PHYS 101: General Physics 1 KOÇ ÜNIVERSITY Fall Semester 2012

College of Sciences

Section 3 Quiz 6 8 November 2012

Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

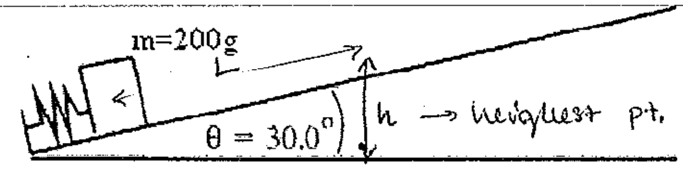
Name: **Student ID:** **Signature:**

A 200 gram block is pressed at rest against a spring of force constant 1400 N/m until the block compresses the spring 10 cm. The spring rests at the bottom of a ramp inclined at 30^0 to the horizontal. Use energy considerations to determine how far up the incline the block moves before it stops.

a.) If there is no friction between block and ramp.

b.) If the coefficient of friction is $\sqrt{3}$.

(Cos 60° = Sin30° = 1/2, Cos30° = Sin60° = $\sqrt{3}/2$)



a) The potential energy stored in the spring is, $PE_s = \frac{1}{2}k(\Delta x)^2$.
When the spring is released, this potential energy first transformed to the kinetic energy of the block and when the block reaches to highest point this kinetic energy is then transformed to the potential energy of the block, $PE_b = mgh$.
Since there is no friction,

$$PE_s = PE_b$$

$$\frac{1}{2}k\Delta x^2 = mgh \rightarrow h = \frac{k\Delta x^2}{2mg}, \quad h = L\sin\theta.$$

$$\Rightarrow L = \frac{k\Delta x^2}{2mg\sin\theta}$$ → the distance that the block travels on the ramp

$g = 10\ m/s^2$

$$= \frac{1400 N/m \cdot (0.1)^2}{2(0.2kg)\,10\,m/s^2 \cdot 1/2} \simeq 7.\ m$$

b)

$$W_{tot} = W_{spring} + W_{grav.} + W_{friction}$$

$$0 = \int_0^{\Delta x} kx\,\hat{i}\cdot dx\,\hat{i} + \int_0^{L\sin\theta} mg(-\hat{j})\cdot dy\,\hat{j} - \mu_k mg\cos\theta$$

$$0 = \frac{1}{2}k\Delta x^2 - mgL\sin\theta - \mu_k mg\cos\theta L$$

$$\Rightarrow L = \frac{k\Delta x^2}{2mg(\sin\theta + \mu_k\cos\theta)} \simeq 1.75\,m$$ ✓

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

A car is traveling on a level road with speed v_0 at the instant when the brakes lock, so that the tires slide rather than roll.

a.) Use work –energy theorem to calculate the minimum stopping distance of the car in terms of v_0, g and the coefficient of kinetic friction μ_k between the tires and the road.

b.) By what factor would the minimum stopping distance change if the coefficient of kinetic friction were doubled?

a) $W = K_2 - K_1$

Only friction force does work

$-\mu_k mgL = 0 - \frac{1}{2} m v_0^2 \Rightarrow L = \frac{v_0^2}{2\mu_k g}$

b) If the new friction coeff. is $\mu_k' = 2\mu_k$, then

$-\mu_k' mgL' = 0 - \frac{1}{2} m v_0^2$ where L' is the new stopping distance.

Thus,

$L' = \frac{v_0^2}{2\mu_k' g} = \frac{v_0^2}{4\mu_k g} = \frac{L}{2}$

The min. stopping distance is halved!

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Section 4 | Quiz 6 | 8 November 2012

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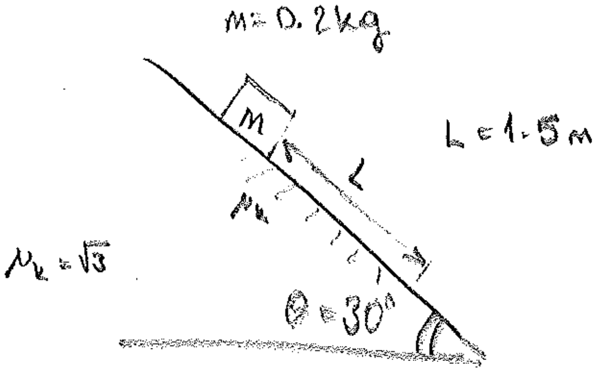
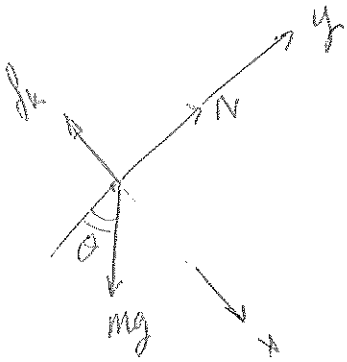
Quiz duration: 10 minutes

