PHYS 101:General PhysicsI **KOÇ UNIVERSITY** **Spring Semester 2016**

College of Sciences

Section 1 **Quiz 7** **25 March 2016**

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

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

A certain spring is found not to obey Hooke's Law; it exerts a restoring force $F_x(x) = -\alpha x - \beta x^2$ is it is stretched or compressed, where $\alpha = 60 N/m$ and $\beta = 18 N/m^2$. The mass of the spring is negligible.

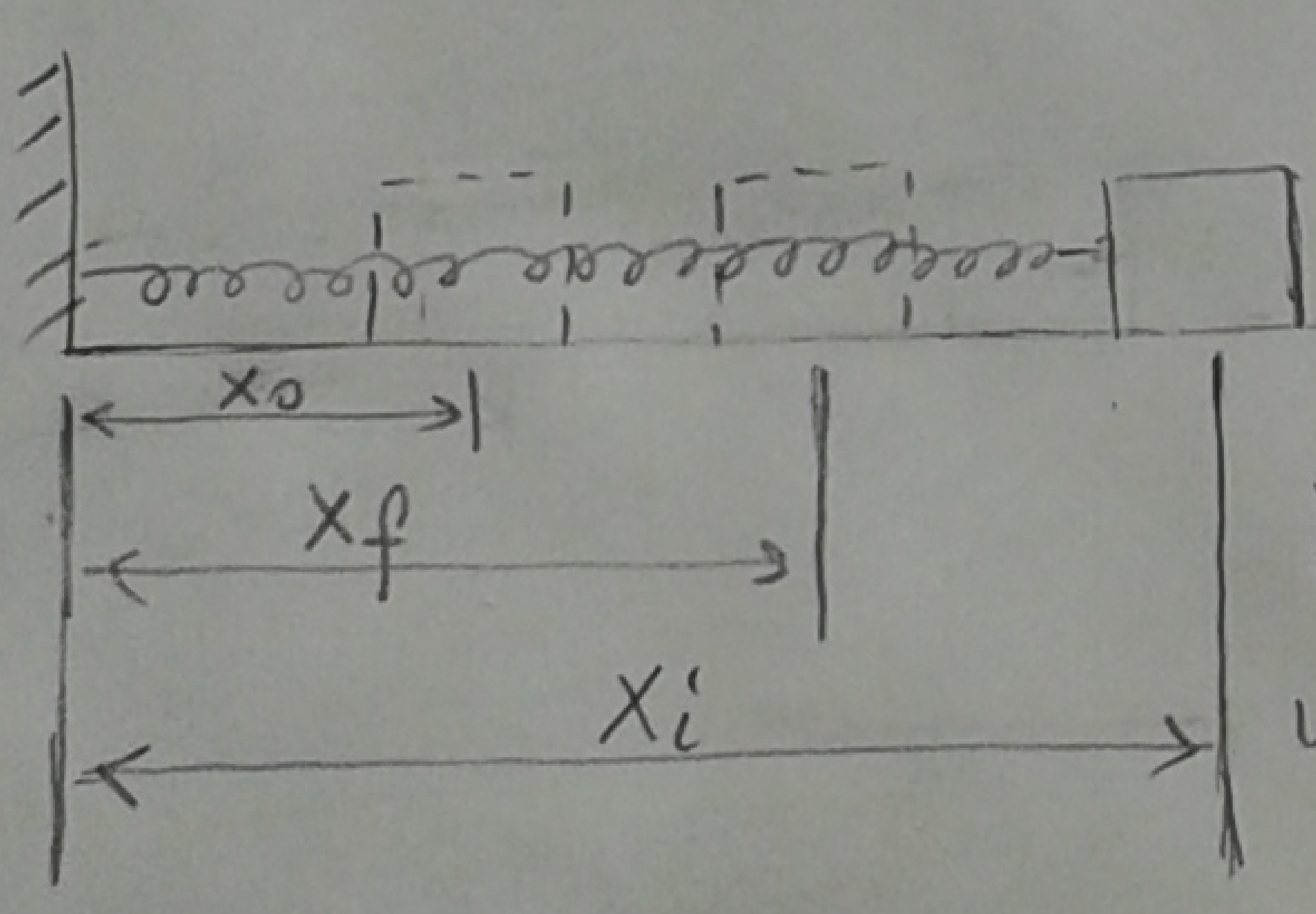
a) Calculate the potential-energy function $U(x)$ for this spring. Let $U=0$ when $x=0$.

