Rotational Motion Review

- Write the rotational counterpart to each linear variable

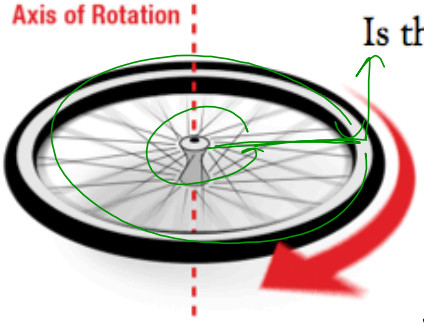
Linear	Angular	Angular Unit
x or y	θ	rad
v	ω	rad/s
a	α	rad/s^2

* Kinematics

$V = V_0 + at$

$X = X_0 + V_0 t + \frac{1}{2} a t^2$

Rotational Motion Review



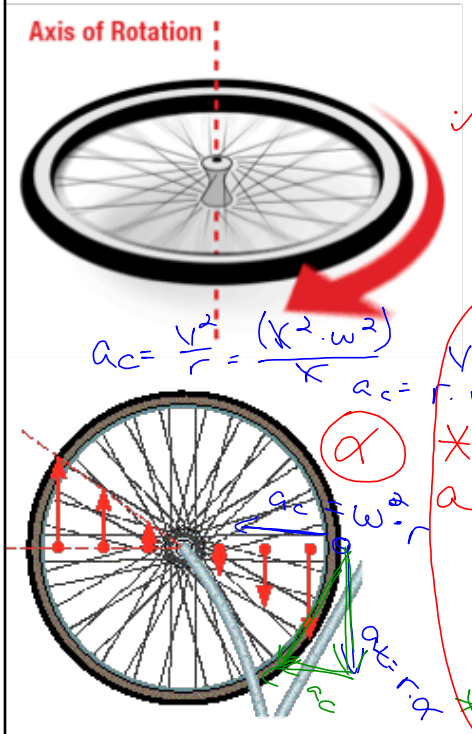
Is the wheel rotating in a positive or negative direction?

What variables are the same for all points on the wheel? Which are different? Why?

$V_t = r \cdot \omega$

$a_t = r \cdot \alpha$

Rotational Motion Review



What variables are the same for all points on the wheel? Which are different? Why?

$a_c = \frac{v^2}{r} = \frac{(r^2 \cdot \omega^2)}{r}$ $v = r \cdot \omega$ $a_c = r \cdot \omega^2$

α

$a_c = \omega^2 \cdot r$

$a_t = r \cdot \alpha$

a

a_t a_c

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

total linear acceleration

What are the two different kinds of acceleration on the wheel? How do they work together?

$\frac{330 \text{ rev}}{1 \text{ min}} \left| \frac{2\pi \text{ rad}}{1 \text{ rev}} \right| \frac{1 \text{ min}}{60 \text{ s}} = 34.56 \frac{\text{rad}}{\text{s}}$

An object is rotating at 330 rpms. What is this object's angular velocity? ω

Formula Recap

Angular Variables

Angular displacement θ

Arc Length Formula $\theta = \frac{l}{r}$

Angular Velocity (ω) $\omega = \frac{\Delta\theta}{\Delta t}$

Angular Acceleration (α) $\alpha = \frac{\Delta\omega}{\Delta t}$

Angular Kinematics

$\omega = \omega_o + \alpha t$

$\theta = \theta_o + \omega_o t + \frac{1}{2}\alpha t^2$

Linear Formulas

(tangential) Velocity (v)

$v = r\omega$

(tangential) Acceleration (a_t)

$a_t = r\alpha$

(radial) Acceleration (a_r)

$a_r = \omega^2 \cdot r$

Total Acceleration (a)

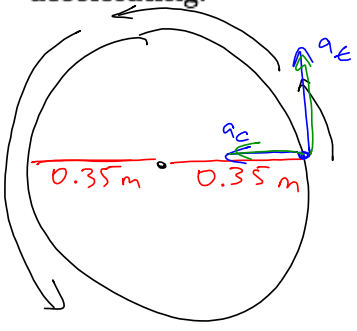
$a = \sqrt{a_r^2 + a_t^2}$

Example 1

A 70.0 cm diameter wheel accelerates uniformly about its center from 130 rpm to 280 rpm in 4.00 s.

