PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Fall Semester 2013**

College of Sciences

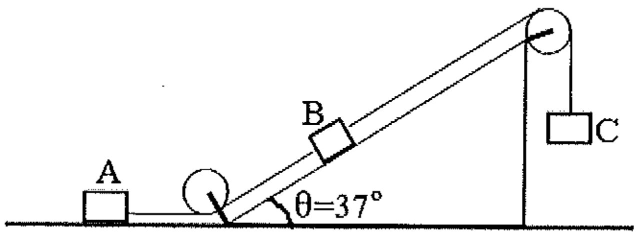
Section 1 **Quiz 5** **31 October 2013**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

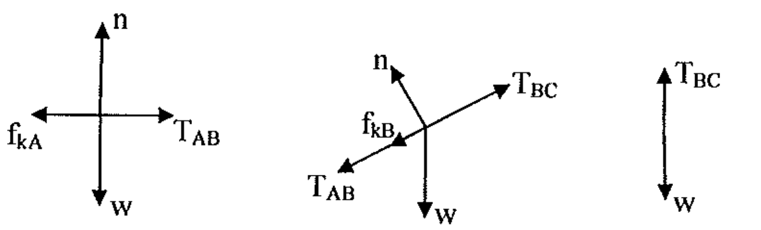
Name: **Student ID:** **Signature:**

Blocks A, B and C are connected by massless strings and pulleys are also massless and frictionless. (See the figure). Both blocks A and B have the same mass, $M_A = M_B = 2.5kg$. The coefficient of kinetic friction between each block and surface is $\mu_k = 0.20$. Block C moves downward with constant speed.

a) Draw three separate free-body diagrams showing all the forces acting on the blocks A, B and C.
b) Calculate the tension in the string connecting blocks A and B.
c) Calculate mass M_C of block C.



a)



For mass A For mass B For mass C

b) Since block C moves with constant speed, acceleration of all masses are zero. Therefore, $T_{AB}=f_{kA}$, $f_{kA}=\mu_k m_A g=5N$.

c) Since acceleration is zero, total force acting on the system is zero.

$f_{kA}+f_{kB}+w_{//B}=w_C$, where $w_{//B}$ is the component of the weight of B parallel to the inclined plane.

$f_{kB}= \mu_k m_A g\cos\theta=4N$

$w_{//B}=m_B g\sin\theta=15N \Longrightarrow w_C=24N \Longrightarrow m_C=2.4kg$

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Section 2 | Quiz 5 | 31 October 2013

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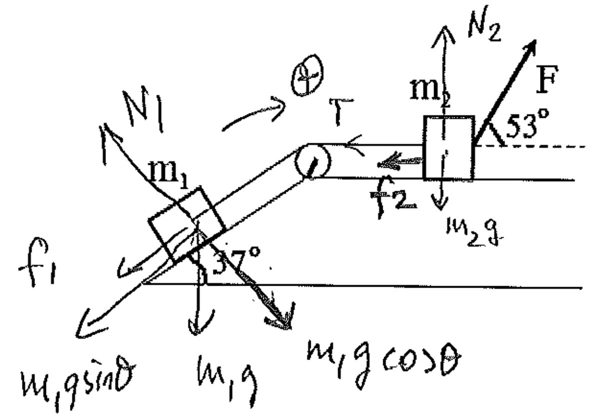
Quiz duration: 10 minutes

Name: Student ID: Signature:

Two blocks, $m_1 = 3.0kg$ on the inclined plane ($\theta = 37^o$) and $m_2 = 5.0kg$ on the horizontal plane are connected by light cord over a frictionless pulley. A force F=50N is acting on m_2 in a direction making 53^0 with the horizontal. Coefficient of static and kinetic frictions for both blocks and surfaces are $\mu_s = 0.3$ and $\mu_k = 0.2$. The system is initially at rest. ($\cos 37^o = \sin 53^o = 0.8, \sin 37^o = \cos 53^o = 0.6, g = 10m/s^2$)

a)If the system is released from rest, how does it behave? Explain briefly giving argument to support your answer.

b)Find the acceleration a of the blocks.



