Physics Workshop Teacher's Notes

Car & Ramp: Force & Inclined Plane

Main Topic	Energy
Subtopic	Energy and Work
Learning Level	Middle
Technology Level	Low
Activity Type	Student

Description: Compare two ways of elevating an object: direct lift vs. inclined plane. Find the force exerted and work done for each.

Required Equipment	Workshop Stand, Ramp, Car, Bolt, Spring Scales, Meter stick.
Optional Equipment	

Educational Objectives

- To investigate the advantages of using an inclined plane to do work.

Key Question

- What is the advantage of using an inclined plane to do work?

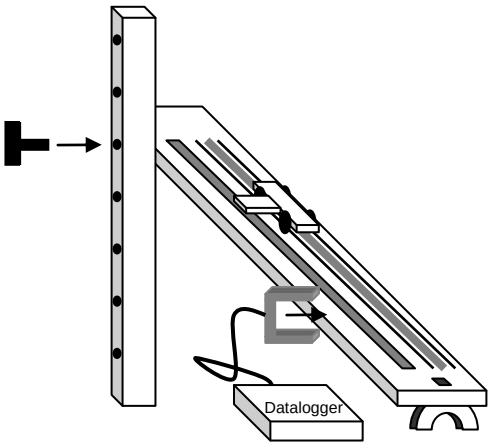
Concept Overview

Students will elevate the car in two ways: lifting directly and pulling up the ramp. They will find that it takes less force to pull the car up the ramp, but they do more work. The extra energy goes into friction in the system.

Lab Tips

Assembly:

1. Push the attachment bolt through the Workshop Stand at the desired height of the top of the ramp.



2. Screw the bolt into the side of the ramp, tightening the ramp against the side of the stand.
3. Push the "foot" up through the hole in the bottom of the ramp.
4. Place the car on the ramp so that the wheels rest in the grooves and the rubber bumper extends down through the hole between the grooves. The bumper is designed to stop the car at the bottom of the ramp without allowing it to fall off.
5. Orient the car so that the side flag extends over the wide hole, toward the printed scale. This flag will block a photogate beam so that students can find its speed at different points on the ramp.
6. The car is designed to accommodate the 500g and 200g masses from the Hooked Mass Set. Secure the masses by stretching the rubber band through the two top hooks and over the mass.
7. Arrange photogates so that the beam goes through the wide hole and will capture the motion of the car's flag as it moves. Support photogates with ring stands or by clamping them directly on the ramp.

8. The angle of the ramp can be adjusted simply by attaching it to different heights on the stand. Angles greater than 45° are not recommended due to possible damage to the car or ramp at the end of the trip.

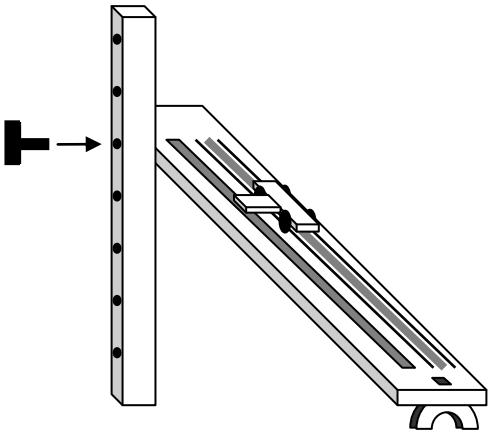
Car & Ramp: Force and the Inclined Plane

Objective: To investigate the advantages of using an inclined plane to do work.

Materials: Workshop Stand, Ramp, Car, Bolt, Spring Scales, Meter stick.

Procedure:

1. Use the spring scale to find the weight (in N) of the car. _____
2. Use the spring scale to slowly lift the car about 50cm. What force (in N) is needed to lift the car? _____
3. Push the attachment bolt through the Workshop Stand, using the 5th hole from the bottom.



4. Screw the bolt into the side of the ramp, tightening the ramp against the side of the stand.
5. Push the "foot" up through the hole in the bottom of the ramp.
6. Place the car on the ramp so that the wheels rest in the grooves and the rubber bumper extends down through the hole between the grooves.
7. Orient the car so that the side flag extends over the wide hole, toward the printed scale.
8. Use the spring scale to support the car on the ramp at this angle. Hold the spring scale parallel to the surface of the ramp. What force is needed to hold the car up? _____
9. Compare this force to the weight of the car. _____
10. For the car to hold still, there must be an upward force on it equal to its weight. In addition to the spring scale, what else is exerting a force on the car? _____
11. Use the spring scale to slowly pull the car from the bottom of the ramp to the top. What force is needed to pull the car? _____
12. Compare the force needed to pull the car up the ramp to the force needed to lift the car directly. _____

13. A simple machine like this inclined plane can reduce the force needed to do work, but it cannot reduce the amount of energy it takes. To find the work done on the car, multiply the force exerted on it by the distance it moves. Calculate the work done on the car pulling it up the length of the ramp.

$$W = F \bullet d$$

14. Find the vertical distance the car moves when you pull it up the ramp. (Find its height above the table at the top, and subtract its height above the table at the bottom.) _____
15. Calculate the work needed to directly lift the car that distance.

16. Compare the answers to #13 and #15.

_____
_____

17. Hopefully, you noticed that it takes slightly more work to pull the car up the ramp than to lift it directly. If it takes more work, why is it sometimes still a good idea to use a ramp? What advantage does it offer?

_____
_____

18. Work done becomes energy gained. The car ends up at the same height in both cases, so why do you need more work to pull it up the ramp? What happens to the rest of the energy?

_____
_____