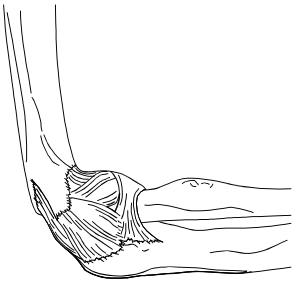
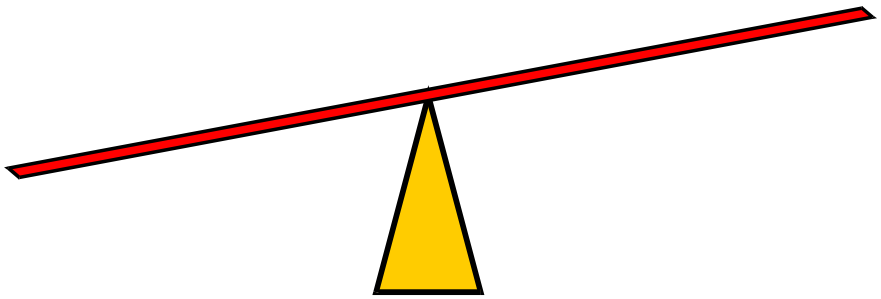
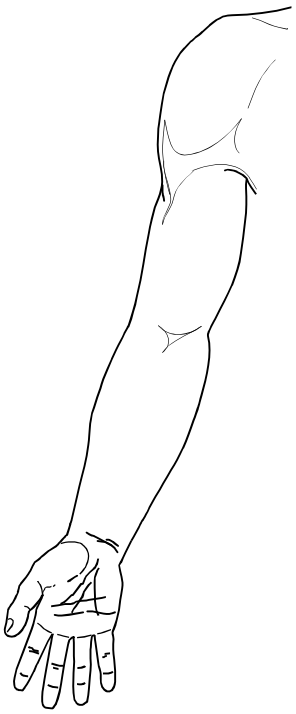
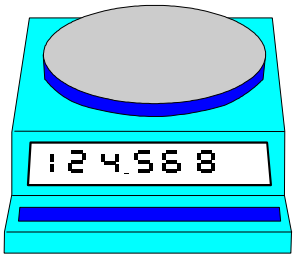


Arms,

Levers,







Balances,

and

a bit of math...