b) An object with mass 9 *kg* on a frictionless, horizontal surface is attached to this spring, pulled a distance 2 *m* to the right (the +x-direction) to stretch the spring, and released. What is the speed of the object when it is 1 *m* to the right of the $x=0$ equilibrium position?

a) $U(x) = -\int_0^x F_x(x)\,dx = \int_0^x [\alpha x + \beta x^2]\,dx = \frac{\alpha x^2}{2} + \frac{\beta x^3}{3}$ //

where $U(x=0) = 0$

b)



$\Delta x_i = x_i - x_0 = 2m \Rightarrow v_i = 0$

$\Delta x_f = x_f - x_0 = 1m \Rightarrow v_f \neq 0$

In general,

$K_i + U_i + W_{others} = K_f + U_f$

where $W_{others} = 0$ (no friction)

$\Rightarrow \cancelto{0}{K_i} + U_i = K_f + U_f$ and $U_i = \left[\frac{\alpha x^2}{2} + \frac{\beta x^3}{3}\right]_{x=2m}$

$\Rightarrow U_i(x=2m) = K_f + U_f(x=1m)$

$\frac{60\cdot 2^{\cancel{2}}}{\cancel{2}} + \frac{\cancelto{6}{18}\cdot 2^3}{\cancel{3}} = K_f + \left(\frac{\cancelto{30}{60}\cdot 1^2}{\cancel{2}} + \frac{\cancelto{6}{18}\cdot 1^3}{\cancel{3}}\right) \Rightarrow K_f = 168 - 78 = 90 J$

$\Rightarrow v_f = \sqrt{\frac{2K_f}{m}} = \sqrt{\frac{2\cdot \cancelto{10}{90}}{\cancel{9}}} = \boxed{\sqrt{20}\ m/s}$ //

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Section 2 Quiz 7 25 March 2016

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

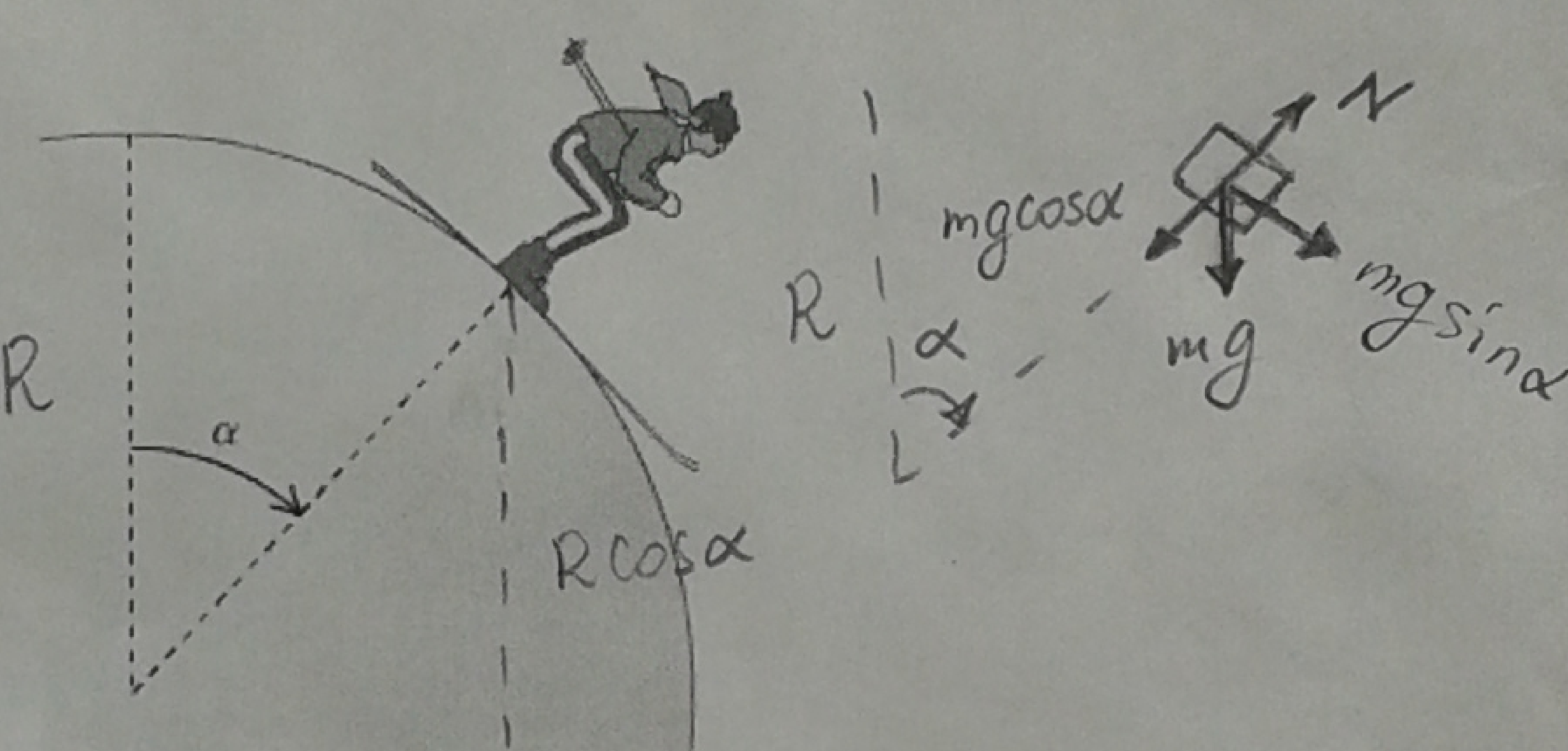
A skier starts at the top of a very large, frictionless snowball, with a very small initial speed, and skis straight down the side as shown in the figure below. At what point does she lose contact with the snowball and fly off at a tangent? That is, at the instant she loses contact with the snowball, what angle α does a radial line from the center of the snowball to the skier make with vertical?

