UF | UNIVERSITY of FLORIDA

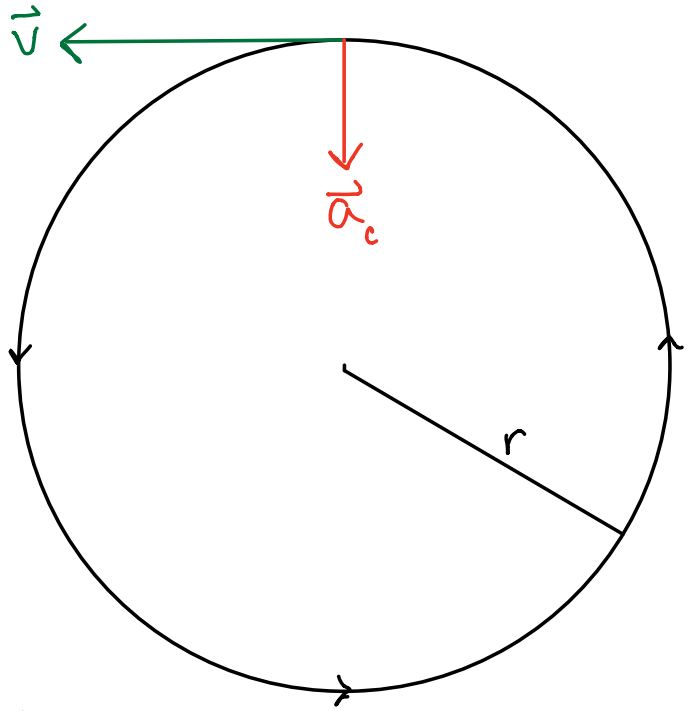
Pre-Health Post-Baccalaureate Program
PHY2053 Study Guide & Practice Problems

Topics Covered:

Circular Motion
Circular Apparent Weight
Gravity and Orbits

Created by Isaac Loy

Circular Motion



→ Distance: circumference

$$C = 2\pi r$$

→ Frequency: revolutions per second

$$f = \frac{1}{t}$$

→ Velocity: $\frac{\Delta d}{\Delta t}$

$$v = \frac{2\pi r}{t} = 2\pi r f$$

→ Acceleration: $\frac{v^2}{r}$

$$a_c = \frac{v^2}{r} = \frac{(2\pi r f)^2}{r} = (2\pi f)^2 r$$

① A CD has a diameter of 120 mm and spins at 540 RPM.

a) What is the CD's tangental velocity?

