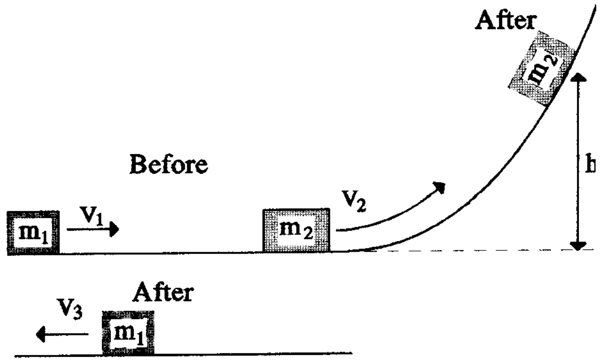
LAB PHYSICS - TEST CHAPTER 7[D]
MOMENTUM CONSERVATION - 100 PTS - 1994-95

BE SURE TO SHOW ALL WORK CAREFULLY!

1. A block, which has a mass of $m_1 = 3.5$ kg is moving toward the right with a velocity of $v_1 = 7.2$ m/sec when it collides elastically with a second block which has a mass of $m_2 = 6.5$ kg. and is moving toward the right with a velocity of $v_2 = 4.2$ m/sec. After the collision m_2 slides up a frictionless hill until it reaches a height of h where it briefly stops and m_1 rebounds to the left as shown with a new velocity v_3.



   a. What is the momentum of m_1 before the collision? [5 pts]
   b. What will be the total momentum of this system before the blocks collide ? [5 pts]
   c. What will be the total momentum of this system immediately after the blocks collide ? [5 pts]

   Suppose that the collision between these two blocks is elastic.

   d. What will be the velocity of each of these two blocks immediately after the collision ? [5 pts +5 pts]
   e. What will be the magnitude of the impulse delivered to m_2 by its collision with m_1 ? [5 pts]
   f. If these two blocks were in contact for 0.015 seconds, what average force was applied to mass m_2 by mass m_1 during the collision ? [5 pts]
   g. How high up the slope h will mass m_2 slide before it momentarily stops? [5 pts]

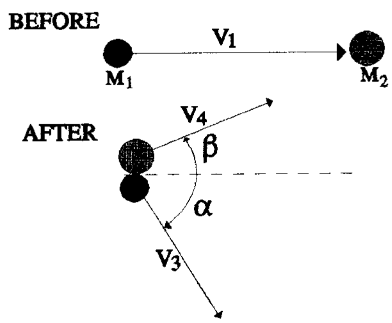
   Suppose, instead, that the collision between these two blocks is inelastic and that the coefficient of restitution is $e = 0.73$.

   h. What will be the velocity of each of these blocks immediately after the collision ? [5 pts + 5 pts]

   Suppose, finally, that m_1 runs into mass m_2 and sticks to it.

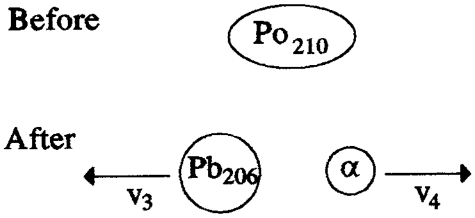
   i. What will be the final velocity of these two blocks immediately after the collision ? [5 pts]
   j. How much energy will be lost in this collision ? [5 pts]

2. A ball, which has a mass of 7.70 kg., is moving toward the right with a velocity of 13.2 m/sec when it collides with a second ball, which has a mass of 4.50 kg and which is initially at rest. After the collision the first ball is deflected to the right of the original path of motion at an angle of $\alpha = 17.5^\circ$ while the second ball is deflected to the left of the original path of motion at an angle of $\beta = 44.7^\circ$ as shown to the right.



   a. What is the initial momentum of this system in the x direction before the collision ? [5 pts]
   b. What will be the momentum of this system in the y direction immediately after the collision ? [5 pts]
   c. What will be the speed of the first ball immediately after the collision ? [5 pts]
   d. What will be the speed of the second ball immediately after the collision ? [5 pts]
   e. How much energy was lost in this collision ? [5 pts]

3. Polonium 210 is a radioactive isotope. When this isotope undergoes Alpha decay the nucleus splits into a Helium nucleus which has a mass of 6.64×10^{-27} kg. and into a Lead nucleus which has a mass of 3.42×10^{-25} kg. The Alpha particle is emitted with a velocity of $v_4 = 1.75 \times 10^7$ m/sec.



   a. What is the total momentum of this system before the Polonium atom decays ? [5 pts]
   b. What will be the total momentum of this system immediately after the Polonium atom decays? [5 pts]
   c. What will be the velocity of the Lead nucleus immediately after the Polonium atom decays ? [5 pts]
   d. How much energy was released in this process ? [5 pts]

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1. $m_1 := 3.5\cdot kg \quad v_1 := 7.2\cdot\frac{m}{sec} \quad m_2 := 6.5\cdot kg \quad v_2 := 4.2\cdot\frac{m}{sec} \quad N := newton \quad J := joule$

a. $p_1 := m_1\cdot v_1 \quad p_1 = 25.2\cdot kg\cdot\frac{m}{sec}$ **1a. The initial momentum of m1. [5 pts]**

b. $p_i := m_1\cdot v_1 + m_2\cdot v_2 \quad p_i = 52.5\cdot kg\cdot\frac{m}{sec}$ **1b. The initial total momentum. [5 pts]**

c. $p_f := p_i \quad p_f = 52.5\cdot kg\cdot\frac{m}{sec}$ **1c. The final momentum is the same as the initial total momentum. [5 pts]**

