Announcements:

- Lab due Tuesday (no exceptions)
- Retakes for energy test by Friday 2/28 (1/2 of points)
- Proficiency proposals due by Friday 2/28 (GO BACK & LOOK AT PRIOR PROPOSAL GUIDELINES)

★ QUIZ THURSDAY → Rotational Kinematics

Mass is the characteristic of an object that resists acceleration; if a net force is applied, an object accelerates:

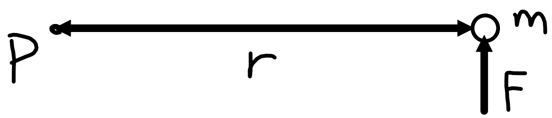
$$\Sigma F = ma$$

The larger the mass, the smaller the acceleration will be.

The larger the mass, the more resistance the object has to being accelerated.

What characteristic of an object resists the angular acceleration that an applied torque attempts to impart to the object?

Consider a mass *m* constrained to remain *r* meters away from a center of rotation at point P.



If F is applied at *m*, *m* will accelerate upward.

$$\Sigma F = m a_t$$
$$F = m a_t$$

m experiences α about the axis of rotation at P

$$a_t = \alpha r$$
$$\therefore F = m a_t = m(\alpha r) = m r \alpha$$
$$\therefore F = m r \alpha$$

Forces must exert torques if there is to be rotation.

$$\tau = F \cdot r$$
$$= (m r \alpha) r$$
$$\tau = m r^2 \alpha$$

"Fixed point mass"

$\Sigma \tau = (m r^2)\alpha$ Generalized for a sum of applied torques.

$m_1 r_1^2 + m_2 r_2^2 + \cdots$

$\boxed{\Sigma \tau = I\alpha}$ Here we define a new quantity -- I

Moment of Inertia

Newton's 2nd Law

$$\Sigma \tau = I \alpha$$ For rotating systems

$$\Sigma F = m a$$ For translating (linear) systems

Resulting acceleraton

Resistance to Acceleration

Net / Total Applied Force/Torque

MOMENT OF INERTIA

$$\Sigma \tau = I \alpha$$

I = MOMENT OF INERTIA

I IS DEPENDENT UPON:

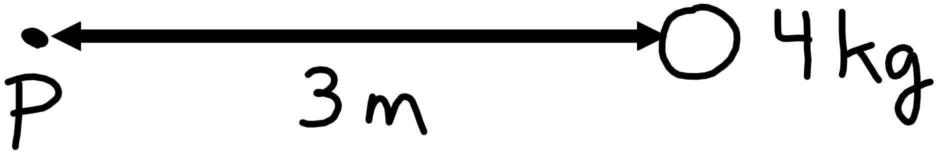
- THE OBJECT
- THE LOCATION OF THE AXIS OF ROTATION

UNITS OF I:

$kg \cdot m^2$ OR $slug \cdot ft^2$

$$I_{\text{POINT MASS}} = mr^2$$

Calculate the moment of inertia for this system if the axis of rotation is through P:

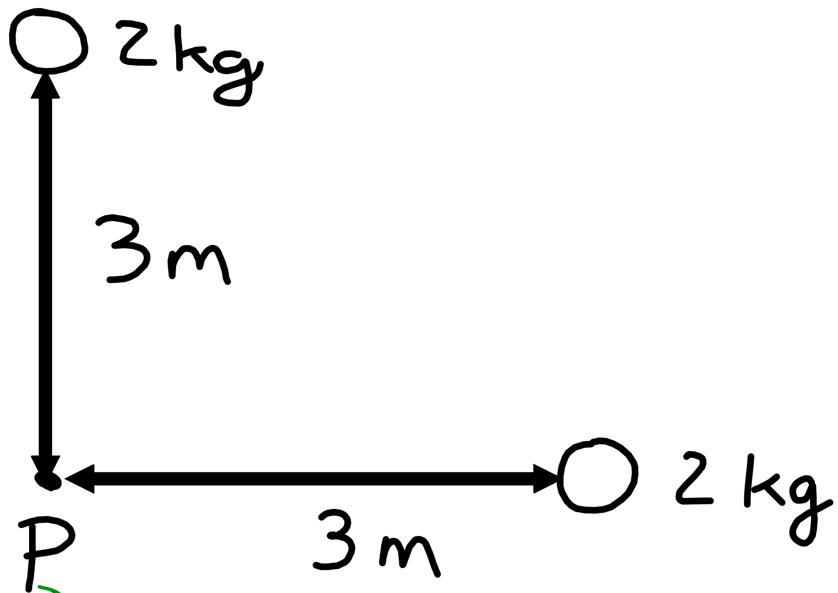


$$I = mr^2 = 4(3)^2 = 36 \text{ kg}\cdot\text{m}^2$$

Calculate the moment of inertia for this system if the axis of rotation is through P:

$$I = mr^2$$
$$= 4(3)^2 = \boxed{36\ \text{kg}\cdot\text{m}^2}$$

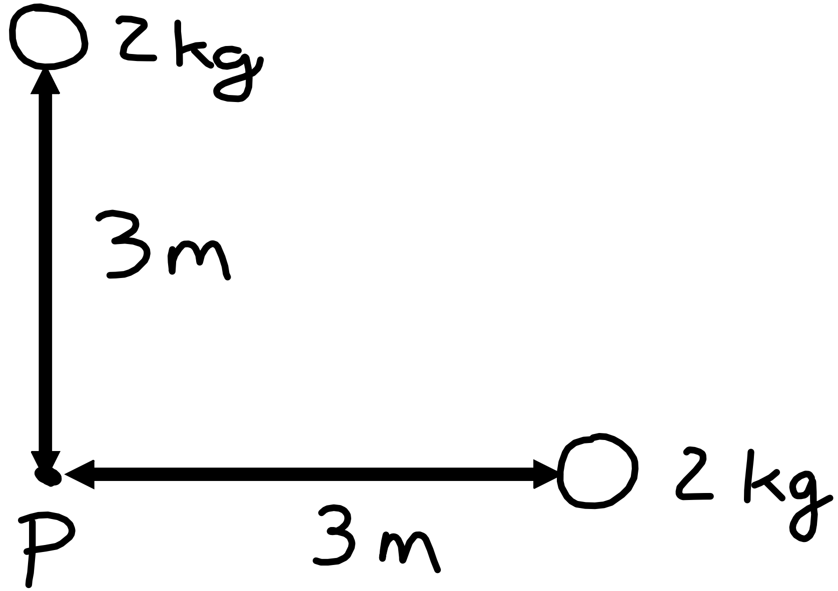
Calculate the moment of inertia for this system if the axis of rotation is through P:



$$I = m_1 r_1^2 + m_2 r_2^2$$

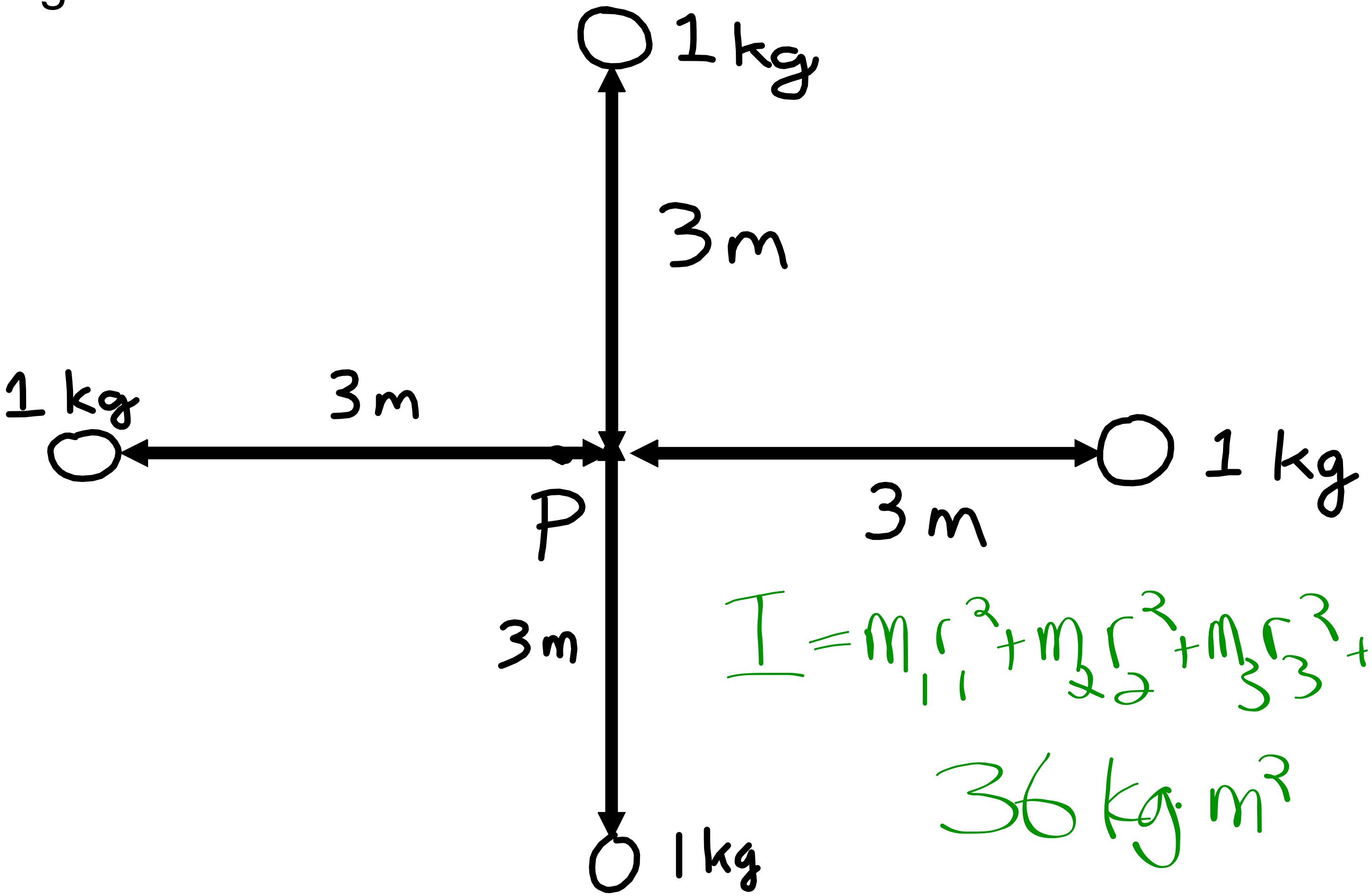
$$2(3)^2 + 2(3)^2 = 36\ \text{kg} \cdot \text{m}^2$$

Calculate the moment of inertia for this system if the axis of rotation is through P:



$$I_{TOTAL} = I_1 + I_2$$
$$= m_1 r_1^2 + m_2 r_2^2$$
$$= 2(3)^2 + 2(3)^2 = \boxed{36\ kg \cdot m^2}$$