$$m_1 \times d_1 = m_2 \times d_2$$

$$\text{effort} \times d_1 = \text{load} \times d_2$$

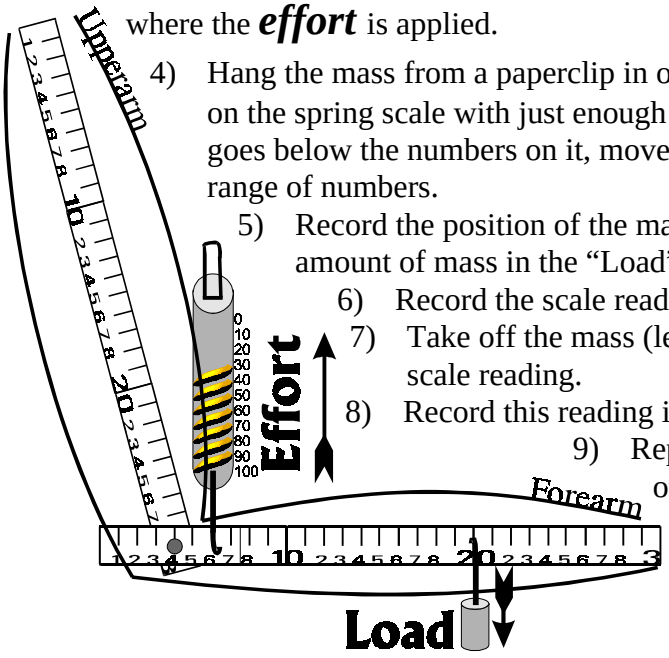
Arm Activity

Group members (circle your name): Date:_____ Period:_____

Shoulder holder:_____ Load maker:_____

Recorder:_____ Other helper:_____

1) Record the position of the fulcrum (elbow joint) at the top of the data table.
2) Hold the back ruler upright near the top.
3) Attach the spring scale through the hole in the lower ruler around the 6 cm mark. Record the position of the spring scale in the first "Position" column. This represents where your muscle pulls up, where the ***effort*** is applied.
4) Hang the mass from a paperclip in one of the holes in the ruler; this is the ***load***. Pull on the spring scale with just enough force to keep the lower ruler horizontal. If the scale goes below the numbers on it, move the mass inward until the scale measures in its range of numbers.
5) Record the position of the mass in the second "Position" column, and the amount of mass in the "Load" column.
6) Record the scale reading in the "Mass and Stick" column.
7) Take off the mass (leave the paper clip on the ruler) and read the new scale reading.
8) Record this reading in the "Stick only" column.
9) Repeat steps 4–8 two more times with other masses or other holes.
10) Compute all of the grey columns in the data table.
11) Compare the two columns "Load × distance" and "Effort × distance." Calculate your percent accuracy like you would a grade (smaller number ÷ larger number × 100) and record this in the "Percent" column.



Example of set-up of activity
Arms drawn in for representation.

Enter your fulcrum position here: _____ (this represents your elbow joint)

Effort (muscle) calculations						**Load calculations**				**Percent**
Scale readings (your muscle)		Effort	Position	Distance of "muscle" from fulcrum	Effort × distance	Load	Position	Distance of load from fulcrum	Load × distance	
Mass & stick	Stick only	Mass only								

Arm measuring:

When you have finished the "Arm Activity," complete the following.

1) Measure the distance between your elbow fulcrum and the joint at the base of your fingers. Record this below as the "distance between fulcrum and load."
2) Measure the distance between your elbow fulcrum and where your biceps attaches to your lower arm (what is the name of these bones? _____ & _____). Record this as the "distance between fulcrum and effort."
3) Assuming you are holding up 5 pounds, how much effort does your biceps have to pull up with?

Distance between fulcrum and load:

Distance between fulcrum and effort:

Calculate how much effort your biceps pulls up with to lift 5 pound:

How much effort does your biceps pull up with to lift 25 pounds?

Whose muscle works harder, a person with short arms or a person with long arms? What else do you need to know to answer this question more accurately?

Holding it Up

In this activity you will be using a mass and a scale on the same side of a fulcrum, just like in the Arm Activity. The mass will provide a force down (due to gravity) and the scale will measure how hard you have to pull up to **Hold It Up.** After trying the activity a few times like Arm Activity, you will exchange the positions of the scale and mass to see if this works as well.

Equipment:

1 meter–stick	1 meter–stick hanger (the ***fulcrum***)
1 large paper clip	1 mass each: 50g, 100g, 200g
1 ring stand with clamp or rod	1 spring scale

Data collection procedures:

1) You will need to place the hanger As close to the "zero" end of the meterstick as you can. If the hanger is not already on the meter–stick, place it on so when you hang it the numbers on the meter–stick are face up. Hang the meter–stick from the ring stand clamp.
2) In this experiment, you will want to know the distances between the mass and the fulcrum and the scale and the fulcrum. What piece of information do you now have that you will need to calculate these distances? Write this information clearly in your lab report.

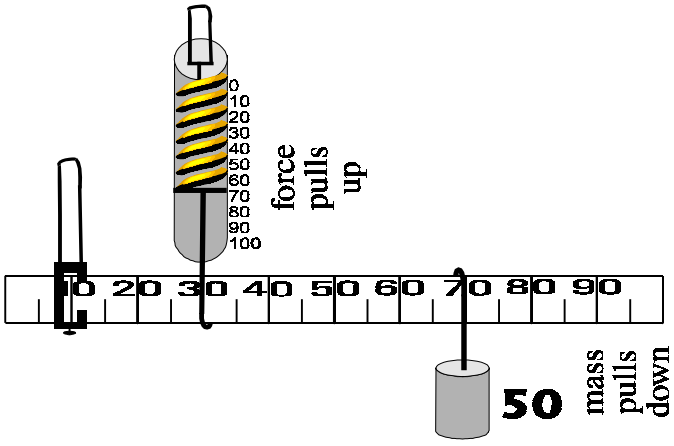


Diagram of activity set up

3) If it is not already unfolded, unfold the large paperclip so you can hang one side from the meter–stick and hang a mass from the other side.
4) You will be measuring the force with the scale for each of the masses. For each mass, you will make two different trials. Use the data table on the next page to enter all of your data.
5) First hold the scale so the meter–stick is horizontal. Record the locations of both the mass and the scale in the data table.
6) Measure the force from both the mass and the stick. Record this number in the column titled ***Scale readings: mass only.***
7) Next, place the 50g mass on a paperclip on the meter–stick without moving the scale and measure the force exerted by both the mass and the stick. Record this number in the column titled ***Scale readings: Mass and stick.***
8) Repeat steps 4 – 7 for each row on the data table.

