Bell Ringer: Force Parallel to an Inclined Plane – ID: 13375

Time required
15 minutes

Topic: Kinematics

- *Describe the relationship between an inclined plane and the component of gravitational force acting parallel to the plane.*

Activity Overview

In this activity, students will use precompiled data to determine the relationship between the component of an object's weight that is parallel to an inclined plane (Fpar) and the angle of the plane.

Materials

To complete this activity, each student or student group will require the following:

- *TI-Nspire™ technology*
- *pen or pencil*
- *blank paper*

TI-Nspire Applications

Lists & Spreadsheet, Graphs & Geometry, Notes

Teacher Preparation

Before carrying out this activity, review with students the relationship between displacement (position) and velocity.

- *The screenshots on pages 2–4 demonstrate expected student results. Refer to the screenshots on page 5 for a preview of the student TI-Nspire document (.tns file). The solution .tns file contains a data analysis and answers to the questions.*
- ***To download the student .tns file and solution .tns file, go to education.ti.com/exchange and enter "13375" in the search box.***
- *For a more extensive exploration of this content, use activity 11039: Forces on an Inclined Plane. Activity 11039, which is longer than this bell ringer and involves data collection and analysis by the students, was designed for a full class period. You can download the files for activity 11039 at education.ti.com/exchange.*

Classroom Management

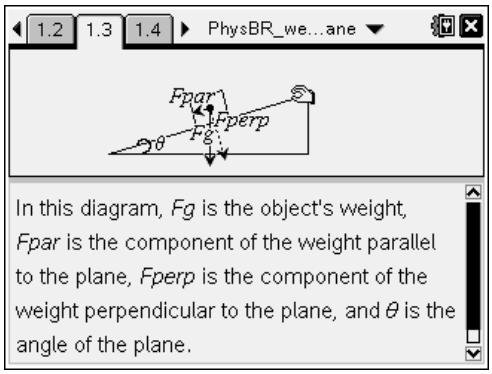
- *This activity is designed to be **teacher-led**, with students following along on their handhelds. You may use the following pages to present the material to the class and encourage discussion. Note that the majority of the ideas and concepts are presented only in **this** document, so you should make sure to cover all the material necessary for students to comprehend the concepts.*
- *If you wish, you may modify this document for use as a student worksheet. You may also wish to use an overhead projector and TI-Nspire computer software to demonstrate the use of the TI-Nspire to students.*
- *The Graphs & Geometry applications on students' devices will need to be set to Degree mode instead of Radian or Gradian mode for the calculations to work properly. To change these settings, press (home) and select Settings & Status > Settings > Graphs & Geometry.. Press (tab) to move between settings, and press (click) to select a setting.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following questions will guide student exploration in this activity:

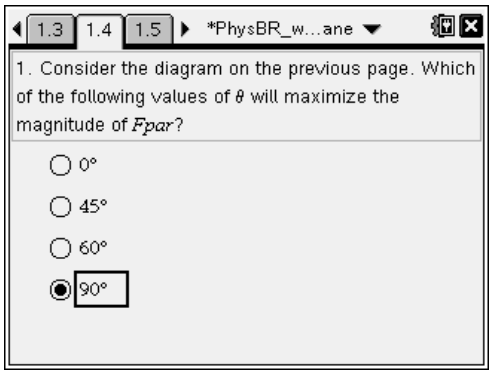
- How does the angle of an inclined plane affect the magnitude of the weight component that acts parallel to the plane?

Students will use a precompiled set of parallel component vs. angle data. They will plot the ratio of the parallel component (*Fpar*) to the weight of the object (*Fg*) versus the angle of the plane. They will then identify the mathematical function that best describes the data.

Step 1: Students should open the file **PhysBR_week06_fpar_incl_plane.tns** and read the first three pages. (Students can press ctrl ▶ and ctrl ◀ to move between pages in the .tns file.) They should study the diagram on page 1.3. They can change the angle of the plane by clicking and dragging the open point. They should experiment with different angles and then answer questions 1 and 2.



Q1. Consider the diagram on the previous page. Which of the following values of θ will maximize the magnitude of *Fpar*?

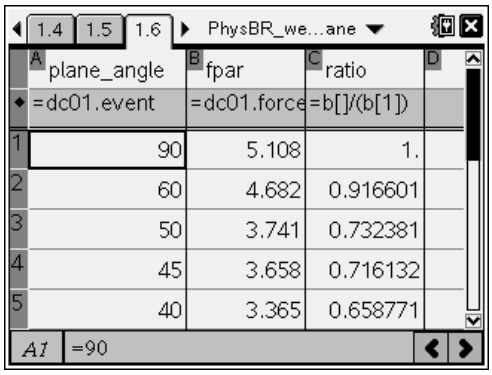


A. *The maximum magnitude of* Fpar *occurs when the inclined plane is vertical—that is, at an angle of 90°.*

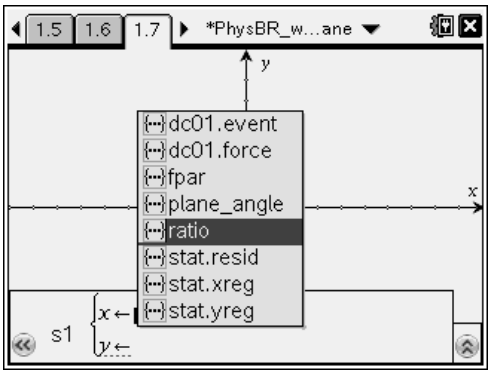
Q2. Which of the following values of θ will minimize the magnitude of *Fpar*?

