Whiteboard Problem 4.5

An old-fashioned single-play vinyl record rotates on a turn-table at 45 rpm. What are:

revs per min

(A) The angular velocity in rad/s?

$$45 \frac{\cancel{\text{rev}}}{\cancel{\text{min}}} \times 2\pi \frac{\text{rad}}{\cancel{\text{rev}}} \times \frac{1}{\frac{60\,\text{sec}}{\cancel{\text{min}}}} = \frac{45(2\pi)}{60}\ \text{rad/s}$$

$$= 4.7\ \text{rads}^{-1}$$

(B) The period of the motion?

$$T = \frac{2\pi}{\omega} = \frac{60}{45}\ \text{sec} = 1.3\ \text{s}$$

Whiteboard Problem 4.6

We don't notice how fast we are moving due to the Earth's rotation because the atmosphere moves with us.

Let's calculate our speed in m/s at this moment as we hurtle through space.

You already know the time period for the Earth's rotation. You also need the Earth's radius: R_e = 6400 km

$$T = 24 \times 60 \times 60 \text{ sec}$$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{24 \times 60 \times 60} = 7.27 \times 10^{-5} \text{ rad s}^{-1}$$

$$v_t = R_e \omega = (\underbrace{6400 \times 10^3}_{\text{in 'm'}})(7.27 \times 10^{-5})$$

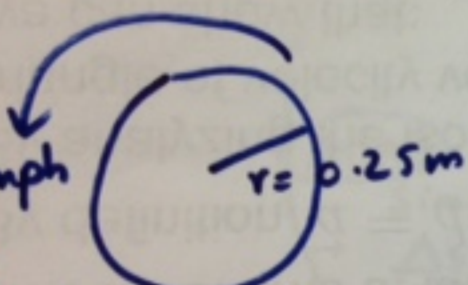
$$= 465 \text{ m/s !}$$

Whiteboard Problem 4.7

Remember the fastest electric car (Buckeye Silver Bullet) can exceed 300 mph. Why can't it go faster, say, at 400 mph? Answer: B/c it's tires explode!

Let's calculate the radial, or centripetal, acceleration required to make a tire of radius 0.25m rotate at 400 mph. Compare it to g! How many g's of acceleration are we talking??

$$400\,\text{mph} = \frac{400\times 1.6\times 1000\ \text{m}}{60\times 60\ \text{s}} = v\ (\text{m/s})$$



400mph ↓ 60mph (factor 6)

$$\frac{a_r}{g} = \frac{\left(\frac{v^2}{r}\right)}{g} = \frac{\left(\frac{400\times 1.6\times 1000}{3600}\right)^2}{0.25} \Big/ g$$

$$= 13{,}500\ g!!$$

What about your car at 60 mph – how many g's do your tires need?

$$\frac{13{,}500\ g}{6^2} \simeq 400g$$

Whiteboard Problem 4.8

The graph below shows the angular-velocity vs time graph for a particle undergoing circular motion. How many revolutions does the object make during the first 4s?

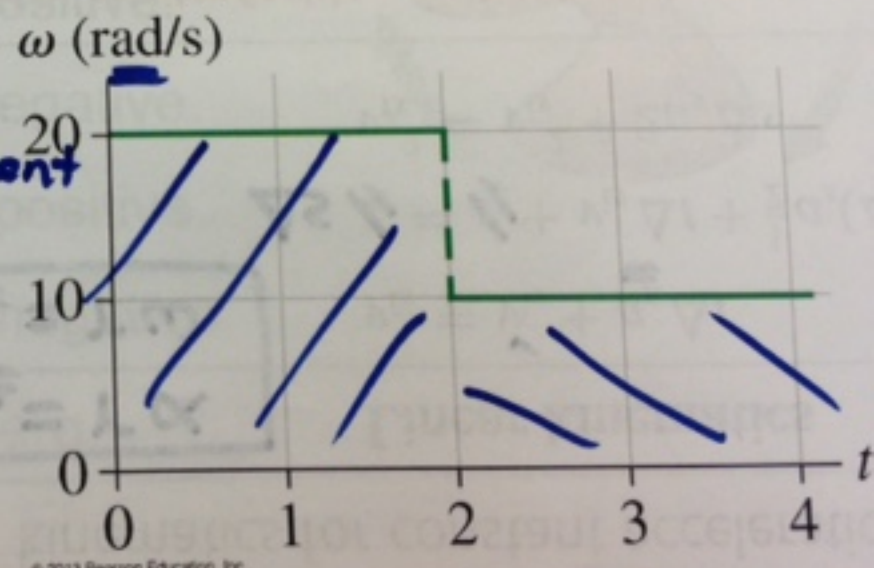
Area under ω-t curve = ang. displacement

$20(2) + 10(2)$

$= 60$ rads

revs → $\frac{60 \text{ rads}}{2\pi}$

$= \frac{30}{\pi} \lesssim 10$ revs.



Whiteboard Problem 4.9 (#4.77)

$\omega_i = 0$

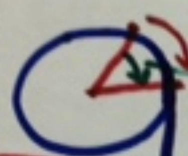
A long string is wrapped around a 6.0-cm-diameter cylinder, initially at rest, that is free to rotate on an axle. The string is then pulled with a constant acceleration of 1.5 m/s² until 1.0 m of string has been unwound. If the string unwinds without slipping, what is the cylinder's angular speed, in rpm, at this time?

$\omega_f = ?$

$\omega_f = \omega_i + \alpha \Delta t$

$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$

$\Delta\theta = \omega_i \Delta t + \frac{1}{2}\alpha(\Delta t)^2$



$1\,m = s = r\theta$

$\underbrace{\theta = \text{angular displacement} = \frac{s}{r} = \frac{1}{0.03}}_{s = r\theta}$

$a_t = 1.5\,m/s^2$

$\omega_f = 0 + \sqrt{2\left(\frac{1.5}{0.03}\right)\left(\frac{1}{0.03}\right)}$

$= 57.73\ rad/s$

$1.5\,m/s^2 = a_t = r\alpha$

$\alpha = \frac{1.5}{.03}$

$\frac{57.73}{2\pi} \times 60$ rpm

$= 551$ rpm