AP Physics Fall 2013
Test 10

Name: Key

Fill in the Blank	________	27 pts
Problem 10	________	20 pts
Problem 11	________	8 pts
Problem 12	________	12 pts
Problem 13	________	6 pts
Problem 14	________	7 pts
Problem 15	________	20 pts
Bonus	________	18 pts
Total	________	

Also Accept

Name: ______________________________

1. The rotational analog of force is torque ______________ or τ

2. The rotational analog of mass is Moment of inertia ______________ or I

3. The rotational analog of velocity is angular velocity ______________ or ω

4. The rotational analog of linear momentum is angular momentum or L

5. The rotational analog of time is time ______________ or t

6. The area under an angular acceleration-time graph gives the ______________

Change in angular velocity ______________ or $\Delta\omega$

7. The slope of the tangent line on an angular position-time graph gives the

angular velocity ______________ or ω

8. The slope of the tangent line on an angular velocity-time graph gives the

angular acceleration ______________ or α

9. The area under an angular velocity-time graph gives the ______________

angular displacement ______________ or $\Delta\theta$

Also accept: "Change in angular position"

Name: ____

20 pts **10.** A uniform wheel of mass 1.5 kg and radius of 0.34 m starts from rest and rotates with a constant angular acceleration of 6.4 rad/s^2.

5 pts **A.** What is the angular displacement of the wheel from t = 0 s to 3.0 s?

+2 $\theta = \cancel{\theta_0}^{0} + \cancel{\omega_0 t}^{0} + \frac{1}{2}\alpha t^2$

$\theta = \frac{1}{2}(6.4 rad/s^2)(3s)^2$

$\theta = \boxed{28.8 rad}$ +2 # / +1 units

$\theta_0 = 0 rad/s$
$\theta = ?$
$\omega_0 = 0 rad/s$
$\omega = ?$
$\alpha = 6.4 rad/s^2$
$t = 3s$

5 pts **B.** What is the wheel's angular velocity at t = 3 s?

+2 $\omega = \cancel{\omega_0}^{0} + \alpha t$

$\omega = (6.4 rad/s^2)(3s)$

$\omega = \boxed{19.2 rad/s}$ +2 # / +1 units

Name: ______________________________

5 pts **C.** What is the wheel's moment of inertia?

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

$I = \frac{1}{2}(1.5\,kg)(0.34\,m)^2$

$I = \boxed{0.0867\ kgm^2}$ — +2 # — +1 units

5 pts **D.** What is the net torque being applied to the wheel?

