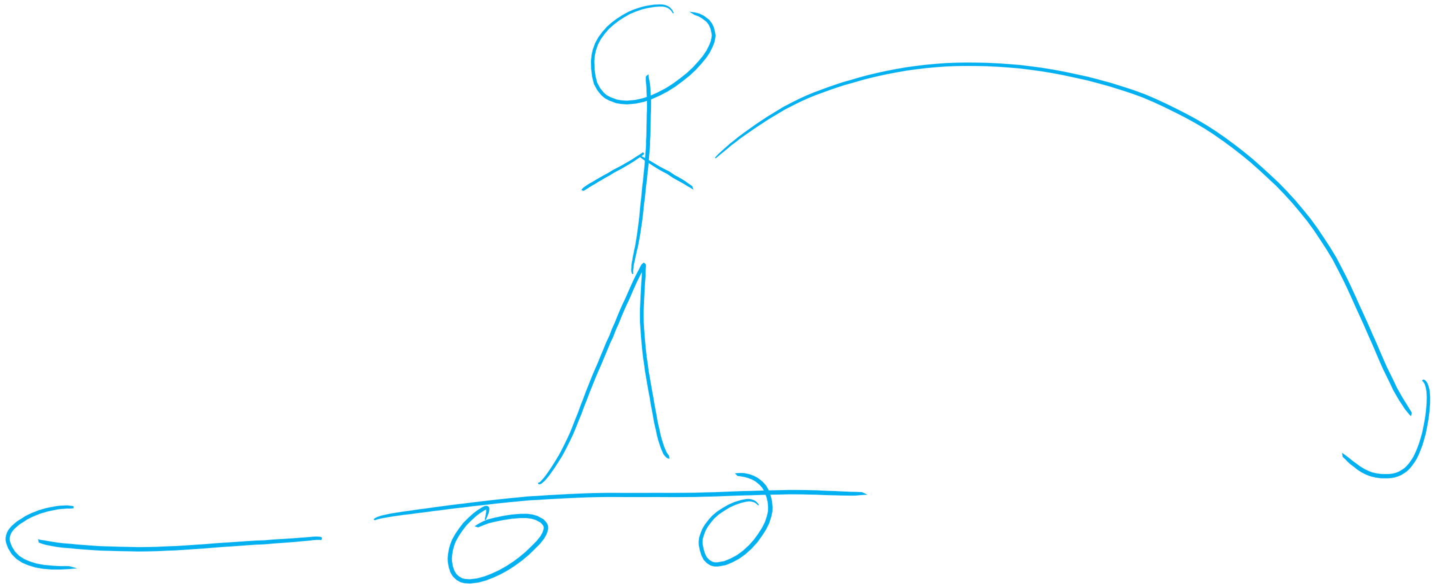
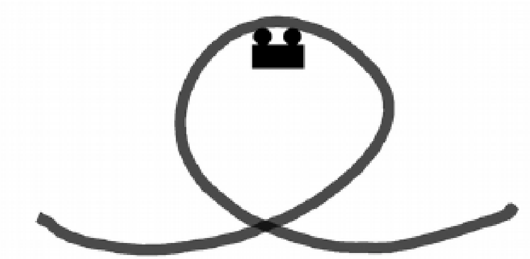
How far can a person jump off a skateboard?



<u>Question 1</u> [4 marks]

A 65 kg person rides a roller coaster while sitting on a bathroom scale. At the top of a loop-the-loop (pictured on the right) of radius 21 m, the roller coaster has a speed of 36 m/s. What does the bathroom scale read at the top of the loop? Answer in newtons (N).