A. Determine its angular acceleration α

B. Find the radial and tangential acceleration components of the linear acceleration of a point on the edge of the wheel 2.00 s after it has started accelerating.



$t = 4.00\ s$

$\omega_0 = 13.6\ rad/s$

$\omega = 29.3\ rad/s$

$\omega = \omega_0 + \alpha t$

$\omega = 21.4$

$21.5\ rad/s$

A.) $\alpha = \frac{\Delta \omega}{\Delta t}$

$\alpha = 3.93\ rad/s^2$

$\alpha = \frac{5}{4}\pi\ rad/s^2$

B.) $a_c = \frac{v^2}{r} = r \cdot \omega^2$

$a_c = (0.35)(21.5)^2$

$a_c = 161\ m/s^2$

$a_t = r \cdot \alpha$

$a_t = (0.35)(3.93) = 1.38\ m/s^2$

Example 2

A turntable with a radius R_1 is turned by a circular rubber roller of radius R_2 in contact with it at their outer edges. Of the linear velocity (v), radius (R), and angular velocity (ω), which are the same and which are different between the two wheels?

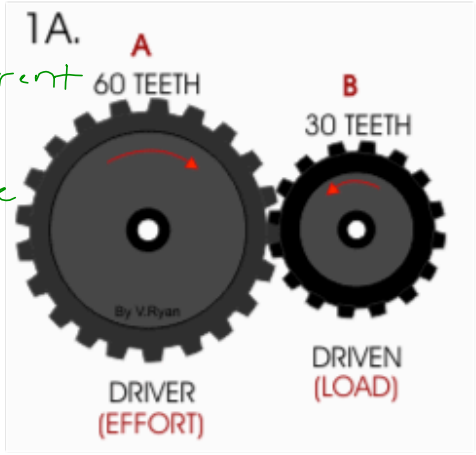
$r_A > r_B$ (A larger, B smaller) radius is different

$\omega_A < \omega_B$ (A larger, B smaller) angular velocity (ω) is different

$V = V$ Linear velocity is the same

$\frac{V_A}{V_B} = 1$

*What would be a ratio of the two velocities and the two angular velocities?

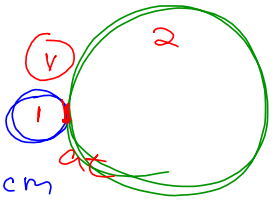


Example 3

A small rubber wheel is used to drive a large pottery wheel, and they are mounted so that their circular edges touch. The small wheel has a radius of 2.00 cm and an angular acceleration of 7.20 rad/s^2, and is in contact with the pottery wheel (radius = 25.0 cm) without slipping. Calculate...

A. The angular acceleration of the pottery wheel

B. The time it will take the wheel to get up to its required speed of 65.0 rpms.



↳ larger pottery wheel
$t = 11.82\,s$

V = same
a_t = same

$r_1 = 2\,cm$
$r_1 = 0.02\,m$
$\alpha_1 = 7.20\ rad/s^2$
$a_t = r \cdot \alpha$

$r_2 = 0.25\ m$
$\alpha = ?$

$r_1 \cdot \alpha_1 = a_t = r_2 \cdot \alpha_2$
$(0.02)(7.20) = (0.25)(\alpha_2)$
$\alpha_2 = 0.576\ rad/s^2$

A Little More Practice

1. A ball is rolled in between two children 3.5 m apart. If the ball makes 15 revolutions to get from one child to another – what is the diameter of the ball?

   diameter = 0.0743 m

2. A centrifuge accelerates uniformly from rest to 15,000 rpm in 220 s. Through how many revolutions did the centrifuge spin during this time?

   θ = 27,500 revolutions

3. A wheel with a 33 cm diameter accelerates uniformly from 240 rpm to 360 rpm in 6.50 s. How many meters would a point on the edge of the wheel have traveled in this time?

   X = 33.8 m