Physics Workshop

Balance and Levers

Main Topic	Forces
Subtopic	Simple Machines
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Investigate balance and three types of levers.

Required Equipment	Physics Workshop Lever, Workshop Stand, Hooked Masses, Spring Scales
Optional Equipment	

Educational Objectives

- To investigate equilibrium using a lever, and to investigate the lever as a simple machine.

Concept Overview

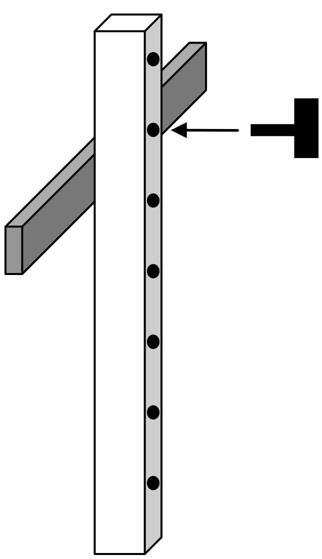
In the first lab, students will investigate the arrangements of weights that result in equilibrium (balance) in the lever system. They will find that both the force and the distance from the fulcrum are important in evaluating the system. This investigation leads naturally into a study of torque.

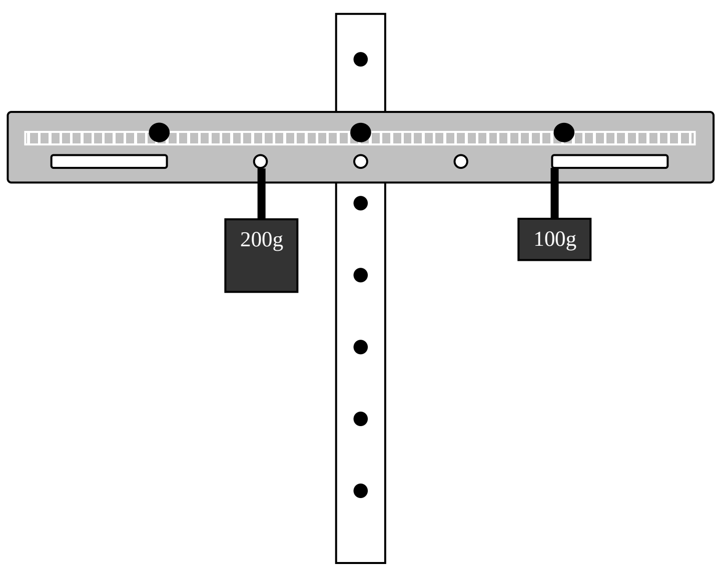
In the next three labs, students will investigate the three classes of levers, organized according to the arrangement of the input and output forces and the fulcrum. They will compare the levers and determine which class is useful in different situations.

Lab Tips

Assembly:

1. Push the attachment bolt through the Workshop Stand at approximately eye level.
2. Screw the bolt into center of the Lever from the back, so that students can see the printed scale.
3. Tighten the bolt and check to see that the lever pivots freely.
4. Hang Hooked Masses in the holes so that the Lever balances.





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Lever: Investigating Balance

Objective: To investigate equilibrium using a lever.

Materials: Workshop Stand, Lever, Bolt, Hooked Masses

Procedure:

1. Use the bolt to attach the Lever to the Workshop Stand, so that the lever is at eye level. Use the center pivot.
2. Check to make sure that the lever balances when empty.
3. Hang a 100g mass at the 20cm mark on the left side of the lever.
4. Hang a second 100g mass at a point that causes the lever to balance. Where did you place the second mass?

