

## Chapter 6: Circular Motion

### Background

Chapter 6 covers key topics, including friction, centripetal force, circular motion, and resistive forces. This unit is the first introduction to non-linear motion, exposing new challenges with rotational motion.

### Topics to Know

(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

### Terms

Kinetic Friction: the friction force between two or more objects in motion, sliding past each other  
Static Friction: a friction force that keeps objects in place, resisting the sliding between two materials

Coefficient of friction: measures resistance between two surfaces placed next to each other; the higher the value, the more friction when sliding

Centripetal force: is a force causing acceleration towards the center of a circle

Drag: a resistive force that opposes the motion of an object moving through either a gas or a liquid

### Formulae

$$\mu = \frac{F_{\text{friction}}}{F_{\text{Normal}}}$$

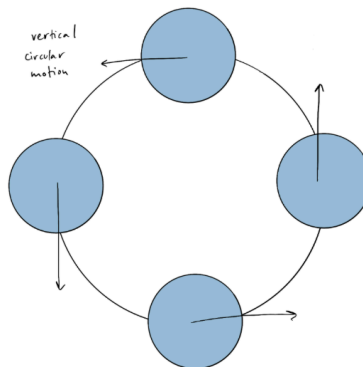
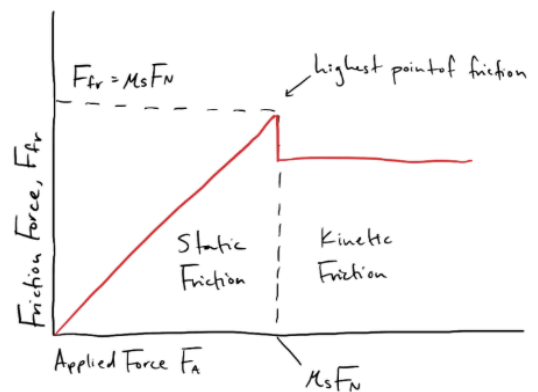
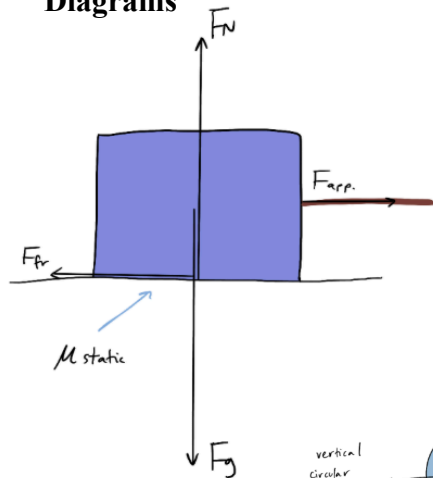
$$a_c = \frac{v^2}{r}$$

$$F_c = \frac{m \cdot v^2}{r}$$

$$R = -bv$$

$$R = \frac{1}{2}D\rho Av^2$$

### Diagrams



## Practice Problems!

All questions are from the Chapter 6 review questions from *University Physics Volume 1* by Jeff Sanny, Samuel J. Ling, and William Moebs.

### #1 (Easy)

By what factor does the drag force on a car increase as it goes from 65 to 110 km/h?

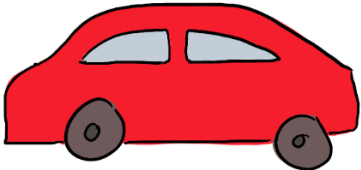
### #2 (Medium)

Find the tension in each of the three cables supporting the traffic light if it weighs  $2.00 \times 10^2$  N. The first cable on the left is at a  $41^\circ$  angle, while the right cable is at a  $63^\circ$  angle.

### #3 (Hard)

A child of mass 40.0 kg is in a roller coaster car that travels in a loop of radius 7.00 m. At point A, the speed of the car is 10.0 m/s, and at point B, the speed is 10.5 m/s. Assume the child is not holding on and does not wear a seat belt. (a) What is the force of the car seat on the child at point A? (b) What is the force of the car seat on the child at point B? (c) What minimum speed is required to keep the child in his seat at point A?