☞ ***A note of warning:*** When the scale is close to the fulcrum, it may try to pull the fulcrum up. If this happens, you will need your partners' help to carefully hold the meter–stick hanger so that it does not rise up.

Notice that in your data table, six columns are gray: They are colored to show that these columns are filled with ***calculations*** and not ***data.*** When you make a data table, you want to be clear what is information you read off a measuring device (scale, ruler, mass, etc.) and what is information you calculated.

Experiment results:

Enter your fulcrum location here: _____***

Load measurements* and calculations**				**Effort measurements*** and calculations**						
Mass	*** Position	Distance from fulcrum	Mass × distance	Scale readings: Stick only ***	Scale readings: Mass & stick ***	Scale of mass only	*** Position	Distance from fulcrum	Mass × distance	Percent
With the scale closer to the fulcrum than the mass										
50g										
50g										
100g										
100g										
200g										
200g										
With the mass closer to the fulcrum than the scale										
50g										
50g										
100g										
100g										
200g										
200g										

Data analysis:

In this activity, we are testing the following equation:

$$\text{load} \times d_1 = \text{effort} \times d_2$$

d_1 represents the distance from the fulcrum to the load, and d_2 represents the distance from the fulcrum to the effort. Does this new equation work for all of your trials? In the last column, calculate the percent accuracy the way you did in "Arm Activity." *(can you think of reasons why? write them down).*

Conclusions:

Write out at least two conclusions you have from this experiment. Also include any suggestions you have for doing it better, or things that you did wrong and had to repeat. Remember, the conclusion should help you in remembering what you did and found out in the experiment, and also help you in other experiments you do in the future. Write down any reasons you can think of why you think your two numbers may be off.

BALANCING ACT

By now, you all are certainly experts at using the scales and masses and the equations for levers. In this activity, you will be balancing two masses on opposite sides of a meter–stick. After ensuring that the new equation presented here works for this lever, you will determine the mass of an unknown object by balancing it against a 200 g mass.

Equipment:

1 meter–stick	1 meter–stick hanger
2 large paper clips	1 mass each: 50g, 100g, 200g
1 ring stand with clamp or rod	1 rock of unknown mass

Data collection procedures:

You will need to place the hanger at the balance point of the meter–stick. If the hanger is not already on the meter–stick, place it on so when you hang it the numbers on the meter–stick are face up. Hang the meter–stick from the ring stand clamp, then move the hanger until you find the balance point.

You will be comparing the 50 g mass to the 100 g mass, and the 50 g mass to the 200 g mass. For each comparison, you will make three different trials. One mass will be placed on each side of the fulcrum.

The equation for this activity is almost the same as the one for "Holding it Up." The only difference is that this time we have replaced the effort with a mass. Thus the equation is written:

$$m_1 \times d_1 = m_2 \times d_2$$

Remember that **m** stands for mass, and **d** stands for the distance between the mass and the fulcrum.

Create **one** draft data table for the information, and show it to your teacher before you have everyone make one. **Once you have a data table with spaces for all the necessary data, and everyone has copied it into their notes, you can begin the experiment.**

After you compare the masses to each other, you will need to measure the mass of the rock. Write out a procedure for making this measurement.

Data analysis and conclusions:

Calculate your percent accuracy for each trial.

When you have determined the mass of your rock, come up to the front of the class and measure the rock on the electronic balance.

Calculate the Percent Error of your rock mass using the following formula:

(mass of rock from balance – mass of rock you calculated) ÷ mass of rock from balance × 100

Write out any conclusions you have from this experiment. Also include any suggestions you have for doing it better, or things that you did wrong and had to repeat. Remember, the conclusion should help you in remembering what you did and found out in the experiment, and also help you in other experiments you do in the future.