Phy 2A 5/22

Monday, May 22, 2017 8:59 AM

Goals for the Lecture:

1) Understand what Momentum is and why it is special (how is it similar to and different from kinetic energy?)
2) Understand what Impulse is (how is it similar to and different from work?)
3) Be able to use the Impulse – Momentum Theorem to solve problems

From today's HW: #7
The distance required for a car to come to a stop will vary depending on how fast the car is moving. Suppose a certain car traveling down the road at a speed of 20 m/s can come to a complete stop within a distance of 80 m. Assuming the road conditions remain the same, what would be the stopping distance required for the same car if it were moving at the following speeds?

$$W = \Delta K$$

$$-f d = 0 - \frac{1}{2} m v_i^2$$

$$f = \frac{m v_i^2}{2d} = \frac{m (20)^2}{2 (80)} = 2.5\, m$$

↑ mass of car

if we want to stop the car from 40 m/s, how long a distance is needed:

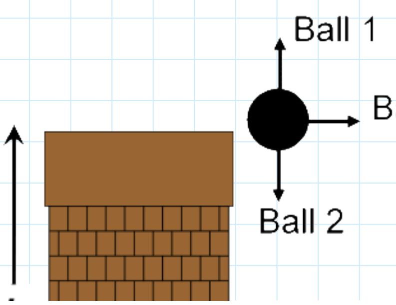
$$-f d = 0 - \frac{1}{2} m v_i^2$$

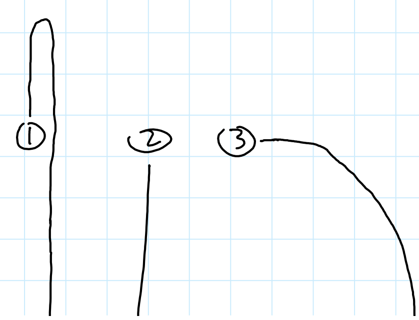
$$-(2.5\, m)\, d = -\frac{1}{2} m (40)^2$$

$$d = \frac{40^2}{2 (2.5)} = 320 \text{ meters}$$

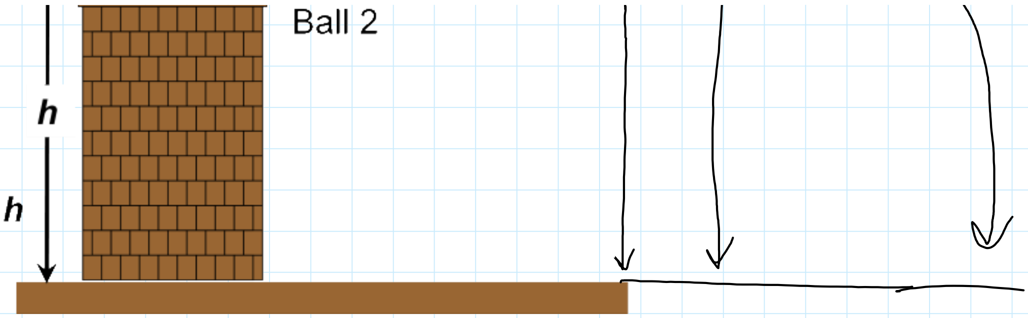
Three balls of equal mass are fired simultaneously with ***equal*** speeds from the same height h above the ground. Ball 1 is fired straight up, ball 2 is fired straight down, and ball 3 is fired horizontally. Rank in order from largest to smallest their speeds $\boldsymbol{v_1}$, $\boldsymbol{v_2}$, and $\boldsymbol{v_3}$ an instant before they hit the ground. (Neglect friction.)

1. $v_1 > v_2 > v_3$
2. $v_3 > v_2 > v_1$
3. $v_2 > v_1 > v_3$
4. v > v > v





3. $v_2 > v_1 > v_3$
4. v > v > v
5. $v_1 = v_2 > v_3$
6. $v_1 = v_2 = v_3$
7. Need to know height *h*



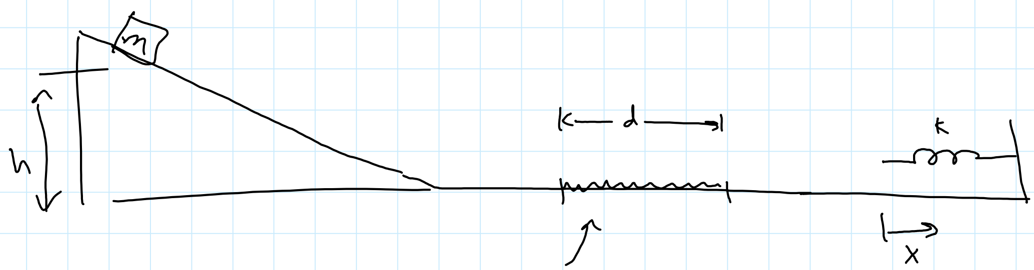
$$E_i = E_f$$

$$(K + U_g)_i = (K + U_g)_f$$

Same

so, K_f must be same for all

Problem:

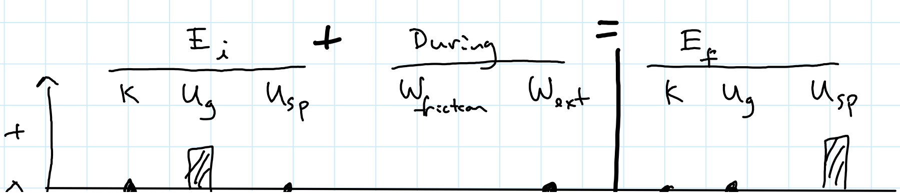


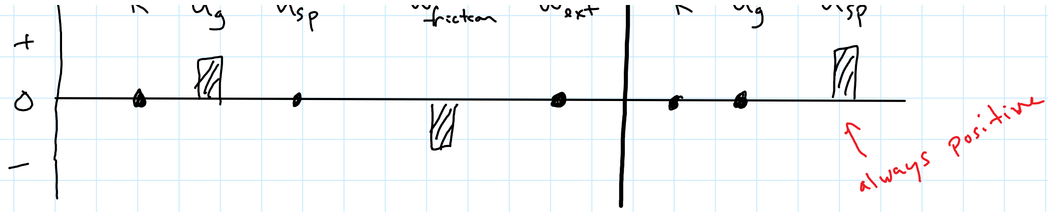
given:
- $h = 3$ m
- $d = 6$ m
- $m = 10$ kg
- $V_i = 0$
- $V_f = 0$
- $k = 2250 \frac{N}{m}$
- $x = 0.3$ m
- spring starts unstretched

find: μ_k

1st - Define system: block, earth, spring all in the system

2nd - Bar chart





$$mgh - f_k d = \frac{1}{2} k x^2$$

$$mgh - \mu_k \underbrace{(mg)}_{N} d = \frac{1}{2} k x^2$$

$$(10)(9.8)(3) - \mu_k (10)(9.8)(6) = \frac{1}{2} (2250)(0.3)^2$$

$$\mu_k = 0.328$$

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Top: If the y-axis is velocity and the x-axis is time

Find the work done on the object for each interval:
Let $m = 2$ kg

A) $W = \Delta K = K_f - K_i = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$$W = 0 - 0 = 0$$

B) $W = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$$= \frac{1}{2}(2)(-6)^2 - \frac{1}{2}(2)(0)^2$$

$$= 36 \text{ J}$$

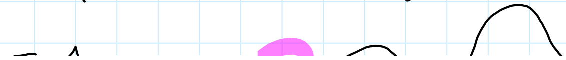
c) $W = 0$

D) $W = \frac{1}{2}(2)(6)^2 - \frac{1}{2}(2)(-6)^2$

$W = 0$

This time: y-axis is force (F_x)
x-axis is position (x)

Find work done on the object for each interval:



Find work done on the object for each interval:

A) $W = 0$

B) $W = -\frac{1}{2}(5)(6) = -15 \text{ J}$

C) $W = -(5)(6) = -30 \text{ J}$

D) $W = -\frac{1}{2}(2.5)(6) + \frac{1}{2}(2.5)(6) = 0$

Bottom: Find ΔK for each

A) $W_{Net} = \Delta K$

$F_{Net}\, d = \Delta K$

$\Delta K = (75)(10) = 750 \text{ J}$

B) $\Delta K = (75)(10) = 750 \text{ J}$

C) $\Delta K = (50)(10) = 500 \text{ J}$

D) $\Delta K = (100)(10) = 1000 \text{ J}$

Momentum

Collisions: 3 types:

1) One object becomes multiple objects (it blows up)

$K + K$

(it blows up)

$K_i \neq K_f$

(usually $K_f > K_i$)

Inelastic

2) Multiple objects become one
(they stick together)

$K_i \neq K_f$

(usually $K_f < K_i$)

Inelastic

3) Things bounce off each other

Don't know how K_i and K_f compare → Need more info

Can be elastic
$K_i = K_f$

Can be inelastic
$K_i \neq K_f$

For all collisions:

Momentum is conserved (constant) for isolated systems

momentum: $\vec{p} = m\vec{v}$ vector

$kg\,\frac{m}{s}$ units

Positive to the Right → +

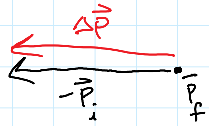
worksheet p. 191

a) $\vec{p}_i = (10\ kg)(4\ \frac{m}{s}) = +40\ kg\ \frac{m}{s}$ $\vec{p}_i$ →

$\vec{p}_f = (10)(0) = 0$ $\vec{p}_f$ •

$$\Delta \vec{p} = \vec{p}_f - \vec{p}_i = 0 - 40 = -40 \ kg \frac{m}{s}$$

$\Delta \vec{p}$:

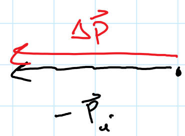


b) $\vec{p}_i = (20)(2) = +40 \ kg \frac{m}{s}$

$\vec{p}_f = 0$

$\Delta \vec{p} = 0 - 40 = -40 \ kg \frac{m}{s}$

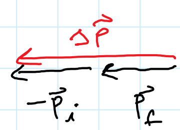
or



c) $\vec{p}_i = (10)(2) = +20 \ kg \frac{m}{s}$

$\vec{p}_f = (10)(-2) = -20 \ kg \frac{m}{s}$

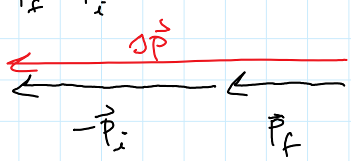
$\Delta \vec{p} = \vec{p}_f - \vec{p}_i = -20 - 20 = -40 \ kg \frac{m}{s}$



d) $\vec{p}_i = (5)(5) = +25 \ kg \frac{m}{s}$

$\vec{p}_f = (5)(-3) = -15 \ kg \frac{m}{s}$

$\Delta \vec{p} = \vec{p}_f - \vec{p}_i = -15 - 25 = -40 \ kg \frac{m}{s}$

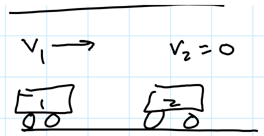


Example

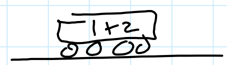
a) initial: $v_1 \rightarrow$ $\quad v_2 = 0$

final: carts stick together

a)



carts stick together



$m_1 = 10$ kg

$m_2 = 20$ kg

$V_{1i} = 5 \frac{m}{s}$

$V_{2i} = 0$

$V_f = ?$

$$\vec{P}_i = \vec{P}_f \qquad \rightarrow +$$

$$m_1 V_{1i} + m_2 \cancel{V_{2i}}^{\,0} = (m_1 + m_2) V_f$$

$$(10)(5) + 0 = (10+20) V_f$$

$$V_f = \frac{50}{30} = \frac{5}{3} \frac{m}{s}$$

$$V_f = 1.67 \frac{m}{s} \text{ to the right}$$

Find K_i and K_f :

$$K_i = K_{1i} + K_{2i}$$

$$= \frac{1}{2} m_1 V_{1i}^2 + \frac{1}{2} m_2 V_{2i}^2$$

$$= \frac{1}{2} (10)(5)^2 + 0$$

$$= 125 \text{ J}$$

$$K_f = \frac{1}{2} (m_1 + m_2) V_f^2$$

$$= \frac{1}{2} (30) (1.67)^2$$

$$= \frac{1}{2} (30) \frac{25}{9}$$

$$= \frac{125}{3} = 41.67 \text{ J}$$

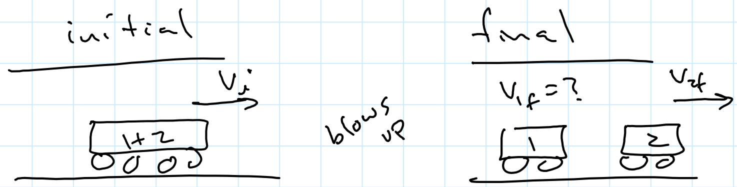
$K_i > K_f$ so, inelastic collision

[illegible]

$K_i > K_f$ so, inelastic collision

(mechanical energy was converted into heat, sound, deformation)

b)



$V_i = 4 \frac{m}{s}$

$m_1 = m_2 = 2 \text{ kg}$

$V_{1f} = ?$

$V_{2f} = 6 \frac{m}{s}$

$$\vec{P}_i = \vec{P}_f \quad \rightarrow +$$

$$(m_1 + m_2) V_i = m_1 V_{1f} + m_2 V_{2f}$$

$$(2+2)(4) = (2) V_{1f} + (2)(6)$$

$$V_{1f} = 2 \frac{m}{s}$$

↑ positive, so to the right

Now, Kinetic energy:

$$K_i = \frac{1}{2}(m_1 + m_2) V_i^2 = \frac{1}{2}(2+2)(4)^2 = 32 \text{ J}$$

$$K_f = \frac{1}{2} m_1 V_{1f}^2 + \frac{1}{2} m_2 V_{2f}^2$$

$$= \frac{1}{2}(2)(2)^2 + \frac{1}{2}(2)(6)^2$$

$$= 4 + 36 = 40 \text{ J}$$

$K_f > K_i$ so, inelastic collision

(we added energy by blowing it into two pieces)