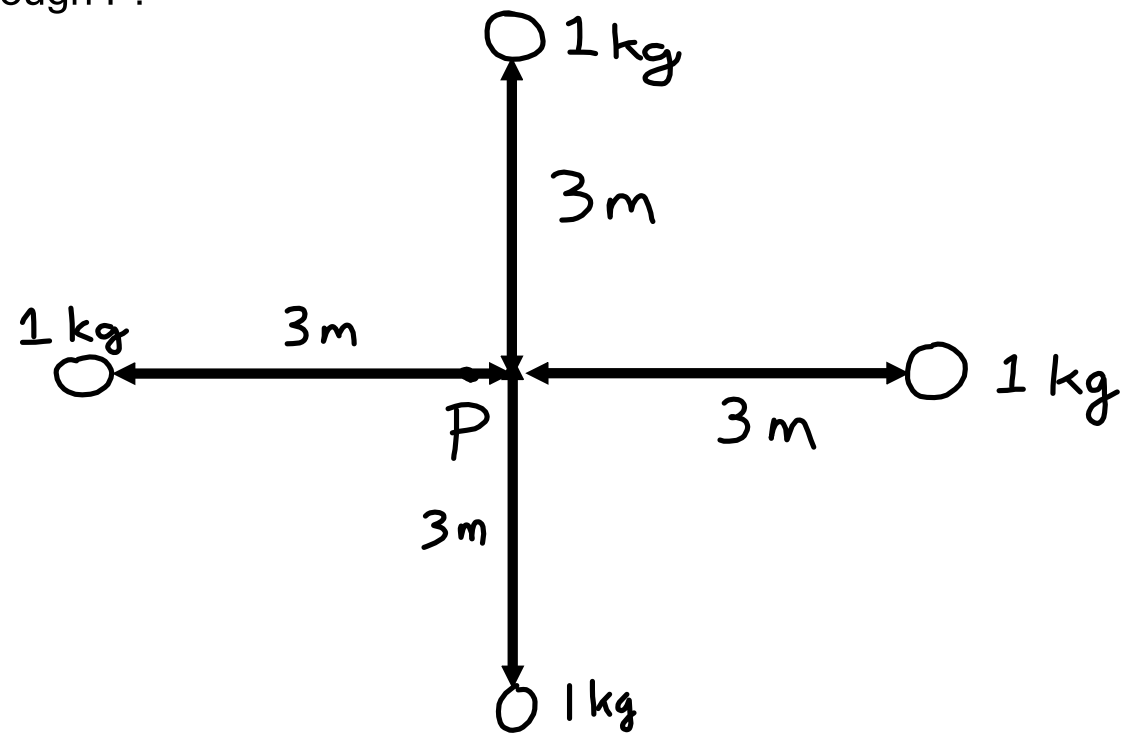
Calculate the moment of inertia for this system if the axis of rotation is through P:



$$I = m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + m_4 r_4^2$$

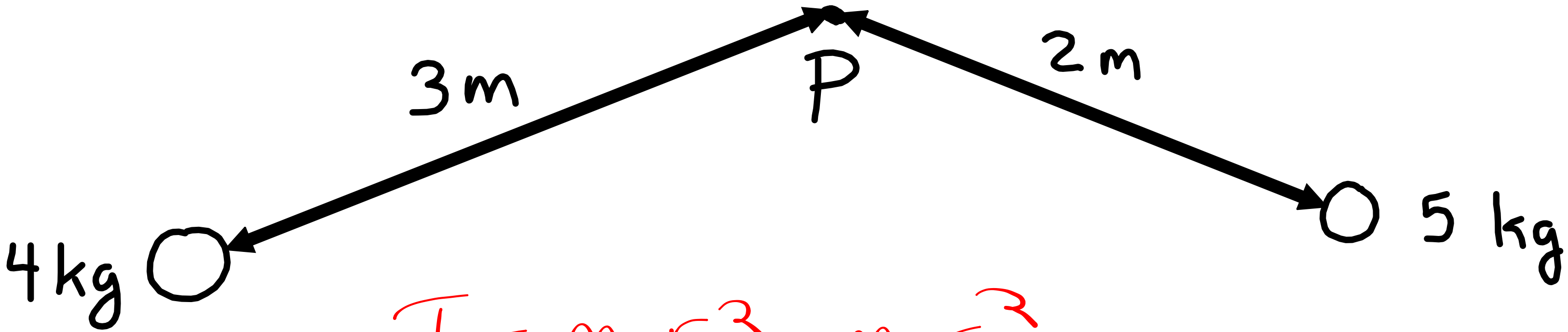
$36 \text{ kg} \cdot \text{m}^2$

Calculate the moment of inertia for this system if the axis of rotation is through P:



$$I_{TOTAL} = I_1 + I_2 + I_3 + I_4$$
$$= m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + m_4 r_4^2$$
$$= (1)(3)^2 + (1)(3)^2 + (1)(3)^2 + (1)(3)^2$$
$$= \boxed{36\ kg \cdot m^2}$$

