PHYS 101: General Physics **KOÇ UNIVERSITY** **Fall Semester 2013**

College of Sciences

Section 1 **Quiz 8** **21 November 2013**

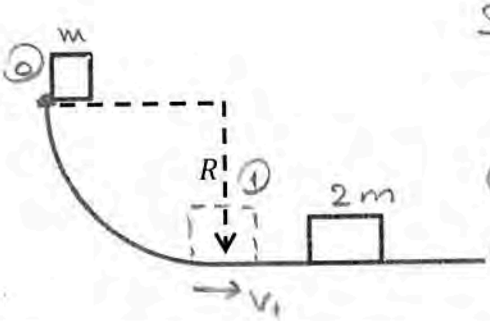
Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes
First Name: **Last name:** **Student ID:** **Signature:**

A block of mass m slides from a quarter circular track of radius R as shown in the figure. After reaching the ground surface, the block makes a completely elastic collision with another block of mass $2m$. There is no friction. Find the height the first block can reach after the collision in terms of R.

SOL.

Cons. of En.

$$mgR = \frac{mv_1^2}{2} \Rightarrow v_1 = \sqrt{2gR}$$



Since there is an elastic coll. cons. of Mom. and En in "x" dir.

① $mv_1 = mv_1' + 2m \cdot v_2'$

② $\frac{mv_1^2}{2} = \frac{mv_1'^2}{2} + \frac{2mv_2'^2}{2}$

$\Rightarrow v_1 = v_1' + 2v_2'$

$\Rightarrow v_2' = \frac{v_1 - v_1'}{2}$

$\Rightarrow v_1^2 = v_1'^2 + 2v_2'^2$

$$\Rightarrow v_1^2 = v_1'^2 + \frac{2(v_1^2 + v_1'^2 - 2v_1 \cdot v_1')}{4}$$

$$\Rightarrow 2v_1^2 = 2v_1'^2 + v_1^2 + v_1'^2 - 2v_1 v_1'$$

$$\Rightarrow 3v_1'^2 - 2v_1 \cdot v_1' - v_1^2 = 0 \Rightarrow (3v_1' + v_1)(v_1' - v_1) = 0$$

$3v_1' + v_1$

$v_1' - v_1$

v_1' should be negative in "-x" dir.

$$\Rightarrow \boxed{v_1' = -\frac{v_1}{3}} \Rightarrow \boxed{v_1' = -\frac{\sqrt{2gR}}{3}}$$

Then Cons. of En.

$$\frac{mv_1'^2}{2} = mgh \Rightarrow h = \frac{v_1'^2}{2g} = \frac{2gR}{2g \cdot 9} = \boxed{\frac{R}{9}}$$ ✓

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Section 2 **Quiz 8** **21 November 2013**

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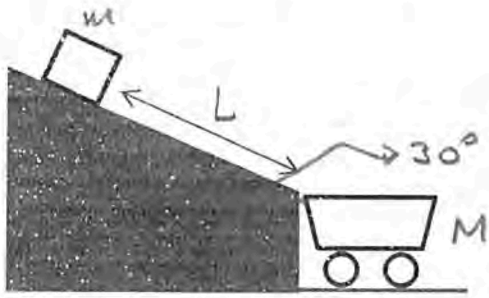
Quiz duration: 10 minutes
First Name: **Last name:** **Student ID:** **Signature:**

A box of mass m slides down on a frictionless inclined surface of length L and drops into a cart of mass M as shown in the figure. The inclination angle is 30^o with the horizontal ground. Find the speed of the cart in terms of given parameters. (ignore the friction between the cart and the ground. Gravitational acceleration is g)



SOL.

① Cons. of En. $\Rightarrow mgL\cdot\sin 30^\circ = \frac{mv^2}{2} \Rightarrow v = \sqrt{2gL\cdot\frac{1}{2}} = \sqrt{gL}$ //

② Cons. of Mom. in "x" direction:

$v_x = v\cdot\cos 30^\circ = \frac{\sqrt{3}}{2}v \Rightarrow m\frac{\sqrt{3}}{2}v = (m+M)V \Rightarrow$ $\boxed{V = \frac{\sqrt{3}\,m}{2(m+M)}}$

V: velocity of the cart + box

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Section 3 | **Quiz 8** | **21 November 2013**

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Quiz duration: 10 minutes
First Name: **Last name:** **Student ID:** **Signature:**

A particle of mass $4m$ moving with speed v on a horizontal frictionless surface explodes into two pieces of mass $3m$ and m. The explosion releases an energy equal to the kinetic energy of the particle before the collision. Determine the speed of the piece with mass m in terms of v.

SOL.

