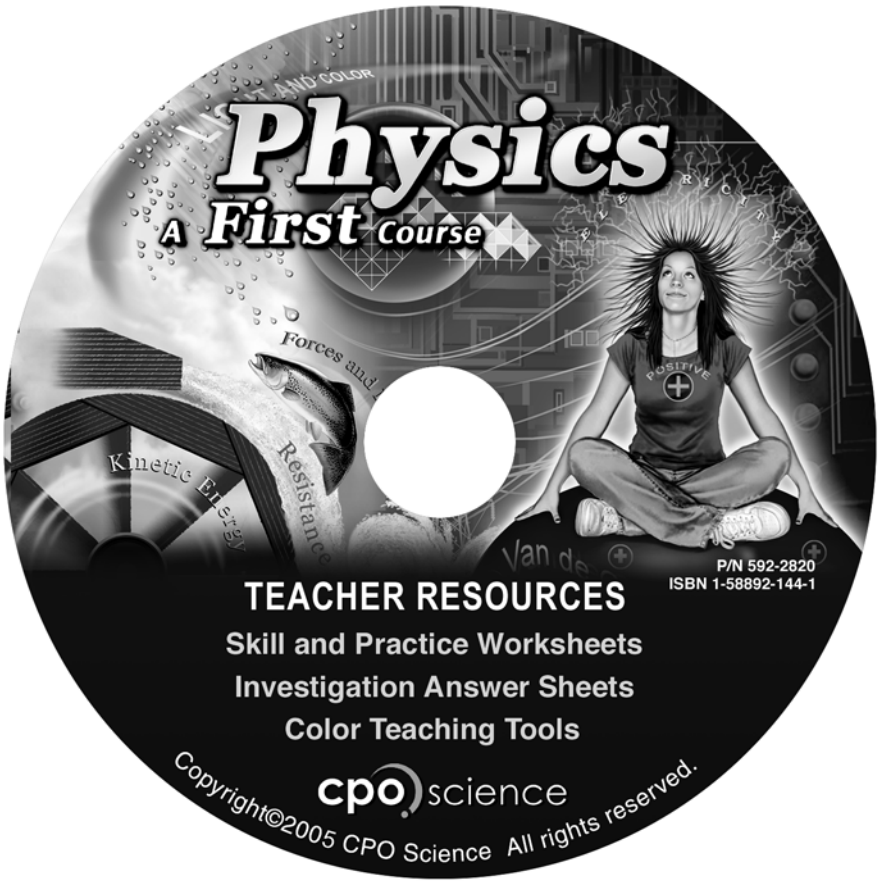
Skill and Practice Worksheets



Physics A First Course
Skill and Practice Worksheets

Credits

CPO Science Curriculum Development Team

Author: *Thomas Hsu, Ph.D.*
Vice Presidents: *Thomas Narro* and *Lynda Pennell*
Writers: *Scott Eddleman, Mary Beth Hughes, Stacy Kissel, Lainie Ives, Erik Benton, Mary Ann Erikson,* and *Patsy DeCoster*
Graphic Artists: *Polly Crisman, Bruce Holloway*, and *Jim Travers*

Curriculum Contributors

David Bliss, Manos Chaniotakis, and *James Sammons*

Technical Consultants

Tracy Morrow and *Julie Dalton*

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CPO Science
26 Howley Street,
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(800) 932-5227
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PRACTICE 112m = 4 sec 4.2

Mechanical Advantage of Simple Machines

READ CPO Science

We use simple machines to make tasks easier. While the output work of a simple machine can never be greater than the input work, a simple machine can multiply input forces OR multiply input distances (but never both at the same time). You can use this skill sheet to practice calculating mechanical advantage (MA) for two common simple machines: levers and ramps.

The general formula for the mechanical advantage (MA) of levers:

$$MA_{lever} = \frac{F_o \text{ (output force)}}{F_i \text{ (input force)}}$$

Or you can use the ratio of the input arm length to the output arm length:

$$MA_{lever} = \frac{L_i \text{ (length of input arm)}}{L_o \text{ (length of output arm)}}$$

Most of the time, levers are used to multiply force to lift heavy objects.