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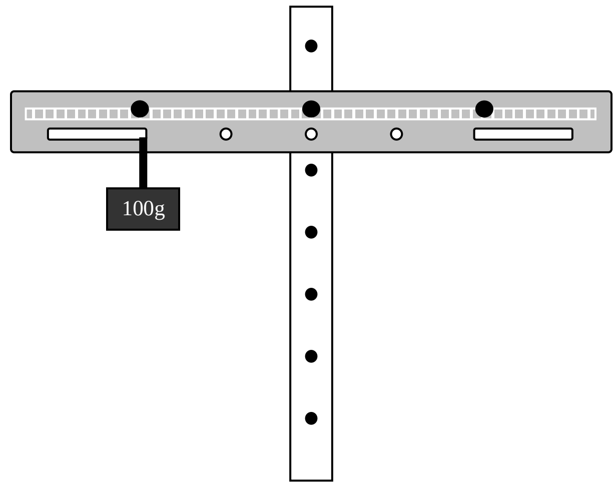
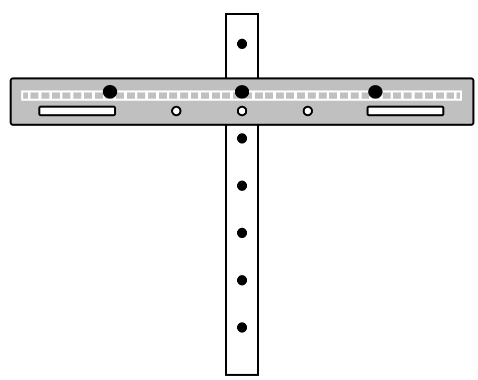


5. Remove the second 100g mass, leaving the 100g mass as shown in the diagram.
6. Hang a 200g mass at a point that causes the lever to balance. Where did you place the 200g mass? ______________________________
7. Remove the 200g mass, leaving the 100g mass as shown in the diagram.
8. Predict where a 50g mass should be hung to cause the lever to balance.

   ____
9. Test your prediction. Can you use a 50g mass to balance the 100g mass at 20cm? Explain.

   ____

   ____
10. Describe an arrangement of a 100g mass and a 50g mass that will cause the lever to balance. Draw your prediction on the lever to the right.
11. Test your prediction. Did the lever balance? ______________________________
12. If the lever did not balance, move the masses until it does and note the changes on your diagram.



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Lever: First Class Lever

Objective: To investigate the use of a lever as a simple machine.

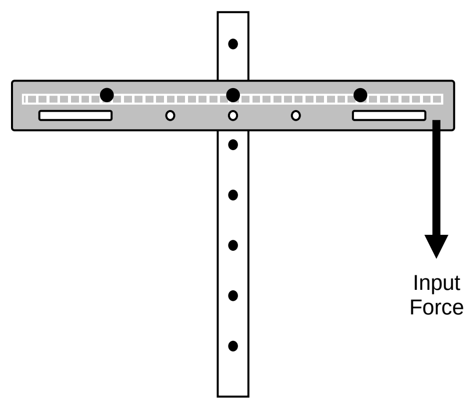
Materials: Workshop Stand, Lever, Bolt, Hooked Masses

Background:

A lever is one of the six types of simple machines. (The others are wheel & axle, inclined plane, wedge, screw, and pulley.) A lever is a rigid bar that is free to move around a fixed point. This fixed point is the fulcrum. The lever is useful for changing the direction or size of an applied force or the distance of which the force is applied.

Levers can be used in different ways. A first-class lever has the fulcrum located between the input force (or effort force) and the output force (or resultant force).

Procedure:



1. Use the bolt to attach the Lever to the Workshop Stand, so that the lever is at eye level. Use the center pivot.
2. Pull down on the right side of the lever. What happens to the left side?

   ____
3. Draw an arrow on the diagram to the right representing the Output Force.

Multiplying Force:

4. Hang a 100g mass at the 20cm mark on the right side. 100g represents the Input Force.
5. Place a 200g mass on the left side so that the lever is balanced. 200g represents the Output Force.
6. Write a sentence describing the relationship between the Input and Output Forces for this arrangement.

   ____
   ____
   ____
7. How far from the fulcrum is the Input Force? ____________________________
   This distance is the Input Arm.
8. How far from the fulcrum is the Output Force? ___________________________
   This distance is the Output Arm.
9. Write a sentence describing the relationship between the Input and Output Arms for this arrangement.

