

**MiSP Simple Machines/Levers Worksheet #2 L3**  
**Clever Lever 3 (AIMS Machine Shop)**

Name \_\_\_\_\_

Date \_\_\_\_\_

L 1, 2, 3

**Key Question:** How does a lever work differently when your push or pull (effort) is closer to the fulcrum than the object you are trying to move (resistance)?

**Introduction:** This experiment uses a third class lever where effort is applied between the fulcrum and the resistance. When a third class lever is used, more effort force is needed than would be used to move the resistance without the lever. So why use a third class lever? A third class lever is used because the resistance moves a greater distance than the effort - an increased distance and an increased speed! Third class levers include fly swatters, baseball bats, lacrosse sticks, brooms, and golf clubs.

The mechanical advantage is less than or equal to 1. Remember, a mechanical advantage of 0.5 means that you will need twice the effort force to move a resistance.) A mechanical advantage of 1 means that the effort force will be the same as the force needed to move the resistance without the simple machine. A mechanical advantage of greater than one means that the effort force will be less than the force needed to move the resistance without the simple machine.

There are several ways to calculate mechanical advantage in levers. In this experiment, we will do it by dividing effort arm length by the resistance arm length:

$$\text{Mechanical advantage} = \frac{\text{Effort arm length (cm)}}{\text{Resistance arm length (cm)}}$$

Another way to calculate mechanical advantage is:

$$\text{Mechanical advantage} = \frac{\text{Distance effort moves (cm)}}{\text{Distance resistance moves (cm)}}$$

Both of these equations are for "ideal" mechanical advantage which means they are calculated value based on lever distance measurements rather than the actual forces (effort and resistance) used on the lever.

**Procedures:** You are going to do Part One of this experiment. Follow the set-up instructions and experimental procedures on pp. 69-70. Your teacher will give more instructions on the set-up. Data will be entered for the experiment on the chart on p. 70 of **AIMS Machine Shop**. Besides carefully making measurements and entering your data, be aware of the changes in the effort force that is applied at the various effort arm lengths used in the experiment.

Graph instructions and questions are on this worksheet.

**Data:**

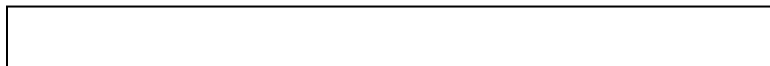
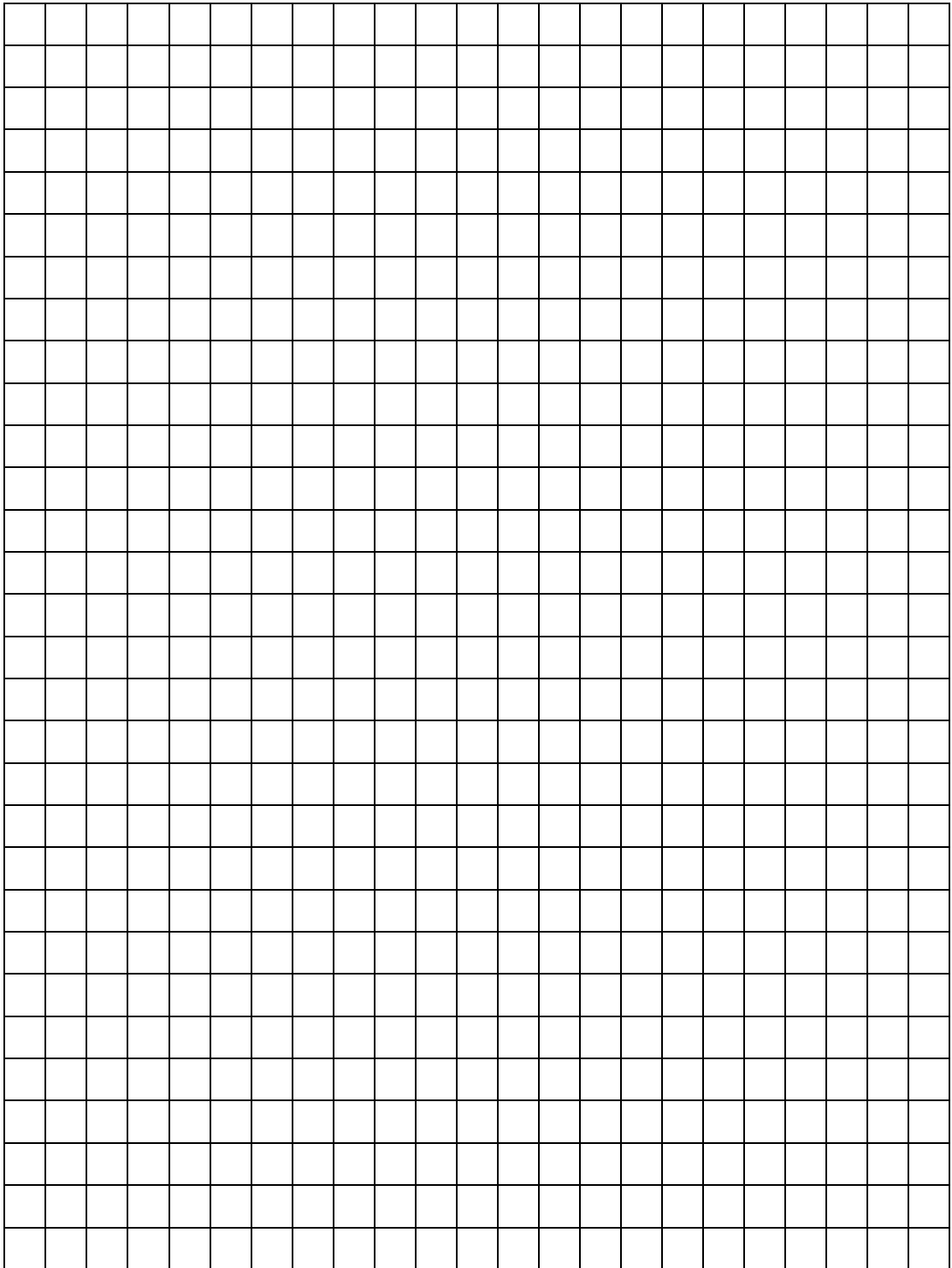
Enter the measurements of how far the effort moved to move the resistance 4.0 cm in the column 'Distance Effort Moves' on the chart on p. 70.

