

611-0040 (40-215) Halls Car

(For use with Inclined Plane, Pulley and Weights)

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept Master Card, Visa, checks and School P.O.'s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse, or normal wear and tear.

How to Teach with Halls Car and Inclined Plane:

Concepts Taught: Work; energy; conservation of mechanical energy. Simple machines. Inclined Plane. Mechanical Advantage.

Curriculum fit: Physics Sequence/ Energy. *Energy Conservation - simple machines. Gr 6-8*

Concepts Taught: Inertia; frictional force; gravitational force; Newton's First and Second Laws. Acceleration due to gravity. Vectors; force as a vector. Coefficient of friction - static and kinetic.

Curriculum Fit: Physics Sequence; Force and Motion. *Causes of Motion & Equilibrium. Grades 6-8 and up.*

Additional Materials Needed:

- **Inclined Plane** - Raised board or book or hinged apparatus such as **611-0035 Inclined Plane** from *Science First®*
- **Set of weights** - Slotted weight or other set of known weights
- **Weight Pan** - Slotted weight holder or weight pan attached to string (can use **611-0050 Weight Pan** from *Science First®*)
- Pulley attachment (**611-1035 Pulley with Rod** from *Science First®* fits most Inclined Planes)
- String, for attaching Halls Car over pulley to weights
- Balance to weigh car and load

Description:

This lightweight, nearly frictionless Hall's Car is ideal for studying the relationship between work and energy. It demonstrates the vector forces in acceleration or static force studies and can be used to determine the Coefficient of Friction of a rolling surface.

It features oil-free sleeve bearings that never need adjustment. Injection molded plastic body is wide with low profile for bulk loads. Coefficient of Friction is a consistently low 0.015 (with no load.)

Safety Note

Do not exceed combined weight of 1 kg (2.2 lb) in well of car. Car may break or drop.

Setting Up:

1. Attach string through small hole in the front of the Hall's Car. Knot end securely.
2. Position free end of string over a pulley wheel.
3. Tie free end of string to pan.
4. Place weights in weight pan.

Setup below uses **611-0035 Inclined Plane Kit** from **Science First** with 611--0040 Halls Car, 611-1035 pulley and 611-0050 weight pan.



Check out our website at www.sciencefirst.com

Inclined Plane, such as 35° and 65°.

8. Determine at what angle the car tends to remain stationary for a given load. At this point the weight in the weight pan equals the weight of the load in the Halls Car times the tangent of the angle (θ) of incline. The tangent of the angle of incline equals the **Coefficient of Friction**. The Coefficient of Friction is the relation of the force of friction to the force perpendicular to the surface. In this instance, the body being studied rolls by means of wheels instead of sliding, and the rolling friction between the wheels and plane, as well as the sliding friction on the axle of the wheel, are factors to consider.

9. Remove the string from the car. Keep the same weight (if any) in the well of the car.

10. Decrease the angle of the Inclined Plane until the car just barely rolls down the plane at uniform speed after being given a small push. Make sure the car does not hit any object at the base of the plane or roll off your surface.

11. Measure the height (h) between the two ends of the plane and the length (b) of the base. This is another way of calculating the Coefficient of Rolling Friction in addition to using $\tan \theta$, as described above.

12. Turn the car upside down and set it upon the Inclined Plane to study sliding friction.

13. Close the Inclined Plane so that it is totally flat and begin to raise it slowly. Determine the force needed to just start the upside-down car from a position of rest.

This is the force of **static friction**.

14. Still using the car in upside-down with the Inclined Plane closed flat, adjust the angle so that the car is just on the verge of slipping.

At this point the tangent of the angle ($\tan \theta$) is the **Coefficient of Static Friction**.

To Operate:

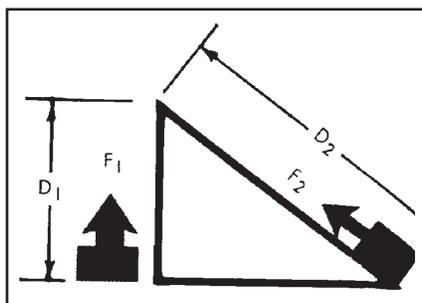
1. Load Hall's Car with weights
2. Weigh loaded Car on balance.
3. Elevate Inclined Plane at an angle of about 15° with the horizontal. Make sure the string pulling the car is parallel to the plane.

4. Give the car a slight push to get it started. Determine the force ($F\mu$) required to pull the car up the incline at a slow uniform speed by adjusting the weights needed.

5. Remove enough weight so the car rolls down the plane at a slow uniform speed after being started. This is $F\alpha$, the force holding back the car from rolling down the incline. This is the force of **rolling friction**.

6. Measure the length (L) of the Inclined Plane and height (h) between the two ends.

7. Repeat for other angles of the



In any experiment involving an Inclined Plane, you must always take two measurements:

- The force required to move the car up the incline ($F\mu$)
- The minimum force required to prevent the car from rolling down the incline ($F\alpha$)

By averaging these two forces, the effects of friction in the pulley or the car itself can be largely eliminated.

friction.

Rolling Friction opposes the rolling of a round object over a solid surface. Rolling friction is less than sliding friction when the weight is the same.

Definitions:

Sliding Friction is a force that opposes, or resists, the motion when one surface slides over another. Starting friction is always greater than sliding

You may be interested in our manual for the 611-0035 Inclined Plane.

Now you can download this and other manuals directly from our website!

www.sciencefirst.com

Accessories:

Science First manufactures many low-cost science labs which are available from most science dealers. For further information, please call us at **1-800-875-3214**.

611-1035 Pulley with Rod - (fits most inclined planes. 0.04 Coefficient of Friction)

611-1215 Ring and Disc - Roll both down an inclined plane. same mass, different distribution of mass. Very low cost.

611-0050 Weight Pan - Plastic well, wire hanger

611-1220 Variable Inertia - brand new! Change distribution of mass by different arrangement of balls inside plastic discs. Roll down inclined plane. Low cost.

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