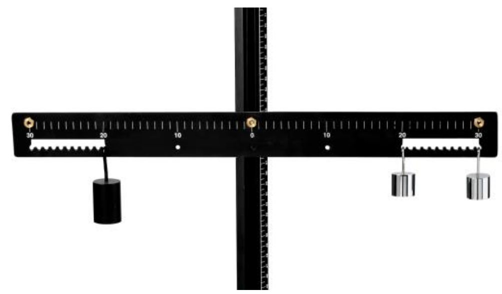


# Lever Lab

P4-1600

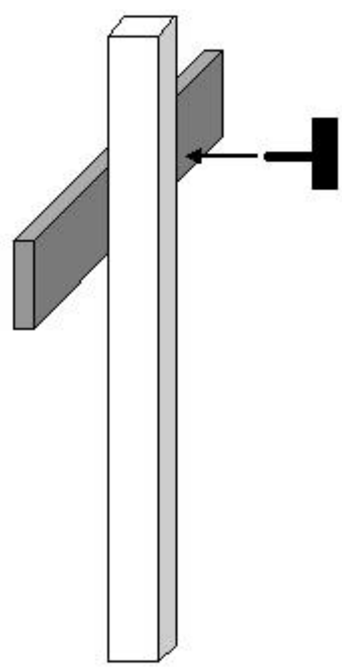
## KIT CONTENTS:

Lever
Attachment Thumb Bolt

**Recommended Accessories:**

**Workshop Stand** (P4-1901)
**Hooked Mass Set of 9** (91-1000)

## ASSEMBLY:



1. Push the attachment thumb bolt through the top hole in the Workshop Stand.
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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# Physics Workshop
# Lever Labs

## Table of Contents:





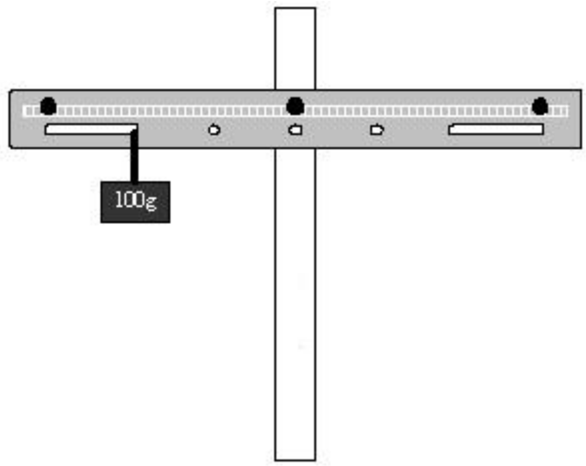
Name: ______________________________
______________________________

# Lever Lab:
## Investigating Balance

**Objective**: To investigate equilibrium using a lever.

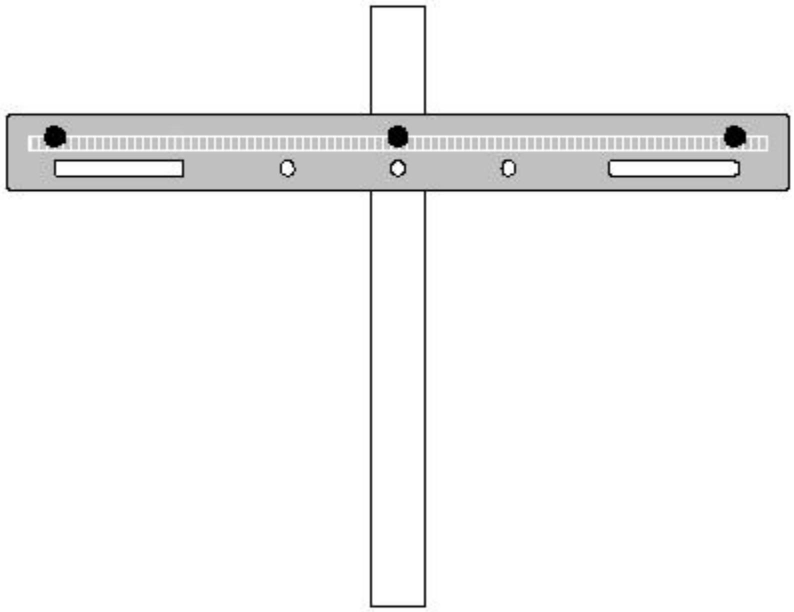
**Materials**: Workshop Stand, Lever, Bolt, Hooked Masses

**Procedure**:




1. Use the bolt to attach the Lever to the top hole of the Workshop Stand. 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?
   ______________________________
   ______________________________
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. 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.



10. Test your prediction. Did the lever balance? ____________________________

11. If the lever did not balance, move the masses until it does and note the changes on your diagram.

# Lever Lab:
## First Class Lever

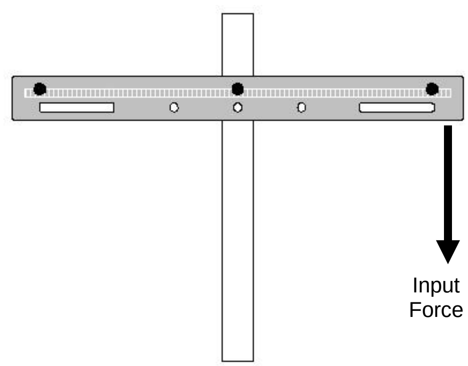
**Objective**: To investigate the use of a lever as a simple machine.

**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.

   ______________________________
   ______________________________
   ______________________________

Name: ______________________________
______________________________

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.

   ______________________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________

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.