$a = v^2/R$

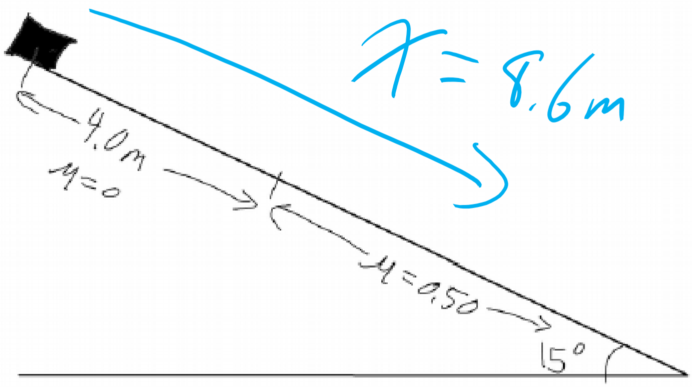
$$n + mg = mv^2/R$$

$$n = m\left(\frac{v^2}{R} - g\right)$$

$$= 65\left(\frac{36^2}{21} - 9.8\right) \sim 3400\,N$$

Question 2 [4 marks]

A 1.0 kg textbook slides down a road which is icy (treat as frictionless) at the top and rough (coefficient of kinetic friction is 0.50) the rest of the way. The road has a constant slope of 15 degrees. If the textbook was released from rest at the top of the icy patch, and the icy patch is 4.0 meters long, what total distance along the hill (including the icy patch) does the book travel before it comes to a stop?



$$\Delta K = K_f - K_i = 0$$

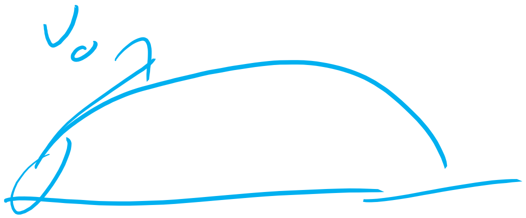
$$W_g + W_f = 0$$

$$\cancel{mg} \sin\theta \; x = \mu n (x-4) = \mu \cancel{mg} \cos\theta \, (x-4)$$

$$4 \mu \cos\theta = x(\mu \cos\theta - \sin\theta) \rightarrow x = 4 \frac{\mu \cos\theta}{\mu \cos\theta - \sin\theta}$$

Question 3 [12 marks]

Modeling Question: A typical tennis ball has a mass of 0.058 kg and a diameter of 0.067 m. How far do you think a typical person can throw a typical tennis ball (on flat ground) if they aim the ball at an angle of 30 degrees above the horizontal (as in they throw it more horizontally than vertically, but it does have some initial upward velocity)? Do not ignore air resistance for this question. Remember to evaluate your result.