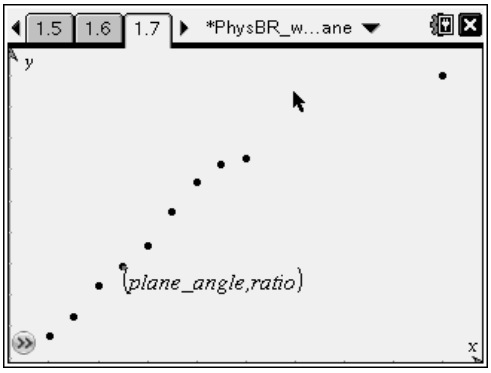
A. *The minimum magnitude of* Fpar *occurs when the inclined plane is horizontal—that is, at an angle of 0°.*

Step 2: Students should move to page 1.6 and study the data there. Explain that the *Lists & Spreadsheet* application on this page contains data collected using a force sensor. The data were collected for an object resting on an inclined plane, as shown on screen 1.3. The data series **plane_angle** is the angle of the inclined plane (θ) in degrees. The series **fpar** is the force that acts parallel to the plane at each angle. The series **ratio** is the ratio of **fpar** to the full weight of the object (which is equal to the value of **fpar** for a ramp angle of 90°).



Step 3: Next, students should move to page 1.7, which contains an empty *Graphs & Geometry* application. Students should use this application to make a graph of the angle-force ratio data set. To make the graph, students first need to change the graph to a scatter plot (**Menu > Graph Type > Scatter Plot**). When they change the plot to a scatter plot, the function bar at the bottom of the screen should change to show *x* and *y* series, as shown to the right. Students should select **plane_angle** as the *x* series and **ratio** as the *y* series. (When students change the plot type, the *x* series box should automatically be highlighted. To select the *x* series, students should click [press ⚲] on the *x* series box. A list of available data sets should pop up. Students should use the NavPad to select the series **plane_angle** and press enter. To choose the *y* series, students should press tab until the *y* series box is highlighted, and then click and use the NavPad again to select the series **ratio** and press enter.) Students may need to change the **Window** settings (**Menu > Window > Zoom-Data**) to see the data set completely. They should study the plot and then answer question 3 on page 1.8.

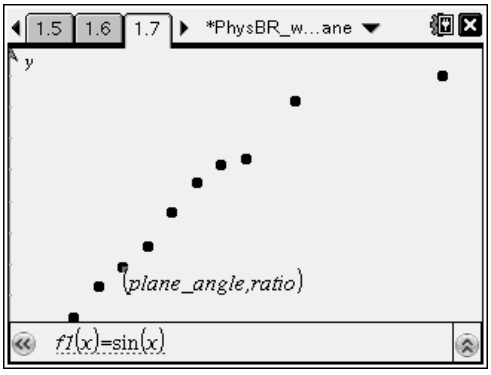




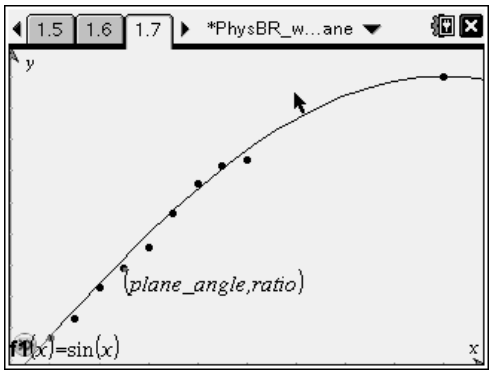
Q3. What type of mathematical function do you think will best fit these data?

A. *Students' answers will vary.*

Step 4: Once students have made a prediction about the mathematical form of the data, they should move back to page 1.7. They should change the graph to a **Function** graph (**Menu > Graph Type > Function**) and plot functions that they think will best fit their data. Encourage class discussion of the data and the most appropriate functional forms. You may need to guide students to try trigonometric functions. (To show or hide the formula bar, students should press ctrl G.) When they have found the best-fit equation, they should answer questions 4 and 5.



Q4. What function produced the best fit to your data?



A. *Students should make sure the angle setting is set to Degrees (⌂ **> Settings & Status > Settings > Graphs & Geometry**) before plotting their data. Students' answers will vary, but a sine function should be the best fit (i.e., **ratio** should be the sine of **plane_angle**).*

Q5. Write a general equation for the relationship between the ratio of *Fpar* to *Fg* and the angle of the inclined plane (θ).

A. *The relevant equation is* $\frac{Fpar}{Fg} = \sin\theta$ *. Once students have reached this conclusion, draw a larger version of the diagram on page 1.3 on the board. Work with students to help them see why the ratio is equal to the sine of the inclined plane.*

Suggestions for Extension Activities: If you wish, you may have students derive the relationship between the normal force (i.e., the component of weight that acts perpendicular to the surface of the inclined plane) and the angle of the plane.

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(Student)TI-Nspire File: *PhysBR_week06_fpar_incl_plane.tns*