+2 $\Sigma \tau = I \alpha$

$\Sigma \tau \cong (0.0867\ kgm^2)(6.4\ rad/s^2)$

$\Sigma \tau \cong \boxed{0.555\ N \cdot m}$ — +2 # — +1 units

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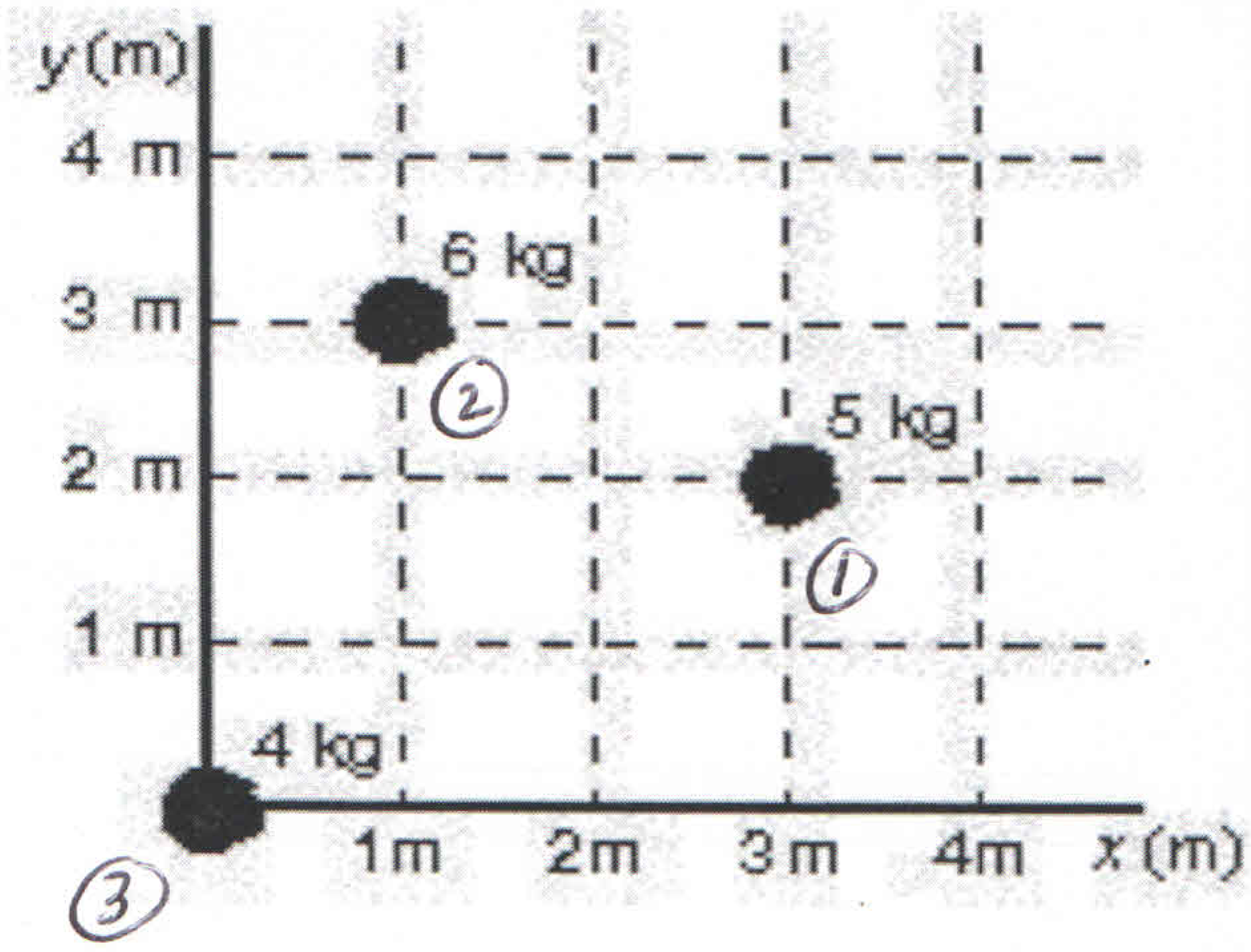
8 pts **11.** Find the Moment of Inertia about an axis perpendicular to the page at the origin for the three particle system shown below:



+3 $I = m_1 r_1^2 + m_2 r_2^2 + m_3 \cancel{r_3^2}^{\,0}$

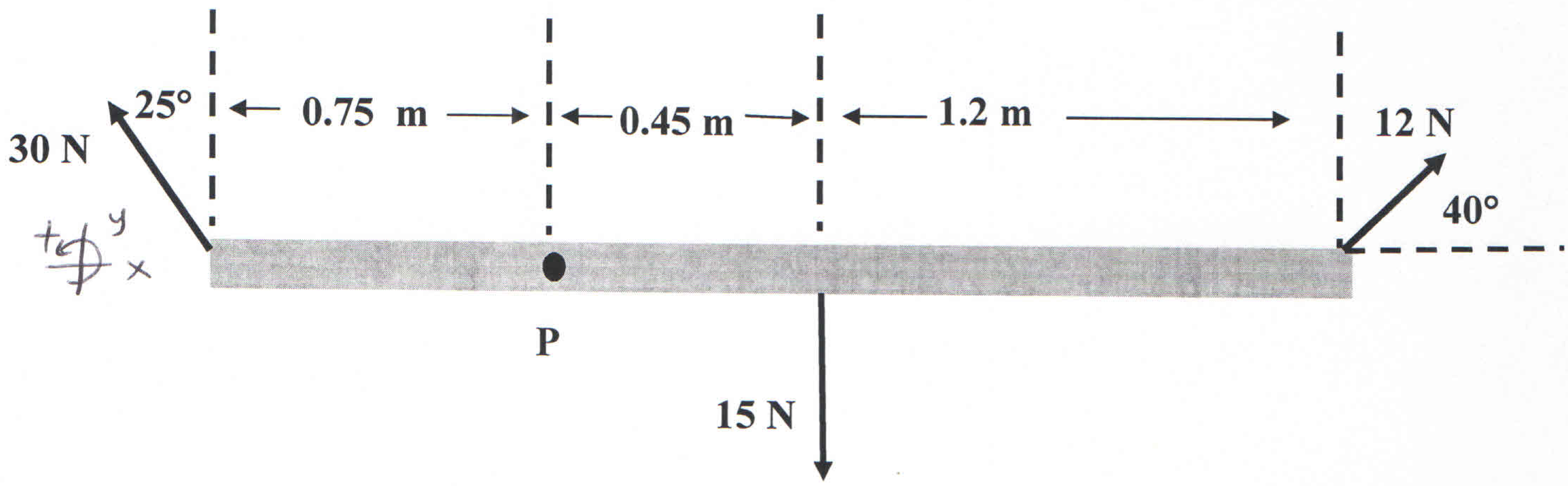
$I = (5\,kg)[(3m)^2 + (2m)^2] + (6\,kg)[(1m)^2 + (3m)^2]$

