PHYS 101: General Physics 1 | **KOÇ UNIVERSITY** | **Fall Semester 2014**

College of Sciences

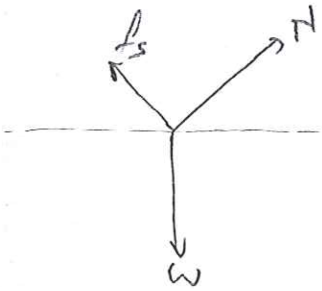
Section 1 | **Quiz 5** | **23 October 2014**

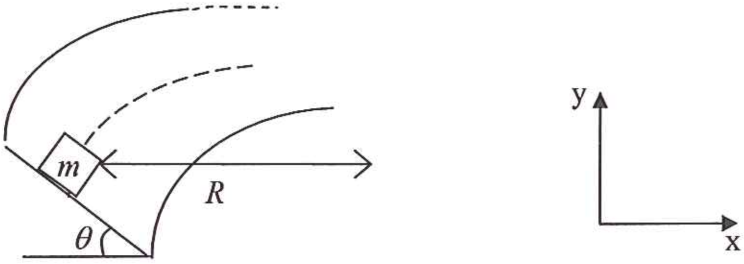
Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: Çağlar KOCA **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 Newton's equations for the motion in each direction using the coordinate axes given in the figure.





$N_x = N\sin\theta$

$N_y = N\cos\theta$

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

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

$$\sum_i F_{iy} = 0 \Rightarrow N_y - mg + f_y = 0$$
$$N\cos\theta - mg + \mu_s N\sin\theta = 0$$
$$N(\cos\theta + \mu_s\sin\theta) = mg$$
$$\Rightarrow N = \frac{mg}{\cos\theta + \mu_s\sin\theta}$$

$$\sum_i F_{ix} = \frac{mv^2}{R} \Rightarrow N_x - f_x = \frac{mv^2}{R}$$
$$N\sin\theta - \mu_s N\cos\theta = \frac{mv^2}{R}$$

$$\left(\frac{mg}{\cos\theta + \mu\sin\theta}\right)(\sin\theta - \mu_s\cos\theta) = \frac{mv^2}{R}$$

$$v \geq \sqrt{\frac{gR(\sin\theta - \mu_s\cos\theta)}{\cos\theta + \mu_s\sin\theta}}$$

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Section 2 **Quiz 5** **23 October 2014**

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Quiz duration: 15 minutes

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

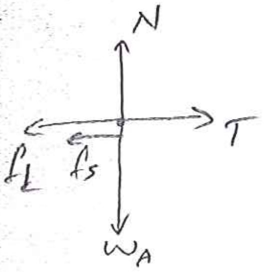
In the figure blocks A, B and C have weights of 20N, 10N and 30N, respectively. The coefficient of static friction between blocks A and B is μ_s and the coefficient of kinetic friction between block A and the horizontal surface is μ_k .There is no friction between block C and the inclined plane. The system of blocks are released from rest. We observe that blocks A and B move together

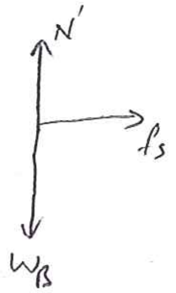
$(g = 10m/s^2; \sin 37^o = 0.6, \cos 37^o = 0.8)$

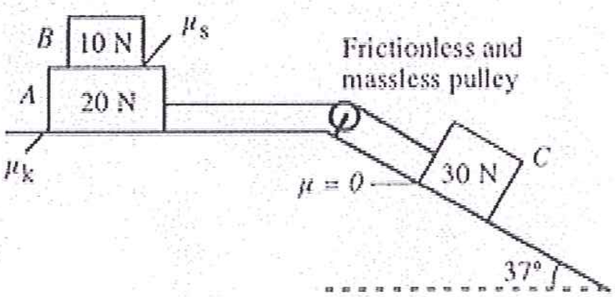
a) Draw free-body diagram for each block just after the release.

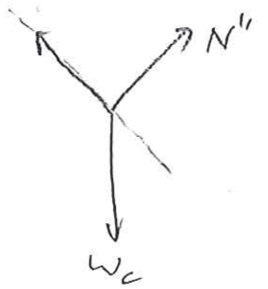
b) In terms of g and μ_s, what is *a,* the maximum acceleration that block B can have without sliding over block A?