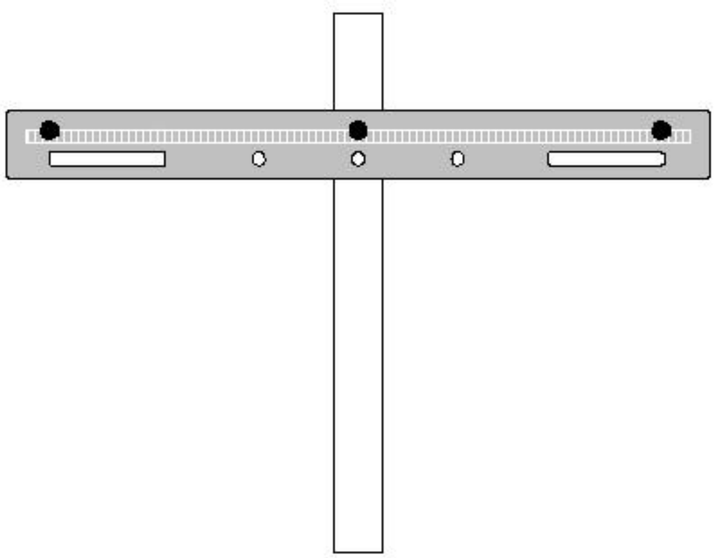
11. How does the Ideal Mechanical Advantage relate to the Input and Output Forces for this system?

    ______________________________________________________________________
    ______________________________________________________________________
    ______________________________________________________________________

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.





Name: ____________________________
____________________________

# Lever Lab:
## Second Class Lever

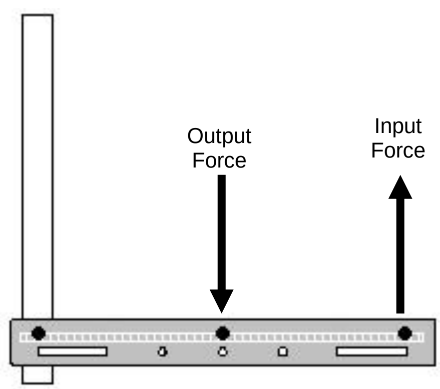
**Objective**: To investigate the use of a lever as a simple machine.

**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. Use the bolt to attach the Lever to the Workshop Stand as shown. Use the far left side pivot (30cm mark) and the lowest hole on the stand.
3. Hook the spring scale into the far right 30cm mark and pull upward enough to lift the lever off the table. This is the location of the input force. Record the reading on the scale (in grams).




_________________________________

4. Since the fulcrum and the input force are both supporting the lever, they should each be lifting half the mass.
5. Hang 200g at the center of the lever (0 cm mark). This is the output force. Read the spring scale and record the new input force value.

________________

6. Subtract the original input force value in # 3 from the value in # 5. This is the effective input force which can lift the 200g mass.



Name: ______________________________
______________________________

**Multiplying Force:**

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

   ________________________________________________________________________
   ________________________________________________________________________
   ________________________________________________________________________

8. How far from the fulcrum is the Input Force? _____________________________
   This distance is the Input Arm.
9. How far from the fulcrum is the Output Force? ____________________________
   This distance is the Output Arm.

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. Predict where to place the 200 g mass to create a mechanical advantage of 3? ______________________

12. The **Input Product** is found by multiplying the <u>Input Arm</u> by the <u>Input Force</u>. Similarly, the **Output Product** is found by multiplying the <u>Output Arm</u> by the <u>Output Force</u>. These two products should be equal. Test this law by moving both the Input force and the Output force and record both new distances and forces. Remember to subtract the new initial reading of the Input force before adding the mass of the output force.

    Input Force (effective) ________ Input Arm _________
    Output Force ________ Output Arm _________

13. Calculate the <u>Input Product</u> and the <u>Output Product</u>.
    Input Product= _________ Output Product= _________

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

Name: ______________________________
______________________________

# Lever Lab:
## Third Class Lever

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

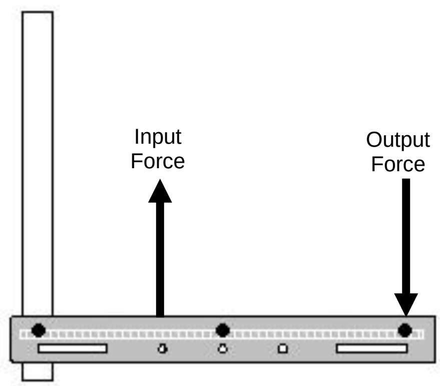
**Materials**: Workshop Stand, Lever, Bolt, Spring Scale (1000g).

**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. Use the bolt to attach the Lever to the Workshop Stand as shown. Use the far left-side pivot (30cm mark) and the lowest hole on the stand.
3. Hook the spring scale into the left side 10cm mark and pull upward enough to lift the lever off the table. This is the location of the input force. Record the reading on the scale (in grams).

   ______________________________




4. Hang 200g at the far right 30cm mark, this is the output force. Read the spring scale and record the new input force value. ______________________________
5. Subtract the original input force value in # 3 from the value in # 4. This is the effective input force which can lift the 200g mass.
6. Draw an arrow representing the effective Input Force on the diagram at right.



Name: ______________________________
______________________________

## Multiplying Force:

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

   ______________________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________

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

    ______________________________________________________________________
    ______________________________________________________________________
    ______________________________________________________________________

11. 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.

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

    ______________________________________________________________________
    ______________________________________________________________________
    ______________________________________________________________________

13. Pull on the spring scale again, as in #4. Which is larger 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)?

    ______________________________________________________________________
    ______________________________________________________________________
    ______________________________________________________________________

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

    ______________________________________________________________________

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**Physics Workshop** Name: ______________________________
**Lever Lab 4** ______________________________

**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. Uses changes in the location of the force in order to make the force seem smaller or larger.
___________ 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.

Name: ____________________________

____________________________

# Lever Lab:
## Torque and Equilibrium

**Objective**: To investigate equilibrium using a lever.

**Materials**: Workshop Stand, Lever, Bolt, Hooked Masses.

**Background:** A system is in equilibrium when the net force is zero. In the case of the lever, equilibrium is synonymous with balance.

In a rotational system such as the lever, it is important to consider both the force and the lever arm (the distance from the fulcrum to the force). The product of the force and the lever arm is called torque. Torque in rotational systems behaves like force does in linear systems. Equilibrium in rotational systems occurs when the net torque is zero.

