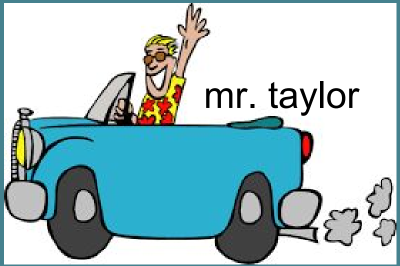


2D Collisions

...

by Chloe Goldstein and Lindsay Schauder

8.6 Collisions of Point Masses in Two Dimensions

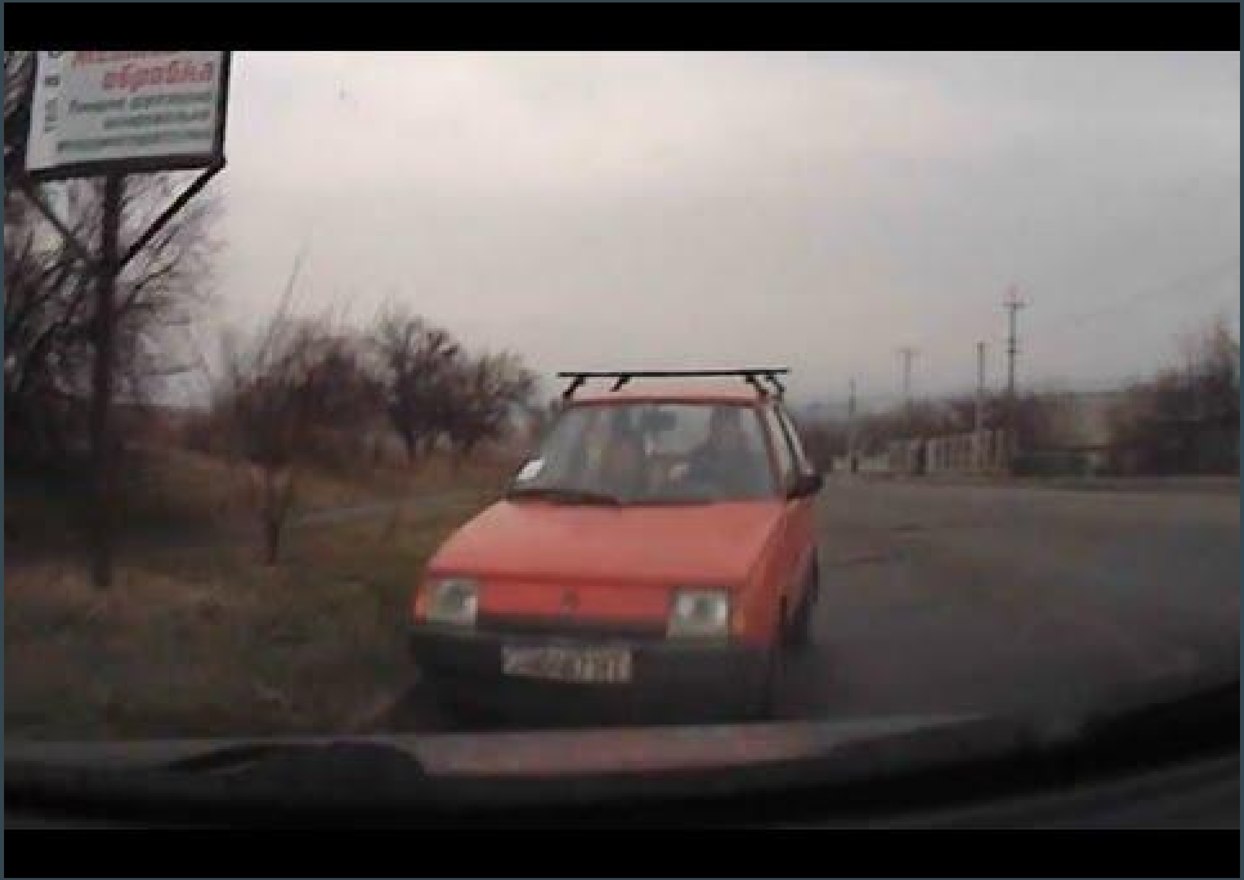
Boom

Crash

Bang

Smash

Video Example of a Collision



8.6 objectives

- Discuss 2D collisions as an extension of 1D analysis

- Define point masses

- Derive an expression for conservation of momentum along the x+y axis

- Describe elastic collisions of 2 objects with equal mass

- Determine the magnitude and direction of final velocity, given initial velocity and scattering angle

Make a Match!

Change in Momentum

A collision that also conserves kinetic energy