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?









b) $m_B g \mu_s = m_B a_{max} \Rightarrow a_{max} = \mu_s g$

c) $m_c g \sin 37° - f_k = (m_A + m_B + m_c) a$

$m_c g \sin 37° - \mu_k (m_A + m_B) g = (m_A + m_B + m_c) a$

$(30N) \cdot (0.6) - (0.4)(30N) = (6\ kg)(a) \Rightarrow a = 1 ms^{-2}$

$f_s = \mu_s N = m_B a \Rightarrow \mu_s = \frac{m_B a}{N} \Rightarrow \boxed{\mu_s = 0.1}$

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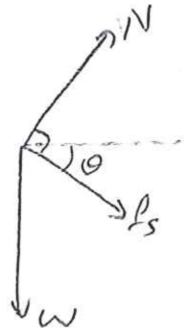
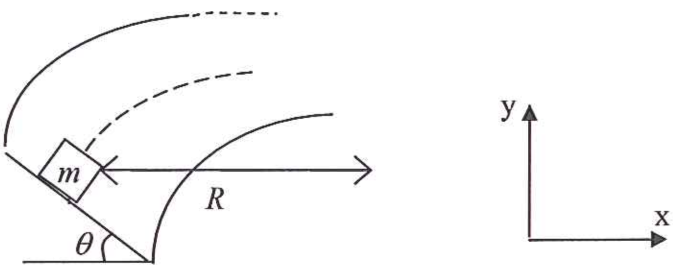
Section 3 | Quiz 5 | 23 October 2014

Closed book. No calculators are to be used for this quiz.
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 Newton's equations for the 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 $\sum_i F_{ix} = m\frac{v^2}{R}$ $\quad \sum_i F_{iy} = 0$

$N_y - w - f_y = 0$

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

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

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

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

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

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

$v \leq \sqrt{\dfrac{gR(\sin\theta + \mu_s\cos\theta)}{\cos\theta - \mu_s\sin\theta}}$

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Section 4 | **Quiz 5** | **23 October 2014**

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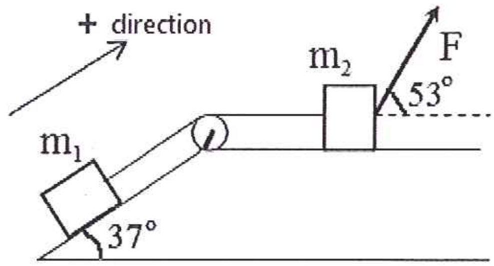
Quiz duration: 15 minutes

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 horizontal. Coefficients 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, in which direction it starts to move? Show your calculations to support your answer.

b) Find the acceleration a of the blocks.



a) Forces in + direction: $F_+ = F\cos 53^\circ = (50N) \cdot 0.6 = 30N$

Forces in − direction: $m_1 g \sin 37 + f_{1s} + f_{2s} = 18 + \mu_s N_1 + \mu_s N_2$

$= 18 + (0.3)(m_1 g \cos 37) + (0.3)(m_2 g - F\sin 53)$

$= 18 + 7.2 + 3 = 28.2N$

Even with μ_s F_+ overcomes F_-. Hence system moves in + direction.

b) Since we know that block is moving, use μ_k.

$\Sigma F = F\cos\theta - m_1 g \sin 37 - f_{1k} - f_{2k}$

$= 30 - 18 - (0.2)(24) - (0.2)(50-40)$

$= 5.2N$

$F = ma \Rightarrow$ $a = \frac{5.2}{8} ms^{-2}$

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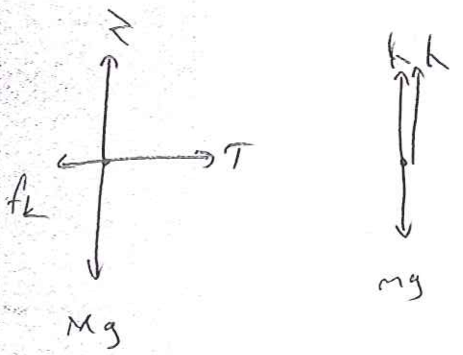
Section 5 **Quiz 5** **23 October 2014**

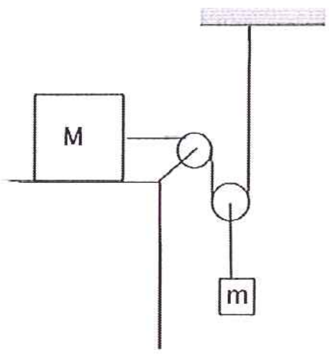
Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

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

Consider the system shown in the figure, where the particle of mass M = 0.5 kg moves at constant speed towards right on a rough table under the influence of mass m = 0.2 kg.

a)Draw the free body diagrams for masses m and M.
b)Write Newton's equations for the motion.
c)What is the coefficient of kinetic friction?
Note that the pulleys are massless and frictionless.
(Take g = 10 m/s^2).





b) M moving with constant speed implies m moving with constant speed as well.

$2T = mg \Rightarrow 2T = 2N \Rightarrow T = 1N$ (for m)

$T = f_k \Rightarrow T - f_k = 0$ for M)

c) $T - f_k = 0$

$1N - \mu_k (10 ms^{-2})(0.5 kg) = 0 \Rightarrow \boxed{\mu_k = 0.2}$