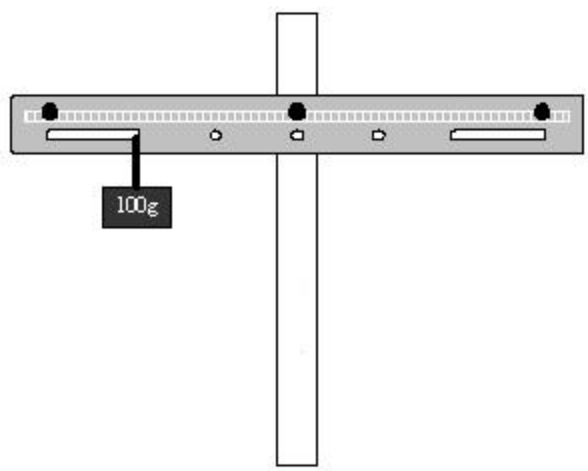
$$\mathrm{T} = Fd$$

**Procedure**:

1. Use the bolt to attach the Lever to the top hole of the Workshop Stand. 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 200g mass at a point that causes the lever to balance. Where did you place the 200g mass?

   ____________________________

   ____________________________




5. Calculate the torque on the left side of the fulcrum. **Remember to convert your masses to (kg) and any distances to (m).**

6. Calculate the torque on the right side of the fulcrum. **Remember to convert your masses to (kg) and any distances to (m).**



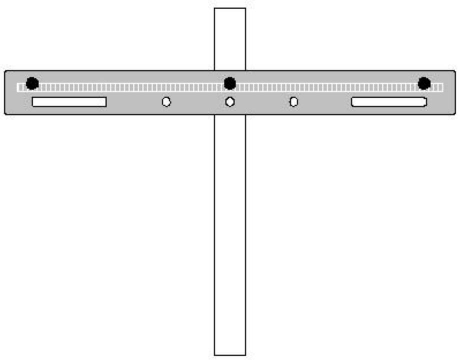
 

Name: ______________________________
______________________________

7. Compare the two torques. What does that mean for the lever overall?

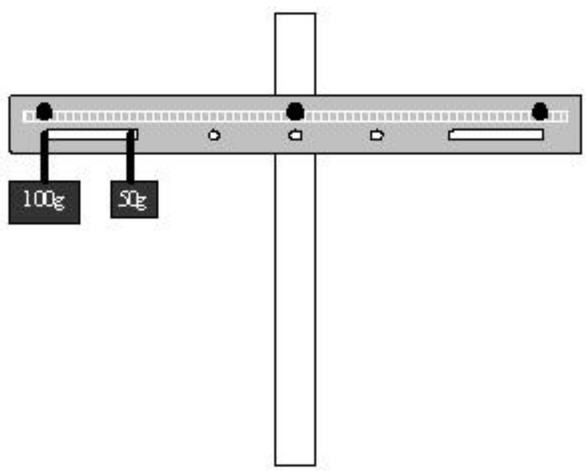
8. Remove the masses. Place a 1000g mass at the 10cm mark. Predict the placement of a 500g mass to establish equilibrium.

9. Test your prediction. Describe the results.



10. On the diagram at left, draw force vectors representing the forces on the lever in #9. Remember to draw the vectors of the correct relative length and to label them in units of force (not mass).

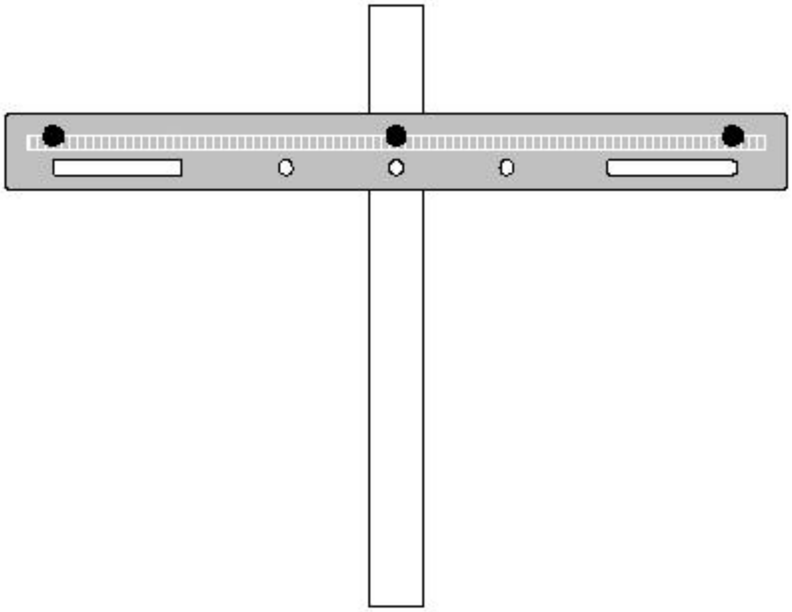
11. Hang a 50g mass and a 100g mass on the left side of the lever as shown. Predict the placement of a 200g mass on to produce equilibrium. Test your prediction and add the 200g mass to the diagram.



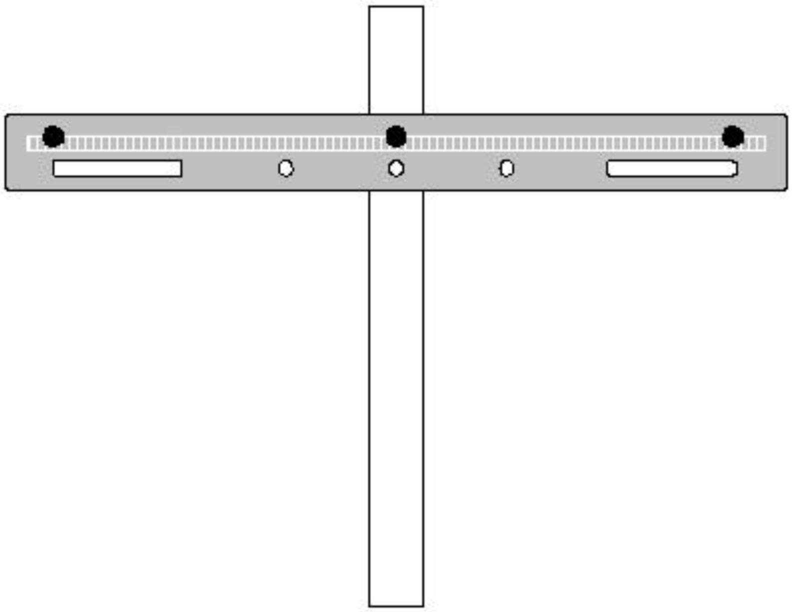


12. Draw force vectors to represent the arrangement in #11.



13. Suggest an arrangement of one 500g mass and two 200g masses that would produce equilibrium. Describe the arrangement in a statement and as a force diagram.





