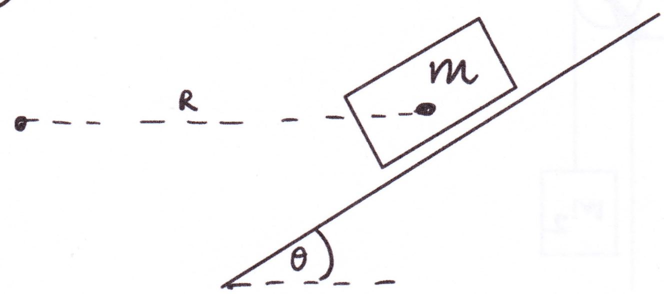
Challenge Problem Set 1
(Nayana Rajapakse)

1



A car (represented with box) is on a banked circular track expecting to drive in circular motion.

here $\theta > \tan^{-1}(\mu_s)$ where μ_s is the static friction coefficient between the the track and the car. R and m are the radius of the expected circular motion and the mass of the car respectively.

(a) Show that the car can't remain in equilibrium unless it is moving.

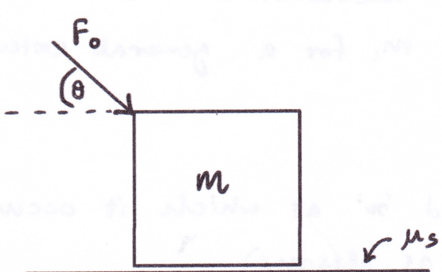
(b) Find the minimum speed at which the car must travel to avoid sliding down.

(c) Find the maximum speed at which the car can travel without sliding sliding on the ramp.

(d) Now articulate an argument from which you could have deduced the answer you got for (d) from that of (c) without redoing the work.

(e) Summorize the results found in (c) and (d) to write down the range of the car's speed in circular motion without sliding.

2



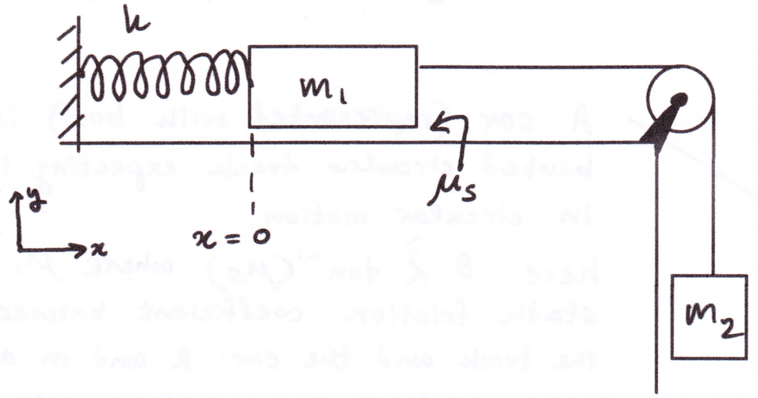
As shown a box with mass m is sitting on a rough surface where the static friction coefficient between the two surfaces is μ_s. An external force F_o is applied on the box as shown making an angle θ with the horizontal.

(a) Find the maximum allowed F_o (i.e, $F_{o,max}$) such that the box would still remain in equilibrium.

(b) Now F_o is slightly increased above the value found in (a) making the box to move. Soon after that F_o is brought back to the value found in (a). Conceptually explain why the box will not return to equilibrium.

(c) After performing the steps in part (b) obtain expression for the acceleration of the block in terms of μ_s, μ_k, θ and g where μ_k is the kinetic friction coefficient

3



Two boxed with masses m_1 and m_2 are connected with a rope and are setup as shown in the figure. μ_s and μ_k are static and kinetic frictional coefficient between the box and the horizontal table. m_1 is connected to spring with a spring constant k which is then connected to a wall as shown. Initially the spring is <u>relaxed.</u> definition of $x = 0$ is shown.

(a) If $\mu_s < m_2/m_1$ show that the system will not be in equilibrium with spring relaxed.

For the subsequent parts assume $\mu_s < m_2/m_1$

(b) For a general extension 'x' of the spring, find an expression for acceleration of m_1 and tension of the string.

(c) Find 'x' (call it x_0) at which instataneous acceleration is zero.

(d) Find an expression for the velocity 'V' of m_1 for a general extention 'x'

$$\left(\text{use } a = \frac{dV}{dt} = V\frac{dV}{dx}\right)$$

(e) Find the maximum of V (call it V_{max}) and 'x' at which it occurs. (you may use any results obtained above as always)

(f) Find the maximum extension of the spring and the acceleration of m_1 and tension of the string at that moment