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Momentum – key words

Momentum: The product of the mass and velocity of an object.
Always conserved. $p = m \cdot v$. Measured in $kg \cdot m/s$

Impulse: The change in momentum. $\Delta p = m\Delta v = F\Delta t$ measured in $N \cdot s$

Elastic collision: collision where total KE is conserved. $\Sigma KE_{Before} = \Sigma KE_{After}$.

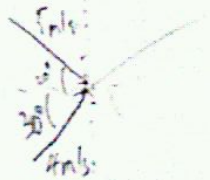
Inelastic collision: collision where total KE is not conserved $\Sigma KE_{Before} \neq \Sigma KE_{After}$

Completely inelastic collision: collision where the masses stick together.

Conservation of Momentum: $P_{before} = P_{after}$

Example:

1 A ball of mass 1.0kg travelling at 5.0m/s at 20° south of east.
A blob of mass 1.5kg travelling at 4.0m/s at 30° north of east.
They collide and stick together.
a) Calculate the velocity of the blobball after the collision.



$P_{before} = P_{after}$. $p = mv$.

$P_x = P_{m_1x} + P_{m_2x} = (1.0kg)(5.0m/s)(\cos 20°) + (1.5kg)(4.0m/s)(\cos 30°)$
$= 9.895\ kg \cdot m/s.$

$P_y = P_{m_1y} + P_{m_2y} = (1.0kg)(5.0m/s)(\sin 20°) - (1.5kg)(4.0m/s)(\sin 30°)$
$= -1.29\ kg\,m/s$

$p_{xafter} = (m_1 + m_2)V_x'$ $\qquad$ $p_{yafter} = (m_1 + m_2)V_y'$

$V_x' = \frac{p_{xafter}}{m_1 + m_2}$ $\qquad$ $V_y' = \frac{p_{yafter}}{m_1 + m_2}$

$V_x' = 3.958m/s$ $\qquad$ $V_y' = -0.516m/s$

$V = 3.99m/s \approx 4.0m/s$ $\qquad$ $\theta = \tan^{-1}\left(\frac{-0.516m/s}{3.958m/s}\right) = 7.4°$

at 7.4° north of east.

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b) Is the collision elastic or inelastic? Why?

If the collision is elastic then $KE_{before} = KE_{after}$

$$\frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 = \frac{1}{2}(m_A + m_B)v_{AB}^2$$

$$\frac{1}{2}(1)(5)^2 + \frac{1}{2}(1.5)(4)^2 = \frac{1}{2}(1+1.5)(4)^2$$

$$24.5\text{J} \neq 20\text{J}$$

$KE_{before} \neq KE_{after}$

the collision is inelastic.

Free Response: and length 1m

A pendulum of 5kg is risen 5.0cm from the surface of the table. We let go of it and it hits a ball of 0.10 kg at the lowest point of its swing. Given that the table is 1.5 m from the floor, how far will the ball land? ~~How long does it take to fall?~~ ~~What is the period of the pendulum~~ after collision? What's the maximum height after collision

