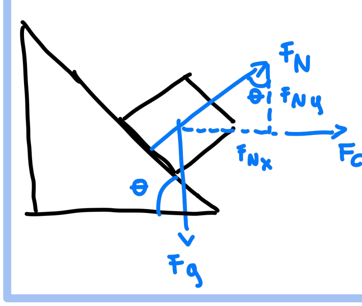
By Emma Bertran

Lab: AP Physics Review Sheets
Ch. 6 Circular Motion

Brief summary:
This chapter explores the physics of circular motion and friction, discusses how different types of forces can cause both linear and rotational motion. It covers the key concepts of static and kinetic friction, centripetal force, resistive (drag) forces, and more.

Major topics:
1. Sliding friction
2. Centripetal force
3. Horizontal circular motion
4. Vertical circular motion
5. Non-uniform circular motion
6. Centrifugal force
7. Resistive forces

Banked curve diagram:



Formulae:

static or kinetic

$$|\vec{F}_f| \leq \mu |\vec{F}_N|$$

$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$

$$v_x = v_{x0} + a_x t$$

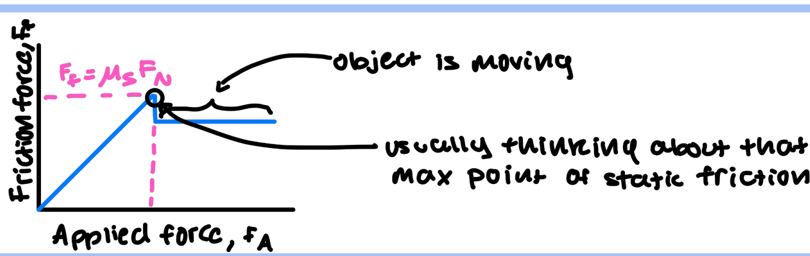
$$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$$

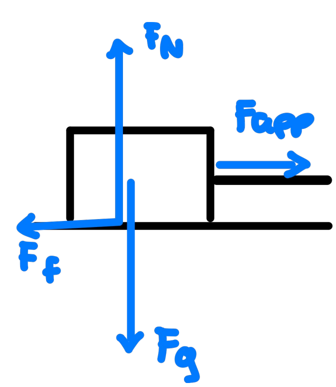
$$a_c = \frac{v^2}{r} = r\omega^2$$

$$F_c = \frac{mv^2}{r}$$

$$F_{net} = ma$$

Key terms/vocabulary:
Sliding friction - friction when two surfaces move across each other
Kinetic friction - friction between surfaces that are already sliding
Static friction - friction preventing motion between two surfaces
Coefficient of friction - a number that describes how "sticky" two surfaces are
Normal force - upward and perpendicular force from a surface that balances part or all of the object's weight/gravity
Centripetal force - force causing circular motion that is directed towards the center
Drag/resistive force - force that opposes motion
Terminal velocity - the constant speed an object reaches when drag balances gravity in freefall





Practice problems:

Source: *All questions have been borrowed from the Chapter 6 review questions from University Physics Volume 1 by Jeff Sanny, Samuel J. Ling, and William Moebs*

1. [easy]

Question 31
A 35.0-kg dolphin accelerates opposite to the motion from 12.0 to 7.50 m/s in 2.30 s to join another dolphin in play. What average force was exerted to slow the first dolphin if it was moving horizontally? (The gravitational force is balanced by the buoyant force of the water.)

2. [medium]

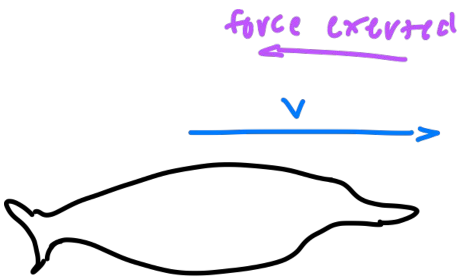
Question 69
(a) What is the radius of a bobsled turn banked at 75.0° and taken at 30.0 m/s, assuming it is ideally banked? (b) Calculate the centripetal acceleration. (c) Does this acceleration seem large to you?

3. [hard]

Question 71
If a car takes a banked curve at less than the ideal speed, friction is needed to keep it from sliding toward the inside of the curve (a problem on icy mountain roads). (a) Calculate the ideal speed to take a 100.0 m radius curve banked at 15.0°. (b) What is the minimum coefficient of friction needed for a frightened driver to take the same curve at 20.0 km/h?

