INSTRUCTIONS: Write your NAME on the front of the blue exam booklet. The exam is closed book, and you may have only pens/pencils and a calculator (no stored equations or programs and no graphing). Show all of your work in the blue book. For problems II-V, an answer alone is worth very little credit, even if it is correct – so show how you get it.

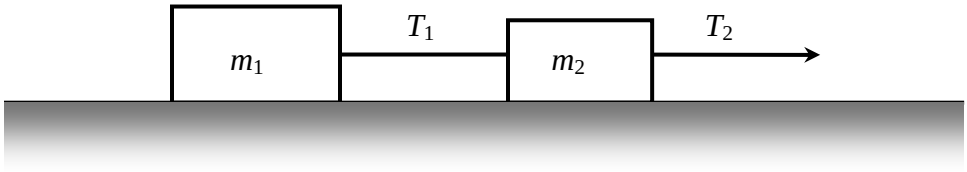
Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

Multiple Choice Questions (4 points each) Please write the letter corresponding to your answer for each question in the grid stamped on the first inside page of your blue book. No partial credit is given for these questions.

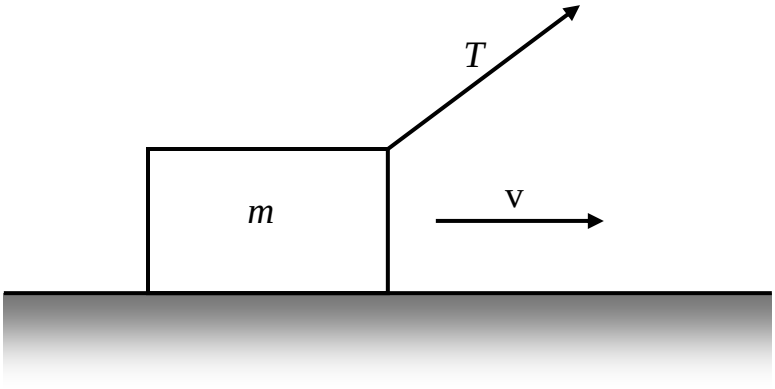
1. A block slides a certain distance down an incline. During the descent the work done by friction is $-|W|$. What is the work done by friction if the block is pushed the same distance up the incline by a force parallel to the surface?

   a) Zero
   b) $|W|$
   c) $-|W|$
   d) Friction cannot do work.
   e) The work cannot be determined unless the distance traveled is given.

2. Two masses, m_1 and m_2, connected by a massless string, are accelerated uniformly on a frictionless surface as shown in the figure. The ratio of the magnitude of the tensions T_1/T_2 is given by:



(a) m_1/m_2 (b) m_2/m_1 (c) $(m_1+m_2)/m_2$ (d) $m_1/(m_1+m_2)$ (e) $m_2/(m_1+m_2)$



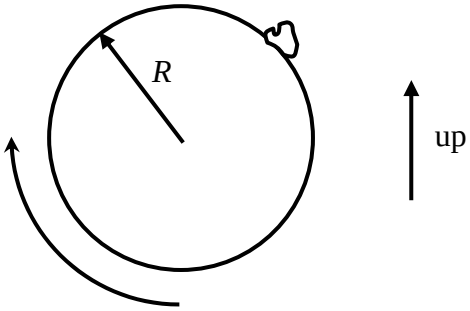
3. A block of mass m is pulled by a massless rope at a constant velocity along a horizontal plane. There is friction between the block and the plane. What can you say about the magnitudes of the tension in the rope, T, of the friction force F_k, of the normal force N, and of the weight mg?

(a) $|T| = |F_k|$ and $|N| = mg$ (b) $|T| > |F_k|$ and $|N| > mg$ (c) $|T| > |F_k|$ and $|N| < mg$

(d) $|T| = |F_k|$ and $|N| > mg$ (e) $|T| < |F_k|$ and $|N| = mg$

4. A wad of chewing gum of mass M is stuck to the outer rim of a rotating wheel so that the gum has uniform circular motion with speed v and radius R. If the wheel is rotating around a horizontal axis, which statement is true?

a) The wheel always exerts a force on the gum with a magnitude greater than Mv^2/R.
b) The work done by gravity on the gum during one complete revolution is positive.
c) The work done by gravity on the gum during one complete revolution is negative.
d) At the bottom of the circle, the wheel exerts an upward force of magnitude $|Mv^2/R - Mg|$ on the gum.
e) At the bottom of the circle, the wheel exerts an upward force of magnitude $|Mv^2/R + Mg|$ on the gum.