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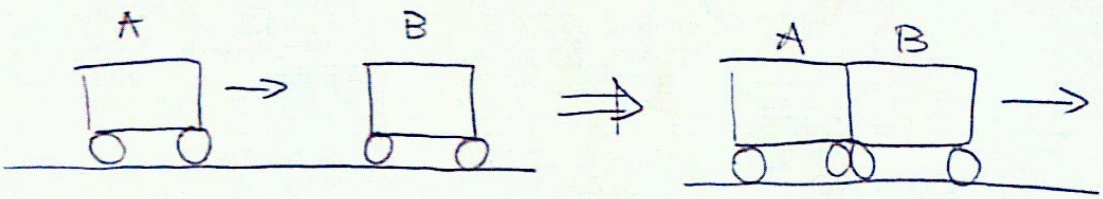
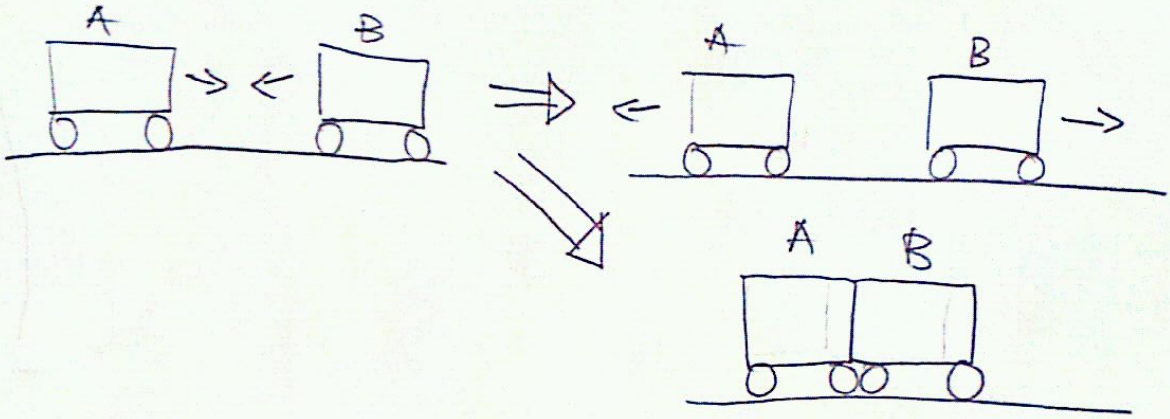
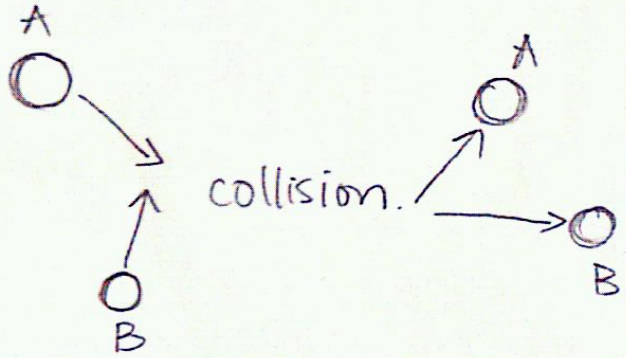
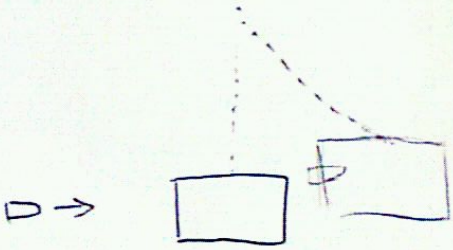
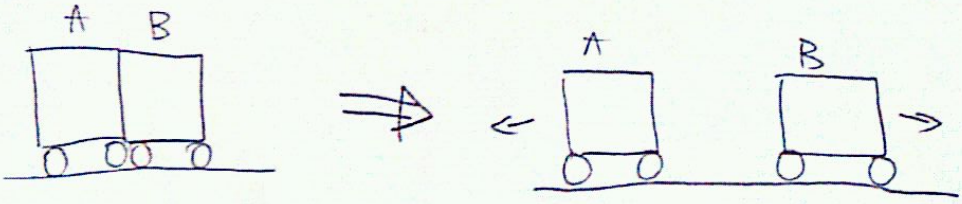
Momentum - Diagrams











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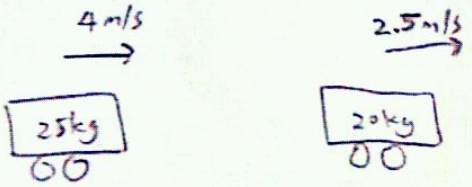
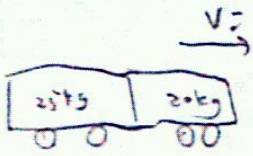


Before



After

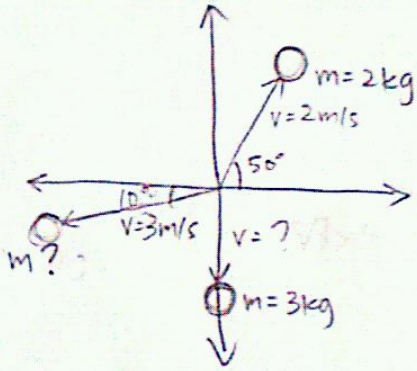
What is the velocity after the collision?

Momentum is conserved.

$m_1v_1 + m_2v_2 = (m_1 + m_2)v_3$

$25kg \cdot 4m/s + 20kg \cdot 2.5m/s = (25kg + 20kg)v_3$

$3.3m/s = v_3$



a) An ice cube explodes, scattering into 3 pieces. What was the original mass of the ice cube?

