PHYS 101:General Physics1 KOÇ UNIVERSITY Fall Semester 2016

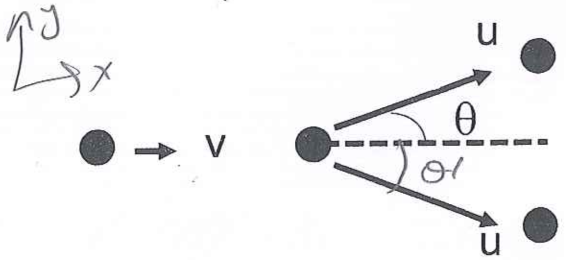
College of Sciences

Section 1 Quiz 6 November 25, 2016

Closed book. Duration: 10 minutes

Name: Student ID: Signature:

A particle with mass m and initial velocity v hits a stationary particle of the same mass. In this process, the internal energy of the particles increases by E, so the mechanical energy of the system decreases by the same amount. If the particles move with the same speed as in the figure, find u and θ.



Mechanical energy of the system decreases by E (inelastic collision)

Before collision, $E_i = \frac{1}{2}mv^2$

After collision, $E_f = \frac{1}{2}mu^2 + \frac{1}{2}mu^2$

(i) $\boxed{E_f - E_i = -E}$

Conservation of momentum:

y) $0 = mu\sin\theta - mu\sin\theta' \Rightarrow \theta = \theta'$

x) $mv = mu\cos\theta + mu\cos\theta \Rightarrow \boxed{v = 2u\cos\theta}$ (ii)

Using (i): $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 - \frac{1}{2}mu^2 = E$

$\frac{v^2}{2} - u^2 = \frac{E}{m} \Rightarrow u = \sqrt{\frac{v^2}{2} - \frac{E}{m}}$

Using (ii) $\cos\theta = \frac{v}{2u} = \frac{v}{2\sqrt{\frac{v^2}{2} - \frac{E}{m}}} \Rightarrow \theta = \cos^{-1}\left(\frac{v}{2\sqrt{\frac{v^2}{2} - \frac{E}{m}}}\right)$

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Section 2 Quiz 6 November 25, 2016

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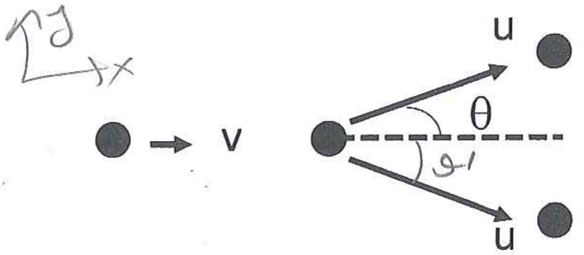
Name: **Student ID:** **Signature:**

A particle with mass m and initial velocity v hits a stationary nucleus of the same mass. In this process, the internal energy of the particles decreases by E, so the mechanical energy of the system increases by the same amount. If the particles move with the same speed as in the figure, find u and θ.



Mechanical energy of the system increases by E
(inelastic collision)

Before collision, $E_i = \frac{1}{2}mv^2$

After collision, $E_f = \frac{1}{2}mu^2 + \frac{1}{2}mu^2$

(i) $\boxed{E_f - E_i = E}$

Conservation of momentum:

$y]$ $0 = mu\sin\theta - mu\sin\theta' \Rightarrow \theta = \theta'$

$x]$ $mv = mu\cos\theta + mu\cos\theta \Rightarrow \boxed{v = 2u\cos\theta}$ (ii)

Using (i): $\frac{1}{2}mu^2 + \frac{1}{2}mu^2 - \frac{1}{2}mv^2 = E$

$u^2 - \frac{1}{2}v^2 = \frac{E}{m} \Rightarrow u = \sqrt{\frac{E}{m} + \frac{v^2}{2}}$

Using (ii): $\cos\theta = \frac{v}{2u} = \frac{v}{2\sqrt{\frac{E}{m} + \frac{v^2}{2}}}$

$\theta = \cos^{-1}\left(\frac{v}{2\sqrt{\frac{v^2}{2} + \frac{E}{m}}}\right)$

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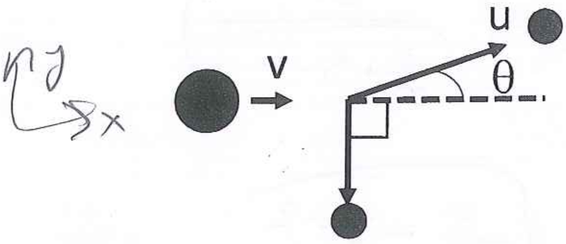
Section 3 **Quiz 6** **November 25, 2016**

Closed book. Duration: 10 minutes

Name: **Student ID:** **Signature:**

A particle with mass 2m and initial velocity v splits into two parts of equal mass m. In this process, the internal energy of the particles decreases by E, so the mechanical energy of the system increases by the same amount. Find u and θ in the figure if the other particle moves perpendicular to the velocity of the initial particle.