Solutions:

1)



using $F = ma$

$v_i = 12.0 \text{ m/s}$

$v_f = 7.50 \text{ m/s}$

$\Delta t = 2.30 \text{ s}$

$F_{avg} = ?$

$m = 35.0 \text{ kg}$

$v_f = v_i + at$ ← kinematics equation from equation sheet

$(7.50) = (12.0) + a(2.30)$

$a = -1.96 \text{ m/s}^2$ ← negative bc decelerating

now F

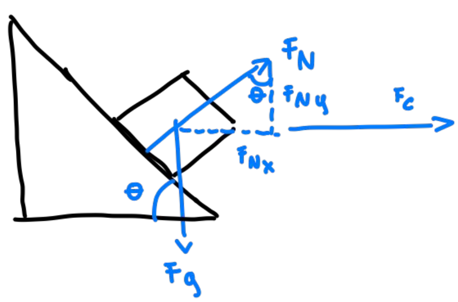
$\Sigma F = ma$

$F = (35.0)(-1.96)$

$\boxed{F_x = -68.6 \text{ N}}$ ← negative force against the velocity of the dolphin

2)

a)



components (x & y)

$F_N \cos(\theta) = mg$ $\quad F_N = \frac{mg}{\cos\theta}$

$F_c = \frac{mv^2}{r} = \underbrace{F_N \sin(\theta)}_{F_{Nx}}$ ← other component

$\frac{mv^2}{r} = F_N \sin\theta$ replace

$\frac{\cancel{m}v^2}{r} = \frac{\cancel{m}g}{\cos\theta}\sin\theta$

$\frac{\sin}{\cos} = \frac{v^2}{rg}$

$\tan\theta = \frac{v^2}{rg}$ ← this is the equation we are going to use

rearrange

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

$r = \frac{(30.0)^2}{(9.81)(\tan 75.0^\circ)} = \boxed{24.6 \text{ m}}$

b) $a_c = \frac{v^2}{r}$ ← from equation sheet

$a_c = \frac{(30.0)^2}{24.6}$

$a_c = \boxed{36.6 \text{ m/s}^2}$

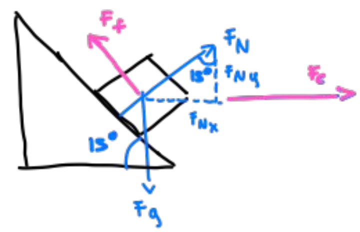
c) $\frac{36.6}{9.8} = 3.73$ g's <u>YES</u>

acceleration

this is a lot of gravity for a human to experience

3.

a) $\tan\theta = \frac{v^2}{rg}$ same equation as derived in question 2



$\sqrt{r \cdot g(\tan\theta)} = \sqrt{v^2}$

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

$v = \sqrt{(100)(9.81)(\tan(15°))}$

$v = \boxed{16.2 \text{ m/s}}$

b) $\frac{20 \text{ km}}{1 \text{ hr}} \left| \frac{1{,}000 \text{ m}}{1 \text{ km}} \right| \frac{1 \text{ hr}}{3{,}600} \Big| = 5.56 \text{ m/s}$

$\Sigma F = ma$ $\qquad$ $F_{f_s} = \mu_s \cdot F_N$

following diagram

y: $F_N \cos\theta - F_f \sin(\theta) = mg$ $\qquad$ adding the forces

x: $F_N \sin\theta + f_s \cos(\theta) = \frac{mv^2}{r}$

plug in

substitute

$\underline{F_N} \cos\theta - \mu_s \underline{F_N} \sin\theta = mg$

$\{F_N(\cos\theta - \mu_s \sin\theta) = \cancel{m}g\}$

— components w/ friction & components of normal force

$\underline{F_N} \sin\theta + \mu_s \underline{F_N} \cos\theta = \frac{mv^2}{r}$

$\{F_N(\sin\theta + \mu_s \cos\theta) = \frac{\cancel{m}v^2}{r}\}$

$\frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta} = \frac{v^2}{rg}$ $\Big\rangle$ dividing the 2 (you can also use substitution)

coefficient of friction

$\frac{\sin 15° + \mu\cos 15°}{\cos 15° - \mu\sin 15°} = 0.0315$

solve

$\mu = 0.2344$

$\boxed{\mu_s = 0.23}$