$I = (5\,kg)(13\,m^2) + (6\,kg)(10\,m^2)$
+1 +1

$I = \boxed{125\,kg\,m^2}$ — +2 #
— +1 units

Name: ____

12 pts **12.** Calculate the magnitude of the net torque on the bar shown below for an axis of rotation coming out of the page at point P :



(+3) $\tau = r F_{\perp}$

$\tau = -\overset{+1}{(0.75m)}\overset{+1}{(30N)\cos(25)} - \overset{+1}{(15N)}\overset{+1}{(0.45m)} + \overset{+1}{(1.65m)}\overset{+1}{(12N)\sin(40)}$

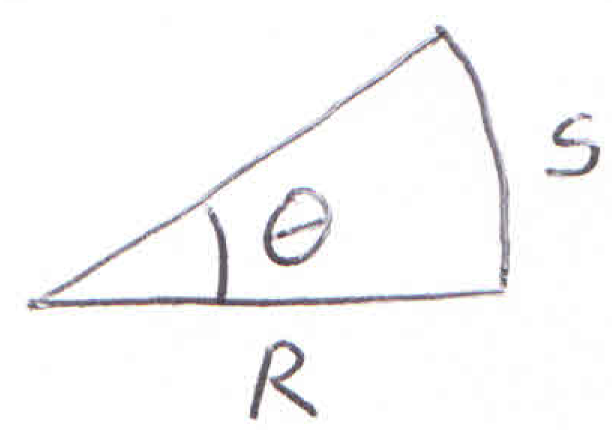
$\tau \cong -20.4\,Nm - 6.8\,Nm + 12.7\,Nm$

$\tau \cong -14.5\,Nm$

$|\tau| \cong \boxed{14.5\,Nm}$ (+2) # (+1) units

Name: ____

6 pts **13.** A child rolls a ball of mass 0.75 kg on a level floor 3.5 m to another child. If the ball makes 23.0 revolutions, what is its radius?



+2 $S = R\theta$

+1 $R = \dfrac{S}{\theta}$

$\theta = (23 \text{ rev})\left(\dfrac{2\pi \text{ rad}}{1 \text{ rev}}\right) \cong 46\pi \text{ rad} \cong 145 \text{ rad}$ +1

either

$R \cong \dfrac{3.5 \text{m}}{46\pi \text{ rad}} \cong \boxed{0.0242 \text{m}}$ or 2.42cm

+1 # +1 units

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7 pts **14.** A cooling fan is turned off when it is running at 23.5 rev/s. It turns 1520 revolutions before it comes to a stop. What was the fan's angular acceleration assuming the angular acceleration was constant?

$$\Delta\theta = (1520\ \text{rev})\left(\frac{2\pi\ \text{rad}}{1\ \text{rev}}\right) \cong 3040\pi\ \text{rad} \cong 9{,}550\ \text{rad}$$

either (+1)

$$\omega_0 = \left(23.5\ \frac{\text{rev}}{\text{s}}\right)\left(\frac{2\pi\ \text{rad}}{1\ \text{rev}}\right) \cong 47\pi\ \frac{\text{rad}}{\text{s}} \cong 148\ \text{rad/s}$$

either (+1)