   ____

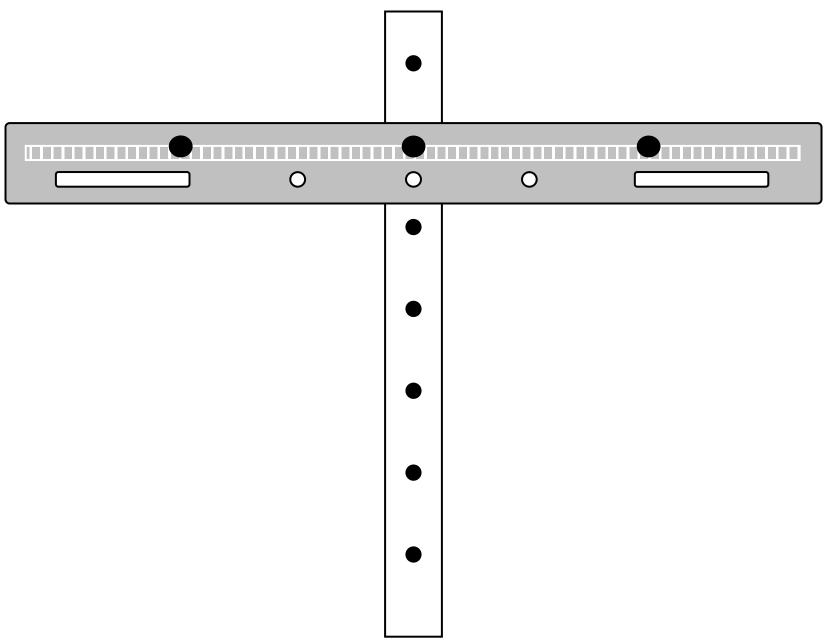
Name: ______________________________

10. The Ideal Mechanical Advantage of a lever is found by dividing the Input Arm by the Output Arm. Calculate the Ideal Mechanical Advantage for this lever.

11. How does the Ideal Mechanical Advantage relate to the Input and Output Forces for this system?

12. Give an example of a common item that is a first-class lever.

13. How would you arrange the lever so that it has an Ideal Mechanical Advantage of 3? Draw the Input and Output Forces in the appropriate places on the diagram below. Test your design and describe the results in the space below.



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Lever: Second Class Lever

Objective: To investigate the use of a lever as a simple machine.

Materials: Workshop Stand, Lever, Bolt, Spring Scale (1000g).

Background:

A second-class lever has its Output Force located between the Fulcrum and the Input Force. In this activity, the Output Force will be represented by the mass of the lever itself. In other words, the purpose of this lever is to lift the weight of the lever itself.

Procedure:

1. Detach the Lever from the Workshop Stand. Hang it from the spring scale and record its mass in grams. ______________________________
2. Since the fulcrum is not at the very end of the lever, you will be lifting about 80% of the mass of the entire lever. Multiply the mass by 0.8 to find the mass you will be lifting. ____________________
3. Use the bolt to attach the Lever to the Workshop Stand as shown. Use the left-side pivot and the lowest hole on the stand.
4. Hook the spring scale into the 30cm mark and pull upward enough to lift the lever off the table. Record the reading on the scale (in grams).
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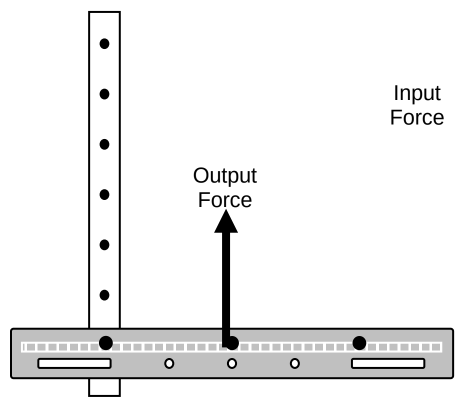
5. Draw an arrow representing the Input Force on the diagram at right.



Multiplying Force:

6. Write a sentence describing the relationship between the Input and Output Forces for this arrangement.
   ____
   ____
   ____
7. How far from the fulcrum is the Input Force? ______________________________
   This distance is the Input Arm.
8. How far from the fulcrum is the Output Force? ______________________________
   This distance is the Output Arm.