Mechanical energy of the system increases by E (inelastic process)

Before splitting, $E_i = \frac{1}{2}(2m)v^2$

After splitting, $E_f = \frac{1}{2}mu^2 + \frac{1}{2}mu^2$

(i) $\boxed{E_f - E_i = E}$

Conservation of momentum:

y| $(2m)v = mu\cos\theta + mu'\underbrace{\cos 90}_{0} \Rightarrow \boxed{2v = u\cos\theta}$ (ii)

x| $0 = mu\sin\theta - mu'\underbrace{\sin 90}_{1} \Rightarrow \boxed{u\sin\theta = u'}$ (iii)

Using (i): $\frac{1}{2}mu^2 + \frac{1}{2}mu'^2 - \frac{1}{2}(2m)v^2 = E$

Using (iii): $\frac{1}{2}mu^2 + \frac{1}{2}m(u\sin\theta)^2 - mv^2 = E$

$$\frac{u^2}{2}(1+\sin^2\theta) = \frac{E}{m} + v^2 \Rightarrow u = \sqrt{\frac{2\left(\frac{E}{m}+v^2\right)}{1+\sin^2\theta}}$$

$$= \frac{2v}{\cos\theta} \text{ (from ii)}$$

$$\left(\sqrt{\frac{2\left(\frac{E}{m}+v^2\right)}{1+\sin^2\theta}} = \frac{2v}{\cos\theta}\right)^2 = u^2$$

$$2\left(\frac{E}{m}+v^2\right)\cos^2\theta = 4v^2\left(\underbrace{1+\sin^2\theta}_{2-\cos^2\theta}\right)$$

$$\Rightarrow \cos\theta = \sqrt{\frac{8v^2}{\frac{2E}{m}+6v^2}}$$

$$\theta = \cos^{-1}\left(\sqrt{\frac{8v^2}{\frac{2E}{m}+6v^2}}\right) = \cos^{-1}\left(\frac{2v}{\sqrt{\frac{E}{m}+3v^2}}\right)$$

$$u = \frac{2v}{\cos\theta} = \frac{2v}{\sqrt{\frac{8v^2}{\frac{2E}{m}+6v^2}}} = \sqrt{\frac{E}{m}+3v^2}$$

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Section 4 **Quiz 6** **November 25, 2016**

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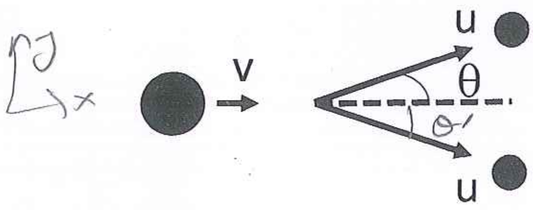
Name: **Student ID:** **Signature:**

A particle with mass 2m and initial velocity v splits into two parts of equal mass m. In this process, the internal energy of the particles decreases by E, so the mechanical energy of the system increases by the same amount. If the particles move with the same speed as in the figure, find u and θ.



Mechanical energy of the system increases by E (inelastic process)

Before splitting, $E_i = \frac{1}{2}(2m)v^2$

After splitting, $E_f = \frac{1}{2}mu^2 + \frac{1}{2}mu^2$

(i) $\boxed{E_f - E_i = E}$

Conservation of momentum:

y) $0 = mu\sin\theta - mu\sin\theta' \Rightarrow \theta = \theta'$

x) $(2m)v = mu\cos\theta + mu\cos\theta \Rightarrow \boxed{v = u\cos\theta}$ (ii)

Using (i): $\frac{1}{2}mu^2 + \frac{1}{2}mu^2 - \frac{1}{2}(2m)v^2 = E$

$u^2 - v^2 = \frac{E}{m} \Rightarrow u = \sqrt{\frac{E}{m} + v^2}$

using (ii): $\cos\theta = \frac{v}{u} = \frac{v}{\sqrt{\frac{E}{m} + v^2}}$

$\theta = \cos^{-1}\left(\frac{v}{\sqrt{\frac{E}{m} + v^2}}\right)$