Scientist:_____ Date:_____ Period_____

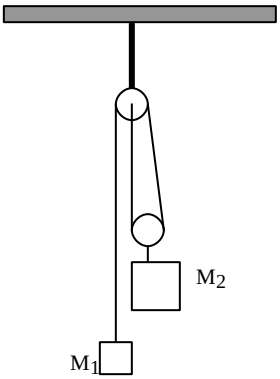
Mechanical Advantage with Pulleys

Purpose: Assemble a pulley system to create a mechanical advantage. Draw free body diagrams and apply Newton's Law to accelerating systems.

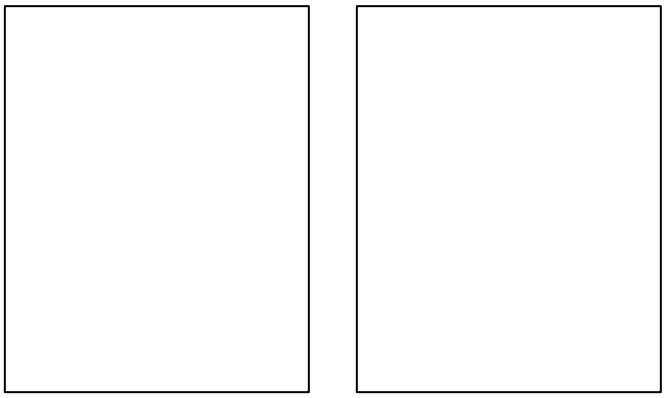
Materials: Assorted pulleys, neon-yellow string, accumulated physics expertise

Procedure:

1. Assemble the following pulley system



Free Body Diagrams



2. Draw the free body diagrams for both M_1 and the bottom pulley in equilibrium.

3. What is the relationship between the tensions in each FBD (free body diagram)?

4. If M_2 equals 100g:
   a. What is the weight on the bottom pulley?

   b. Calculate the tension in the string at equilibrium. ($\sum F=0$)

   c. Using the tension from b. calculate the weight of M_1.

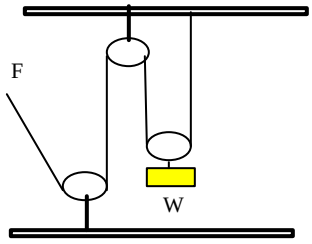
   d. Now calculate the mass of M_1. How does this value compare to M_2 ?

5. Attach the 100g mass to the bottom pulley (M_2). Find M_1 at the end of the string to create equilibrium.

6. How do the masses in #'s 4d. and 5 compare? Discuss the results and account for any differences.

7. You can never get something for nothing! What is the trade-off that enables us to lift more weight with less force?

8. What is the relationship between F and W for the system to the right? (hint: no calculations necessary!)



9. Analyze the complex pulley system from the class demonstration.
   a. Draw the free body diagram for the bottom pulley.

   b. Assuming a person weighs 600N, calculate the tension necessary to maintain equilibrium.

   c. In real-life estimate the force necessary to lift this person at a constant velocity.

Free Body Diagram

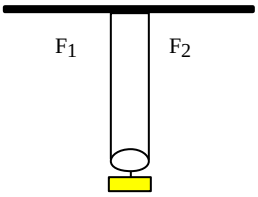
Extra Credit

Apply pulley concepts and use the remaining pulleys to create the largest mechanical advantage. See how much weight can be lifted with the least amount of force.

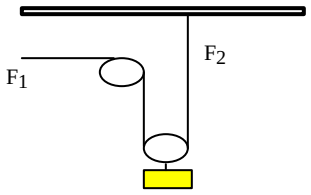
Homework Questions

S F = m a
Analyze the forces in the x and y directions independently

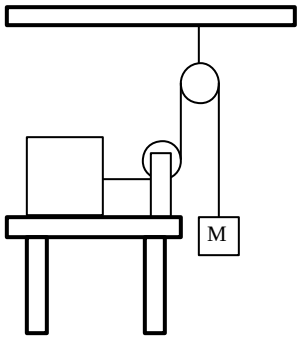
1. The 5-kg box is suspended with a rope and pulley system as shown. What are the forces of tension, F_1, and F_2, in the rope? showing all of the forces on the box.



2. The 5-kg box is now suspended with a rope and pulley system as shown. What is the force, F_1 required to
   A. keep the block stationary?
   B. accelerate the block with **upward** acceleration of 2 m/s^2?
   C. keep the block moving **upward** at constant velocity of 3 m/s?
   D. accelerate the block **downward** with a = 9.8 m/s^2?



3. A 10-kg box sits on a table with a mass and pulley system attached to it as shown below. If the coefficient of static friction is $\mu_s = 0.3$, what is the maximum mass, M, possible such that the box on the table will not slide? Hint: Draw a free body diagram for **each** mass.



This worksheet created by LEAPS Graduates Logan McLeod and Chuck Schelle, and LEAPS Undergraduates Kok Cheng and Shera Wu.