GUIDED PROBLEM: GEAR RATIOS

Rotation Day 2 — Linear–Angular Connections

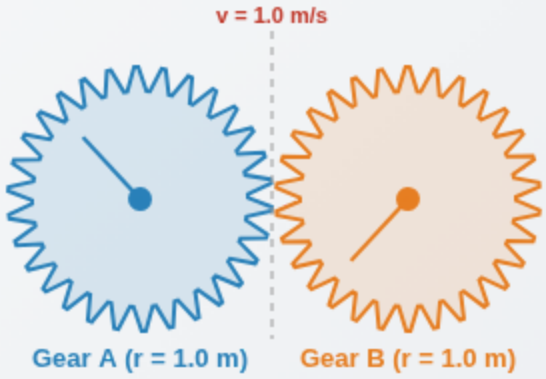
KEY IDEA

When two gears are **meshed** (teeth interlocked), their edges move at the **same linear speed**. The teeth push each other at the contact point, so:

$$v_A = v_B \quad \Longrightarrow \quad \omega_A r_A = \omega_B r_B$$

A bigger gear turns *slower*. A smaller gear turns *faster*. But the edge speed is always the same where they touch.

⚙ Interactive Gear Simulation



Gear B radius: 1.0 m

⚙ GEAR A (FIXED)		⚙ GEAR B (ADJUSTABLE)	
Radius:	1.0 m	Radius:	1.0 m
ω:	1.0 rad/s	ω:	1.00 rad/s
v (edge):	1.0 m/s	v (edge):	1.0 m/s

Notice: The edge speed v is *always* the same for both gears. Adjust the slider and watch which values change and which stay constant.

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GUIDED QUESTIONS — USE THE SIMULATION

Gear A is **locked** at $r_A = 1.0$ m and $\omega_A = 1.0$ rad/s. Fill in the table below for different Gear B radii.

Gear B Radius r_B	Gear A Edge Speed $v_A = \omega_A r_A$	Gear B Edge Speed v_B	Gear B Angular Velocity $\omega_B = v_B / r_B$
0.5 m			
1.0 m			
2.0 m			
3.0 m			

1 Pattern Recognition

As you increased Gear B's radius from 0.5 m to 3.0 m, what happened to...

(a) Gear B's *edge speed* v_B? ☐ Increased ☐ Decreased ☐ Stayed the same

(b) Gear B's *angular velocity* ω_B? ☐ Increased ☐ Decreased ☐ Stayed the same

(c) Explain in one sentence *why* ω_B changes when r_B changes, even though v_B doesn't:

2 Prediction

Without using the simulation, predict: if Gear B has radius $r_B = 0.25$ m (smaller than Gear A), what would ω_B be?

3 The Gear Ratio

Starting from $\omega_A r_A = \omega_B r_B$, solve for the ratio $\dfrac{\omega_B}{\omega_A}$ in terms of the radii.

Use your result: If Gear B is **3× bigger** than Gear A, it spins _____ as fast.

4 Real-World Connection

A bicycle's pedal sprocket has radius 8.0 cm and connects via chain to a rear sprocket of radius 4.0 cm. You pedal at 60 rpm.

(a) Chain speed (edge speed of pedal sprocket):

(b) ω of the rear sprocket:

(c) The rear sprocket spins ☐ faster / ☐ slower than the pedal sprocket because it is ☐ bigger / ☐ smaller.

✓ **Big Takeaway:** Meshed gears (or linked sprockets) share the same **tangential speed** at the contact point. A gear with **larger radius** has **smaller angular velocity**, and vice versa. The ratio $\omega_B/\omega_A = r_A/r_B$ is the **gear ratio**.