

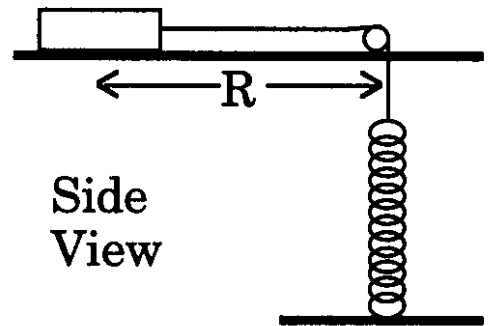
**Problem 3** (20 points)

This is a variation on a lecture demonstration. A disk of mass  $M$  is held by a string and is moving in a circle on a horizontal, frictionless table. The string passes through a hole in the center of the table on a frictionless pulley. In the lecture demonstration, a hanging weight provided the string tension. In this problem, a spring with spring constant  $k$  is attached to the end of the

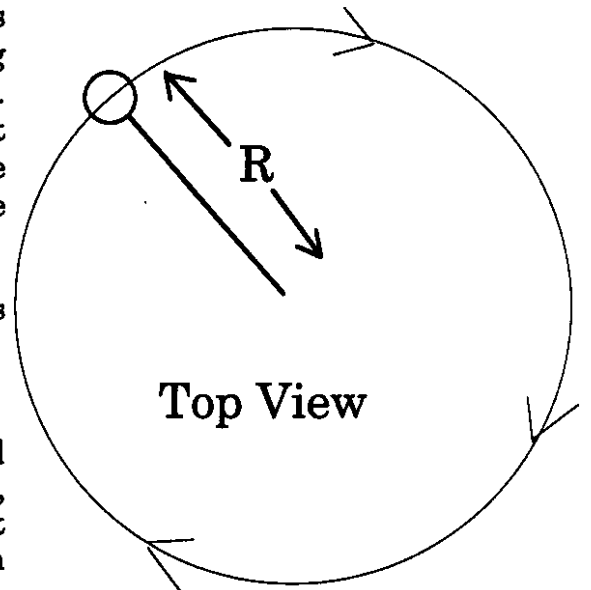
string as shown. The other end of the spring is connected to the floor. Both the string and spring are very light so you can ignore their masses. Assume that the length of the string is such that the spring is just beginning to stretch when the disk is at  $R=0$ . The disk completes one full circle every  $\tau$  seconds (this is the period of the motion).

a) Draw a clear diagram showing all the forces acting on the block and its acceleration (if any).

b) Find the value of  $\tau$  in terms of numerical constants and the given quantities ( $M$ ,  $g$ ,  $k$ , and  $R$ ). [Hint: Surprisingly, the correct answer depends on only two of the given quantities.]



Side View



Top View

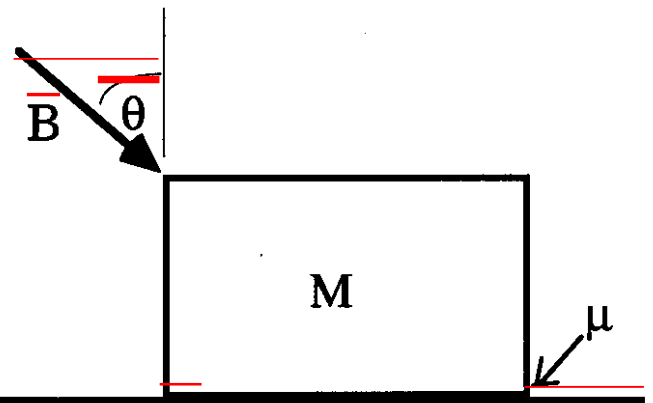
~~**Problem 4** (25 points)~~

~~An astronaut is pushing a block of mass  $M$  that is sitting on a surface as shown. The magnitude of the force exerted by the astronaut is given by  $B$  and the direction is shown by the angle  $\theta$  in the drawing. This experiment is done in outer space where gravity can be neglected. The coefficients of static and kinetic friction between the block and the surface are both equal to  $\mu$ .~~

~~a) Assume initially that the block does not move. Draw a clear diagram showing all of the forces acting on the block.~~

~~b) Still assuming that the block does not move, find the magnitude of all the forces acting on the block (other than the astronaut's hand) in terms of the given quantities.~~

~~c) Now assume that the astronaut wants the block to start moving. She will accomplish this by pushing harder (changing  $B$ ) or by pushing at a different angle (changing  $\theta$ ) or by changing both angle and magnitude. Find the requirements for  $B$  and  $\theta$  in order for the block to just barely start to move. If there are no restrictions on the value of either  $B$  or  $\theta$ , or both, clearly explain why that is the case.~~



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Physics 8.01L

SAMPLE EXAM 2

SOLUTIONS

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**Problem 1**

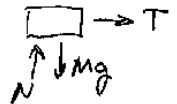
- ~~i) a) Object A Same force, smaller mass, so A has a bigger acceleration and moves the same distance in a shorter time.~~  
~~ii) c) Both are the same. Same force, same distance, so the same change in kinetic energy.~~  
~~iii) a) Object A. Smaller mass so smaller normal force, therefore smaller friction. Net force is larger on A, so it gains more kinetic energy.~~  
~~iv) a) Object A. B moves up and stops completely. At its maximum height, A still has horizontal motion.~~  
~~v) b) Objects B They start with the same kinetic energy (KE). B converts all of its KE to gravitation potential energy (PE), while A always has some non-zero KE.~~

**Problem 2**

- ~~A) iv) Same force by Newton's 3rd law.~~  
~~B) iv) None of the above.  $N_A - M_A g - F = -M_A a$ ,  $\Rightarrow N_A = M_A g + F - M_A a$~~   
~~C) iii) Less than  $m_A g$  but not zero.  $T - M_A g = -M_A a$ ,  $T = M_A (g - a)$~~   
~~D) iv) Normal force does work and creates PE.  $N$  points up, motion is up  $\Rightarrow$  + Work KE is constant, but PE rises.~~

**Problem 3**

a)



$a = \frac{v^2}{R}$ ,  $v = \frac{2\pi R}{\tau}$   
 b)  $a = \frac{v^2}{R} = \frac{4\pi^2 R}{\tau^2}$  Spring is stretched a distance  $R$  so:  
 $T = kR = ma = m \left( \frac{4\pi^2}{\tau^2} \right) R$ ,  $R$  drops out.  
 $\tau = 2\pi \sqrt{\frac{m}{k}}$

**Problem 4**

a)

