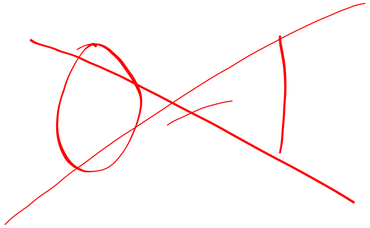
$\mu \rightarrow$?



What does it mean if $\mu > 1$?

What do really big values of μ mean?

a_{net}, a_c, a_t

↳ mathematical + conceptual relationship

↳ what is weird about the lab #'s and what does that mean

↳ Distance of rotating object to center of rotation? How do these #'s relate to <u>FORCES</u>?

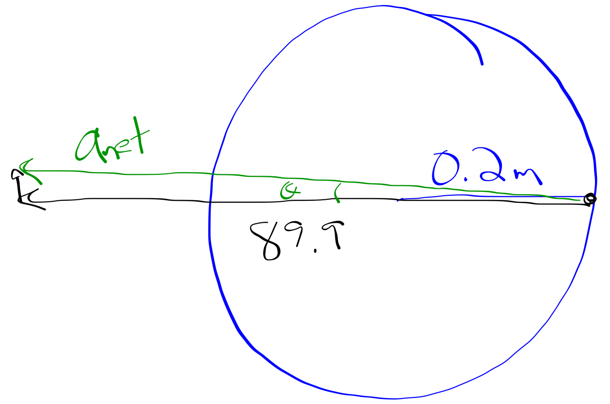
14. A 40-cm diameter wheel accelerates uniformly from 80 rpm to 300 rpm in 3.6 seconds. Assume the axis of rotation is fixed and the wheel is just spinning. Determine $8.37 \, rad/s$ $31.4 \, rad/s$

   a) its angular acceleration.

   b) the radial and tangential components of the linear acceleration of a point on the edge of the wheel 2.0 seconds after it started accelerating. (Hint: what acceleration have we talked about that points into the center of circular motion? What acceleration have you learned about that is always tangent to the object's circular path?)

a) $\omega = \omega_0 + \alpha t$

$\alpha = 6.4 \, rad/s^2$



b) $\omega = \omega_0 + \alpha t$

$\omega = 8.37 + (6.4)(2)$

$\omega = 21.2 \, rad/s$

$a_t = \alpha \cdot r = (6.4)(0.2) = 1.28 \, m/s^2$

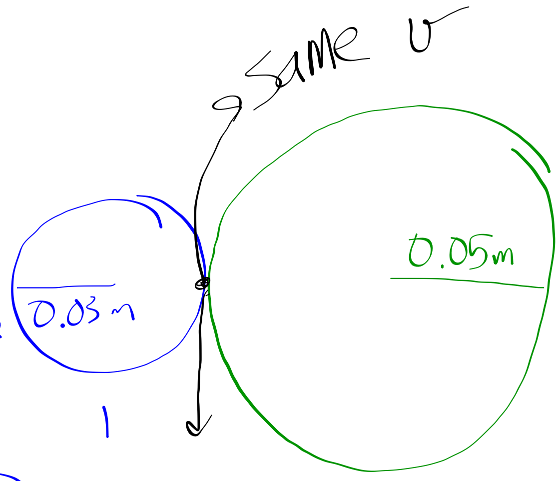
"a_r" $= a_c = \omega^2 \cdot r = (21.2)^2 \cdot 0.2 = 89.9 \, m/s^2$

18. Two rubber wheels are mounted next to one another so their circular edges touch. The first wheel, of radius $R_1 = 3.0$ cm, accelerates at a rate 0.88 rad/s^2 and drives the second wheel, of radius $R_2 = 5.0$ cm, by contact (without slipping).

a) Starting from rest, how long does it take the second wheel to reach an angular speed of 33 rpm?

b) What was the angular acceleration of the second wheel?