Calculate the moment of inertia for this system if the axis of rotation is through P:

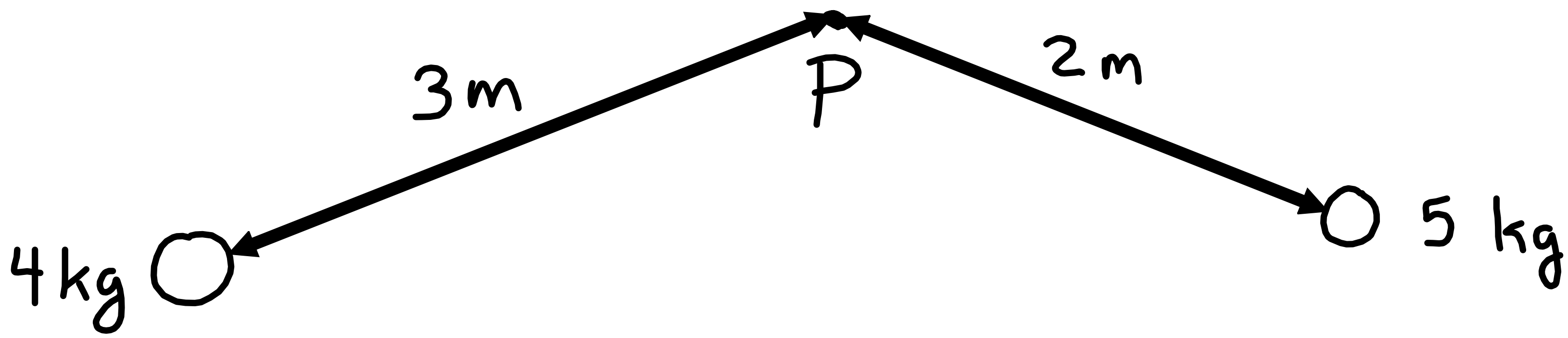


$$I = m_1 r_1^2 + m_2 r_2^2$$

$$5 \cdot 2^2$$

$$36 + 20 = 56\ kg \cdot m^2$$

Calculate the moment of inertia for this system if the axis of rotation is through P:



$$I_{TOTAL} = I_1 + I_2$$
$$= m_1 r_1^2 + m_2 r_2^2$$
$$= 5(2)^2 + 4(3)^2 = \boxed{56 \text{ kg}\cdot\text{m}^2}$$

IN SUMMARY:

$\mathbf{I}_{system}$ = the sum of all of the $\mathbf{I}$'s of all of the parts

$\mathbf{I}$ depends upon not just mass, but its distance from the axis of rotation

$\mathbf{I}$ depends upon the location of the axis of rotation

$\mathbf{I}$ is object dependent

$\mathbf{I}_{point\ mass} = mr^2$

$\mathbf{I}_{hoop} = mr^2$ (rotating about its center like a wheel)

$\mathbf{I}_{disk} = 1/2mr^2$ (rotating about its center like a wheel)

The moments of inertias you will need to know; all others will be provided, or you will solve for.

Many objects enjoy symmetry and uniformity and as a result, there moments of inertias can be expressed in terms of their masses, radii, lengths, and other basic parameters.

Note: you always must pay attention to where the axis of rotation is! These relations always apply to a specific location for the axis of rotation!

This link will take you to a table of moments of inertias for various objects:

http://www.livephysics.com/physical-constants/mechanics-pc/moment-inertia-uniform-objects/

So what do you do to determine the moment of inertia of an object that isn't "nice" (i.e. one that doesn't enjoy symmetry or uniformity and therefore doesn't have a simple equation for its moment of inertia?)

So what do you do to determine the moment of inertia of an object that isn't "nice" (i.e. one that doesn't enjoy symmetry or uniformity and therefore doesn't have a simple equation for its moment of inertia?)

FIND I EXPERIMENTALLY!

$$\Sigma\tau = I\alpha$$

1 APPLY A KNOWN TORQUE

2 MEASURE THE RESULTING α

3 SOLVE FOR I!