**Physics Workshop**
**Lever Lab 5**

Name: ______________________________
______________________________

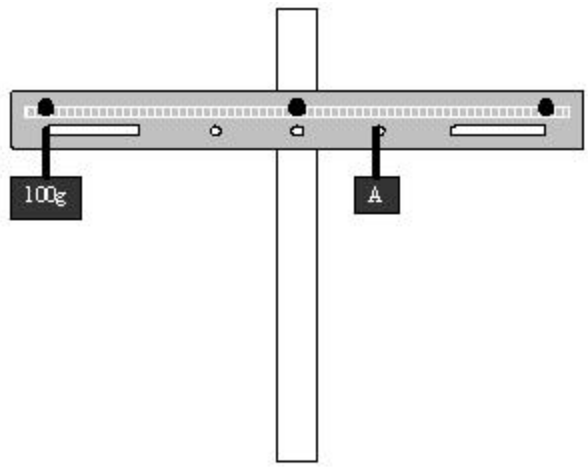
## Part 2: Finding an Unknown Mass

**Objective**: To use the concepts of torque and equilibrium to find an unknown mass.

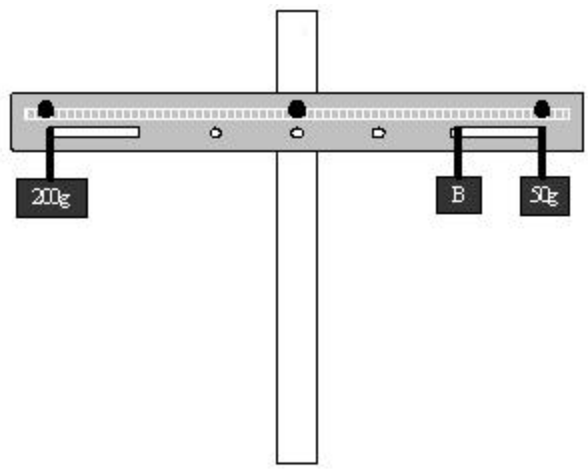
**Materials**: Workshop Stand, Lever, Bolt, Hooked Masses.

**Exercise:** Predict the mass of the unknown object in each of the following situations. Show your calculations and record the mass in the blank.

1. Mass A = __________




2. Mass B = ____________

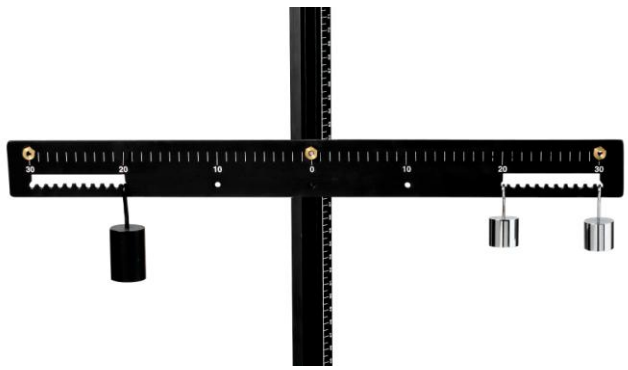


# Lever Lab:
## Curriculum Guide & Answer key

**Introduction**: The Lever can be used to give students hands-on experience in a range of topics in both physical science and physics classes. The five labs listed below develop the concepts and relationships between force, work, and torque. Part 1 of this guide provides an introduction and notes on each of the five labs. Part 2 gives the answer key to each lab.

**Activity Titles**

1. Investigating Balance
2. First Class Lever
3. Second Class Lever
4. Third Class Lever
5. Torque and Equilibrium




| Lever Curriculum | Grade Level | |
|---|---|---|
| **Content** | **8-9** | **10-12, college** |
| Forces: Newton's Laws | 1 | 1 |
| Work: Simple Machines | 2,3,4 | (optional) |
| Rotation: Torque | | 5 |

# Notes on Lever Activities

## 1. Investigating Balance

### Key Concepts:

Different distributions of weight will cause the lever to balance.

There is an inverse relationship between the balancing weight and its distance from the pivot.

### Prerequisites:

Terms: Mass, balance

### Considerations:

Units of measurement: Even though students are ultimately dealing with force in this activity, it will unnecessarily complicate the lab to change each mass unit to one of force. Only the proportions are important.

Precision: The lever should be very nearly horizontal when it is balanced.

## 2. First Class Lever

### Key Concepts:

A first class lever can change the direction of force.

A first class lever can change the size of a force.

The Ideal Mechanical Advantage describes the amount that the force is multiplied.

### Prerequisites:

Terms: First class lever, force, input, output, fulcrum.

### Considerations:

Units of measurement: Even though students are ultimately dealing with force in this activity, it will unnecessarily complicate the lab to change each mass unit to one of force. Only the proportions are important.

Precision: The lever should be very nearly horizontal when it is balanced.

Prepare students beforehand to recognize the directions of the Input and Output forces. With a symmetrical lever such as this, the distinction between Input and Output is essentially arbitrary. Students should understand that the Input force is the one that they apply to the lever (by hanging a mass on it), and the Output force is the one that the lever applies to another weight (by lifting or supporting another hooked mass).

It may be possible to complete activities 2, 3, and 4 in one class period.

## 3. Second Class Lever

### Key Concepts:

A second class lever does not change the direction of a force.

A second class lever changes the size of force.

The Ideal Mechanical Advantage describes the amount that the force is multiplied and is greater than 1.

### Prerequisites:

Lab #2 - First Class Lever

Terms: Second class lever, force, input, output, fulcrum.

### Considerations:

Units of measurement: Even though students are ultimately dealing with force in this activity, it will unnecessarily complicate the lab to change each mass unit to one of force. Only the proportions are important.