$\alpha_1 = 0.88 \, \text{rad/s}^2$



$3.45 \, \text{rad/s}$

$v_1 (\text{edge}) = v_2 (\text{edge})$

$a_t = a_t$

$\theta_0 = 0$

$\theta =$

$\omega_0 = 0$

$\omega =$

$\alpha = 0.88$; $a_t = \alpha \cdot r = 0.0264$

$t = 6.53 \, s$

$\theta_0 = 0$

$\theta =$

$\omega_0 = 0$

$\omega = 3.45 \, \text{rad/s}$

$\alpha = \frac{a_t}{r} = 0.528$ $a_t = 0.0264$

$t = 6.53 s$

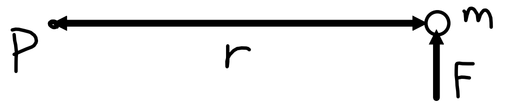
Mass is the characteristic of an object that resists acceleration; if a net force is applied, an object accelerates:

$$\Sigma F = ma$$

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

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

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.

$$\Sigma F = ma$$
$$F = ma$$

m experiences α about the axis of rotation at P

$$a = \alpha r$$
$$\therefore F = ma = m(\alpha r) = mr\alpha$$
$$\therefore F = mr\alpha$$

Forces must exert torques if there is to be rotation.

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

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

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

Newton's 2nd Law (rotating)

sum of torques

"Moment of inertia"

angular acceleration

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 — DISTRIBUTION OF MASS
- THE LOCATION OF THE AXIS OF ROTATION

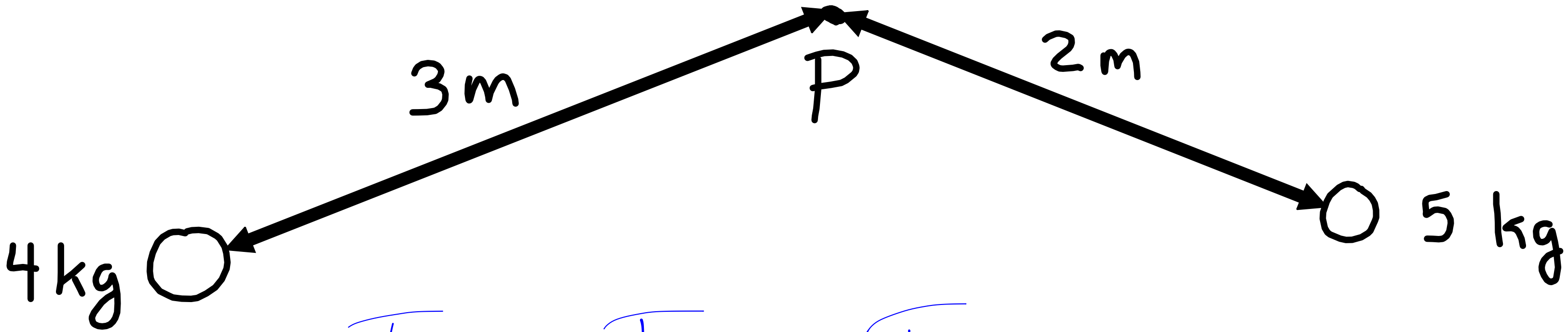
UNITS OF I:

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

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

(sum for multiple points)

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



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

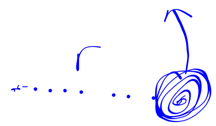
IN SUMMARY:

$\mathbf{I}_{system}$ = 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

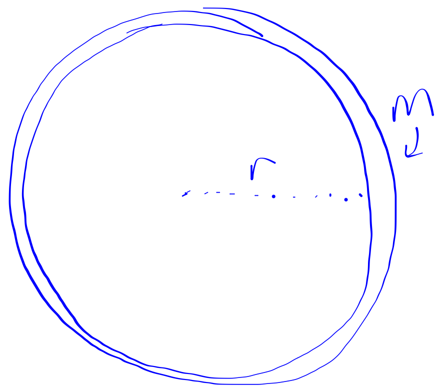


$\mathbf{I}_{point\ mass} = mr^2$

$\mathbf{I}_{hoop} = mr^2$ (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?)

measure

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

measure

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

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!