Inelastic Collision

A collision in which internal kinetic energy is not conserved

Elastic Collision

The difference between the final and initial momentum (mass x ΔV)

Internal Kinetic Energy

Structureless particles with no rotation or spin

Point Masses

The sum of the kinetic energies of the objects in a system

Conserv. of Momentum Principle

When the net force is zero, the total momentum of the system is constant

- Two-dimensional collisions of point masses where mass 2 is initially at rest conserve momentum along:

- The initial direction of mass 1 (the x-axis)

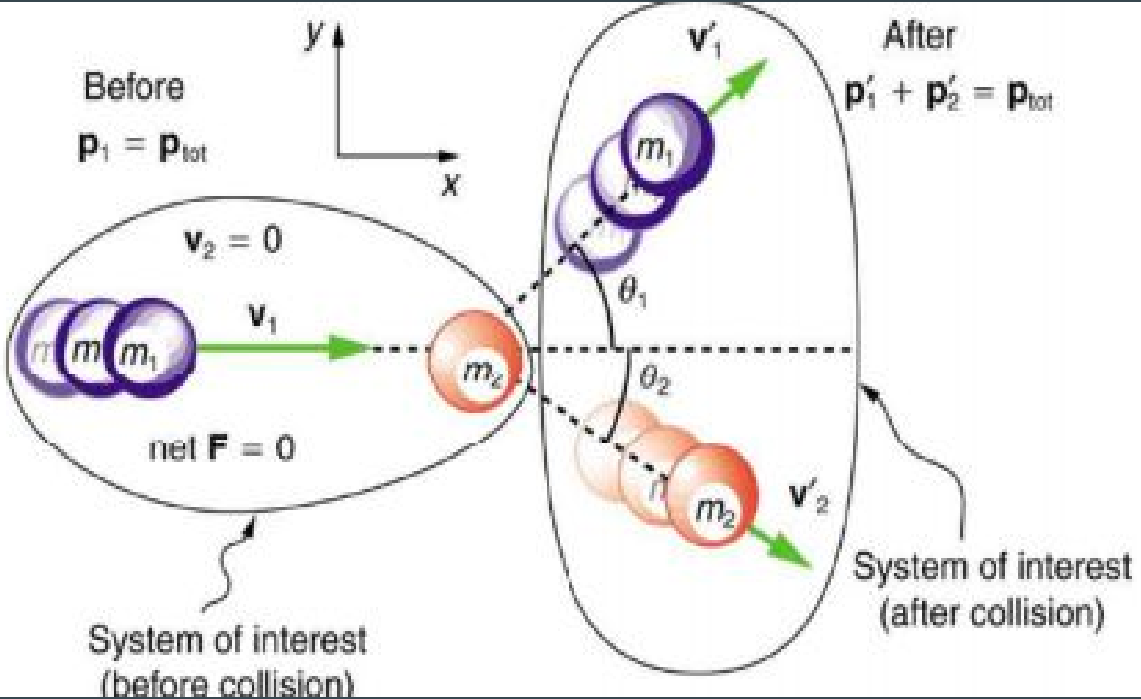
$$M1V1 = M1V1 \, Cos\Theta1 + M2V2 \, Cos\Theta2$$

