



Science Objectives

- Describe an inclined plane as a simple machine
- Calculate the mechanical advantage of different inclined planes
- Use the formula for applied force on an inclined plane

Vocabulary

- acceleration due to gravity
- inclined plane
- mass
- simple machine
- work

About the Lesson

- In this simulation, students explore an inclined plane as an example of a simple machine. Because of its mechanical advantage the force required to push an object up a ramp is easier than lifting it straight up, even though the overall amount of energy required is the same.

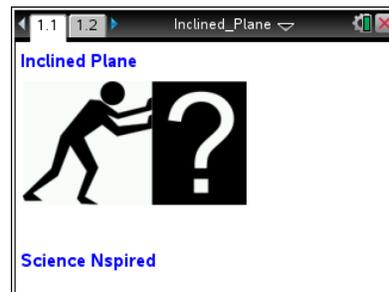


TI-Nspire™ Navigator™

- Send out the *Inclined_Plane.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to allow students to show how they manipulate positions that effect results.

Activity Materials

- Compatible TI Technologies:  TI-Nspire™ CX Handhelds,  TI-Nspire™ Apps for iPad®,  TI-Nspire™ Software



Tech Tips:

- This activity includes screen captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>

Lesson Files:

Student Activity

- Inclined_Plane_Student.doc
- Inclined_Plane_Student.pdf

TI-Nspire document

- Inclined_Plane.tns



Discussion Points and Possible Answers

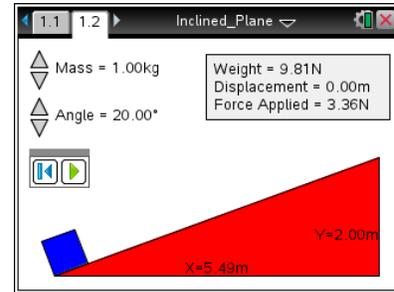
Allow students to read the background information on the activity sheet.
 Have students answer all questions on the student worksheet.

Part 1: Varying the Mass of the Block

Move to page 1.2.

In the first part of the activity, student will change the mass of the blue box while keeping the angle of the ramp the same.

1. When starting the simulation, have students read the directions in the pop-up box. They can select  to close the directions and view the simulation. If needed at any time during the simulation, students can select  if they would like to view the directions again.



Tech Tip: To view the directions again, select  > **Inclined Plane** > **Directions**. Students may need to back-out to the main Tools Menu  to see the desired menu option.



Tech Tip: When students select the Reset button  the block will be reset to the bottom of the incline but the mass of the block and the angle of the plane will stay the same. The vertical distance, or height of the plane, is always 2 meters regardless of the angle.

- Q1. The formula for calculating the amount of work is $Work = Force \cdot Distance$. Calculate the work done in lifting the mass vertically. **Note:** The weight shown in the gray box in the top right corner of the page is the force.

Answer: 19.62 N-m



Tech Tip: Students can either insert a *Calculator* page by selecting   or use the Scratchpad by pressing . They can use their preferred method for all subsequent calculations in this activity.



Tech Tip: To insert a *Calculator* page, students can select  > **Calculator**.



2. Select the Play button  to see the blue block move up the ramp. The displacement is the amount of distance traveled along the inclined plane.

Q2. Calculate the work required to push the block, using the **force applied** and the **displacement**.

Answer: 19.66 N-m

Q3. What do you notice about the work involved in lifting the blue block straight up and the work involved in sliding it along the inclined plane?

Answer: About the same amount of work is required.

Q4. Choose five different values of mass between 1 kg and 20 kg and use the simulation to complete the table. **Note:** Before choosing a new mass, students need to select the Reset button .

Sample Answers:

Mass	Weight	Work to Lift Vertically	Force Applied	Displacement	Work to Slide on Plane
2 kg	19.62 N	39.24 N-m	6.71 N	5.85 m	39.25 N-m
6 kg	58.86 N	117.72 N-m	20.13 N	5.85 m	117.76 N-m
11 kg	107.91 N	215.82 N-m	36.91 N	5.85 m	215.92 N-m
15 kg	147.15 N	294.30 N-m	50.33 n	5.85 m	294.43 N-m
20 kg	196.20 N	392.40 N-m	67.10 N	5.85 m	392.54 N-m

Q5. What do you notice about the work involved in lifting the mass vertically and sliding it along the plane?

Answer: About the same amount of work is required.