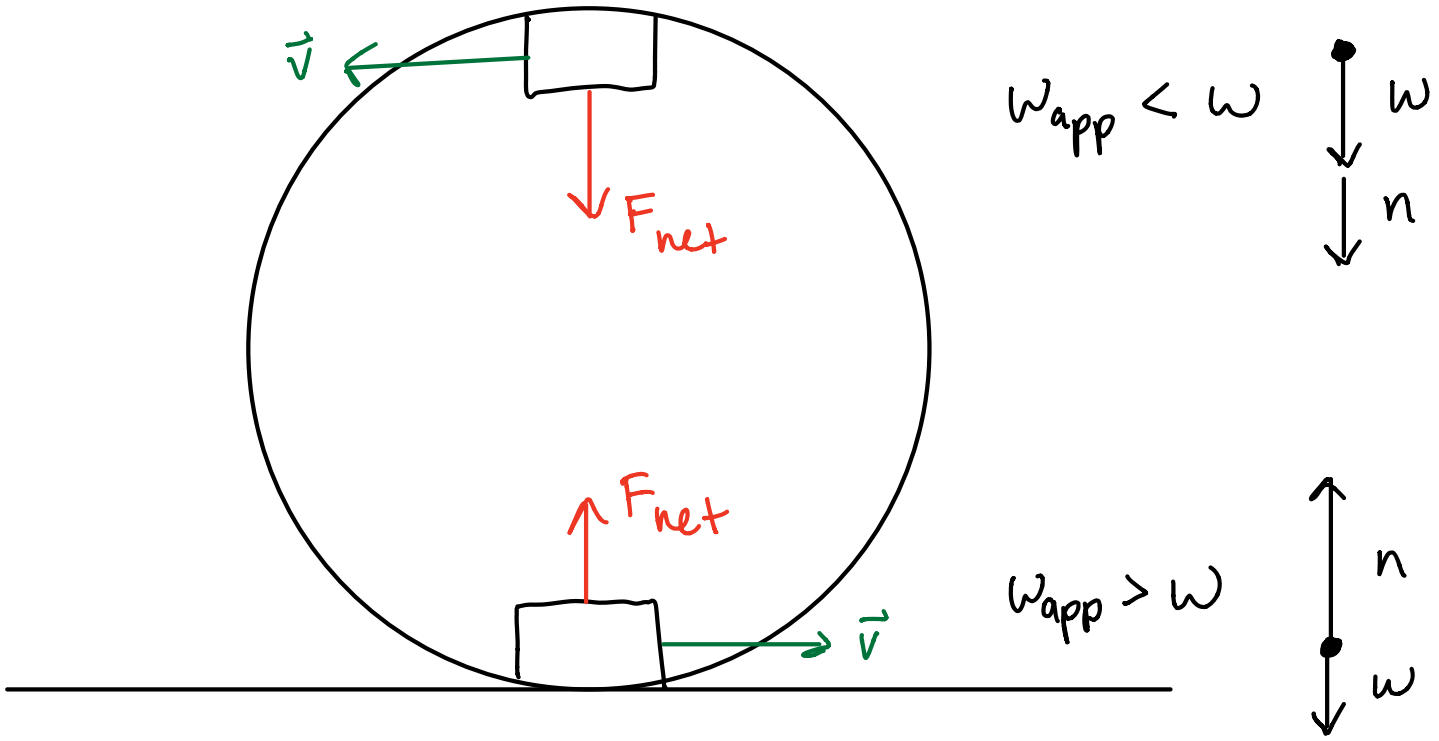
b) What is the CD's acceleration?

(2) A circular racetrack has a diameter of 70m and is banked at a 15° angle.

a) Draw the FBD (looking straight at the front of the car).

b) At what speed can the racecar take this turn with no assistance from friction?

Apparent Weight in Circular Motion

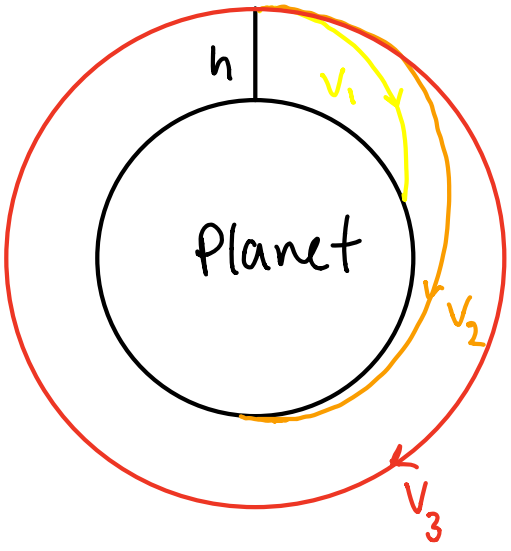


→ Critical speed, v_c, is the velocity at which $n = 0$. It is the slowest possible speed at which the passenger can complete the loop:

$$v_c = \sqrt{\frac{rw}{m}} = \sqrt{\frac{rmg}{m}} = \sqrt{rg}$$

Orbital Motion

→ Think about it like a projectile — objects in orbit are constantly in free fall



$v_3 >>> v_2 >>> v_1$

→ velocity of orbit:

$$a = \frac{F_{net}}{m} = \frac{w}{m} = \frac{mg}{m} = g$$

$$a = \frac{v_{orbit}^2}{r}$$

$$\therefore \quad g = \frac{v_{orbit}^2}{r} \Rightarrow v_{orbit} = \sqrt{rg}$$

→ Period of orbit:

$$v = \frac{d}{t}$$

$$\Rightarrow t = \frac{d}{v} = \frac{2\pi r}{\sqrt{rg}} = 2\pi\sqrt{\frac{r}{g}}$$

