PHYS 101: General Physics 1 KOÇ UNIVERSITY **Fall Semester 2011**

College of Sciences

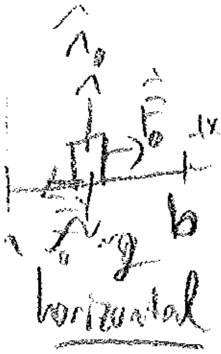
Section 5 **Quiz 5** **27 October 2011**

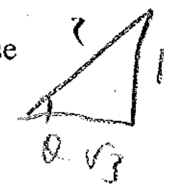
Closed book. No calculators are to be used for this quiz.
Quiz duration: 10 minutes

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

$\sin\theta = \frac{1}{2}$

$\cos\theta = \sqrt{3}/2$





The power required to move a car of mass m with constant speed v_0 on a horizontal road is P_0. The kinetic friction coefficient between the car and the road is μ_k. Suppose that the road becomes inclined with a slope. $1/\sqrt{3}$.

$\tan\theta = 1/\sqrt{3}$

1. Draw the free-body diagram of the car when it is moving on the slope.
2. Find the power that is required to drive the car with the same speed up the slope. Express your answer only in terms of μ_k. (Neglect the air resistance)

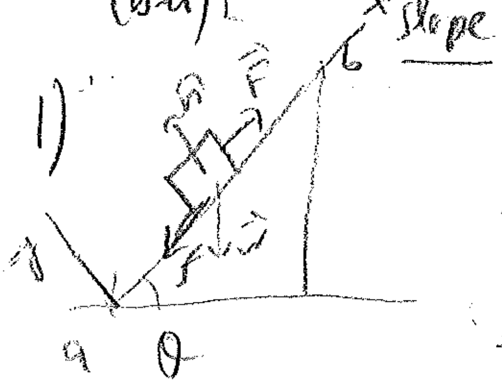
$P_0 = \frac{\Delta E}{\Delta t}$; $\Delta t = \frac{\Delta x}{v_0} = \frac{(b-a)}{v_0}$; $\Delta E = W_{force} + W_{friction}$

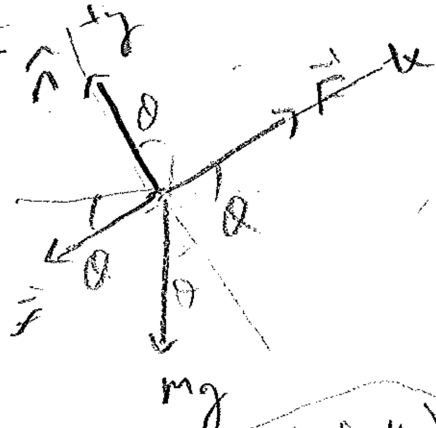
$K_{final} - K_{initial} = 0 = \frac{1}{2}m(v_0^2 - v_0^2)$

$\to F_0 = f$

$P_0 = \frac{v_0}{(b-a)} F_0 (b-a) = (mg\mu_k v_0)$

1)





y: $n - mg\cos\theta = ma_y = 0$

$n = mg\cos\theta$

x: $F - n\mu_k - mg\sin\theta = ma_x$

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

$v_0 \to a_x = 0$

$F = mg(\cos\theta + \mu_k)$

2) F_{net} ; Work: on +x direction

$W = [F - mg(\cos\theta + \mu_k)](b-a) = \Delta E = \frac{1}{2}m(v_0^2 - v_0^2) = 0$

$P_F = \frac{\Delta E_F}{\Delta t} = \frac{\Delta W_F}{\Delta t}$

$\boxed{v_0 F_{\parallel} = v_0 mg(\sin\theta + \mu_k\cos\theta) = P}$

$F = mg(\sin\theta + \mu_k\cos\theta)$

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Section 1 **Quiz 5** **27 October 2011**

