Name: ____

LAB 7. SIMPLE MACHINES

Introduction

"Simple" machines use the energy provided by the operator to perform their task. They are nonetheless useful because they can produce a greater force, or a greater speed, than their input. This useful feature is a manifestation of conservation of energy.

This lab comprises four activities. In all of them, you compare the input and output forces of simple machines, along with variables that correlate to travel distance.

Supplies

Hydraulics: wooden frame holding syringes of different diameter, Vernier calipers, ruler
Lever: meter stick, support, bearing clip, two mass hanger clips, hanging weights
Inclined plane: track with pulley, cart, cable, level, table clamp, meter stick, rod clamp, rod, hanging weights
Block and tackle: table clamp, two fixed pulleys, hanging weight, balance, mass hanger, accessory masses

Data Collection

Hydraulic syringes

Please do not dismantle the assembly.

1. With the Vernier calipers, measure the inner diameters d of the two syringes. Record in the table
2. With the calipers or ruler, measure the distance L between two marked volumes V_a and V_b on each syringe barrel. It doesn't matter what the volumes are, just that you can accurately measure the distance between them. Record in the table.

Hydraulic Data Table

Syringe	d	V_a	V_b	L	A	$L/\Delta V$	$A\ L/\Delta V$
Small							
Large							

3. Push down on the plunger of the small syringe. What happens to the plunger of the large syringe? ____
4. Push down on the plunger of the large syringe. What happens to the plunger of the small syringe? ____
5. Which plunger moves the farthest? ______________________________
6. Which plunger is easiest to depress? ______________________________

Lever

1. Take the mass hanger clips off the meter stick. Position the bearing clip near the center of the meter stick and set it in the cradle of the support. Adjust the position of the meter stick in the bearing clip so that the stick balances horizontally when it is allowed to hang freely. Record the position A of this axis. A = ______________
2. Measure and record the masses m_a and m_b of the two mass hanger clips.
   m_a = ___________ m_b = ___________
3. Hang a 1000-g mass from one clip (the one with mass m_a), as close to the support as possible without touching it. Balance the meter stick, so that it is horizontal, by hanging a counterweight from the other clip (the one with mass m_b) on the other side of the axis and adjusting its position. Do this with 500-g, 200-g, and 100-g counterweights. Each time, record the mass m_1 and position x_1 of the 1000-g weight assembly (including clip), and the mass m_2 and position x_2 of counterweight assembly (including clip).
4. Move the 1000-g assembly so that it hangs 10.0 cm from the axis. Try to balance it with the counterweight assemblies. Record the masses and positions of the counterweights that succeed.
5. Move the 1000-g assembly so that it hangs 20.0 cm from the axis. Try to balance it with the counterweight assemblies. Record the masses and positions of the counterweights that succeed.

Lever Data Table

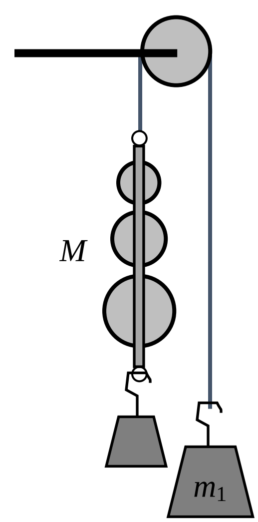
m_1	x_1	m_2	x_2	R	r	Rm_1	rm_2

Block and Tackle

In this activity you will determine the counterweights that balance a load supported by 1, 2, and 4 segments of cord.

Measure the mass M of the three-pulley assembly plus 200-g hanging mass. Record it here.