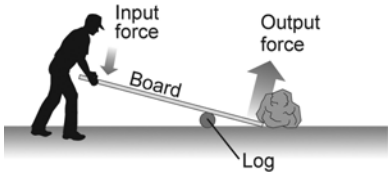
The general formula for the mechanical advantage (MA) of ramps:

$$MA_{ramp} = \frac{\text{ramp length}}{\text{ramp height}}$$

A ramp makes it possible to move a heavy load to a new height using less force (but over a longer distance). The mechanical advantage of a ramp can be found using this formula:

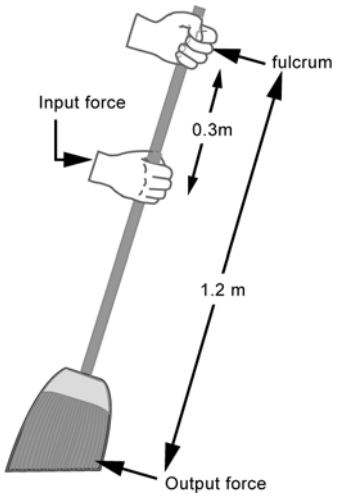
EXAMPLES

Example 1: A construction worker uses a board and log as a lever to lift a heavy rock. If the input arm is 3 meters long and the output arm is 0.75 meters long, what is the mechanical advantage of the lever?



$$MA = \frac{3 \text{ meters}}{0.75 \text{ meter}} = 4$$

Example 2: Sometimes levers are used to multiply distance. For a broom, your upper hand is the fulcrum and your lower hand provides the input force: Notice the input arm is shorter than the output arm. The mechanical advantage of this broom is:



$$MA = \frac{0.3 \text{ meter}}{1.2 \text{ meters}} = 0.25$$

A mechanical advantage less than one doesn't mean a machine isn't useful. It just means that instead of multiplying force, the machine multiplies distance. A broom doesn't push the dust with as much force as you use to push the broom, but a small movement of your arm pushes the dust a large distance.

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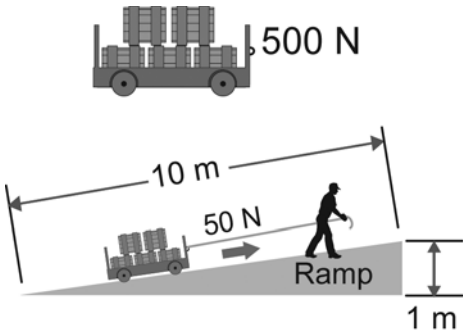
Example 3: A 500-newton cart is lifted to a height of 1 meter using a 10-meter long ramp. You can see that the worker only has to use 50 newtons of force to pull the cart. You can figure the mechanical advantage in either of these two ways:



$$MA_{ramp} = \frac{\text{ramp length}}{\text{ramp height}} = \frac{10 \text{ meters}}{1 \text{ meter}} = 10$$

Or using the standard formula for mechanical advantage:

$$MA = \frac{\text{output force}}{\text{input force}} = \frac{500 \text{ newtons}}{50 \text{ newtons}} = 10$$

Mechanical advantage $= \frac{\text{ramp length}}{\text{height}} = \frac{10}{1}$

PRACTICE

Lever problems

1. A lever used to lift a heavy box has an input arm of 4 meters and an output arm of 0.8 meters. What is the mechanical advantage of the lever?
2. What is the mechanical advantage of a lever that has an input arm of 3 meters and an output arm of 2 meters?
3. A lever with an input arm of 2 meters has a mechanical advantage of 4. What is the output arm's length?
4. A lever with an output arm of 0.8 meter has a mechanical advantage of 6. What is the length of the input arm?
5. A rake is held so that its input arm is 0.4 meters and its output arm is 1.0 meters. What is the mechanical advantage of the rake?
6. A broom with an input arm length of 0.4 meters has a mechanical advantage of 0.5. What is the length of the output arm?
7. A child's toy rake is held so that its output arm is 0.75 meters. If the mechanical advantage is 0.33, what is the input arm length?

Ramp problems

8. A 5-meter ramp lifts objects to a height of 0.75 meters. What is the mechanical advantage of the ramp?

9. A 10-meter long ramp has a mechanical advantage of 5. What is the height of the ramp?

10. A ramp with a mechanical advantage of 8 lifts objects to a height of 1.5 meters. How long is the ramp?

11. A child makes a ramp to push his toy dump truck up to his sandbox. If he uses 5 newtons of force to push the 12-newton truck up the ramp, what is the mechanical advantage of his ramp?

12. A ramp with a mechanical advantage of 6 is used to move a 36-newton load. What input force is needed to push the load up the ramp?

13. Gina wheels her wheelchair up a ramp using a force of 80 newtons. If the ramp has a mechanical advantage of 7, what is the output force (in newtons)?

14. **Challenge!** A mover uses a ramp to pull a 1000-newton cart up to the floor of his truck (0.8 meters high). If it takes a force of 200 newtons to pull the cart, what is the length of the ramp?