ROTATION DAY 2: LINEAR–ANGULAR CONNECTIONS

Warm-Up (3 min): Two ants ride on a spinning vinyl record. Ant A is 5 cm from the center; Ant B is 15 cm from the center. The record spins at a steady rate.

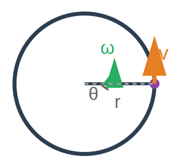
(a) Which ant completes a circle faster? ____________
(b) Which ant travels a greater distance per revolution? ____________
(c) Which ant has a greater speed? ____________
(d) Both sweep the same ______________ per second.

THE BRIDGE EQUATIONS

LINEAR–ANGULAR BRIDGE

$$v = \omega r \quad a_t = \alpha r \quad s = \theta r$$

Tangential speed: $v = \omega r$
Tangential accel: $a_t = \alpha r$
Arc length: $s = \theta r$



Key Insight: These equations are the Rosetta Stone of rotation. They let you translate any angular quantity to a linear one, and vice versa. The radius *r* is the conversion factor.

WE DO **The Record Player Revisited**

A vinyl record (r = 15 cm) spins at 33⅓ rpm.

(a) Convert to rad/s:

(b) Linear speed at rim:

(c) Speed 5.0 cm from center:

(d) Verify ratio:

ROTATION DAY 2 (CONTINUED)

YOU DO Bicycle Wheel

A bicycle wheel has radius 0.35 m and rotates at 10 rad/s.

(a) Speed of a point on the rim:

(b) Tangential acceleration (α = 2.0 rad/s²):

(c) Centripetal acceleration of that point:

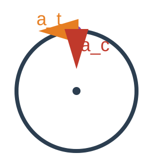
Warning: Don't confuse *tangential acceleration* ($a_t = \alpha r$, along the edge) with *centripetal acceleration* ($a_c = v^2/r$, toward the center). Tangential changes speed; centripetal changes direction.

TWO ACCELERATIONS

Tangential: $a_t = \alpha r$
Speeds up or slows down.

Centripetal: $a_c = v^2/r$
Turns the path (inward).

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



QUICK Which Acceleration?

Fill in the table with Yes/No. a_t = tangential, a_c = centripetal.

Situation	$a_t = 0$?	$a_c = 0$?
Constant ω, circular path		
Speeding up, circular path		
Constant v, straight line		

ROTATION DAY 2 (CONTINUED)

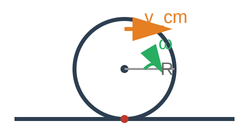
CONSTRAINTS — WHEN OBJECTS ROLL OR CONNECT

ROLLING WITHOUT SLIPPING

When a wheel rolls without slipping, the contact point is momentarily at rest. This means:

$$v_{cm} = \omega R$$

The center-of-mass speed equals angular velocity times radius.



WE DO **Car Tire Speed**

A car tire has radius 0.32 m. The car drives at 25 m/s (about 56 mph).

(a) Find ω of the tire:

(b) Braking α (5.0 s to stop):

(c) Revolutions while braking:

YOU DO **Pulley System**

A string wraps around a pulley of radius 0.10 m. A mass hangs and drops at 2.0 m/s².

(a) Angular acceleration of the pulley:

(b) If mass drops 0.80 m from rest, radians turned:

EXIT TICKET & HOMEWORK

Exit Ticket (5 min): Two gears mesh together. Gear A has radius 10 cm; Gear B has radius 30 cm. Gear A spins at 120 rpm.

(a) Linear speed at the edge of Gear A:

(b) ω for Gear B (edges have same linear speed):

(c) Which gear has more angular velocity? Which edge has more linear speed?

HOMEWORK

1. Merry-Go-Round

A 3.0 m radius merry-go-round makes one revolution in 8.0 s.

(a) Find ω: ___________ **(b) Speed at rim:** ___________ **(c) Speed 1.0 m from center:** ___________

2. Centrifuge

A centrifuge tube is 12 cm from the axis. The centrifuge spins at 4000 rpm. Find the centripetal acceleration in m/s^2 and as a multiple of *g*.

3. Chain & Sprocket

On a bicycle, the pedal sprocket (r = 8.0 cm) connects by chain to the rear sprocket (r = 4.0 cm). The chain moves at the same linear speed at both sprockets. If you pedal at 60 rpm, what is the rear wheel sprocket's angular velocity? (Hint: same $v = \omega r$ idea.)