$\omega = 0$ rad/s

$\alpha = ?$

$t = ?$

(+2) $$\cancel{\omega^2}^{\,0} = \omega_0^2 + 2\alpha\Delta\theta$$

$$2\alpha\Delta\theta = -\omega_0^2$$

(+1) $$\alpha = -\frac{\omega_0^2}{2\Delta\theta}$$

$$\alpha \cong -\frac{(47\pi\ \text{rad/s})^2}{2(3040\pi\ \text{rad})} \cong \boxed{-1.14\ \text{rad/s}^2}$$

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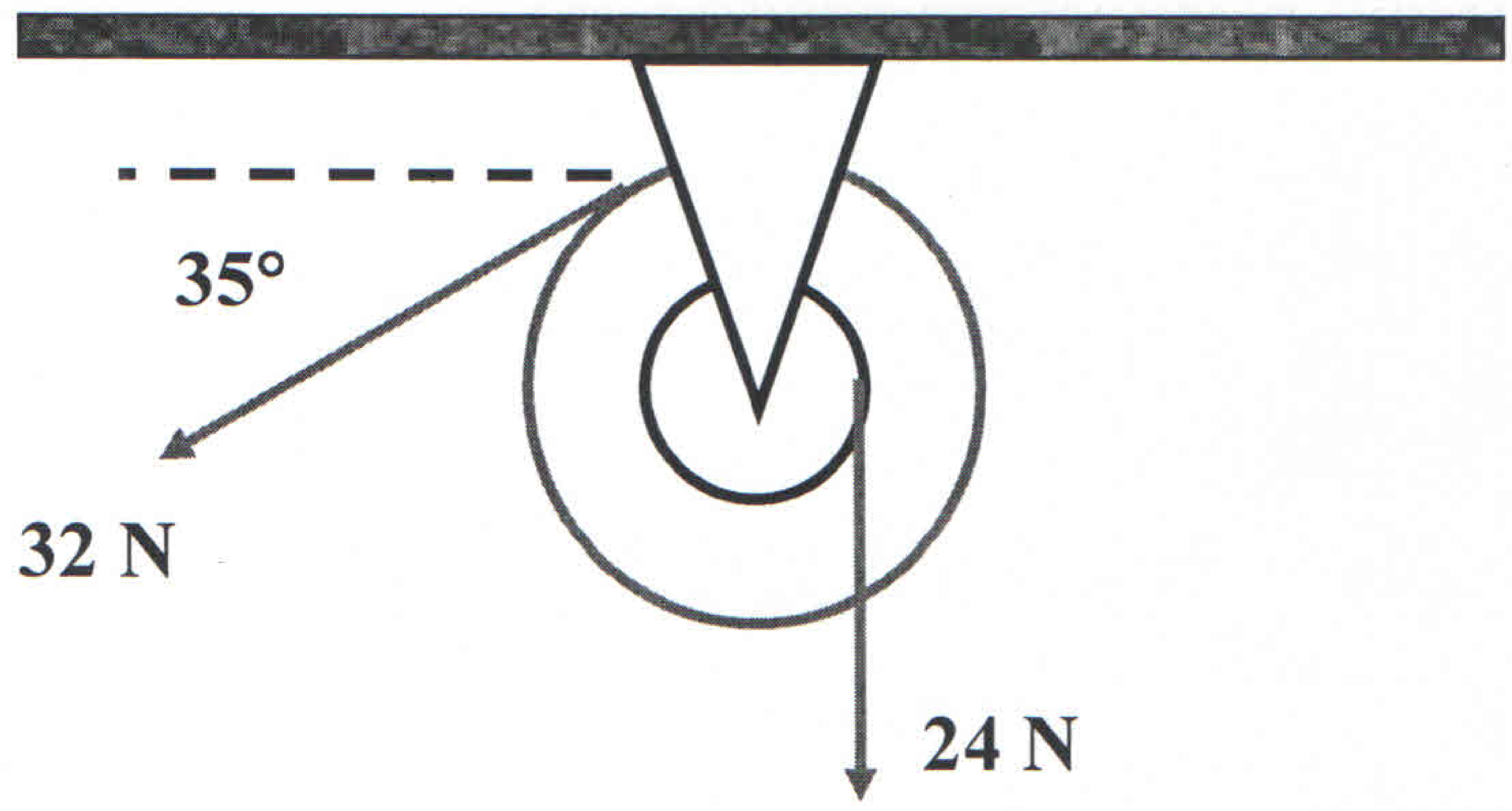
