building big things
mechanical advantage

Mechanical Advantage

In the Predict-Observe-Explain investigations, you learned that to move something, you have to apply an unbalanced force. If the object is really heavy, like a big bucket of blocks or a heavy iron beam, you have to apply a large force to move it. You have to apply a large force because there are large resisting forces acting on it, such as friction or gravity.

Machines can help you move heavy objects by acting as force transformers. Machines act as force transformers by changing the amount or direction of the applied force. However, there is always a trade-off when you use a machine. A trade-off means that in order to get something you want, you have to give up something. For example, imagine that you and your friends collect and trade baseball or football cards. One of your friends has the card of a star player that you want very much. To trade for that card though, you have to give him one of your favorite cards. In the trade, you got the card you wanted, hut you also had to give up a card.

When you use a machine, the same thing happens. If you want to apply less force to move something, you have to apply the force through a greater distance. You gain the ability to use less force, but you have to trade applying the force through a greater distance to get it. This trade-off for machines is called the mechanical advantage of the machine.

Machines can transform a small applied force into a large force. The trade-off is that the smaller force needs to be applied over a longer distance to do the same task. For example, instead of pushing really hard and applying a big force to lift a heavy box off the floor, you can use a machine to help you lift that box with a much smaller force. The trade-off is that you have to apply the smaller force through a longer distance. The machine transforms the small force you apply through a larger distance into a larger force through a smaller distance to lift the box. This larger force results in unbalanced forces acting on the heavy box, and the box's motion changes. The box moves from its resting position.

Machines can also transform a large applied force into a small force. You may wonder why anyone would want to apply a large force instead of a small force. The advantage is in the trade-off of distance. For example, think about raking leaves in the fall. When you use a rake, you move the top of the handle with quick, sharp strokes. The amount of force you apply is greater than the amount of force needed to move the leaves, but the distance your hand moves is much less than the distance the leaves move. In this case, because the leaves are so light, it is easier for you to apply more force through a short distance than less force through a greater distance to gather up the leaves.

As you can see, the force-distance trade-off is the mechanical advantage of machines. There is an advantage to using the machine instead of doing the task yourself. The advantage is either you have to apply less force through a longer distance, or you have to apply a greater force through a shorter distance.

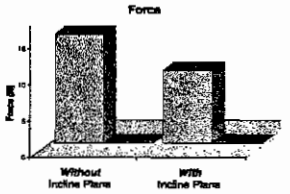
Our goal is to find out what the advantage is to using a ramp or inclined plane

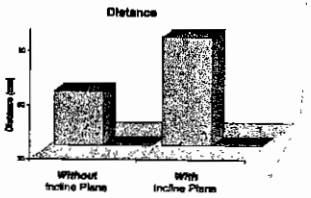
performance standard S7c, S6d

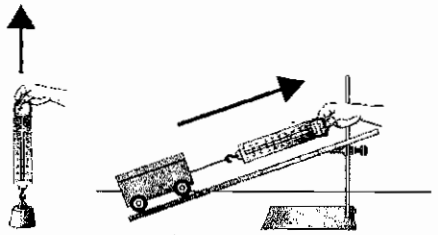
[redacted] bob

reading assignment

The mechanical advantage of a machine can be seen most clearly in graphs that show the relationship between force and distance. The graphs shown above are similar to the graphs that you created in class when you investigated the simple machines. These two graphs show the results of an investigation where Jessica tried to move a block from the floor to the top of a table that was 60 cm high. She first lifted it straight up; then she used an inclined plane to help her. In the first graph, Jessica compares the amount of force she applied to move the block. Without an inclined plane, she applied 15 N of force to move the block. When she used an inclined plane, she only needed to apply 10 N of force. This is the advantage of using the inclined plane: Jessica needed less force to move the block. What was the trade-off? When Jessica moved the block without the inclined plane, she needed to apply the force through a distance of 60 cm. However, when she used the inclined plane to move the block, she needed to apply the force through 90 cm. The trade-off for using the inclined plane was that Jessica needed to apply the force through a longer distance.







How would Jessica write a conclusion for this investigation? Her conclusion would need to describe what the data show. In general, Jessica found that she needed to apply less force to move the block when she used an inclined plane than when she lifted it straight up. She also needed to apply the force through a longer distance when she used an inclined plane. Jessica might write a conclusion like the following:

"When I used an inclined plane to move the block, I applied less force but I applied the force through a greater distance than when I lifted the block straight up."

What evidence does Jessica have that this conclusion is correct? She can use the data from her investigation as evidence to support her conclusion. What is the evidence to support the claim that when she used the inclined plane, she *applied less force*? In her investigation, Jessica found that when using the inclined plane she needed to apply 10 N and when lifting straight up she needed to apply 15 N of force. A force of 10 N is less than 15 N, so this evidence supports her claim.

Now look at the second part of her conclusion. Jessica claims that when she used the inclined plane, she needed to *apply the force through a greater distance* than when she lifted the block directly? What is the evidence to support this claim? In her data, Jessica recorded that when she used an inclined plane, her hand moved 90 cm. When lifting straight up, her hand moved only 60 cm. A distance of 90 cm is greater than 60 cm, so this evidence supports her claim that the distance was greater using the inclined plane.

from pp 60-63 (text) phys text

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inclined plane

what does mechanical advantage mean?	right there question

Give an example of something you might trade in everyday life. In this trade what do you get? What do you give up?

in my head question

How are force and distance <u>Related</u> in the use of an inclined plane	think and search question

bob

name _____ class ____

team ____ seat ____ date ____

parent signature _____

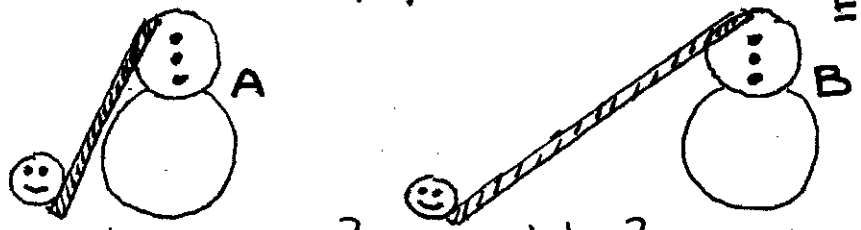
It snowed really heavy one weekend. You and your friends want to build a snow person

As you build, you realize that the head is too <u>heavy</u> to lift up.

How do you finish the snow person?

in my head questions

How could these boards help you?



Which is easier? A or B Why?