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

A 200 gram package slides 1.5m down a long ramp that is inclined at 30^0 below the horizontal. The coefficient of kinetic friction between the package and the ramp is $\sqrt{3}$. Calculate;

a.) The work done on the package by friction.
b.) The work done on the package by gravity.
($\text{Cos } 60° = \text{Sin}30° = 1/2$, $\text{Cos}30° = \text{Sin}60° = \sqrt{3}/2$)





$$\sum F_y = m a_y = 0$$

$$N - mg\cos\theta = 0 \longrightarrow N = mg\cos\theta$$

$$f_k = \mu_K N = \mu_K mg\cos\theta$$

a) $$W_{fric.} = \int_0^L (-\mu_k mg\cos\theta\,\hat{i})\cdot(dx\,\hat{i}) = -\mu_k mg\cos\theta L$$

$$W_{fric} \cong -\sqrt{3}\ 0.2\,kg \cdot 10\,m/s^2\ \frac{\sqrt{3}}{2}\ .1.5\,m$$

$$W_{fric} \cong -4.5\ J$$

b) $$W_{grav} = \int_{h=L\sin\theta}^{h=0} \vec{W}\cdot d\vec{\ell} = +mgL\sin\theta$$

$$W_{grav} \cong 1.5\ J$$

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Section 2 | Quiz 6 | 8 November 2012

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Quiz duration: 10 minutes

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

An object is attracted toward the origin with a force given by $F_x = -k/x^2$.

a.) Calculate the work done by the force F_x when the object moves in the x direction from x_1 to x_2. If $x_2 > x_1$, is the work done by F_x positive or negative? Show your work.

b.) The only other force acting on the object is a force that you exert with your hand to move the object slowly from x_1 to x_2. How much work do you do? If $x_2 > x_1$, is the work done by F_x positive or negative. Show your work.

a) $W_{F_x} = \int_{x_1}^{x_2} \vec{F_x} \cdot d\vec{l} = \int_{x_1}^{x_2} \left(-\frac{k}{x^2}\hat{i}\right)\cdot(dx\,\hat{i}) = \frac{k}{x}\Big|_{x_1}^{x_2} = k\left(\frac{1}{x_2} - \frac{1}{x_1}\right)$, where $\left(\frac{1}{x_2} - \frac{1}{x_1}\right) < 0$

Since $x_2 > x_1 \Rightarrow 1/x_2 < 1/x_1$

$W_{F_x} < 0$ (provided that $k > 0$)

b) $W_{hand} = \int_{x_1}^{x_2} \vec{F}_{hand} \cdot d\vec{l}$

F_x ← o → F_{hand}

Since the object move slowly there is no acceleration!

$\sum F_x = m a_x$, $a_x = 0$

$F_{hand} - F_x = 0 \Rightarrow F_{hand} = \frac{k}{x^2}$

$\Rightarrow W_{hand} = \int_{x_1}^{x_2} \frac{k}{x^2}\hat{i} \cdot dx\,\hat{i} = -\frac{k}{x}\Big|_{x_1}^{x_2} = k\left(\frac{1}{x_1} - \frac{1}{x_2}\right)$, where $\left(\frac{1}{x_1} - \frac{1}{x_2}\right) > 0$

Since $x_2 > x_1$: $\frac{1}{x_1} > \frac{1}{x_2}$

Thus $W_{hand} > 0$

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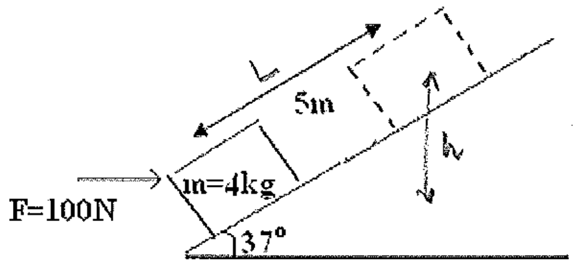
Name: **Student ID:** **Signature:**

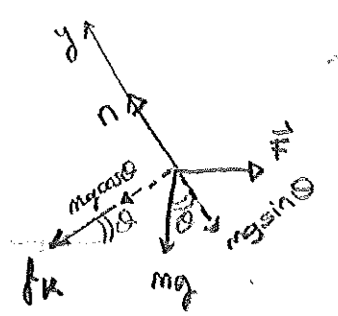
A 4 kg. block is pushed 5m up a 37^0 inclined plane by a horizontal force **F** of magnitude 100 N. The coefficient of kinetic friction between the block and the incline plane is 0.5. Calculate

a.) The work done on the block by friction.
b.) The work done on the block by gravity.

(Cos 53° = Sin37° = 0.6, Cos37° = Sin53° =0.8)



Free · Body Diagram



$\sum F_y = m\cancel{a_y} = 0 \Rightarrow n - mg\cos\theta - F\sin\theta = 0$

$\vec{n} = (mg\cos\theta + F\sin\theta)\hat{j}$

$f_k = \mu_k n$

$\vec{f_k} = -\mu_k(mg\cos\theta + F\sin\theta)\uparrow$

a) $W_{friction} = \int \vec{f_k}\cdot d\vec{\ell}$ where

$= -\mu_k(mg\cos\theta + F\sin\theta)L < 0$

$= -0.5\,(4kg \cdot 10 m/s^2 \cdot 0.8 + 100N \cdot 0.6)\,5m$

$= -230 J$

b) $h = L\sin\theta$

$W_{gravity} = \int \vec{w}\cdot d\vec{\ell} = -mgh = -120 J < 0$