Mechanical Advantage

An inclined plane is an example of a simple machine. It simplifies the effort to lift a mass up a vertical distance. The mechanical advantage is the ratio of the weight of the mass to the force needed to slide it along the plane.

Q6. Copy the mass, weight, and force applied for each trial from the table in Q4. In the last column of the table below, calculate the mechanical advantage.



Sample Answers:

Mass	Weight	Force Applied	Mechanical Advantage
2 kg	19.62 N	6.71 N	2.92
6 kg	58.86 N	20.13 N	2.92
11 kg	107.91 N	36.91 N	2.92
15 kg	147.15 N	50.33 n	2.92
20 kg	196.20 N	67.10 N	2.92

Q7. What do you notice about the mechanical advantage as the mass of the block changes?

Answer: It is the same.

Q8. How do you think you could change the plane to increase or decrease the mechanical advantage?

Answer: Increase or decrease the angle of the incline.

Part 2: Varying the Angle of the Plane

In this part of the activity, students are able to manipulate another variable of the simple machine, the angle of the inclined plane. Students will see that vertical distance, or height, remains the same (2 m), but the distance along the plane changes.

3. Students are to select the up and down arrows of the Angle slider to change the degree of the angle of the plane. They should select a mass for the block and keep it the same. **Note:** Before choosing a new angle, students need to select the Reset button .

Q9. Complete the table for different angle values. Calculate the mechanical advantage.

Sample Answers:

Mass	Angle	Weight	Force Applied	Mechanical Advantage
1 kg	20°	9.81 N	3.36 N	2.92
1 kg	25°	9.81 N	4.15 N	2.36
1 kg	35°	9.81 N	5.63 N	1.74
1 kg	45°	9.81 N	6.94 N	1.41

Q10. What happens to the mechanical advantage as the angle increases in size?

Answer: The mechanical advantage decreases.



An Alternative Way to Calculate Mechanical Advantage

Students will use another method of calculating the mechanical advantage by finding the ratio of the vertical height and the displacement.

4. Students are to use the up and down arrows to vary both the angle of the plane and the mass of the block. Encourage students to complete an investigation systematically.

Q11. Complete the table below for each trial. In all trials, the vertical distance, or height, (h) is constant at 2 m. Calculate the mechanical advantage using the two different ratios.

Sample Answers:

Mass	Angle	Weight (W)	Force Applied (FA)	Displacement (D)	Mechanical Advantage (W/FA)	Mechanical Advantage (D/h)
10 kg	20°	98.1 N	33.55 N	5.85 m	2.92	2.93
20 kg	20°	196.2 N	67.10 N	5.85 m	2.92	2.93
10 kg	30°	98.1 N	49.05 N	4.02 m	2	2.01
20 kg	30°	196.2 N	98.10 N	4.02 m	2	2.01
10 kg	40°	98.1 N	63.06 N	3.13 m	1.56	1.57
20 kg	40°	196.2 N	126.11 N	3.13 m	1.56	1.57

Q12. What do you notice about the mechanical advantage using the two different ratios?

Answer: They are about the same.

Part 3: Deriving the Equation for the Force Applied

Students are shown how the equation for the force applied is derived using the trig ratio for sine. Make sure that they understand it uses the previous finding from the table in Q11 that the ratio of weight to force applied is equal to the ratio of displacement to height.

5. Students are to compare the values for the applied force using the formula just derived and the values from the simulation. Choose different mass values and angle measures.

Q13. Record the mass and angle of the plane, and the force applied given in the simulation in the table. In the last column, calculate the force applied using the formula. (Use a value of $g = 9.8 \text{ m/sec}^2$.)



Sample Answers:

Mass	Angle	Force Applied (Measured)	Force Applied (Calculated)
10 kg	25°	41.46 N	41.42 N
10 kg	35°	56.27 N	56.21 N
20 kg	25°	82.92 N	82.83 N
20 kg	35°	112.54 N	112.42 N

Q14. What do you notice about the measured value and calculated value for the force applied?

Answer: The values are about the same. (Have students check their work if they have discrepancies.)



TI-Nspire Navigator Opportunities

Make a student a Live Presenter to illustrate the simulation for different masses and angles of the inclined plane. Throughout the lab, discuss the activity with students using Slide Show. At the end of the lab, collect the .tns files and save to Portfolio.

Wrap Up

When students are finished with the activity, retrieve the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions embedded in the .tns file. The questions will be graded when the .tns file is retrieved. The Slide Show will be utilized to give students immediate feedback on their assessment.
- Summative assessment will consist of questions/problems on the chapter test.