Collisions in 1- and 2-D

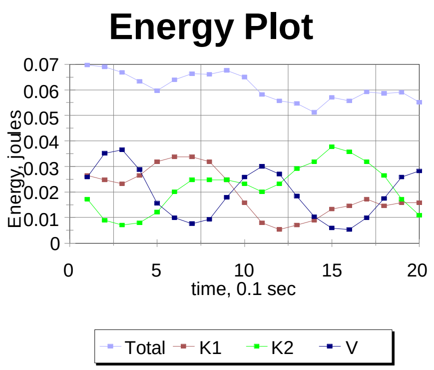
Momentum and Energy Conservation

Physics 109, Class Period 9
Experiment Number 6 in the
Physics 121 Lab Manual
16 October 2007

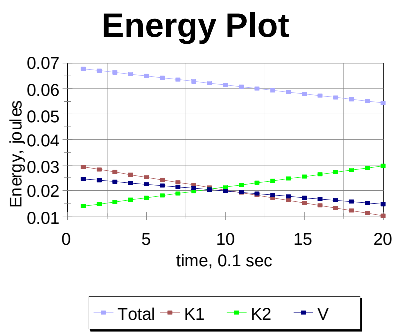
Outline

- Brief summary of Binary Star Experiment
- Description of the Collision Experiment
  - Collisions in one dimension
    - Perfectly Elastic
    - Partially Elastic
    - Totally Inelastic
  - Collision in two dimensions
    - Elastic collision of two pucks
- Impulse
- Problems based on homework
- Other problems based on collisions

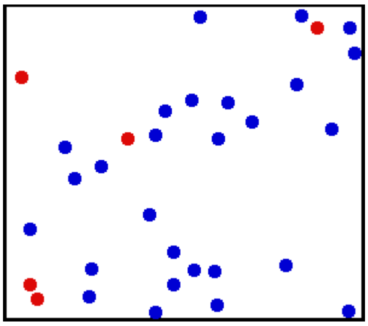
Energies from Binary Star Expt.



Energies with Linear Fit



Example of Elastic Collisions



Helium atoms at room temperature (slowed 2 x 10^9 times)

Perfectly Elastic Collisions

- Momentum and Energy are Conserved in the Collision.
- Equal masses, with one initially stationary
- After collision, the first mass stops, and the second mass moves with the same velocity as the first mass.

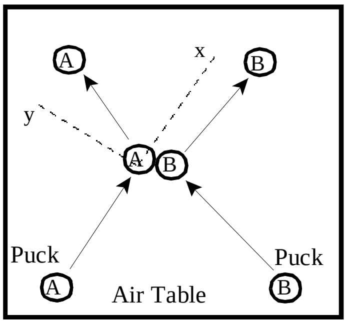
Partially Elastic Collisions

- In this case, Q is not zero.
- The *assumption* of momentum conservation is tested.
- The masses of the two cars are not identical so we need to measure both final velocities

Totally Inelastic Collisions

- In this case, the two masses stick together upon colliding.
- The final velocity is given by the ratio of the first mass to the sum of the two masses, times the initial velocity

Elastic Collisions in Two Dimensions



Two –Dimensional Elastic Collision

- This case is like the one-dimensional case
- The two masses now move in two dimensions.
- Assume conservation of momentum
  - Sum of the x components of the initial velocities is equal to the sum of the x components of the final velocities.
  - Same for y velocity components.