Complete the other columns

Graph the data on the next page to show the relationship between the mechanical advantage (no unit) and distance effort moves (cm).

- Label the x axis
- Label the y axis
- Draw a best fit line between the points.

Simple Machines – Levers Worksheet #2 L3



Discussion L1-3

Clever Lever 3 Connecting Learning (AIMS Machine Shop pp. 73-74 -- #2 and 6 - not required)

1. How does a third-class lever differ from the first and second-class levers?

---

---

---

3. As the distance of the effort arm gets greater, what happens to the distance the effort must move to make the resistance move 4 cm?

---

---

4. As the distance of the effort arm gets greater, what happens to the ideal mechanical advantage?

---

---

5. What similarities and differences are there between the ideal mechanical advantage and the ratio of the distance the forces moved [column 6: effort distance/resistance distance]?

---

---

Additional questions:

7. Use the graph to predict the distance the effort moves if the effort arm length is 10 cm: (Remember that mechanical advantage =  $\frac{\text{Effort arm length (cm)}}{\text{Resistance arm length (cm)}}$ )

10 cm (mechanical advantage = \_\_\_\_\_) \_\_\_\_\_ cm

8. Use the words increases or decreases to complete the sentence below:  
 If a third class lever has a resistance arm length of 80 cm and moves a resistance 4 cm, increasing the effort arm length \_\_\_\_\_ the mechanical advantage and \_\_\_\_\_ the distance the effort moves.

### Discussion L2-3

9. Look at the graph you drew. Notice that as the mechanical advantage increases, the distance the effort moves seems to increase by a constant amount. Use the information from the graph to calculate the unit rate of change (slope) for the Clever Lever 3 graph. If your data points all lie on a line, determine the unit rate of change (slope) of the line. If your data points do not produce a line, determine the slope of the best-fit line that you drew. *(If you use the best fit line, the ordered pairs to determine slope must be from the best fit line, not from your data chart.)*

$$\text{Unit Rate of Change} = \frac{\Delta \text{Distance effort moves (cm)}}{\Delta \text{Mechanical advantage}} = \frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

Ordered Pair used for calculation ( $x_1, y_1$ ) ( $x_2, y_2$ )	$\Delta$ Distance effort moves (cm) $\Delta y$	$\Delta$ Mechanical Advantage $\Delta x$	Unit Rate of Change (slope) $\Delta y / \Delta x$

10A. According to the calculated unit rate of change, to move the effort the least, do you move the effort closer to the fulcrum (mechanical advantage decreases) or further away from the fulcrum (mechanical advantage increases)?

\_\_\_\_\_.

10B. Based on the unit rate of change, if a student changed the effort arm distance so the mechanical advantage INCREASED BY 0.1 units, what would be the change in the distance the effort moves? \_\_\_\_\_ cm.

### Discussion L3

11. Use the equation for a line to calculate the y-intercept. Use the line or best fit line you used in #9. The equation for a line is

$$y = mx + b$$

where  $m$  is the unit rate of change (slope) and

$b$  is the y-intercept

Y Intercept
$m =$ Ordered pair $(x, y) = ( \_\_\_ , \_\_\_ )$ $y = mx + b$ Solve for $b$ :

12. Based on the unit rate of change (slope) that you calculated above and the y intercept, write an equation for line or best fit line on the Clever Lever 3 graph. Remember that the equation for a line is  $y = mx + b$  and  $m$  is the unit rate of change (slope) and  $b$  is the y intercept.

Equation - Clever Lever 3 graph

13a. An effort is applied to the Clever Lever 3 set-up at an arm length of 0.1 cm. Reminder: the resistance arm length is 80 cm. Calculate the mechanical advantage be (mechanical advantage = effort arm length/resistance arm length)?

---

13b. Using the above equation for a line in #12 for the Clever Lever 3 line, what would be the distance (in cm) that the effort would move if the effort arm length = 0.1 cm?

---

13c. Based on your answer to 13b, a little movement in the effort force produces a much greater movement in the resistance. What is the trade-off to get that effect? (Consider the mechanical advantage calculated in 13a and your experience in the experiment where you and your partners moved the resistance 4 cm and applied the effort/push at different effort arm lengths.)

---

---