#1

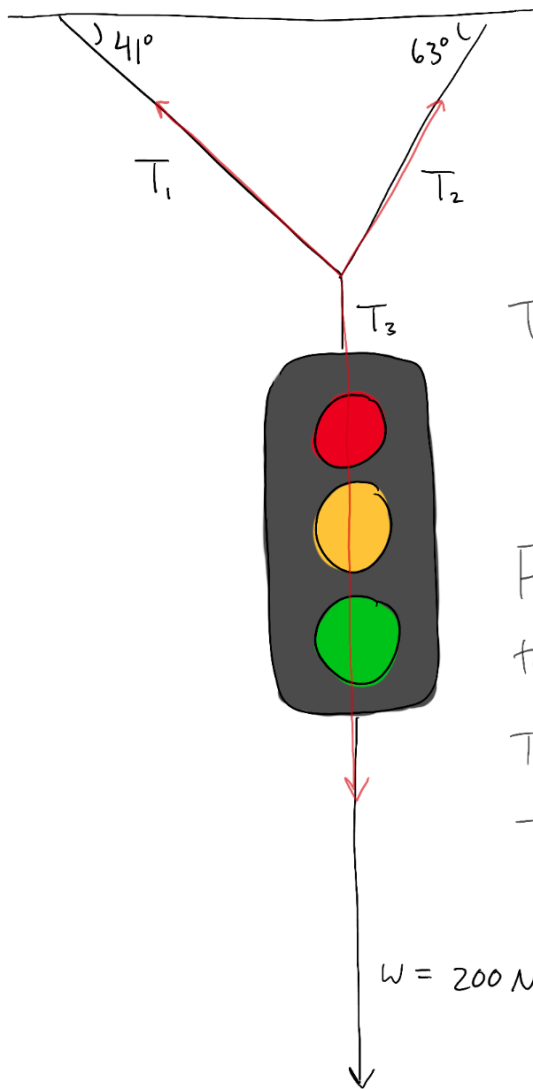
$$R \propto V^2 \quad \frac{R_2}{R_1} = \left( \frac{V_2}{V_1} \right)^2$$


problem gives 2 speeds: 65 to 110 km/hr

$$\frac{R_2}{R_1} = \left( \frac{110}{65} \right)^2 \rightarrow 2.86 \text{ which is}$$

approx. a factor of three

#2



$T_3$ : this cable isn't at an angle so the Tension is just the weight.

There is no acceleration, meaning

$$F_T = m \cdot a \rightarrow F_{T_3} = 200\text{ N}$$

For the next tensions, separate the vertical + horizontal components

$$T_1 \cos(41) = T_2 \cos(63)$$

$$T_1 \sin(41) + T_2 \sin(63) = 200$$

use substitution:

$$T_1 = \frac{\cos(63)}{\cos(41)} T_2$$

$$\frac{\cos(63)}{\cos(41)} T_2 \sin(41) + T_2 \sin(63) = 200$$

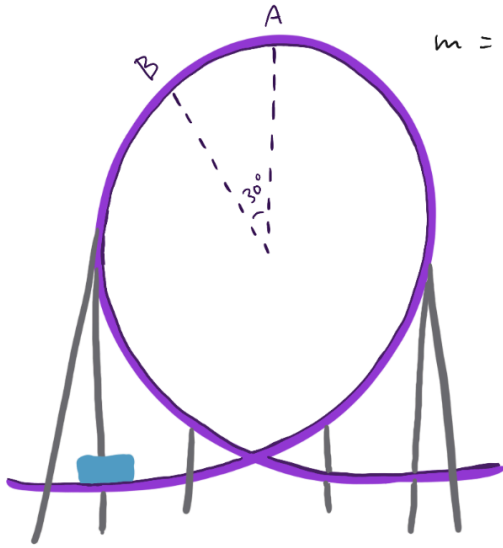
$$T_2 = 155.6\text{ N}$$

← isolate and plug into calculator

substitute back in  $T_1 \cos(41) = 155.6 \cdot \cos(63)$

$$T_1 = 93.6\text{ N}$$

#3



$m = 40 \text{ kg}$     $r = 7.0 \text{ m}$     $@A = 10 \text{ m/s}$   
 $@B = 10.5 \text{ m/s}$

a) Force of car seat on child @ A?



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

$$F_N + F_g = \frac{mv^2}{r}$$

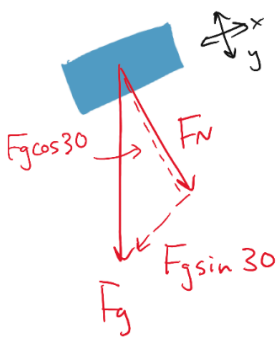
$$F_N + mg = \frac{mv^2}{r}$$

$$F_N = \frac{mv^2}{r} - mg$$

$$F_N = \frac{(40)(10)^2}{7} - (40)(9.8)$$

$$F_N = 179.4 \text{ N}$$

b) Force of car seat on child @ B?



\* tilted axis

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

$$F_N + mg \cos 30 = \frac{mv^2}{r}$$

$$F_N = \frac{(40)(10.5)^2}{7} - (40)(9.8) \cos 30$$

$$F_N = 290.5 \text{ N}$$

c) min. speed to keep child in seat @ A?

can ignore  $F_N$  down bc at min. speed only  $F_g$  affects movement

$$F_c = \frac{mv^2}{r} = mg \quad v = \sqrt{rg}$$

$$v = \sqrt{(7)(9.8)} = 8.28 \text{ m/s}$$

