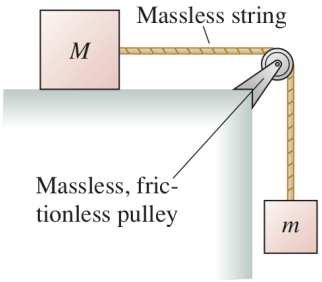
Homework 4

Due in recitation on Thursday or Friday, February 23 or 24

Note: For all problems, in order to receive credit, you must draw force diagrams for all relevant objects. These diagrams must be at least two inches (5 cm) tall to receive full credit. This is for your benefit, not mine; carefully drawing clear diagrams will help you with these problems more than anything else.

1. An object of mass M sits on a frictionless table; it is connected by a light string to a hanging mass m. (See figure.)

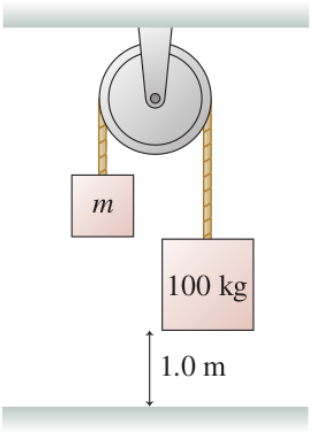


   (a) Find both the tension in the string and the acceleration of the masses in terms of M, m, and g.

   (b) What is the tension in the limit where $M \gg m$ (that is, the mass on the table is very heavy)? Is this what you expect it to be?

   (c) What is the acceleration in the limit where $m \gg M$ (that is, the hanging mass is very heavy)? Is this what you expect it to be? Think about two cases: (i) M is a bowling ball and m is a feather, and (ii) M is a feather and m is a bowling ball.

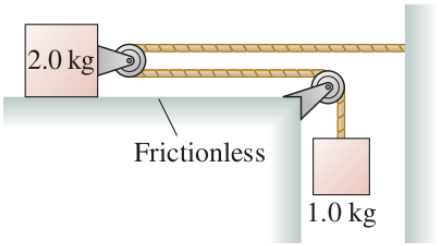
2. Two masses are connected by a light string and draped over a light, frictionless pulley. One has mass m, which you will find; the other has mass $M = 100$ kg. (See figure.)



   (a) Find an expression for the acceleration of the mass M in terms of M, m, and g.

   (b) If it takes a time $\tau = 7$ s to hit the ground after it is released, what is the value of m?

3. A rope-and-pulley system is set up as shown.



   (a) How does the acceleration of the two blocks relate? (*Hint: If the hanging mass moves downward by one meter, how far does the block on the table move?*)

   (b) What is the acceleration of the 2 kg block sitting on the table?

4. Two blocks connected by a cable slide down an incline angled at 30° above the horizontal, connected by a cable. The top block has a mass of $m_1 = 1$ kg, and the bottom one has a mass of $m_2 = 2$ kg. The coefficients of kinetic friction are $\mu_{k_1} = 0.2$ (top block) and $\mu_{k_2} = 0.1$ (bottom block). What is the tension in the cable that connects them?

5. A person wants to slide a heavy table of mass $m = 100$ kg over a flat floor by pushing on it. The coefficient of friction between the table and the floor is $\mu = 0.6$. Note that they don't need to make the table accelerate; they just want to move it at a constant rate.

   What force must they apply to the table to move it if...

   (a) ... they push horizontally?

   (b) ... they push diagonally upward on the table, at an angle directed 30° above the horizontal?

   (c) ... they push diagonally downward on the table, at an angle directed 30° below the horizontal?

   (d) ... they push diagonally downward on the table, at an angle directed 65° below the horizontal? *(This means they are pushing at a steep angle, closer to directly downward than before.)*

6. A heavy ball with mass 10 kg is suspended by a rope of length 4.5 m. It is pulled to one side and released, swinging like a pendulum; at its lowest point, it reaches a speed of 6 m/s.

   (a) What is the tension in the rope at that point?

   (b) Explain in words (without using mathematics) why the tension in the rope here is greater than the weight of the ball.

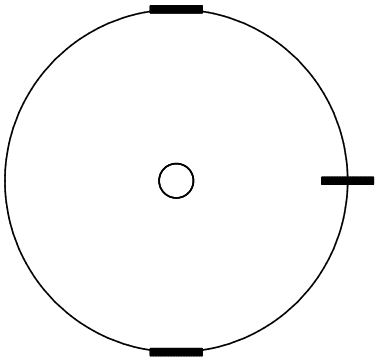
7. A ball is attached to the end of a string hanging from the roof of a subway car. The train goes around a curve, turning to the left. You know that the car is traveling at 60 km/hr.

   (a) Which way will the ball appear to swing?

   (b) What force pushes the ball in that direction? If there is no such force, explain why the ball swings to the side even though there is no force pushing on it.

   (c) If the ball swings at an angle of 15°, what is the radius of curvature of the curve in the tracks?

8. A carnival ride consists of a vertical wheel of radius r rotating at angular velocity ω around a horizontal axis. There is a horizontal platform attached to it; a person stands on the platform. (This platform stays horizontal, and does not rotate; the person remains upright during the whole ride.) This person has mass m, and stands on a scale.



   (a) Draw force diagrams for the person at the top of the circle, the bottom of the circle, and the position at the same height as the middle of the circle. (You will need to think carefully about the third one of these.)

   (b) How does the scale reading relate to the forces that act on the person standing on the platform?

   (c) In terms of m, g, r, μ_s, and ω, what is the scale reading at the top? (Your answer may not depend on all of these.)

   (d) In terms of m, g, r, μ_s, and ω, what is the scale reading at the bottom? (Your answer may not depend on all of these.)

   (e) What coefficient of static friction is required for the person not to slide at the position at the same height as the middle, in terms of m, g, r, and ω?