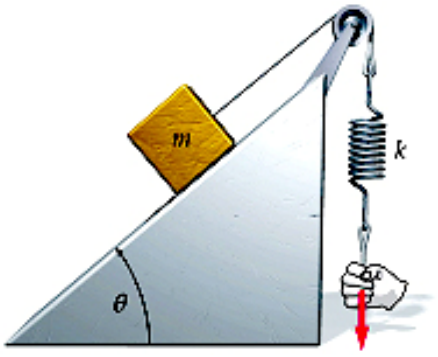


5. A block of mass m is pushed up against a spring, compressing it a distance x, and is then released. The spring projects the block along a frictionless horizontal surface, giving the block a speed v. The same spring projects a second block of mass $3m$, giving it a speed $2v$. What distance was the spring compressed in the second case?

a) x b) $2x$ c) $3x$ d) $6x$ e) $x\sqrt{12}$

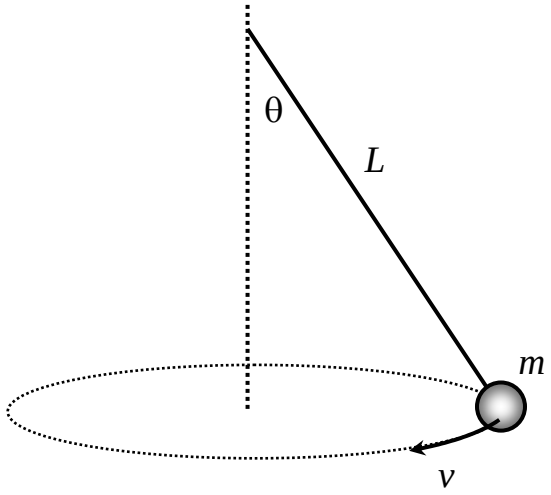
Problems (20 points each)

II. A block of mass m = 3 kg rests on an inclined plane with $\theta = 20^o$. The coefficient of static friction between the block and the incline is $\mu_s = 0.4$. The mass is connected to spring with k = 200 N/m via a massless pulley and a string. A gradually increasing downwards force is applied to the spring. At the moment just before the block starts to move, find:



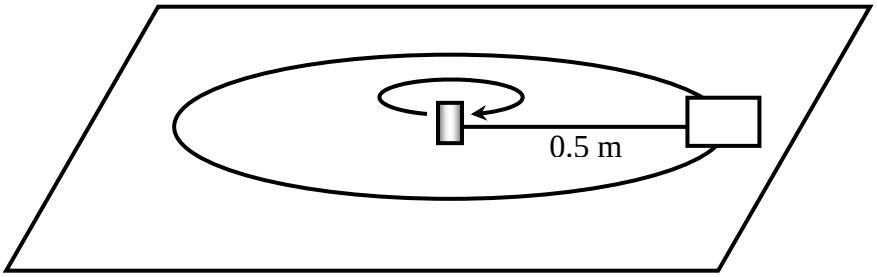
a) The magnitude and direction of the static friction force between the block and the incline.
b) The elongation of the spring.
c) The work done *by* the force after it has stretched the spring.

III. A ball of mass *m* on the end of a string of length *L* executes uniform circular motion in what is called a "conical pendulum" where the ball moves in a horizontal circle around an axis that passes through its pivot point. The period of the motion is *T*.



a) Draw a free body diagram for the ball, indicating the forces acting on it.
b) Choose (and label!) a coordinate system, and write down Newton's Laws for the ball's motion in your chosen coordinate system.
c) Find an expression for the angle θ that the string makes with the vertical axis in terms of *L*, *m*, *T*, and *g*, the acceleration due to gravity. Do not plug in 9.8 m/s^2 for *g*. The velocity *v* should not appear in your final answer.
d) In terms of the same variables, find the magnitude of the tension in the string, which we'll call F_T in order not to confuse it with the period *T*.

IV. A 2 kg block slides on the end of a 0.5 meter rod on a horizontal table. The rod is being spun by a central axle resulting in a *tangential acceleration* of 1.5 m/s^2. The coefficient of kinetic friction between the block and the table is $\mu_k = 0.3$. Assume throughout this problem that the radius of the circle in which the block moves remains 0.5 meters.



a) The block starts from rest and is spun up to a final speed of 6 m/s. How long does this take?
b) Find the work done by the spinning force associated with the axle and the work done by the force of friction during this time. Hint: the total distance traveled by the block is necessary.
c) Power to the axle is cut removing the accelerating force, and the block slows until it is at rest. How far does the block travel before it stops? Assume the rod stays taut throughout.

V. You throw a 0.5 kg overripe tomato straight down from the roof of a building with an initial speed of 10 m/s. The tomato is released a distance 15 meters from the ground.

a) How much work does gravity do on the tomato before it splats on the ground?
b) Assume that there is some air resistance. What is the tomato's speed just before it hits the ground if air resistance does work of magnitude 40 J on the tomato?
c) If the tomato were thrown horizontally with the same initial speed, how would your answer to part (a) change? Explain briefly.
d) Including the work done by air resistance as in part (b), find the tomato's speed just before it hits the ground if it is thrown horizontally instead of straight down.