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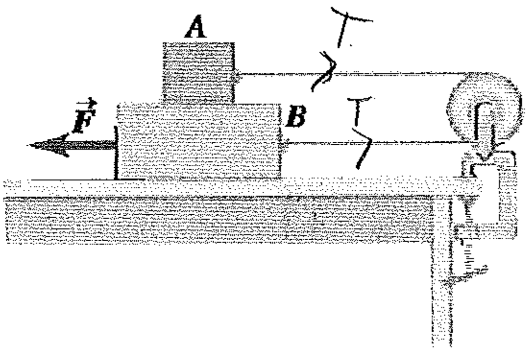
Quiz duration: 10 minutes

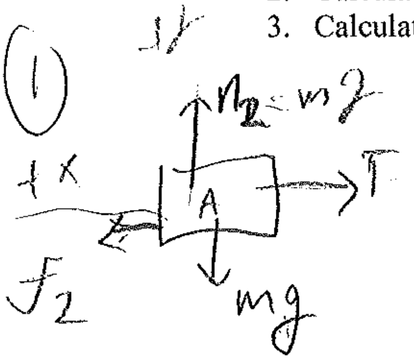
Name: **Student ID:** **Signature:**

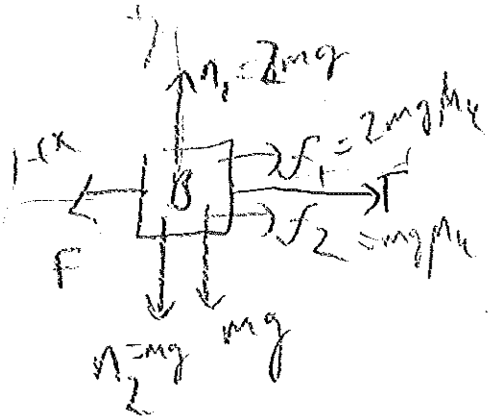
The system shown in the figure moves at constant speed. Given that $m_A = m_B = m$ and the kinetic friction coefficient on all surfaces is μ_k. Suppose that the objects have moved by an amount x. Answer the following in terms of m, μ_k, g, and x. Assume that during the motion A is always on top of B.

1. Draw the respective free body diagrams of A and B.
2. Calculate the total work done by the friction forces in the system.
3. Calculate the total work done by the tension forces in the system.



(1)





A:

y: $n_2 - mg = 0$

$n_2 = mg$

x: $n_2 \mu_k - T = 0$

$T = mg\mu_k$

B:

x: $F - f_1 - f_2 - T = 0$

$F - 4mg\mu_k = 0$

$F = 4mg\mu_k$

(3) A: $W_{T_A} = Tx = mg\mu_k x$

$W_{T_B} = -mg\mu_k x$

$W_{total\,T} = 0$

(2) $W_{f_A} = +f_2(-x) = -mg\mu_k x$

$W_{f_B} = W_{f_{1B}} + W_{f_{2B}} = (-3mg\mu_k)(+x) = -3mg\mu_k x$

$W_{total} = -4mg\mu_k x$

PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Fall Semester 2011**

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Section 2 **Quiz 5** **27 October 2011**

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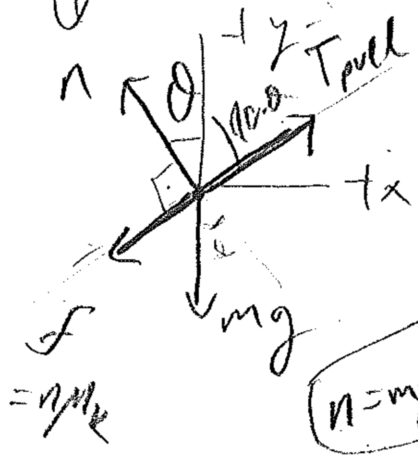
Quiz duration: 10 minutes

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

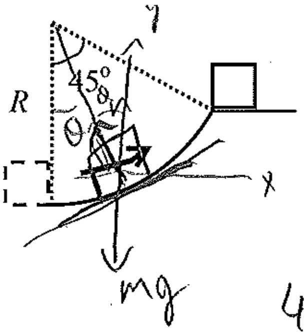
The particle of mass m (rectangular box of negligible size) in the figure is being pulled up along the circular arc very slowly such that it's nearly in equilibrium at all times. The pulling force is always tangent to the circular arc so that the normal force is only due to the gravitational force on the object. The kinetic friction coefficient of the circular surface is μ_k. The radius of the circular arc is R.