- The initial direction perpendicular to the initial direction (the y-axis)

$$0 = M1V1y + M2V2y$$

- The internal kinetic force before and after the collision of two objects with equal masses
- $\frac{1}{2} MV1^2 = \frac{1}{2} MV1^2 + \frac{1}{2} MV2^2$

- Point masses are structureless particles that cannot spin



Before
$\mathbf{p}_1 = \mathbf{p}_{tot}$
y
x
$\mathbf{v}_2 = 0$
$\mathbf{v}_1$
m_1
m_2
net $\mathbf{F} = 0$
System of interest
(before collision)
After
$\mathbf{p}'_1 + \mathbf{p}'_2 = \mathbf{p}_{tot}$
$\mathbf{v}'_1$
θ_1
θ_2
$\mathbf{v}'_2$
System of interest
(after collision)

47.

3000 kg cannon is mounted so it can recoil only in the positive horizontal direction

a. calculate the recoil velocity when it fires a 15 kg shell at 480 m/s at an angle of 20 degrees.
b. what is the kinetic energy of the cannon? This energy is dissipated as a heat transfer in shock absorbers that stop its recoil.
c. what happens to the vertical component to linear kinetic energy in the collision?

47. givens: 3000kg
15kg shell @ 480 m/s 20° initial horizontal speed: $v = V_i \cos\theta$

a. initial momentum of shell: $m \cdot V_i = P$

horiz. speed = 480(cos 20) = 451 m/s

initial momentum = (15)(451) = 6766 kg m/s

horizontal recoil velocity of cannon = P_i / m

6766/3000 = -2.26 m/s b/c its recoiling

initial KE

b. $KE = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = J$

$\frac{1}{2} m V^2 = (.5)(3{,}000)(2.26)^2 = 7630\text{ J}$

c. ground will exert normal force in vertical direction opposite recoil. Momentum is transfered to Earth, making a dent where cannon is.

50.

Two cars collide at an icy intersection and stick together afterward. The first car has a mass of 1200 kg and is approaching at 8.00 m/s due south. The second car has a mass of 850 kg and is approaching at 17.0 m/s due west.

a. Calculate the final velocity (magnitude and direction) of the cars.
b. How much kinetic energy is lost in the collision? (This energy goes into deformation of the cars.)
    i. Note that because both cars have an initial velocity, you cannot use the equations for conservation of momentum along the x-axis and y-axis; instead, you must look for other simplifying aspects.

(A) In the west direction:

$$M_1V_1 = M_1V_1\cos\theta 1 + M_2V_2\cos\theta 2$$

$$V_x(1200 + 850) = 1200(0) + 850(17.0)$$

$$V_x = 7.05\ m/s$$

In the south direction:

$$M_1V_1 = M_1V_1\cos\theta 1 + M_2V_2\cos\theta 2$$

$$V_y(1200 + 850) = 1200(8.0) + 850(0)$$

$$V_y = 4.68\ m/s$$

$$V = \sqrt{(7.05^2 + 4.68^2)} \rightarrow \boxed{\text{velocity} = 8.46\ m/s}$$

$$\tan\theta = \frac{V_y}{V_x} \rightarrow \tan\theta = \frac{4.68}{7.05} \rightarrow \theta = 54° \text{ south of west}$$

(B) original equation $\rightarrow \frac{1}{2}M_1V_1^2 = \frac{1}{2}M_2V_1^2 + \frac{1}{2}MV_2^2$

$$KE_{lost} = \frac{1}{2}M_1V_1^2 + \frac{1}{2}M_2V_2^2 - \frac{1}{2}(M_1 + M_2)(V)^2$$

$$= \frac{1}{2}(1200)(8)^2 + \frac{1}{2}(850)(17)^2 - \frac{1}{2}(2050)(8.46)^2$$

$$= 87{,}864$$

Mega Joules

$$\rightarrow = \boxed{88\ J}$$

lab

2. Collision with both on the ramp

Thank you :)