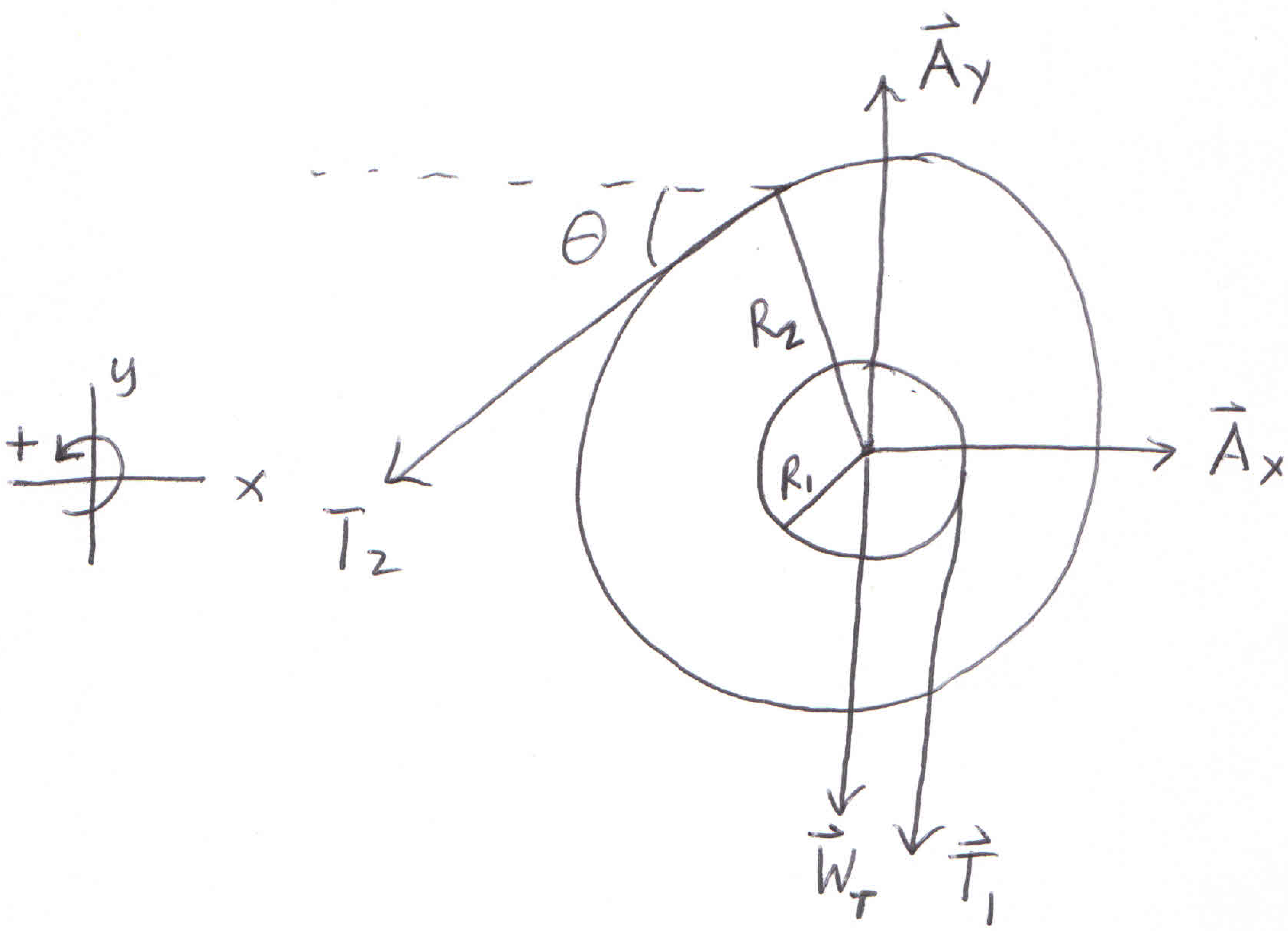
20 pts **15.** A compound pulley is created by wielding a pulley with a radius of 2 m and mass 0.85 kg to a second pulley with a radius of 4 m and mass of 3.2 kg. The compound pulley is attached to the ceiling by a bracket with an axle through its center and two ropes are attached to the compound pulley as shown.