9. Write a sentence describing the relationship between the Input and Output Arms for this arrangement.

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10. The Ideal Mechanical Advantage of a lever is found by dividing the Input Arm by the Output Arm. Calculate the Ideal Mechanical Advantage for this lever.

11. How does the Ideal Mechanical Advantage relate to the Input and Output Forces for this system?

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12. Pull on the spring scale again, as in #4. Describe the relationship between the Input Distance (the distance the scale moves as it pulls) and the Output Distance (the distance the lever's center of mass, roughly the 0cm mark, moves).

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13. Give an example of a common item that is a second-class lever.

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Name: ______________________________
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Lever: Third Class Lever

Objective: To investigate the use of a lever as a simple machine.

Materials: Workshop Stand, Lever, Bolt, Spring Scale (1000g).

Background:

A third-class lever has its Input Force located between the Fulcrum and the Output Force. In this activity, the Output Force will be represented by the mass of the lever itself. In other words, the purpose of this lever is to lift the weight of the lever itself.

Procedure:

1. Detach the Lever from the Workshop Stand. Hang it from the spring scale and record its mass in grams. ______________________________
2. Since the fulcrum is not at the very end of the lever, you will be lifting about 80% of the mass of the entire lever. Multiply the mass by 0.8 to find the mass you will be lifting. ______________________
3. Use the bolt to attach the Lever to the Workshop Stand as shown. Use the left-side pivot and the lowest hole on the stand.
4. Hook the spring scale into the 10cm mark (between the 0 and the fulcrum) and pull upward enough to lift the lever off the table. Record the reading on the scale (in grams).

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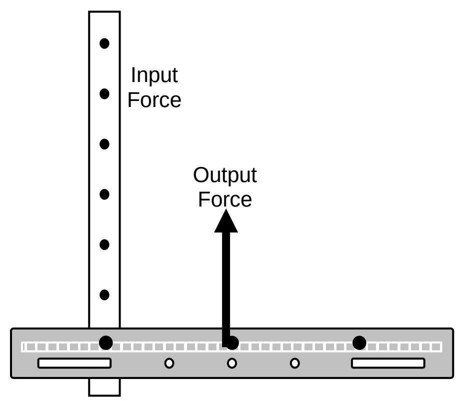
5. Draw an arrow representing the Input Force on the diagram at right.



Multiplying Force:

6. Write a sentence describing the relationship between the Input and Output Forces for this arrangement.

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7. How far from the fulcrum is the Input Force? ______________________
   This distance is the Input Arm.
8. How far from the fulcrum is the Output Force? ______________________
   This distance is the Output Arm.

Name: ______________________________
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9. Write a sentence describing the relationship between the Input and Output Arms for this arrangement.
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10. The Ideal Mechanical Advantage of a lever is found by dividing the Input Arm by the Output Arm. Calculate the Ideal Mechanical Advantage for this lever.

11. How does the Ideal Mechanical Advantage relate to the Input and Output Forces for this system?
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12. Pull on the spring scale again, as in #4. Describe the relationship between the Input Distance (the distance the scale moves as it pulls) and the Output Distance (the distance the lever's center of mass, roughly the 0cm mark, moves).
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13. Give an example of a common item that is a second-class lever.
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Review Questions

List the types of lever that apply to each situation. Some may have more than one answer.

a. First-Class Lever
b. Second-Class Lever
c. Third-Class Lever

___________ 1. A small Input Force is used to move a larger Output Force.
___________ 2. A large Input Force is used to move the Output Force a large distance.
___________ 3. Changes the size of a force.
___________ 4. Changes the direction of a force.
___________ 5. Can have a Mechanical Advantage greater than 1.
___________ 6. Can have a Mechanical Advantage less than 1.
___________ 7. A baseball bat is an example.
___________ 8. A triple-beam balance is an example.
___________ 9. Scissors are an example.
___________ 10. A wheelbarrow is an example.