Inclined Planes
4th or 5th Grade
Ivy

Benchmarks:
(4th)   SLC 10: Students will identify and explain how simple machines help mechanical devices operate (e.g., bicycles, pencil sharpener, fishing rod, etc.) by describing the work a machine can do (e.g., change the size of the force, change the direction of force, and/or change the distance a force moves something).
(5th)   SLC 6: Students will identify the differences between work and force as they relate to each of the 6 simple machines.

Objectives:
        To teach students that an inclined plane consists of a straight, sloped surface with no moving parts and that inclined planes are used to reduce the force needed to move an object to a certain height.

Materials:
- 3 stacks of books about 15-20 centimeters high
- 2 boards of varying lengths
- 3 of the same toy cars
- 4 pulleys (optional)
- String
- Small paper cups with string attached
- Pennies
- Meter sticks

Initial Demonstration:
        Present the following idea to the students: You are going with your mom to take your baby sister to the babysitter. She is pushing a stroller and holding the baby bag and some other items in her hand. When she gets to the front of the building where the babysitter is there is the option of going up five short steps or going around a ramp. Ask the students, "Which way should your mom go to get to the front door with the least amount of hassle: the stairs or the ramp?" You may need to remind the students that if you choose for her to take the steps she has to lift the baby in the stroller, and she still has the other bags in her hand. Have the students explain their predictions.

Fig. 1   Fig. 2
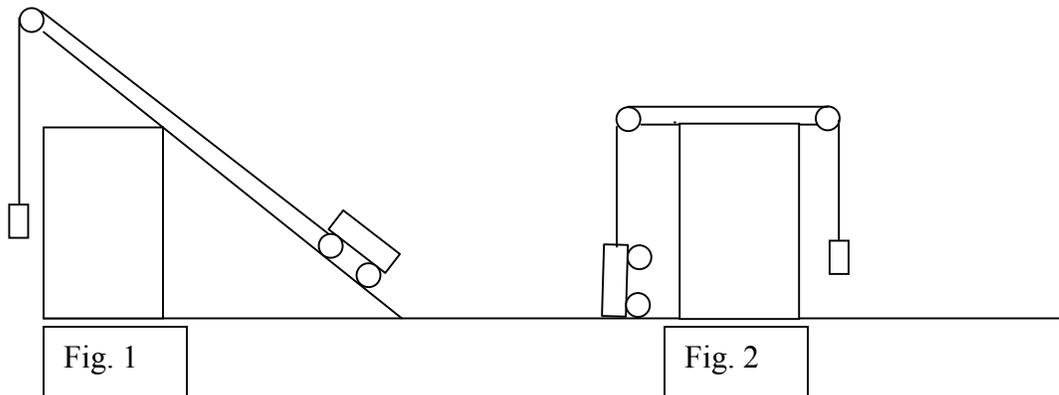
Target Observations:
- She should go up the ramp because then she won't have to lift the stroller.
  or
- She should go up the stairs because the ramp is uphill/it is longer to walk.

Target Model:
-It is easier to go up a ramp than stairs because you don't need to carry (i.e. pick up) anything up a ramp.
Or
-It is easier to go up the stairs than a ramp because it is shorter and you don't have to walk uphill as much.

Procedure:
Break the class up into groups. Give each group 3 books, a board with pulleys attached to both ends, a toy cart, a small paper cup with a long piece of string attached to the end, and some pennies. Ask the students to test their guesses: will it take more pennies to move a cart up stairs or up to the same height using a ramp? Design an experiment to test this. As the students are designing their experiments, guide them to understand that they should probably measure: the height the cart is raised; the number of pennies used; and the distance the cart travels for each experiment. The following is a "Target" data collection table the students should generate for themselves.

Height of Book (cm)	Distance cart travels (cm)	Amount of Pennies to Move Cart (#)

Target Experiment: Students stack the books 3 high, place the board on top, and measure the minimum number of pennies needed to lift the cart to the top (see Fig. 1). Students then take one of the pulleys off of the board, lean the board against the stack of books, and measure the minimum number of pennies needed to lift the cart up to the top (see Fig. 2). Students may have to tape the board in place.
As students perform their experiments, lead them to realize that while the ramp took less force to pull up the car, it did so over a larger distance.

Target Observations:
- It took fewer pennies to lift the cart up the ramp than it did to lift the cart up the stairs.
- The smaller the number of pennies needed to lift the cart, the easier it is for the cart to be lifted.

Target Revised Model:
-It is easier to go up a ramp than stairs because you don't need to carry (i.e. pick up) anything up a ramp.
Or
~~-It is easier to go up the stairs than a ramp because it is shorter and you don't have to walk uphill as much.~~

-Ramps make lifting easier, but require a larger distance.

Discussion:
    Which way should you suggest your mom take the baby: up the stairs or up the ramp?
    Would it be easier to lift the cart if we made the ramp longer (i.e. longer distance) or shorter? Have the students design an experiment to test whether (or how) the length of the incline plane makes it easier to lift the cart. Remind the students to keep in mind that you should only change one variable at a time in a science experiment, otherwise you don't know what could be causing the changes you're seeing.
    <u>Target Experiment</u>: Students keep the books stacked as they were for the last experiment. Students change the length that the cart travels by bringing the end of the ramp closer or further from the stack of books. Students measure the length of the ramp from the ground to the top of the books, the number of pennies needed, and the height of the books.

Target Observations:
- The longer the distance the cart travels, the fewer number of pennies are needed to lift it.

Target Revised Model:
-It is easier to go up a ramp than stairs because you don't need to carry (i.e. pick up) anything up a ramp.
-Ramps make lifting easier, but require a larger distance.
-Longer ramps are easier to go up than shorter ramps.

Discussion:
    What did you find: does a long or a short ramp make it easier to lift things up? What would be the <u>easiest</u> ramp to use (i.e. a *very* long one)? Other than this example, what are some practical applications of this? (hint: how do you think the Egyptians built the pyramids!) How is this similar to other simple machines you know?