sphere
-4 no md^2
-4 MMI's don't cancel
-4 wrong md^2
-4 no Irod
-4 L is length, not ang momentum
-4 incomplete
+4 for finding some I
+2 attempt