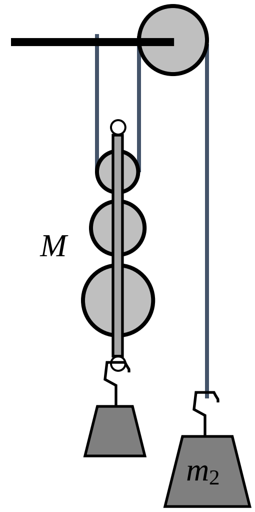
M = ___________



One segment of cord

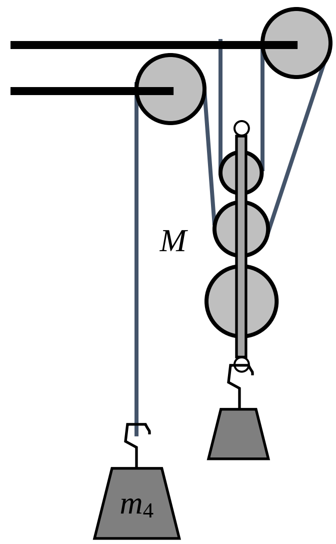
Attach one end of a cord to the top (by the small pulley) eye of the three-pulley assembly and the 200-g hooked mass to the bottom eye (by the large pulley). Run the cord over a fixed pulley, and hang the mass hanger from the other end of the cord. Place masses on the hanger to balance the pulley and 200-g mass. Record the mass m_1 of the hanger assembly.

Disconnect the cord from the top eye of the three-pulley assembly.



Two segments of cord

Attach one end of the cord to a fixed support, run the cord under the small pulley of the three-pulley assembly, and then over a fixed pulley. Hang the mass hanger from the other end of the cord. Place masses on the hanger to balance the system. Record the mass m_2 of the hanger assembly.



Four segments of cord

Now, with one end of the cord still attached to the fixed support, run the cord, in order, under the small pulley of the assembly, over a fixed pulley, under the medium pulley of the assembly, and over another fixed pulley. Hang the mass hanger from the remaining end of the cord. Place masses on the hanger to balance the system. Record the mass m_4 of the hanger assembly.

Six segments of cord

It should work, in principle. Try to make it so.

Block and Tackle Data Table

Segments *n*	***M***	***m***	***nm***
1			
2			
4			
6			

Inclined plane

A string running over the pulley at the end of the ramp connects a mass hanger to a dynamics cart. For a given hanging mass (less than the cart mass), find the height of the ramp that keeps the cart and hanging weight from accelerating either up or down.

1. Measure and record the mass of the cart. Mass M = ______________________.
2. Measure the distance from the beginning of the ramp to the support rod.
   Distance D = ______________.
3. Lower the ramp to the table. Level the ramp.
4. Mark the point on the side wall of the ramp directly underneath the support rod.
5. Place the needed mass (50 g, 100 g, 150 g, 200 g, 250 g, or 300 g) on the hanger. Run the string over the pulley at the end of the ramp.
6. Adjust the height of the rod supporting the ramp so that the cart rolls neither up nor down. Tighten the rod clamp to lock the ramp into place.
7. Measure the height h of the point marked on the side wall of the ramp above the table. Record the value.
8. Complete steps 3–5 for each hanging mass.

Inclined Plane Data Table

Hanging mass *m* (g)	**Height *h***	***hM***	***Dm***
50			
100			
150			
200			
250			
300			

Data Processing

Hydraulic syringes

1. Calculate A, the cross-sectional area of each syringe. Recall that the area of a circle with radius r and diameter d is $A = \pi r^2 = \pi d^2/4$. Enter into the table
2. Calculate ΔV, the volume difference $\Delta V = V_b - V_a$ for each syringe. Use it to calculate $L/\Delta V$, the distance traveled by the plunger when 1 mL of fluid enters or leaves the syringe. Enter into the Table. Don’t neglect the units!
3. Calculate $A\ L/\Delta V$, the area times the characteristic distance $L/\Delta V$. Enter into the Table.

Levers

1. Calculate R, the displacement from the axis to the 1000-g assembly: $R = A - x_1$. Enter into the Table.
2. Calculate r, the displacement from the axis to the counterweight assembly: $r = A - x_2$. Enter into the Table.
3. Calculate the products Rm_1 and rm_2. Enter into the Table.

Block and tackle

Calculate nm, the product of the counterweight mass and the number of cord segments suspending the three-pulley assembly. Enter into the Table.

Inclined plane

1. Calculate hM, the product of cart mass and the height of the indicated point on the wall of the track. Enter into the Table.
2. Calculate Dm, the product of the length of the track and the hanging mass. Enter into the Table.

Lab Report

Show the completed data tables.