Summation of the forces acting in $\oplus$ direction

$$\sum F_+ = F\cos 53^\circ = 50\,(0.6) = 30\,N$$

Summation of the forces acting in $\ominus$ direction

$$\sum F_- = m_1 g \sin 37^\circ + f_{1s} + f_{2s} = 18 + \mu_s N_1 + \mu_s N_2$$

$$(3)(10)(0.6) + (0.3)(m_1 g \cos 37^\circ) + (0.3)(m_2 g - F\sin 53^\circ)$$

$$\sum F_- = 18 + 7.2 + 3 = 28.2\,N$$

Since $\sum F_+ > \sum F_-$ system starts to move in $\oplus$ direction.

b.) $a = \dfrac{\sum F_+ - \sum F_-}{m_1 + m_2}$

System is moving we must use f_{1k} and f_{2k} in our calculations

$$\sum F_+ = F\cos 53^\circ = 30\,N$$

$$\sum F_- = 18 + (0.2)(24) + (0.2)(50-40) = 24.8\,N$$

$$a = \frac{30 - 24.8}{8} = \frac{5.2}{8}$$

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Section 3 **Quiz 5** **31 October 2013**

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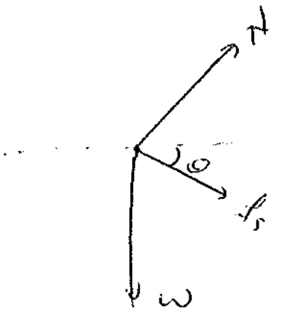
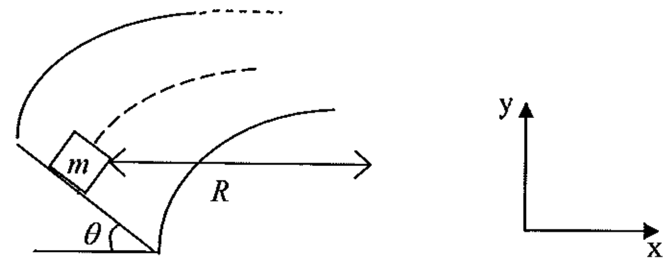
Quiz duration: 15 minutes

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

A car rounds a banked curve (where the coefficient of static friction is μ) as shown in the figure . The radius of curvature of the road is R and the banking angle is θ.

What is the maximum speed the car can have before sliding up the banking (express your answer in terms of R, g, θ and μ). Draw the free body diagram for the car and write the equations of motion in each direction using the coordinate axes given in the figure.





$N_x = N\sin\theta$

$N_y = N\cos\theta$

$f_x = f_s\cos\theta \Rightarrow f_x = \mu_s N\cos\theta$

$f_y = f_s\sin\theta \Rightarrow f_y = \mu_s N\sin\theta$

We know that $\sum_i F_{ix} = m\frac{v^2}{R}$ $\quad \sum_i F_{iy} = 0$

$N_y - w - f_y = 0$

$N_y = mg + \mu_s N\sin\theta$

$N\cos\theta = mg + \mu_s N\sin\theta$

$N(\cos\theta - \mu_s\sin\theta) = mg$

$N = \frac{mg}{\cos\theta - \mu_s\sin\theta}$

$N\sin\theta + \mu N\cos\theta = m\frac{v^2}{R}$

$N(\sin\theta + \mu\cos\theta) = m\frac{v^2}{R}$

$\frac{mg}{\cos\theta - \mu\sin\theta}(\sin\theta + \mu\cos\theta) = m\frac{v^2}{R}$

$$\boxed{v^2 \leq \frac{(\sin\theta + \mu\cos\theta)gR}{\cos\theta - \mu\sin\theta}}$$

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Section 4 | Quiz 5 | 31 October 2013

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Quiz duration: 10 minutes

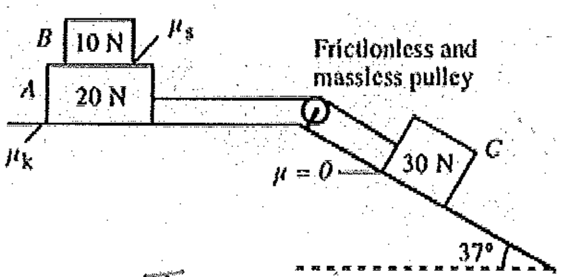
Name: Student ID: Signature:

In the figure blocks A, B and C have weights of 20N, 10N and 30N, respectively. The coefficient of static friction between blocks A and B is μ_s and the coefficient of kinetic friction between block A and the horizontal surface is μ_k. There is no friction between block C and the inclined plane. The system of blocks are released from rest. We observe that blocks A and B move together ($g = 10 m/s^2; \sin 37^o = 0.6, \cos 37^o = 0.8$)