Prepare students beforehand to recognize the directions of the Input and Output forces. With a symmetrical lever such as this, the distinction between Input and Output is essentially arbitrary. Students should understand that the Input force is the one that they apply to the lever (by hanging a mass on it), and the Output force is the one that the lever applies to another weight (by lifting or supporting another hooked mass).

It may be possible to complete lab activities 2, 3, and 4 in one class period.

## 4. Third Class Lever

### Key Concepts:

A third class lever does not change the direction of a force.

A third class lever changes the size of force.

The Ideal Mechanical Advantage describes the amount that the force is multiplied and is less than 1.

### Prerequisites:

Lab #2 – First Class Lever

Lab #3 - Second Class Lever

Terms: Third class lever, force, input, output, fulcrum.

### Considerations:

Units of measurement: Even though students are ultimately dealing with force in this activity, it will unnecessarily complicate the lab to change each mass unit to one of force. Only the proportions are important.

Prepare students beforehand to recognize the directions of the Input and Output forces. With a symmetrical lever such as this, the distinction between Input and Output is essentially arbitrary. Students should understand that the Input force is the one that they apply to the lever (by hanging a mass on it), and the Output force is the one that the lever applies to another weight (in this case, its own weight).

It may be possible to complete activities 2, 3, and 4 in one class period.

## 5. Torque and Equilibrium

### Key Concepts:

Equilibrium occurs when the lever is subjected to balanced torques.

Torque is proportional to the size of the applied force and its distance from the fulcrum.

### Prerequisites:

Terms: Torque, force, lever arm, equilibrium.

### Considerations:

Units of measurement: Even though students are ultimately dealing with force in this activity, it may unnecessarily complicate the lab to change each mass unit to one of force. Only the proportions are important. Of course, you may also ask your students to use standard units everywhere if you wish.

Precision: The lever should be very nearly horizontal when it is balanced.

# Lever Lab:
## Investigating Balance

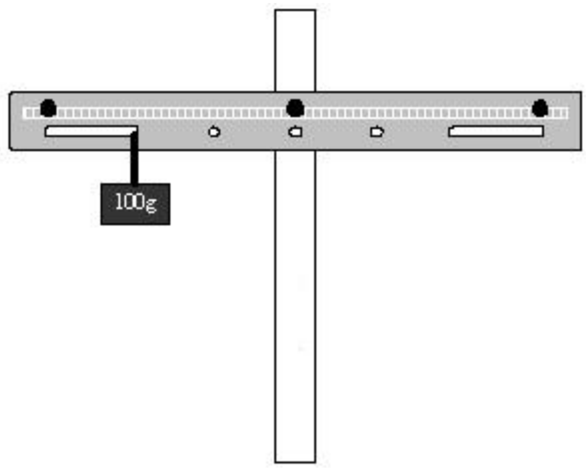
Note: Numerical answers given here are sample answers. Student results may vary, but ultimate conclusions should be the same. Coach students on how to interpret results as being "close enough" to be equal.

**Objective**: To investi

**Materials**: Workshop

**Procedure**:

1. Use the bolt to attach the Lever to the top hole of the Workshop Stand. 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?

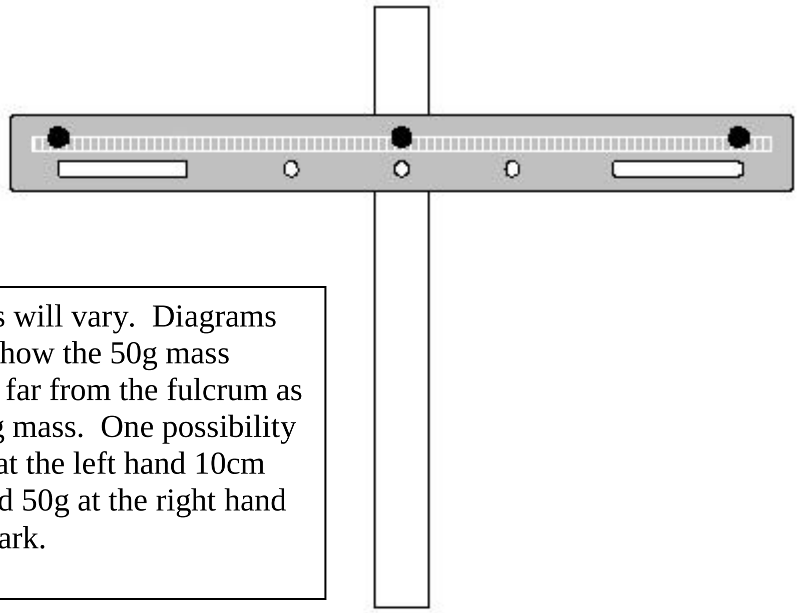



20 cm mark on the right hand side

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? 10 cm mark on the right hand side
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.

40 cm mark on the right hand side

9. 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.



Answers will vary. Diagrams should show the 50g mass twice as far from the fulcrum as the 100g mass. One possibility is 100g at the left hand 10cm mark and 50g at the right hand 20cm mark.

10. Test your prediction. Did the lever balance? ______ Yes/No ______

11. If the lever did not balance, move the masses until it does and note the changes on your diagram.

# Lever Lab:
## First Class Lever

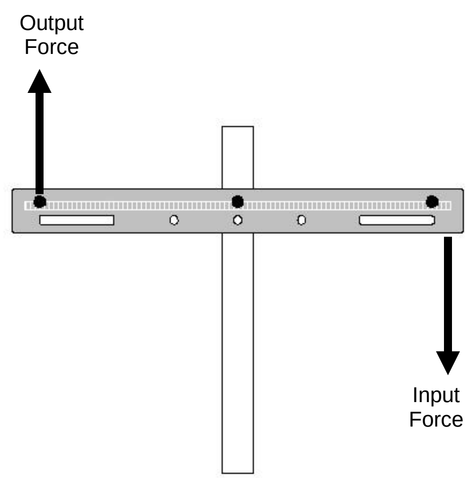
**Objective**: To investigate the use of a lever as a simple machine.