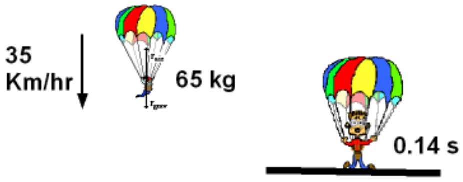
Impulse

- Collisions generally occur over a short time period.
- We are interested in determining the force involved in a collision.
- This force is called an IMPULSIVE FORCE
- Impulsive force = Momentum Change/time

Problems to Work in Class

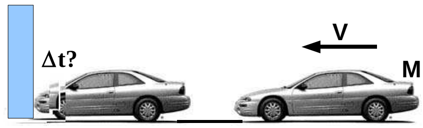
- Homework problems
  - Parachutist
  - Car and wall
  - Train cars
  - Sled and children
- A collision
- Perfectly elastic collision
- Totally inelastic collision
- Truck and car problems
- A croquet ball problem

A 65 kg parachutist hits the ground at 35 Km/hr and stops in 140 ms. How does the impulsive force compare with his weight?



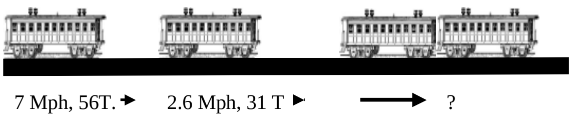
- A. Less than. B. Equal
- C. Greater than. C D. Cannot be determined.

Given the speed, mass of the car and a maximum for the impulsive force, how do we calculate the minimum time for the car to stop?



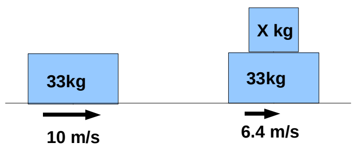
- A. ½ mv^2/force B. mgx/force
- C. mv/force C D. None of the above.

What is the speed of the cars after they couple?



- A. More than 7 Mph B. Less than 2.6 Mph
- C. Between 2.6 and 7 Mph Correct
- D. Cannot be determined
- What was lost in this collision?
- A. Momentum B. Kinetic Energy Corr.
- C. Potential Energy D. Heat

A child and sled of 33 kg mass is sliding horizontally at 10 m/s. Another child jumps on with negligible speed and speed drops to 6.4 m/s. What principle do we use to solve this problem?



A. Conservation of energy B. Conservative forces.

C. Conservation of momentum C. D. Conservation of mass

An object, A, strikes another, B, which is initially at rest. The collision reverses the direction of object A. Which statement is correct?

- A. Object A is more massive.
- B. Object B is more massive. Correct
- C. Impossible to determine relative masses.
- D. None of the above.

In a perfectly elastic collision:

- A. Momentum is conserved.
- B. Energy is conserved.
- C. Both of the above. Correct
- D. Neither of the above.

In a totally inelastic collision:

- A. Momentum is conserved. Correct
- B. Energy is conserved.
- C. Both of the above.
- D. Neither of the above

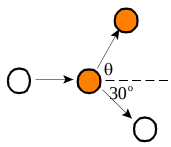
A truck of mass 9M moves with a speed of v = 15km/hr and collides with a parked car of mass M. The collision is elastic. What happens?

- A. The truck stops and the car is propelled backwards.
- B. Both vehicles continue in the same direction at the same speed.
- C. Both vehicles continue in the same direction at different speeds. Correct
- D. None of the above.

Reverse the collision– a car of mass M moving at a speed of 15 km/hr. collides with a parked truck of mass 9M, Now what happens?

- A. The car stops, and the truck moves off in the same direction.
- B. Both vehicles move on in the same direction, but the car is slower.
- C. The car rebounds and moves backward, and the truck moves more slowly in the same direction that the car was moving. C
- D. None of the above.

A moving croquet ball strikes a stationary one of equal mass. The incident ball goes off at 30 deg. to its original direction. In what direction does the other ball move?



A. 0 deg. B. 30 deg. C. 60 deg. C. D. 75 deg.

Discussion of the previous problem:

Momentum: v_1 (initial) = v_1(final) + v_2 (final)

Energy: $(v_{1i})^2 = (v_{1f})^2 + (v_{2f})^2$

After several steps (see page 274 in the text)

$2v_{1f}v_{2f}\cos(\theta + 30) = 0$

So, $\cos(\theta + 30) = 0$, and $\theta = 60^o$

(We tested this using the air table and pucks. It did not work. Why?)