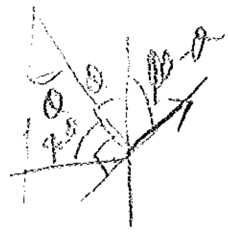
1. Draw the free-body diagram of the object when it is at an arbitrary point on the circular arc, where the angle of the radius vector with the vertical direction is θ.
2. Calculate the work done by the friction force when the object reaches to the top position as shown in the figure. Express the answer only in terms of m, μ_k, g and R. The friction force at any point is tangent to the circular arc at that point.

(1)



$n = mg\cos\theta$





$45° = \frac{\pi}{4}$ rad

(2) $W_{friction} = m g \mu_k \int_0^{45} \cos\theta \, R \, d\theta = m g \mu_k R \sin\theta \Big|_0^{45}$

along the arc

$\theta = 0 \rightarrow \theta = 45° = \frac{\pi}{4}$ rad

Integral $= m g \mu_k R \frac{\sqrt{2}}{2}$

$mg\cos\theta \, \frac{\pi R}{4}$

PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Fall Semester 2011**

College of Sciences

Section 3 **Quiz 5** **27 October 2011**

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Quiz duration: 10 minutes

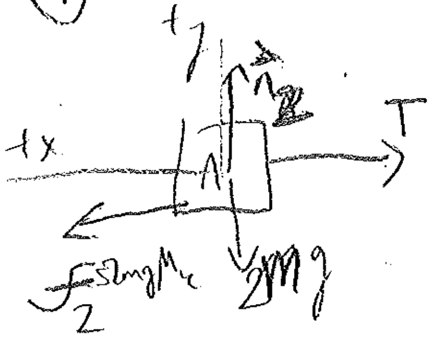
Name: **Student ID:** **Signature:**

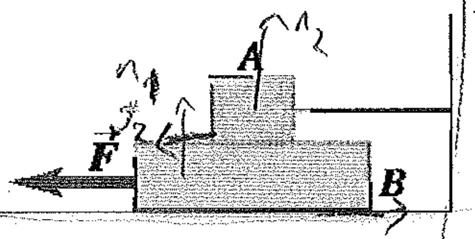
In the system shown in the figure, A is on top of B and connected by a string to the wall. B moves with constant speed under the applied force F, when $m_A = 2m$, $m_B = m$, and the kinetic friction coefficient between all surfaces is μ_k. Answer the following in terms of m, μ_k, g, and x only.

1. Draw the free-body diagram of A and calculate the work done by the tension force on A, when the object B has moved by an amount x.
2. Suppose that the objects A and B are exchanged: B is on the top connected to the string and A is at the bottom, acted on by *same* force F. Calculate the speed of A after it has moved by an amount x.

(1)

total work on A is zero but T does work equal to the work of friction





A: $x: T - f_2 = m a_x = 0$

$T = f_2 = \mu_k n_2 = 2\mu_k mg$

$y: n_2 - 2mg = 0$, $n_2 = 2mg$

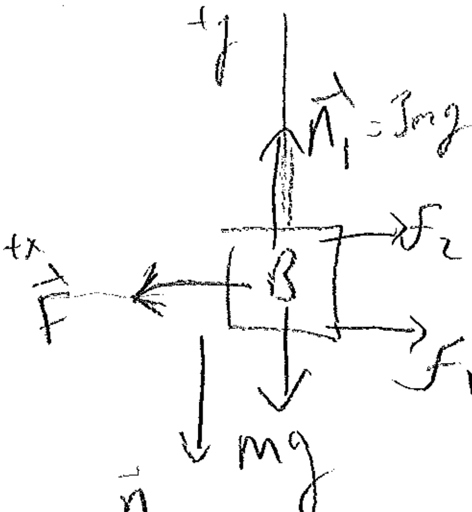
A doesn't displace, but surface displaces