**Materials**: Workshop Stand, Lever, Bolt, Hooked Masses

**Background:** A lever . (The others are wheel & axle, incli ver is a rigid bar that is free to move ar ulcrum. The lever is useful for char ce or the distance of which the

Note: Numerical answers given here are sample answers. Student results may vary, but ultimate conclusions should be the same. Coach students on how to interpret results as being "close enough" to be equal.

Levers can be used in 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

   The left side goes up.
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.

   The output force is twice the input force.

7. How far from the fulcrum is the Input Force? This distance is the Input Arm. 20cm
8. How far from the fulcrum is the Output Force? This distance is the Output Arm. 10cm
9. Write a sentence describing the relationship between the Input and Output Arms for this arrangement.

   The input arm is twice the output arm.

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.

$$IMA = \frac{InputArm}{OutputArm} = \frac{20cm}{10cm} = 2$$

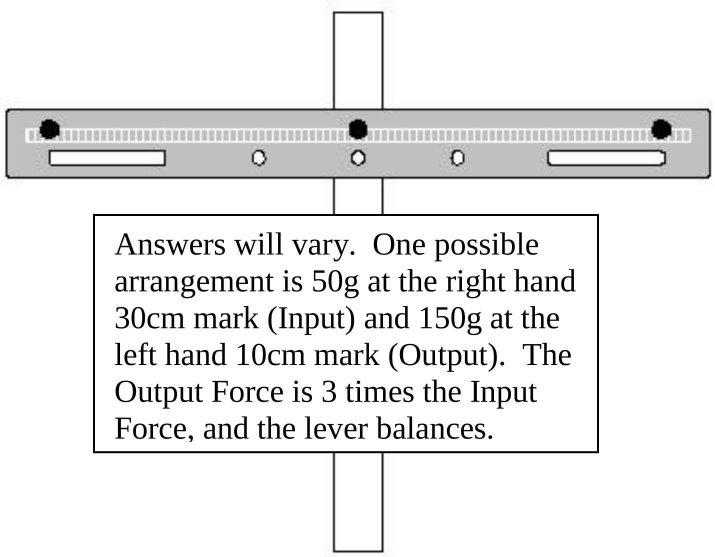
11. How does the Ideal Mechanical Advantage relate to the Input and Output Forces for this system?

    The Ideal Mechanical Advantage is the relationship between the input and output forces.

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

    Seesaw, tongs, scissors. (Answers will vary.)

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.



Answers will vary. One possible arrangement is 50g at the right hand 30cm mark (Input) and 150g at the left hand 10cm mark (Output). The Output Force is 3 times the Input Force, and the lever balances.

# Lever Lab:
## Second Class Lever

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

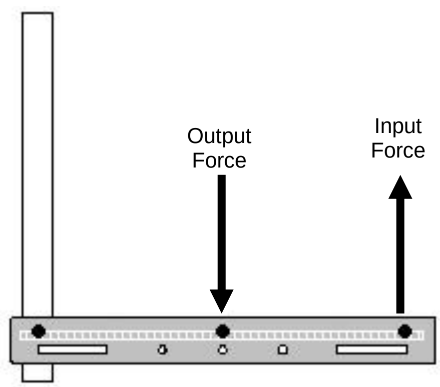
**Materials**: Workshop Stand, Lever, Bolt, Spring Scale (1000g).

Note: Numerical answers given here are sample answers. Student results may vary, but ultimate conclusions should be the same. Coach students on how to interpret results as being "close enough" to be equal.

**Background:** A seco … between the Fulcrum and the Input … ill be represented by the ma … urpose of this lever is to lift the weig…

**Procedure**:

1. Detach the Lever from the Workshop Stand. Hang it from the spring scale and record its mass in grams. 400g
2. Use the bolt to attach the Lever to the Workshop Stand as shown. Use the far left side pivot (30cm mark) and the lowest hole on the stand.




3. Hook the spring scale into the far right 30cm mark and pull upward enough to lift the lever off the table. This is the location of the input force. Record the reading on the scale (in grams). 200g
4. Since the fulcrum and the input force are both supporting the lever, they should each be lifting half the mass.
5. Hang 200g at the center of the lever (0 cm mark). This is the output force. Read the spring scale and record the new input force value. 300g
6. Subtract the original input force value in # 3 from the value in # 5. This is the effective input force which can lift the 200g mass.

   100g

**Multiplying Force:**

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

   The output force is twice the input force.

8. How far from the fulcrum is the Input Force? This distance is the Input Arm. 60cm

9. How far from the fulcrum is the Output Force? This distance is the Output Arm. 30cm

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.

$$IMA = \frac{InputArm}{OutputArm} = \frac{60cm}{30cm} = 2.0$$

11. Predict where to place the 200 g mass to create a mechanical advantage of 3? 20cm

12. The **Input Product** is found by multiplying the Input Arm by the Input Force. Similarly, the **Output Product** is found by multiplying the Output Arm by the Output Force. These two products should be equal. Test this law by moving both the Input force and the Output force and record both new distances and forces. Remember to subtract the new initial reading of the Input force before adding the mass of the output force.

    Input Force (effective) 100g    Input Arm 60cm
    Output Force 200g    Output Arm 30cm

13. Calculate the Input Product and the Output Product.
    Input Product= 6.00cm.g    Output Product= 6.00cm.g

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

    Wheelbarrow. Answers will vary.

# Lever Lab:
## Third Class Lever

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

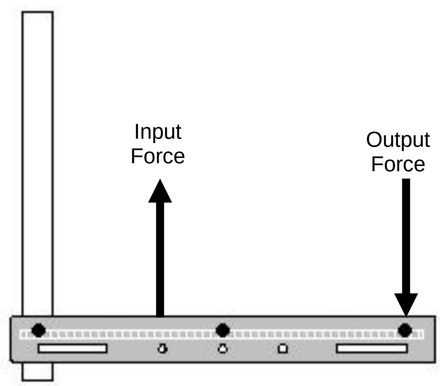
**Materials**: Workshop Stand, Lever, Bolt, Spring Scale (1000g).

Note: Numerical answers given here are sample answers. Student results may vary, but ultimate conclusions should be the same. Coach students on how to interpret results as being "close enough" to be equal.