① Cons. of Momentum

$4mv = 3mv_1 + mv_2 \Rightarrow 4v = 3v_1 + v_2$

$\Rightarrow v_1 = \frac{4v - v_2}{3}$

② Conservation of Energy

$K_i + W_{others} = K_f$

where W_{others} is the energy released during the explosition and $W_{others} = K_i$

$\Rightarrow \frac{1}{2} 4mv^2 + \frac{1}{2} 4mv^2 = \frac{3mv_1^2}{2} + \frac{mv_2^2}{2} \Rightarrow 8v^2 = 3v_1^2 + v_2^2$

where $v_1 = \frac{4v - v_2}{3}$

$\Rightarrow 8v^2 = \left(\frac{4v - v_2}{3}\right)^2 \cdot 3 + v_2^2 \Rightarrow 8v^2 = \frac{16v^2 + v_2^2 - 8vv_2}{3} + v_2^2$

$\Rightarrow 24v^2 = 16v^2 + v_2^2 - 8vv_2 + 3v_2^2 \Rightarrow 8v^2 = 4v_2^2 - 8vv_2$

$\Rightarrow v_2^2 - 2vv_2 - 2v^2 = 0$

$v_2 = v \pm \sqrt{v^2 + 4v^2} = v \pm \sqrt{5}\, v$

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Section 4 **Quiz 8** **21 November 2013**

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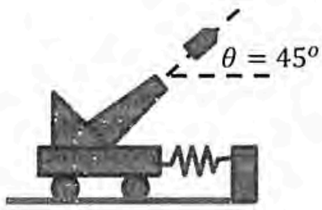
Quiz duration: 10 minutes
First Name: **Last name:** **Student ID:** **Signature:**

A cannon aimed at 45^o above the horizontal is attached to a spring at rest (spring constant k) as shown in the figure. The other end of the spring is fixed. The mass of the cannon is M and it contains a projectile of mass m. If the projectile is fired with a speed v from the cannon, determine the maximum extension of the spring during the recoil of the cannon (ignore all friction).



SOL.

Cons of Mom. in "x" direction: M-m: mass of canon

$P_{i,x} = P_{f,x} = \text{const.} \Rightarrow M\cdot 0 = mv\cdot\cos 45^\circ + (M-m)V$

$\Rightarrow 0 = mv\cdot\frac{\sqrt{2}}{2} + (M-m)V \Rightarrow \boxed{V = \frac{mv\cdot\frac{\sqrt{2}}{2}}{M-m}}$

Cons. of Energy

$\frac{(M-m)\cdot V^2}{2} = \frac{kx^2}{2} \Rightarrow x = \sqrt{\frac{(M-m)V^2}{k}} = V\sqrt{\frac{(M-m)}{k}}$ V: velocity of the canon

$\Rightarrow x = \frac{mv\sqrt{2}/2}{M-m}\cdot\sqrt{\frac{(M-m)}{k}} = \frac{mv\sqrt{2}}{2}\frac{1}{\sqrt{(M-m)k}} = \boxed{\frac{mv}{2}\sqrt{\frac{2}{(M-m)k}}}$

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Section 5 **Quiz 8** **21 November 2013**

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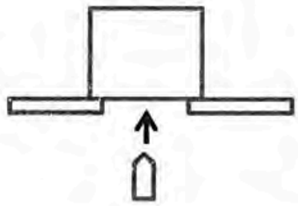
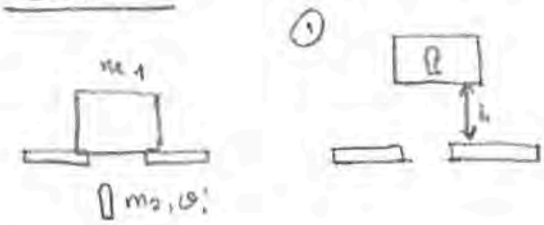
Quiz duration: 10 minutes
First Name: **Last name:** **Student ID:** **Signature:**

A wooden block with mass m_1 rests on a table over a large hole as shown in figure. A bullet with mass m_2 enters into the block from the bottom with speed v_i and remains in the block. If the block and the bullet rise to a height of h above the table, determine v_i in terms of given quantities (gravitational acceleration: g).



SOL.

①



Conservation of Energy after the collision

$$\frac{(m_1+m_2)V_1^2}{2} = (m_1+m_2)gh$$

$$V_1 = \sqrt{2gh}$$

where V_1 is the inital velocity of the total mass

② Conservation of Momentum

(the mass of the bullet m_2 is so small that the effect of the grav. can be neglected)

$$\vec{P_i} = \vec{P_f} = \text{const} \Rightarrow m_2 v_i = (m_1+m_2)V_1 \Rightarrow v_i = \frac{m_1+m_2}{m_2}\sqrt{2gh}$$