B: v_0 constant

$W = F_{net_x} \Delta x = 0$

$W_{total} = 0$

$$\boxed{W_{Tension} = -W_{friction} = -f_2 x}$$



B: $v_0 \rightarrow a_x, a_y = 0$

$x: F - f_1 - f_2 = m a_x = 0$

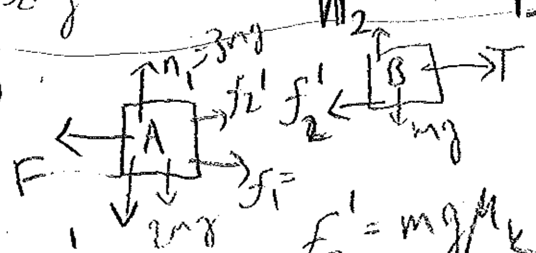
$F - \mu_k(n_1 + n_2) = 0$

$(F = 5\mu_k mg)$

$y: n_1 - n_2 - mg = 0$

$n_1 = 3mg$

(2)



$f_2' = mg\mu_k$

$f_1' = 3mg\mu_k$

$W_A = (F - f_1' - f_2')x = (5 - 3 - 1)mg\mu_k$

$= mg\mu_k x$

$\Delta E = K_2 - K_1 = \frac{1}{2} m v^2 = mg\mu_k x$

$v = \sqrt{2g\mu_k x}$

PHYS 101: General Physics 1 KOÇ UNIVERSITY Fall Semester 2011

College of Sciences

Section 4 Quiz 4 27 October 2011

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

Name: Student ID: Signature:

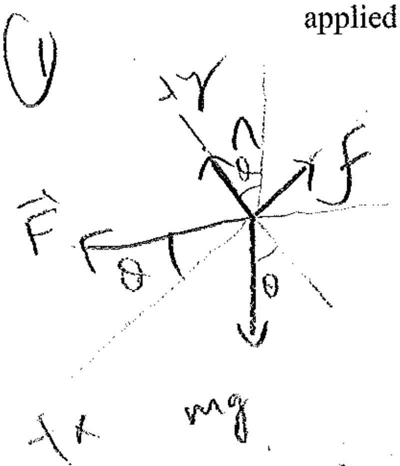
An object of mass m is being pulled by a horizontal force F on the inclined surface as shown in the figure. The kinetic friction coefficient between the object and the inclined surface is μ_k .

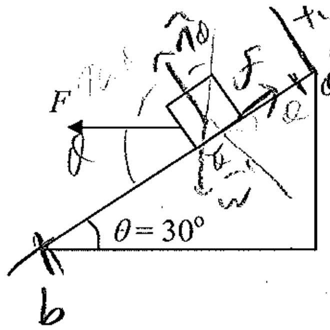
1. Draw the free-body diagram of the object.
2. If the object is moving with constant speed, v_0, calculate the power of the applied force F. Express your answer in terms of m, μ_k, g, and v_0 only.

$n = mg\cos\theta - F\sin\theta$

$n + F\sin\theta - mg\cos\theta = 0$

(1)





$y: n - mg\cos\theta = ma_y = 0$

$n = mg\cos\theta$

$x: F\cos\theta + mg\sin\theta - n\mu_k$

$v_0 \to a_x = 0 \quad F\cos\theta = -mg\sin\theta + n\mu_k \Big| = ma_x$

(2) $\Delta t = \frac{\Delta x}{v_0} = \frac{(b-a)}{v_0}$; $W = F_x \Delta x = (F\cos\theta + mg\sin\theta - mg\mu_k\cos\theta)(b-a) =$

$= \Delta E = K_2 - K_1 = 0$

$P_F = \frac{\Delta E}{\Delta t} = \frac{v_0}{\cancel{(b-a)}} F\cos\theta \cancel{(b-a)} = v_0 [mg\mu_k\cos\theta - mg\sin\theta]$