Arvind Borde / PHY 11, Week 7: Linear Momentum

Definition of momentum:

Remember that

Therefore, as long as mass is fixed,

$$\vec{F} =$$

This may be rewritten as .

1 $\Delta\vec{p}$ is called the _____

(1) What are the units for p (two ways).

_____

(2) How much force do you need to accelerate an object of mass $60\,\text{gm}$ from rest to $55\,\text{m/s}$ in 4-thousandth of a second?

_____

2

Conservation of Momentum

For an *isolated* system momentum cannot change. It is *conserved*.

In other "words"

(Masses assumed to be constant.)

3

(3) A $3\,\text{kg}$ sticky ball moving at $5\,\text{m/s}$ to the right hits another sticky ball, of mass $2\,\text{kg}$, at rest. They stick (*duh*). In what direction does the stuck pair move, and at what speed?

4

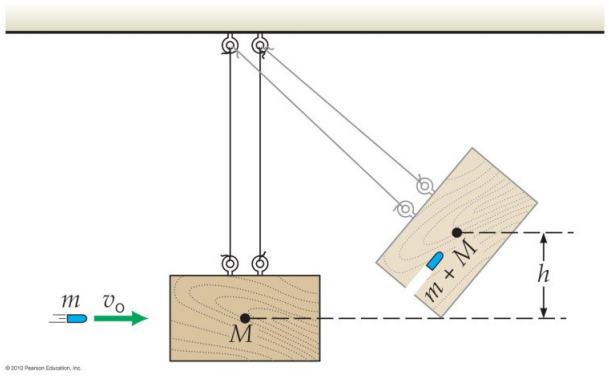
(4) What's the KE of the system at the start?

(5) What's the KE of the system at the end?

(6) Where did the lost energy go?

5 _____

The Ballistic Pendulum



6

ADDITIONAL NOTES

(7) OK, What's the connection with the sticky stuff from the previous problem?

7

Let $M = m_1 + m_2$ from now on.

Our interest is in finding v_i. To do that we need to know v_f, but it's tricky to measure directly.

8

(8)

9

So

where m_1 is mass of bullet, v_{1i} its initial speed, and M the combined mass of bullet and pendulum.

As we've seen, KE is not conserved in such a process. Such collisions are called _____

Collisions that that conserve KE are called _____

10

2-body Elastic Collisions

Momentum conservation:

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

11

KE conservation:

$$\frac{1}{2} m_1 v_{1_i}^2 + \frac{1}{2} m_2 v_{2_i}^2 = \frac{1}{2} m_1 v_{1_f}^2 + \frac{1}{2} m_2 v_{2_f}^2$$

or $$m_1 v_{1_i}^2 + m_2 v_{2_i}^2 = m_1 v_{1_f}^2 + m_2 v_{2_f}^2$$

(1)

Divide this equation by eqn. 1:

12

ADDITIONAL NOTES

Using $a^2 - b^2 =$ _____, we can rewrite the previous as

So,

or

13

For many problems these are what you need:

Conservation of momentum

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

Conservation of KE + momentum

$$(v_{1i} - v_{2i}) = -(v_{1f} - v_{2f})$$

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(**9**) A ball traveling with velocity $\vec{v}$ collides elastically with a ball of equal mass at rest. What happens after the collision?

Momentum:

KE+Mom:

15

Adding the two gives

So,

16

(**10**) A ball traveling with velocity $\vec{v}$ collides elastically with a ball of twice its mass at rest. What happens after the collision?

17

Adding the two gives

18

ADDITIONAL NOTES

(**11**) A ball traveling with velocity $\vec{v}$ collides elastically with a ball of half its mass at rest. What happens after the collision?

19

Subtracting the two gives

20

Center of Mass

It captures the concept of where the effective mass is.

m_1 and m_2 are two masses at positions x_1 and x_2 along the line between them. Then x is the position of the center of mass of the system.

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Two equal masses are at rest a distance 10 m apart.

(**12**) Where do you *expect* their CoM to be?

(**13**) Where do you *calculate* it to be?

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