6 pts **A.** Draw a proper Free Body Diagram of the compound pulley.



5 forces @ +½ each = +2.5
3 angles+dimensions @ ½ = +1.5
Body is Isolated = +1
1 Axis with Rotation = +1

If the Student drew two weight vectors, this is ok.

6 pts **B.** Find the magnitude of the torque on the pulley about the center axis.

$$+2 \quad \Sigma\tau_c = -T_1 R_1 + T_2 R_2$$

$$+2 \quad \Sigma\tau_c = -(24N)(2m) + (32N)(4m)$$

$$\Sigma\tau_c = \boxed{80Nm} \quad +1 \text{ units} \quad +1 \ \#$$

8 pts **C.** What is the magnitude of the force applied by the axle?

+1 Applied Newton II

$$\Sigma F_x = m\cancel{a_x}^{0} = 0 \qquad \Sigma F_y = m\cancel{a_y}^{0} = 0$$

$$A_x - T_2 \cos\theta = 0 \qquad A_y - W_T - T_1 - T_2 \sin\theta = 0$$

$$+1 \quad A_x = T_2 \cos\theta \qquad +1 \quad A_y = mg + T_1 + T_2 \sin\theta$$

$$A_x = (32N)\cos(35°) \qquad A_y = (0.85kg + 3.2kg)(9.8m/s^2) + 24N + 32N\sin(35°)$$

$$+1 \quad A_x \cong 26.2N \qquad +1 \quad A_y \cong 82.0N$$

$$+1 \quad A = \sqrt{A_x^2 + A_y^2}$$

$$A \cong \sqrt{(26.2N)^2 + (82.0N)^2} \cong \boxed{86.1N} \quad +1 \text{ units} \quad +1 \ \#$$

Name: ___________________________________

BONUS PROBLEMS

8 pts **1.** After performing an experiment on a rotating object, you find that your data plotted on an angular position-time graph gives a parabola with the following fit where angular position is measured in radians and time in seconds. (2pts each)

$$\theta = At^2 + Bt + C$$
$$A = 4.31 \pm 0.03$$
$$B = 2.53 \pm 0.01$$
$$C = -4.23 \pm 0.04$$

A. Circle the type of motion that best describes this experiment:

1. Stationary Object
2. Constant Angular Velocity
3. Constant Angular Acceleration
4. Variable Angular Acceleration

B. What is the object's initial angular position?

$\theta_0 = \boxed{-4.23 \text{ rad}}$ (+1) units (+1) #

C. What is the object's initial angular velocity?

$\omega_0 = \boxed{2.53 \text{ rad/s}}$ (+1) units (+1) #

D. What is the object's angular acceleration at t = 1s?

$\alpha = 2A = \boxed{8.62 \text{ rad/s}^2}$ (+1) units (+1) #

Name: ____________________

6 pts **2.** A toy train is going around a circular track of radius 2.5 m. At a specific moment it has an angular acceleration of 1.3 rad/s^2 and an angular velocity of 0.75 rad/s.

2pts **A.** What is the train's tangential acceleration?

$$a_t = \alpha r = (1.3\,\text{rad/s}^2)(2.5\,\text{m}) \cong \boxed{3.25\,\text{m/s}^2}$$

+1 +1

2pts **B.** What is the train's centripetal acceleration?

$$a_c = \omega^2 r = (0.75\,\text{rad/s})^2(2.5\,\text{m}) \cong \boxed{1.41\,\text{m/s}^2}$$

+1 +1

2 pts **C.** What is the train's total acceleration?