**Background:** A thir … etween the Fulcrum and the Out … e will be represented by the r … purpose of this lever is to lift the wei …

**Procedure**:

1. Detach the Lever from the Workshop Stand. Hang it from the spring scale and record its mass in grams. 400g
2. Use the bolt to attach the Lever to the Workshop Stand as shown. Use the far left-side pivot (30cm mark) and the lowest hole on the stand.
3. Hook the spring scale into the left side 10cm mark and pull upward enough to lift the lever off the table. This is the location of the input force. Record the reading on the scale (in grams). 700g




4. Hang 200g at the far right 30cm mark, this is the output force. Read the spring scale and record the new input force value. 1500g
5. Subtract the original input force value in # 3 from the value in # 4. This is the effective input force which can lift the 200g mass. 800g
6. Draw an arrow representing the effective Input Force on the diagram at right.

**Multiplying Force:**

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

The Input Force is 4 times larger than the Output Force.

8. How far from the fulcrum is the Input Force? 20cm
This distance is the Input Arm.
9. How far from the fulcrum is the Output Force? 60cm
This distance is the Output Arm.
10. Write a sentence describing the relationship between the Input and Output Arms for this arrangement.

The Input Arm is 1/3 the Output Arm.

11. 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.

$$IMA = \frac{InputArm}{OutputArm} = \frac{20cm}{60cm} = \frac{1}{3}$$

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

The IMA is much less than the ratio of Input Force to Output Force.

13. Pull on the spring scale again, as in #4. Which is larger 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)?

The Input Distance is smaller than the Output Distance.

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

Baseball bat, hockey stick, golf club. (Answers will vary.)

Answer Key

**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

| | |
|---|---|
| a, b | 1. A small Input Force is used to move a larger Output Force. |
| c | 2. A large Input Force is used to move the Output Force a large distance. |
| a, b, c | 3. Uses changes in the location of the force in order to make the force seem smaller or larger. |
| a | 4. Changes the direction of a force. |
| a, b | 5. Can have a Mechanical Advantage greater than 1. |
| c | 6. Can have a Mechanical Advantage less than 1. |
| c | 7. A baseball bat is an example. |
| a | 8. A triple-beam balance is an example. |
| a | 9. Scissors are an example. |
| b | 10. A wheelbarrow is an example. |

# Lever Lab:
## Torque and Equilibrium

**Objective**: To investigate equilibrium using a lever.

**Materials**: Workshop Stand, Lever, Bolt, Hooked Masses.

**Background:** A sys zero. In the case of the lever, equilibri
In a rotational syster der both the force and the lever arm (th The product of the force and the lever a ystems behaves like force does in line ems occurs when the net torque is zero.

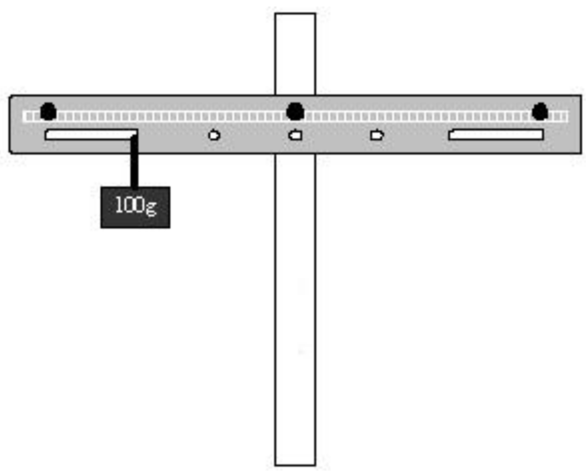
Note: Numerical answers given here are sample answers. Student results may vary, but ultimate conclusions should be the same. Coach students on how to interpret results as being "close enough" to be equal.

$$\mathrm{T} = Fd$$

**Procedure**:

1. Use the bolt to attach the Lever to the top hole of the Workshop Stand. 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 200g mass at a point that causes the lever to balance. Where did you place the 200g mass?

   10cm on the right side mark




5. Calculate the torque on the left side of the fulcrum. **Remember to convert your masses to (kg) and any distances to (m).**

$$\mathrm{T} = Fd = 0.1kg \times 9.8m/s \times 0.2m = 0.196Nm$$

6. Calculate the torque on the right side of the fulcrum.

$$\mathrm{T} = Fd = 0.2kg \times 9.8m/s \times 0.1m = 0.196Nm$$

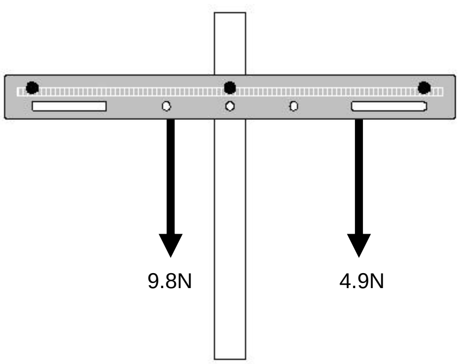
7. Compare the two torques. What does that mean for the lever overall?

The torque is equal. The net torque is zero. The lever is balanced (not rotating).

8. Remove the masses. Place a 1000g mass at the 10cm mark. Predict the placement of a 500g mass to establish equilibrium.

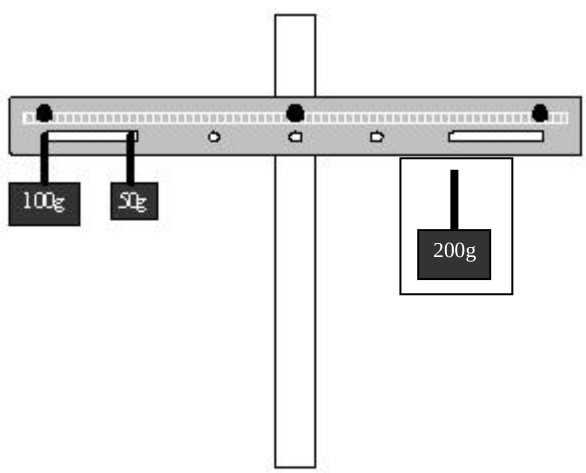
.02m = 20cm. (Answers may vary.)