assume

$c_D = \frac{1}{2}$

$V_0 = 20\ m/s$

$a_x = \text{constant} = \frac{a_{max}}{2}$

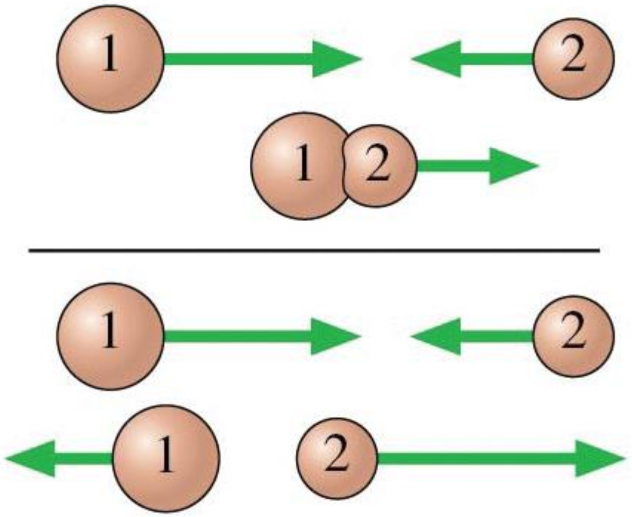
$F_D \to a_x \sim 7\ m/s^2$ max

$a_x = \text{const} = 3.5\ m/s^2$

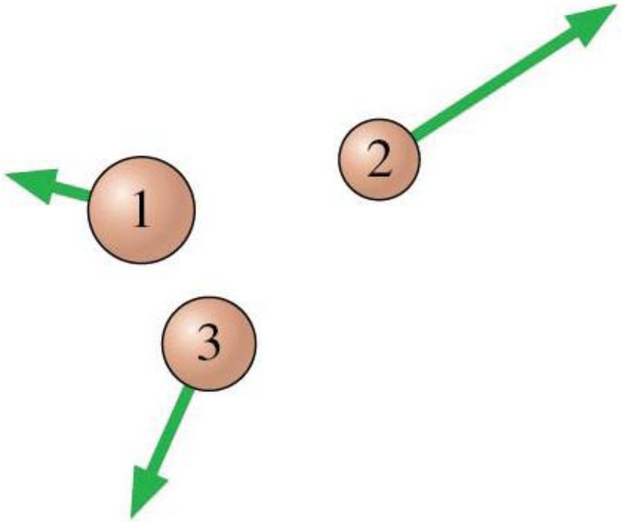
Chapter 11 – Impulse and Momentum

- Momentum, impulse
- When is momentum conserved?
- Collisions and explosions
- ~~Rockets~~

In a **perfectly inelastic collision,** two objects stick together and move with a common final velocity. In a **perfectly elastic collision,** they bounce apart and conserve mechanical energy as well as momentum.



In an **explosion,** two or more objects fly apart from each other. Their total momentum is conserved.



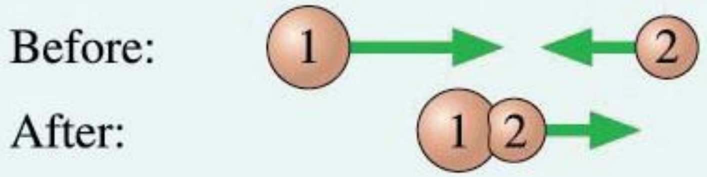
MODEL 11.1

Collisions

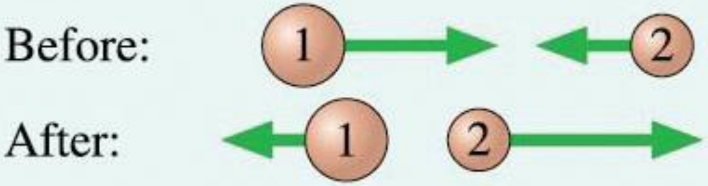
For two colliding objects.

- Represent the objects as elastic objects moving in a straight line.
- In a **perfectly inelastic collision,** the objects stick and move together. Kinetic energy is transformed into thermal energy. Mathematically:

$$(m_1 + m_2)v_{fx} = m_1(v_{ix})_1 + m_2(v_{ix})_2$$



- In a **perfectly elastic collision,** the objects bounce apart with no loss of energy. Mathematically:



  - If object 2 is initially at rest, then

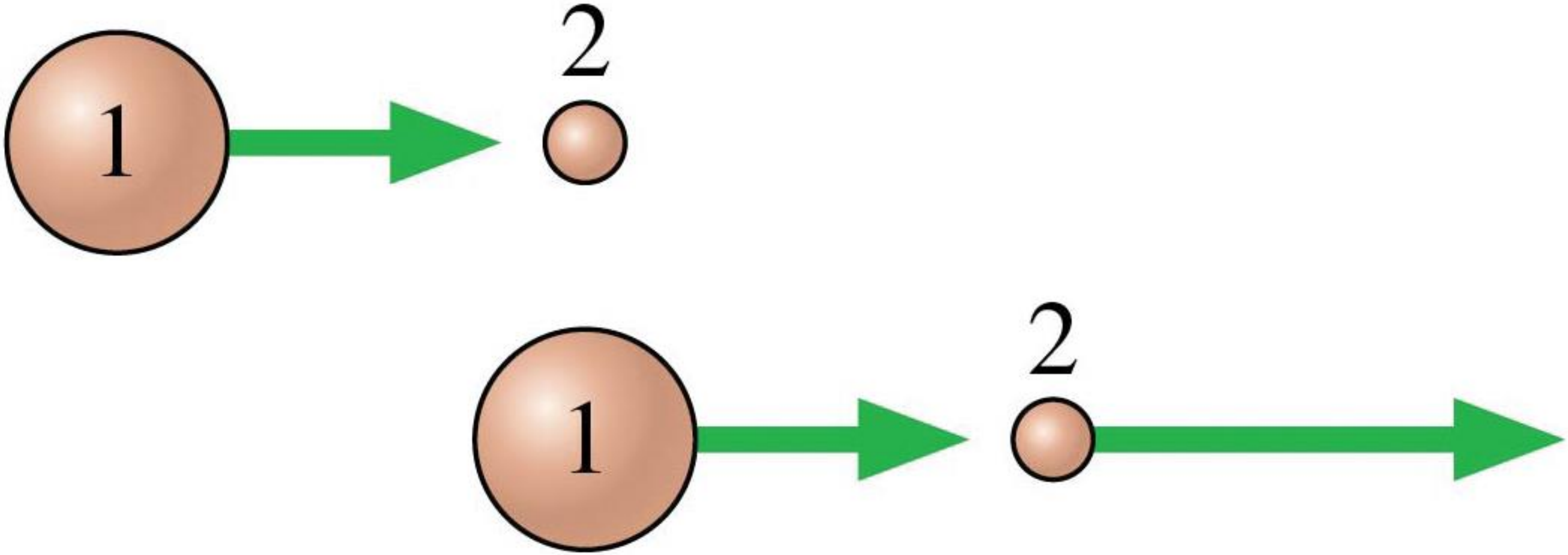
$$(v_{fx})_1 = \frac{m_1 - m_2}{m_1 + m_2}(v_{ix})_1 \qquad (v_{fx})_2 = \frac{2m_1}{m_1 + m_2}(v_{ix})_1$$