d. $v_3 := 1\cdot\frac{m}{sec} \quad v_4 := 1\cdot\frac{m}{sec} \quad e := 1$

GIVEN $p_f = m_1\cdot v_3 + m_2\cdot v_4 \quad -e = \frac{v_4 - v_3}{v_2 - v_1}$

$\begin{pmatrix} v_3 \\ v_4 \end{pmatrix} := FIND(v_3, v_4) \quad v_3 = 3.3\cdot\frac{m}{sec} \quad v_4 = 6.3\cdot\frac{m}{sec}$ **1d. The final velocities of the two masses after the collision. [5 pts + 5 pts]**

e. $\Delta p_2 := m_2\cdot v_4 - m_2\cdot v_2 \quad \Delta p_2 = 13.65\cdot kg\cdot\frac{m}{sec}$ **1e. The impulse delivered to m2. [5 pts]**

f. $\Delta t := 0.015\cdot sec \quad F := \frac{\Delta p_2}{\Delta t} \quad F = 910\cdot N$ **1f. The average force applied to m2. [5 pts]**

g. $KE_f := \frac{1}{2}\cdot m_2\cdot v_4^{\,2} \quad KE_f = 129\cdot J \quad h := \frac{KE_f}{m_2\cdot g} \quad h = 2.024\cdot m$ **1g. The height to which m2 will slide. [5 pts]**

h. $e := .73$

GIVEN $p_f = m_1\cdot v_3 + m_2\cdot v_4 \quad -e = \frac{v_4 - v_3}{v_2 - v_1}$

$\begin{pmatrix} v_3 \\ v_4 \end{pmatrix} := FIND(v_3, v_4) \quad v_3 = 3.827\cdot\frac{m}{sec} \quad v_4 = 6.016\cdot\frac{m}{sec}$ **1h. The final velocities if the elastic coefficient is 0.73. [5 pts + 5 pts]**

i. $v_4 := \frac{p_f}{(m_1 + m_2)} \quad v_4 = 5.25\cdot\frac{m}{sec}$ **1i. The final velocity of the two masses if they stick together. [5 pts]**

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j. $E_{lost} := \frac{1}{2}\cdot m_1\cdot v_1^{\,2} + \frac{1}{2}\cdot m_2\cdot v_2^{\,2} - \frac{1}{2}\cdot(m_1 + m_2)\cdot v_4^{\,2} \quad E_{lost} = 10.238\cdot J$ **1j. The energy lost in this inelastic collision. [5 pts]**

2.

$m_1 := 7.7\cdot kg \quad v_1 := 13.2\cdot\frac{m}{sec} \quad v_3 := 10.5\cdot\frac{m}{sec} \quad \alpha := 23\cdot deg \quad k := .83 \quad J := joule$

$m_2 := 4.5\cdot kg \quad v_2 := 0\cdot\frac{m}{sec} \quad v_4 := 3\cdot\frac{m}{sec} \quad \beta := 12\cdot deg \quad e := 1$

a. $p_{ix} := m_1\cdot v_1 \quad p_{ix} = 101.64\cdot kg\cdot\frac{m}{sec}$ **2a. The initial momentum in the x direction. [5 pts]**

b. $p_{iy} := 0$ **2b. The initial moemtum in the y direction. [5 pts]**

2. [cont.]

GIVEN

$m_1 \cdot v_1 = m_1 \cdot v_3 \cdot \cos(\alpha) + m_2 \cdot v_4 \cdot \cos(\beta)$ $m_1 \cdot v_3 \cdot \sin(\alpha) = m_2 \cdot v_4 \cdot \sin(\beta)$ $m_1 \cdot v_1^2 \cdot k = m_1 \cdot v_3^2 + m_2 \cdot v_4^2$

$\begin{bmatrix} \alpha \\ \beta \\ v_4 \end{bmatrix} := \text{FIND}(\alpha, \beta, v_4)$ $\alpha = 17.477 \cdot \text{deg}$ $\beta = 44.717 \cdot \text{deg}$ $v_4 = 7.669 \cdot \frac{m}{sec}$

c. $v_3 = 10.5 \cdot \frac{m}{sec}$ **2c. The final velocity of the first ball. [5 pts]**

d. $v_4 = 7.669 \cdot \frac{m}{sec}$ **2d. The final velocity of the second ball. [5 pts]**

e. $E_{lost} := \frac{1}{2} \cdot m_1 \cdot v_1^2 - \left(\frac{1}{2} \cdot m_1 \cdot v_3^2 + \frac{1}{2} \cdot m_2 \cdot v_4^2 \right)$ $E_{lost} = 114.04 \cdot J$ **2e. The energy lost in this collision. [5 pts]**

3. $m_1 := 3.42 \cdot 10^{-25} \cdot kg$ $m_2 := 6.64 \cdot 10^{-27} \cdot kg$ $v_4 := 1.75 \cdot 10^7 \cdot \frac{m}{sec}$ $v_3 := 1 \cdot \frac{m}{sec}$

a. $p_i := 0 \cdot kg \cdot \frac{m}{sec}$ $p_f := p_i$ **3a. The initial momentum of the system. [5 pts]**

b. $p_f = 0 \cdot kg \cdot \frac{m}{sec}$ **3b. The momentum after the decay. [5 pts]**

c. $v_3 := \frac{m_2 \cdot v_4}{m_1}$ $v_3 = 3.398 \cdot 10^5 \cdot \frac{m}{sec}$ **3c. The final velocity of the Lead atom. [5 pts]**

d. $E_{released} := \frac{1}{2} \cdot m_1 \cdot v_3^2 + \frac{1}{2} \cdot m_2 \cdot v_4^2$ $E_{released} = 1.036 \cdot 10^{-12} \cdot J$ **3d. The energy released in the decay process. [5 pts]**