MiSP Simple Machines/Levers Worksheet #2 L3

Name ______________________________ Date _____________

CLEVER LEVER 3 (AIMS MACHINE SHOP)

Key Question:

Does a lever work differently when your push or pull (effort) is closer to the fulcrum than it is to the object you are trying to move (resistance)? How?

Introduction:

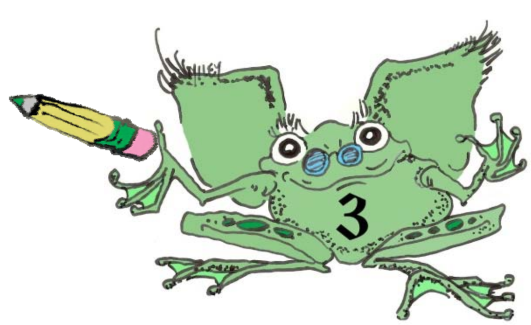
This experiment uses a third-class lever where effort is applied between the fulcrum and the resistance. When a third-class lever is used, more effort force is needed than would be used to move the resistance without the lever. So why use a third-class lever? A third-class lever is used because the resistance 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 1 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; that is, they are a calculated value that is 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 setup instructions and experimental procedures found on pages 69–70. Your teacher will give more instructions on the setup. Data will be entered for the experiment on the chart found on page 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.

Record your data:

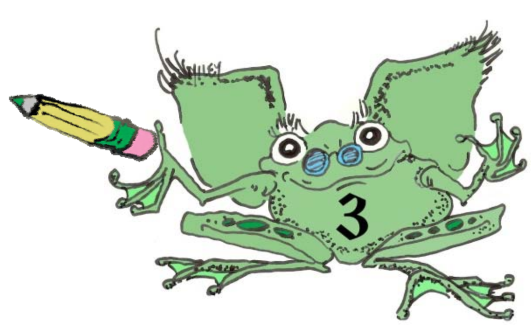
Enter the measurements of how far the effort moved to move the resistance 4.0 cm in the column "Distance Effort Moves" on the chart on page 70.

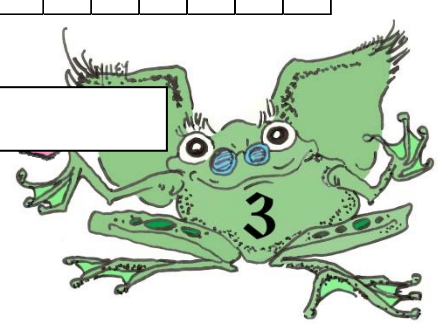
Complete the other columns.

Graph your data:

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.

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Discussion Questions:

Clever Lever 3 Connecting Learning (AIMS *Machine Shop*, pp. 73–74); questions #2 and #6 are not required)

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

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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?

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

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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)?

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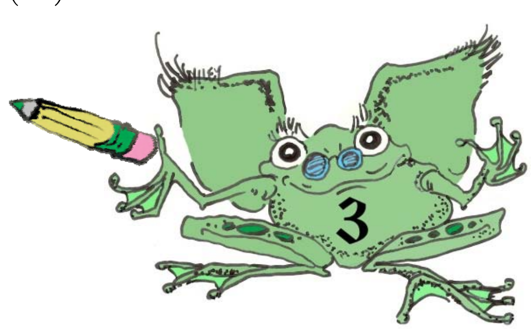
Additional questions:

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.

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.)*

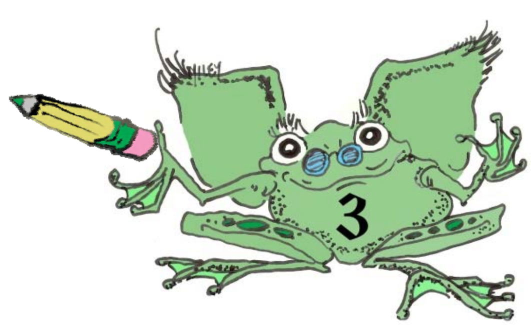
$$\textbf{Unit Rate of Change} = \frac{\Delta \text{ Distance effort moves (cm)}}{\Delta \text{ Mechanical advantage}} = \frac{\Delta y}{\Delta x} = \frac{(y_2 - y_1)}{(x_2 - x_1)}$$

Ordered Pair used for calculation (x_1, y_1) (x_2, y_2)	Δ Distance effort moves (cm) Δy	Δ Mechanical Advantage Δx	**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 farther 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



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 the line or the best-fit line on the Clever Lever 3 graph. Remember that the equation for a line is $\boldsymbol{y = mx + b}$ 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 setup at an arm length of 0.1 cm. Reminder: The resistance arm length is 80 cm. Calculate the mechanical advantage (mechanical advantage = effort arm length / resistance arm length).

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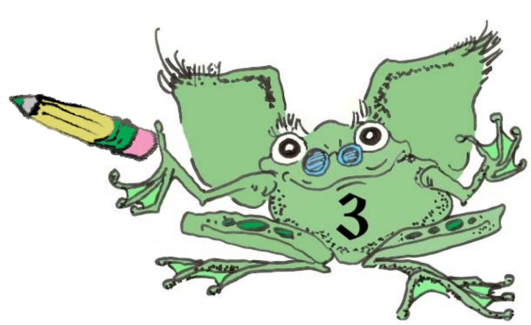

13b. Using the above equation for a line in #12 for the Clever Lever 3 line, what would be the distance (in cm) that the effort would move if the effort arm length = 0.1 cm?

13c. Your answer to 13b showed that 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.)