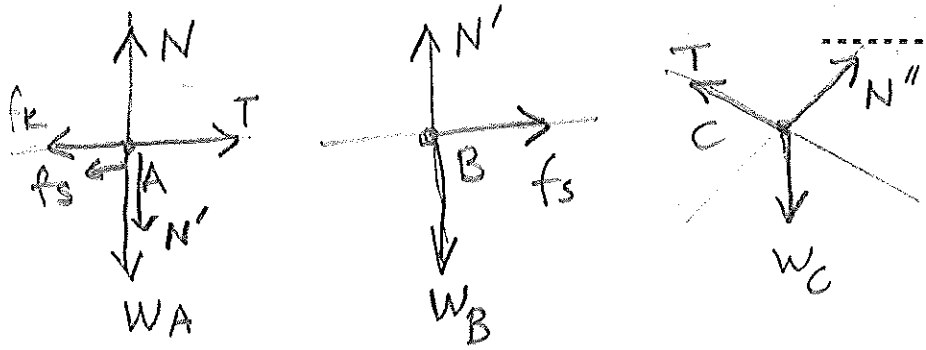
a)Draw free-body diagram for each block just after the release.

b)In terms of g and μ_s, what is a, the maximum acceleration that block B can have without sliding over block A?

c)If μ_k=0.4, what is the minimum μ_s between A and B so that B does not slip and they (A and B) move together?



1.)



.) $m_B g \mu_s = m_B a_{max}$, $a_{max} = \mu_s g$

) Blocks move with $a_A = a_B = a_C = a$
Newton's 2nd Law for each block;

$\cancel{f_s} = m_B a$

$T - \cancel{f_s} - f_k = m_A a$

$+ \; m_C g \sin 37° - \cancel{T} = m_C a$

$m_C g \sin 37° - f_k = (m_a + m_b + m_c) a$

→ where $f_k = \mu_k N = \mu_k (m_A + m_B) g$

$f_k = (0.4)(30N) = 12 N$

then $(30 N)(0.6) - 12 N = (6 kg) a$

$a = 1 m/s^2$

$f_s = \mu_s N = m_B a$, $\mu_s = \frac{m_B a}{N} = \frac{\cancel{m_B} a}{\cancel{m_B} g}$

$\mu_s = \frac{1}{10} = 0.1$

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Section 5 | Quiz 5 | 31 October 2013

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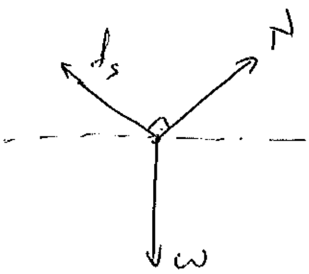
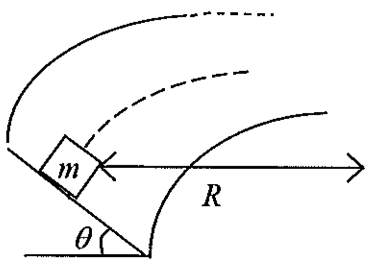
Quiz duration: 15 minutes

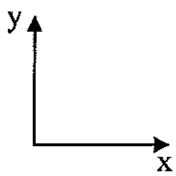
Name: Student ID: Signature:

A car rounds a banked curve (where the coefficient of static friction is μ) as shown in the figure .The radius of curvature of the road is R and the banking angle is θ.

What is the minimum speed the car can have before sliding down the banking (express your answer in terms of R, g, θ and μ). Draw the free body diagram for the car and write the equations of motion in each direction using the coordinate axes given in the figure.







$N_x = N\sin\theta$

$N_y = N\cos\theta$

$f_x = f_s\cos\theta \Rightarrow f_x = \mu_s N\cos\theta$

$f_y = f_s\sin\theta \Rightarrow f_y = \mu_s N\sin\theta$

$\sum_i F_{iy} = 0 \Rightarrow N_y - mg + f_y = 0$

$N\cos\theta - mg + \mu_s N\sin\theta = 0$

$N(\cos\theta + \mu_s\sin\theta) = mg$

$N = \dfrac{mg}{\cos\theta + \mu_s\sin\theta}$

$\sum_i F_{ix} = \dfrac{mv^2}{R} \Rightarrow N_x - f_x = \dfrac{mv^2}{R}$

$N\sin\theta - \mu_s N\cos\theta = \dfrac{mv^2}{R}$

$\left(\dfrac{\cancel{m}g}{\cos\theta + \mu_s\sin\theta}\right)(\sin\theta - \mu_s\cos\theta) = \dfrac{\cancel{m}v^2}{R} \Rightarrow v^2 \geq \dfrac{gR(\sin\theta - \mu_s\cos\theta)}{\cos\theta + \mu_s\sin\theta}$