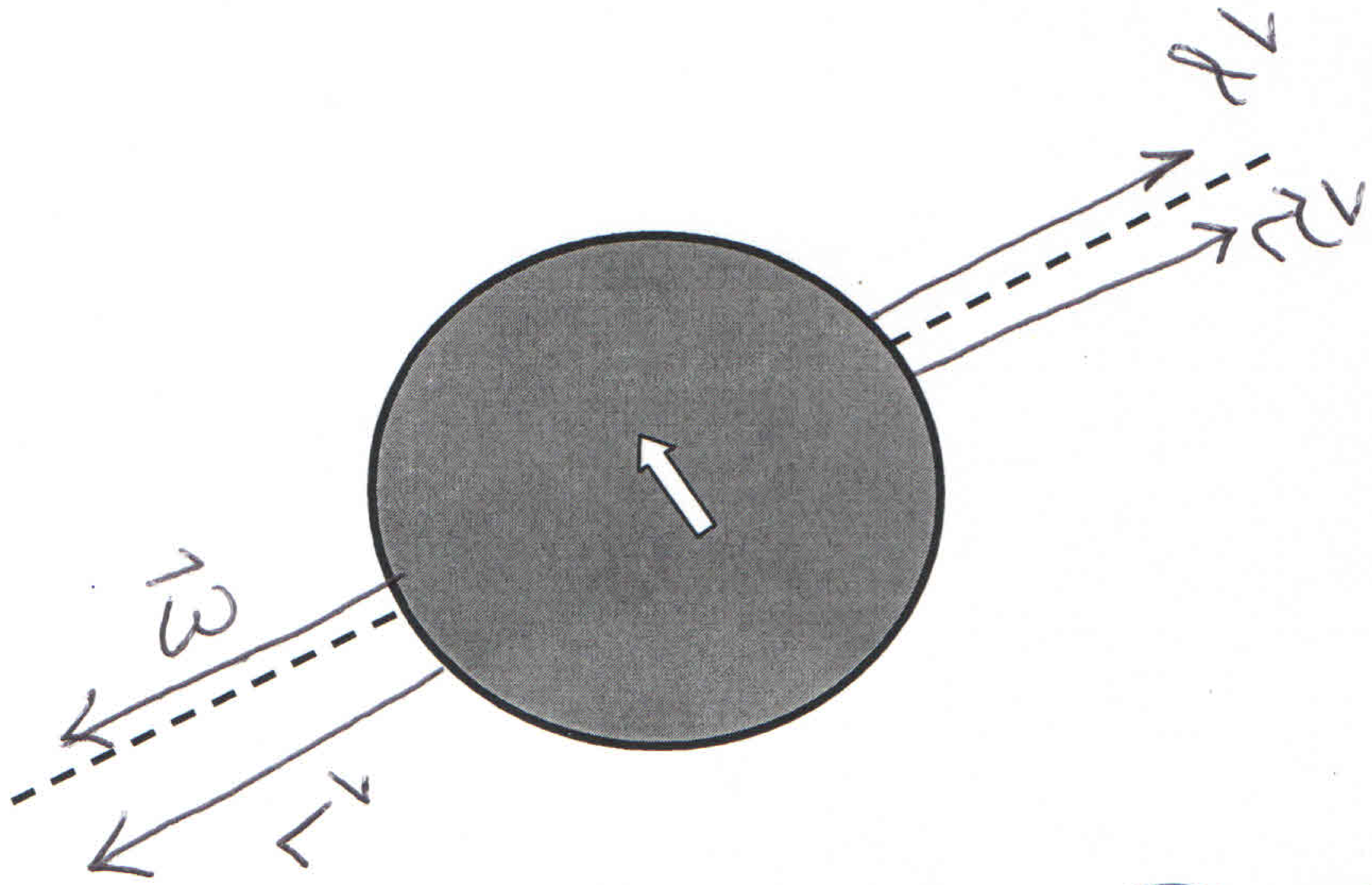
+1 $$a = \sqrt{a_t^2 + a_c^2}$$

$$a \cong \sqrt{(3.25\,\text{m/s}^2)^2 + (1.41\,\text{m/s}^2)^2}$$

+1 $$a \cong \boxed{3.54\,\text{m/s}^2}$$

Name: ____

4 pts **3.** A neutron star is spinning on a tilted axis with a direction of spin as shown below. Assuming that the rotation of the neutron star is decreasing, draw arrows on the diagram showing the direction of the **a)** angular velocity, **b)** angular acceleration, **c)** torque, and **d)** angular momentum vectors. Label each vector.



By Right Hand Rule – ω

$L = I\omega$ α's direction is opposite ω as it is slowing down

$\tau = I\alpha$