

ROTATION DAY 1: ANGULAR KINEMATICS

Warm-up (3 min): A clock's minute hand (15 cm) completes one revolution in 60 min. A point halfway along the hand is at 7.5 cm.

(a) How far does the tip travel in one full revolution?

(c) Which point is moving faster in m/s?

(b) How far does the halfway point travel?

(d) What quantity is the SAME for both?

ANGLES IN RADIANs

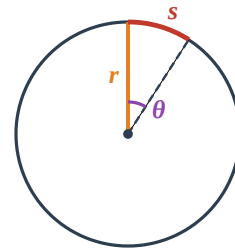
THE RADIAN

Instead of degrees, we measure rotation in **radians**:

$$\theta \text{ (rad)} = \frac{s}{r}$$

where: s = arc length (m), r = radius (m), θ = angle (rad)

Full revolution = 2π rad = 360° | $\text{deg} \times \frac{\pi}{180} = \text{rad}$



$\theta = s / r$ (1 rad shown)

WE DO Convert These Angles

(a) Convert 45° to radians

(b) Convert $3\pi/2$ rad to degrees

(c) How many radians in 2.5 revolutions?

ANGULAR VELOCITY & ACCELERATION

THE PARALLEL

Linear motion and rotation have identical structure. Just swap variables:

Quantity	Linear Symbol	Quantity	Angular Symbol
Position	x	Angular position	θ
Velocity	$v = \frac{\Delta x}{\Delta t}$	Angular velocity	$\omega = \frac{\Delta \theta}{\Delta t}$
Acceleration	$a = \frac{\Delta v}{\Delta t}$	Angular accel.	$\alpha = \frac{\Delta \omega}{\Delta t}$
Units	m, m/s, m/s ²	Units	rad, rad/s, rad/s ²

Key insight: Every kinematic equation you memorized has a rotational twin. Just swap $x \rightarrow \theta$, $v \rightarrow \omega$, $a \rightarrow \alpha$.

Physics in the Wild: Your Car's Tachometer

That gauge on the dashboard labeled "RPM \times 1000"? It reads angular velocity — your engine's ω in real time. When you floor the gas in first gear, the needle sweeps from \sim 1000 RPM to \sim 5000 RPM in about 6 seconds. That sweep IS angular acceleration.

THE FOUR KINEMATIC EQUATIONS

ROTATIONAL FORM (CONSTANT ANGULAR ACCELERATION)

$$\begin{aligned}\omega &= \omega_0 + \alpha t \\ \theta &= \omega_0 t + \frac{1}{2} \alpha t^2 \\ \omega^2 &= \omega_0^2 + 2\alpha\theta \\ \theta &= \frac{1}{2}(\omega_0 + \omega)t\end{aligned}$$

WE DO Spinning Up a Wheel

A bicycle wheel starts from rest and accelerates uniformly at $\alpha = 4.0 \text{ rad/s}^2$.

(a) What is ω after 3.0 s?

(b) How many radians does it turn?

(c) How many full revolutions is that? (Hint: 1 rev = 2π rad)

YOU DO Braking Turntable

A turntable spins at $33\frac{1}{3}$ rpm (common vinyl speed). When turned off, it decelerates uniformly and stops in 8.0 s.

(a) Convert $33\frac{1}{3}$ rpm to rad/s

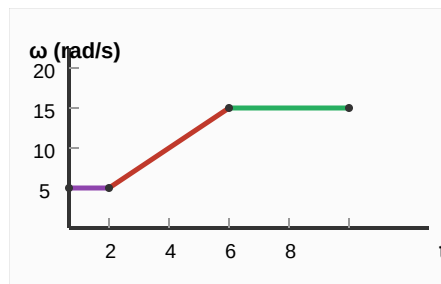
(b) Find α

(c) How many revolutions does it make while stopping?

READING ANGULAR VELOCITY GRAPHS

QUICK Interpreting an ω - t Graph

Study this angular velocity vs. time graph:



(a) What is α during 0–2 s?

(b) What is α during 2–5 s?

(c) What is the total angular displacement from 0 to 8 s? (Hint: area under the ω - t graph.)

EXIT TICKET & HOMEWORK

EXIT Fan Blade Acceleration

A fan blade accelerates from $\omega_0 = 2.0 \text{ rad/s}$ to $\omega = 10.0 \text{ rad/s}$ in $t = 4.0 \text{ s}$. Find α and the number of revolutions.

HOMEWORK PROBLEMS

1 Unit Conversion

(a) Convert 120 rpm to rad/s

(b) Convert 15 rad/s to rpm

(c) A car tire (radius 0.32 m) rotates at 80 rad/s. What is the car's speed in m/s? (Preview: tomorrow we connect linear and angular motion.)

2 Centrifuge Spin-up

A centrifuge starts from rest and reaches 12,000 rpm in 30 s with constant α .

(a) Find α in rad/s^2

(b) How many revolutions during spin-up?