Lost contact:

$mg\cos\alpha - \overset{=0}{\cancel{N}} = m a_r$

where $a_r = \frac{v^2}{R}$

↳ $\cancel{m}g\cos\alpha = \frac{\cancel{m}v^2}{R}$



From the conservation of energy:

$\cancel{m}gR = \cancel{m}gR\cos\alpha + \frac{\cancel{m}v^2}{2} \Rightarrow v = \sqrt{2gR(1-\cos\alpha)}$

↳ $\cancel{g}\cos\alpha = \frac{2\cancel{g}\cancel{R}(1-\cos\alpha)}{\cancel{R}} \Rightarrow \cos\alpha = 2 - 2\cos\alpha$

↳ $\cos\alpha = \frac{2}{3} \Rightarrow \boxed{\alpha = \cos^{-1}(2/3)}$ //

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Section 3 Quiz 7 25 March 2016

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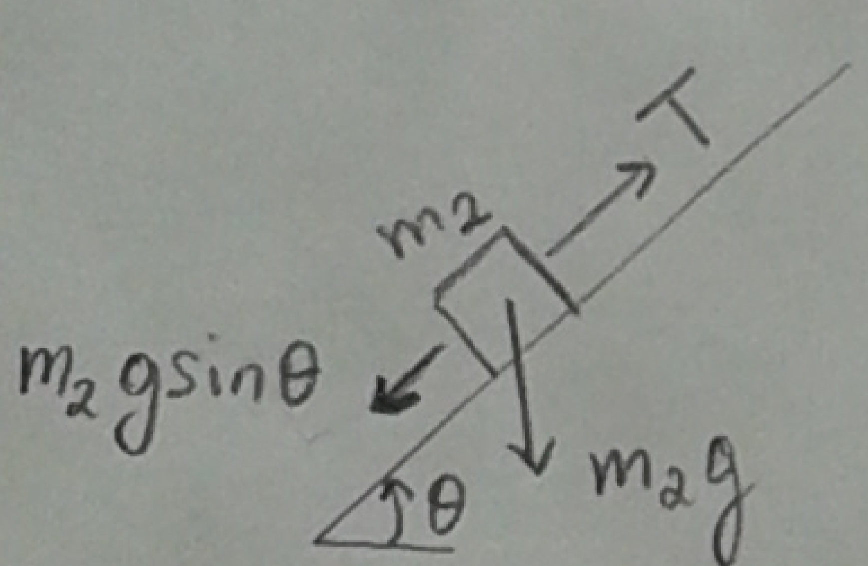
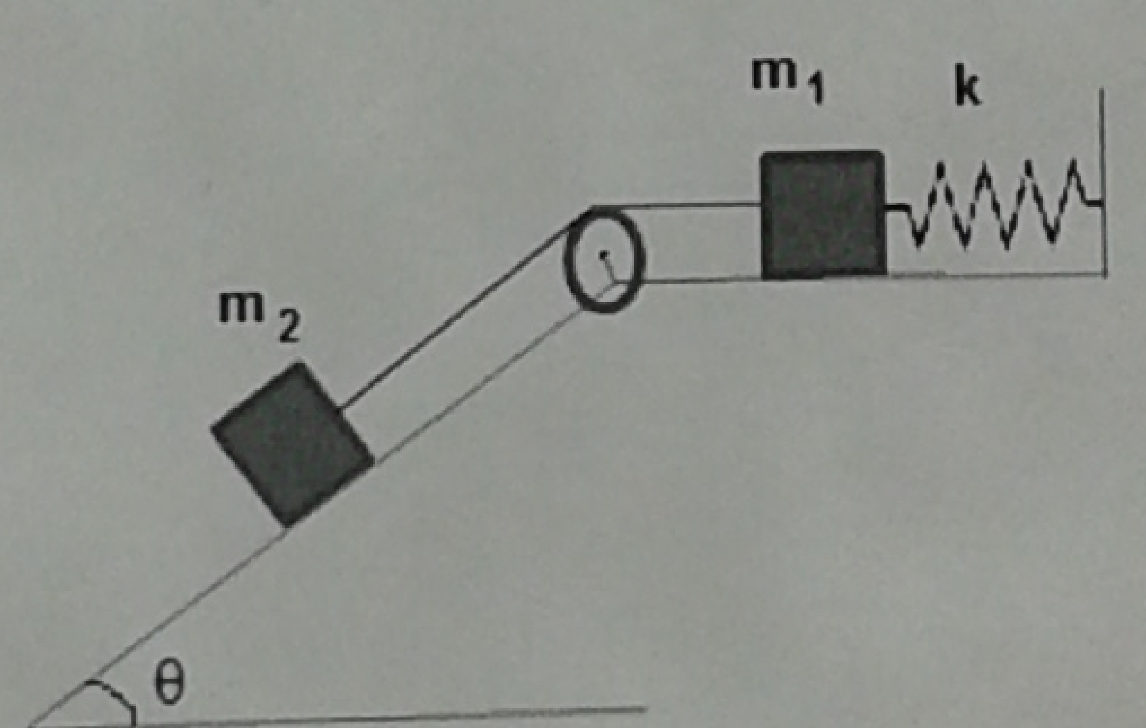
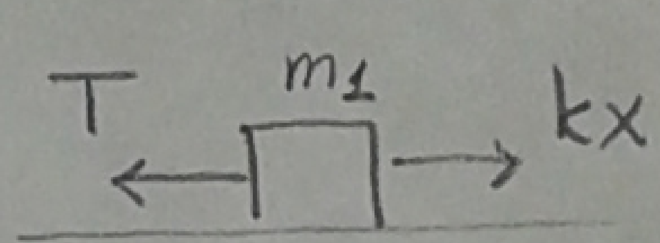
In the figure below, the block of mass m_1 is connected by a spring to a wall on the right side and to block of mass m_2 by a string through a pulley on the left side. The block m_2 is suspended on an inclined plane. The string is always tight. The gravitational acceleration is g. The whole system is frictionless. Answer the following questions. Express your answer only in terms of g, k and θ.

Suppose that the system is released from the position, when the spring is unstretched/uncompressed and masses are not moving. What will be the maximum potential energy stored in the spring during the first forward motion?

Free body diagrams :







$T = kx$

$$m_2 g\sin\theta = T \Rightarrow kx = m_2 g\sin\theta \Rightarrow x = \frac{m_2 g\sin\theta}{k}$$

$$U_{spring} = \frac{1}{2}kx^2 = \frac{1}{2}k\left(\frac{m_2 g\sin\theta}{k}\right)^2 = \frac{m_2^2 g^2 \sin^2\theta}{2k^{\cancel{2}}}\cdot\cancel{k} =$$

$$= \boxed{\frac{m_2^2 g^2 \sin^2\theta}{2k}} \;//$$