Newton's Law of Gravity

→ Every object in the universe attracts every other object

→ The force is directly proportional to the products of the masses

→ Gravitational Force, F_G:

$$F_{1 \text{ on } 2} = F_{2 \text{ on } 1} = \frac{G m_1 m_2}{r^2}$$

where $G = 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$

→ This is an inverse-square relationship!

→ g ("litte g") of a planet:

$$g_{planet} = \frac{G M_{planet}}{R^2_{planet}}$$

③ What is the gravitational force of the earth (mass of 5.98×10^{24} kg and radius of 6.37×10^{6} m) on a 60 kg person?

Solutions

① a) $v = 2\pi f r$

$$f = \frac{540 \text{ rev}}{\cancel{\text{min}}} \times \frac{1 \cancel{\text{min}}}{60 \text{ s}} = 9 \text{ s}^{-1}$$

$r = 0.06 \text{ m}$

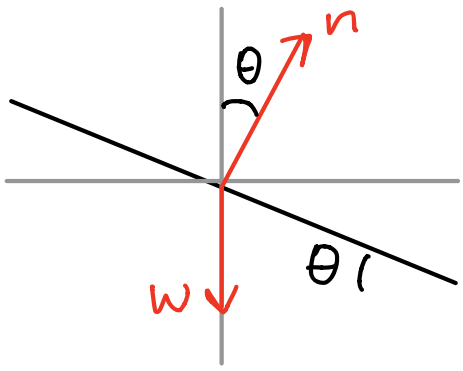
$$v = 2\pi f r = 2\pi (9)(0.06) = 3.4 \text{ m/s}$$

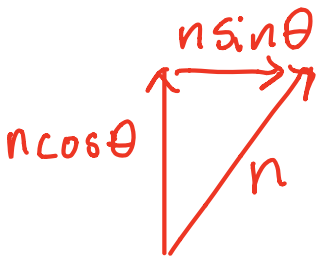
b) $a_c = \frac{v^2}{r}$

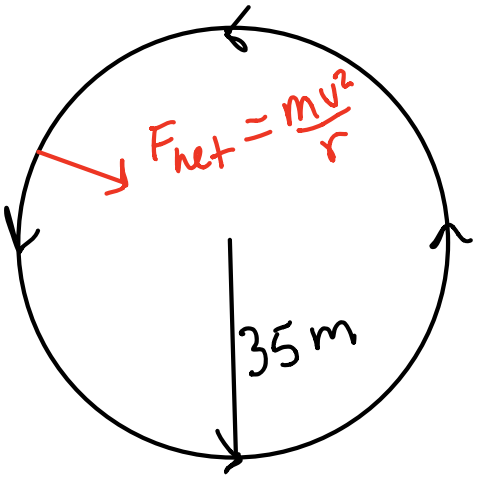
$$a = (2\pi f)^2 r = 190 \text{ m/s}^2$$

(2)

a)







b) $\sum F_y = n\cos\theta - w = 0$

$n\cos\theta - w = 0$

$n\cos\theta = w$

$n = \frac{w}{\cos\theta} = \frac{mg}{\cos\theta}$

$\sum F_x = n\sin\theta = \frac{mv^2}{r}$

$\left(\frac{mg}{\cos\theta}\right)\sin\theta = \frac{mv^2}{r}$

$g\tan\theta = \frac{v^2}{r}$

$\sqrt{gr\tan\theta} = \sqrt{v^2}$

$v = \sqrt{gr\tan\theta}$

$v = \sqrt{35(9.8)(\tan 15)}$

$v = 9.6\ m/s$

(3) $F = w = mg = 60(9.8) = 588\,N$

Don't overthink the problem!