Momentum is conserved.

$P_x = 2(\cos 50°)(2) - 3(\cos 10°)m = 0$

$m = 0.87\,kg$

$M_0 = 0.87 + 2 + 3 = 5.87\,kg$

b) What was the velocity of the 3kg mass?

$P_y = 0$ so $2 \times (2) \times (\sin 50) = 3v + 3(\sin 10°)(0.87)$

$v = 0.87\,m/s$

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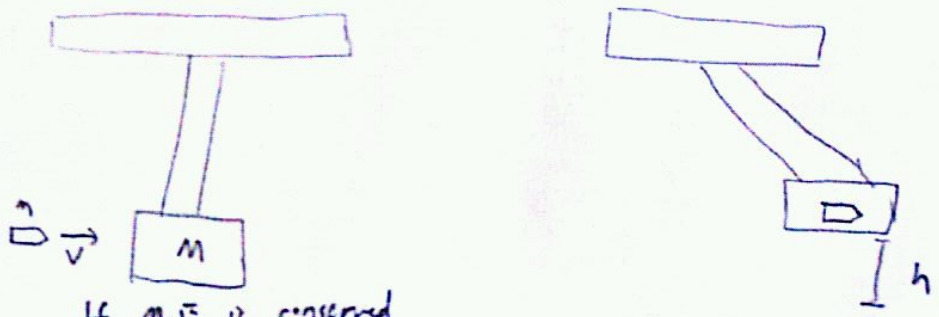
Momentum - MC

1. A billiard ball with velocity v m/s hits a billiard ball of the same mass initially at rest. Then it comes to a stop, and the billiard ball that it hits travels with a velocity of v m/s. What is true?

   A. Only momentum is conserved
   B. Only mechanical energy is conserved
   C. Both momentum and mechanical energy are conserved
   D. Mechanical energy is lost
   E. Momentum is lost.

2.



If M.E. is conserved
What is h, in terms of other variables?

   A. $\frac{Mv^2}{2g(m+M)}$
   B. $\frac{mv^2}{2g(m+M)}$
   C. $\frac{mv}{g(m+M)}$
   d. $\frac{Mv}{g(m+M)}$
   e. $\frac{mv}{2g(m+M)}$

3. What is the velocity of the system right after collision?

   A. $\sqrt{\frac{Mv^2}{m+M}}$
   B. $\sqrt{\frac{(m+M)v^2}{m}}$
   C. $\sqrt{\frac{mv^2}{m+M}}$
   D. $\frac{Mv}{m+M}$
   E. $\frac{mv}{m+M}$

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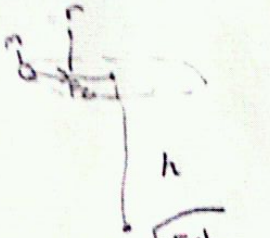
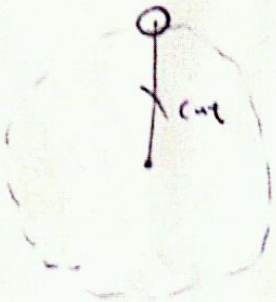
C
B
6



A. $\sqrt{\frac{Fgh}{2m}}$
B. $\sqrt{\frac{2Fgh}{m}}$
C. $\sqrt{\frac{Fgh}{m}}$
D. $\sqrt{\frac{2Fgh}{m}}$
E. $\sqrt{\frac{Fgh}{m}}$

When the rope is cut. How far does it travel before it hits the ground, from its initial position?

Top view



In which dir will the obj fly?

A. →
B. ↓
C. ↗
D. ←
E. ↑

Free Response Answer

M.E. is conserved.

$\cancel{K.E^{0}} + P.E = K.E + \cancel{P.E^{0}}$

$mgh = \frac{1}{2}mv^2$

$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 0.05\,m} = 0.99\,m/s$

Momentum is conserved

$mv = mv$

$0.99 \times 5kg = 0.1kg\ v$

$v = 49.5\,m/s$

$d = \frac{1}{2}at^2$

$1.5m = \frac{1}{2} \cdot 9.8\frac{m}{s^2} \cdot t^2$

$t = 0.55s$

$d = vt = 49.5 \times 0.55\,s = 27.4m$

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