9. Test your prediction. Describe the results.




10. On the diagram at left, draw force vectors representing the forces on the lever in #9. Remember to draw the vectors of the correct relative length and to label them in units of force (not mass).

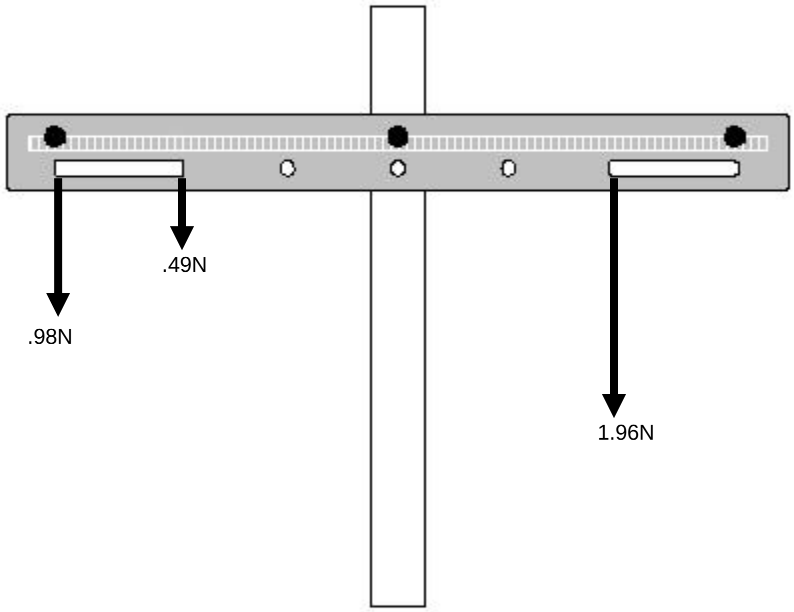
11. Hang a 50g mass and a 100g mass on the left side of the lever as shown. Predict the placement of a 200g mass on to produce equilibrium. Test your prediction and add the 200g mass to the diagram.



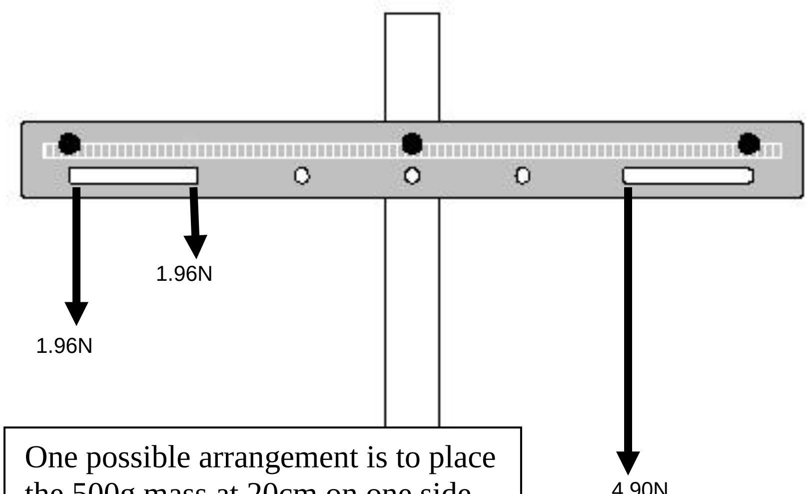


12. Draw force vectors to represent the arrangement in #11.




13. Suggest an arrangement of one 500g mass and two 200g masses that would produce equilibrium. Describe the arrangement in a statement and as a force diagram.




One possible arrangement is to place the 500g mass at 20cm on one side, and the 200g masses at 20cm and 30cm on the other side. Many other arrangements may be possible.

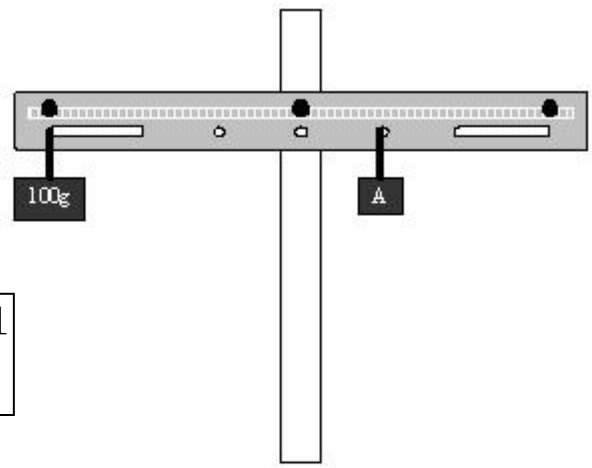
**Part 2**: **Finding an Unknown Mass**

**Objective**: To use the concepts of torque and equilibrium to find an unknown mass.

**Materials**: Workshop Stand, Lever, Bolt, Hooked Masses.

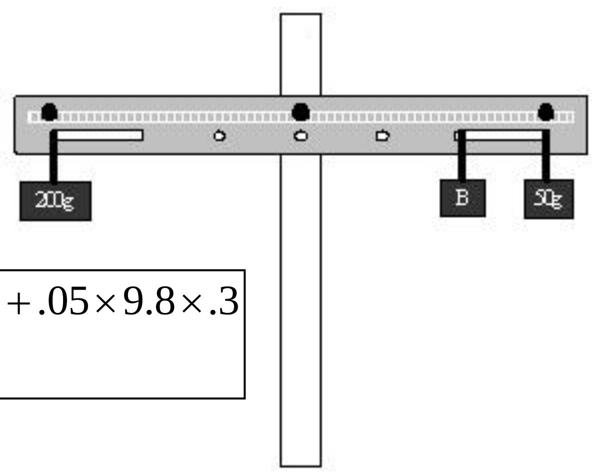
**Exercise:** Predict the mass of the unknown object in each of the following situations. Show your calculations and record the mass in the blank.

1. Mass A = 300g




$$0.1 \times 9.8 \times 0.3 = Mass_A \times 9.8 \times .1$$
$$A = .3Kg = 300g$$

2. Mass B = 225g




$$0.2 \times 9.8 \times 0.3 = Mass_b \times 9.8 \times .2 + .05 \times 9.8 \times .3$$
$$B = .225Kg = 225g$$