  - If both objects are moving, use the Galilean transformation to transform the velocities to a reference frame in which object 2 is at rest.

- Limitations: Model fails if the collision is not head-on or cannot reasonably be approximated as a “thud” or as a “perfect bounce.”

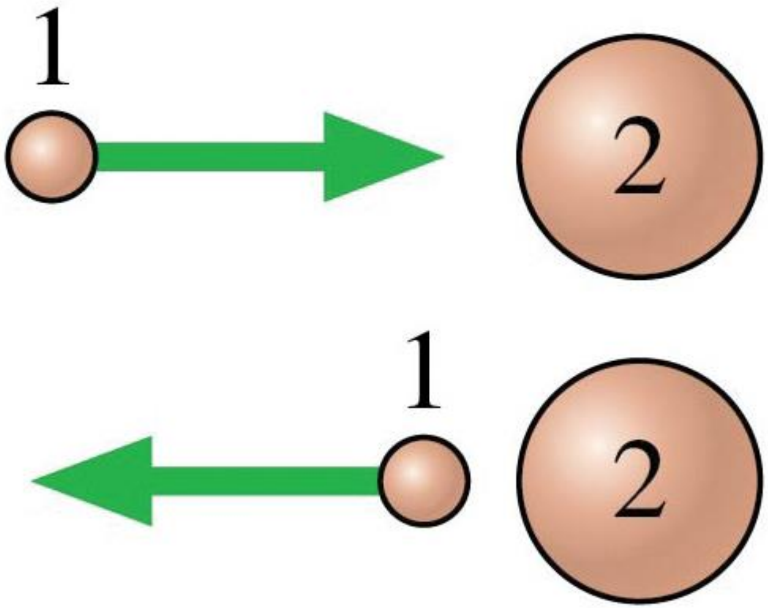
Exercise 22

Case b: $m_1 \gg m_2$



Ball 1 hardly slows down. Ball 2 is knocked forward at $v_{f2} \approx 2v_{i1}$.

Case c: $m_1 \ll m_2$



Ball 1 bounces off ball 2 with almost no loss of speed. Ball 2 hardly moves.

Team Up Questions

Is the impulse negligible?

$$J = \int F(t)\, dt = \Delta \vec{p}$$

$F_s \rightarrow$ definition of a large force

$\hookrightarrow J = F \Delta t$

$\hookrightarrow$ usually tiny

How far can a person jump off a skateboard?

explosion

$$p_i = 0 = mv_1 + Mv_2$$

$$-v_2 = v_1 \frac{m}{M} \sim v_1 \frac{1}{60} \sim \frac{10}{60} \sim 0.16 \text{ m/s}$$

assume $m \sim 1$ kg

$M \sim 60$ kg

$v \sim 10$ m/s

$t_{air} \sim 1$ sec

$d \sim 16$ cm