Bell Ringer: Sliding Down an Inclined Plane– ID: 13390

From an activity by Peter Fox

Time required
15 minutes

Topic: Force and Motion

- *Describe the effects of friction and gravitational force on the motion of an object.*

Activity Overview

In this activity, students explore the relationship between the coefficient of friction and the time required for an object to slide down an inclined plane. Students use an animation of a block on an inclined plane to explore these relationships. Students can change the coefficient of friction and observe the animation to determine how long it takes the block to slide down the plane.

Materials

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

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

TI-Nspire Applications

Notes, Graphs & Geometry

Teacher Preparation

Before carrying out this activity, make sure students are familiar with the concepts of frictional forces, the coefficient of friction, gravity, and the normal to a plane.

- *The screenshots on pages 2–4 demonstrate expected student results. Refer to the screenshots on pages 6 and 7 for a preview of the student TI-Nspire document (.tns file). The solution .tns file contains answers to the questions.*
- ***To download the .tns file, go to education.ti.com/exchange and enter "13390" in the search box.***
- *For a more extensive exploration of this content, use activity 9520: Friction and Inclined Planes. Activity 9520, which is longer than this bell ringer, was designed for a full class period. You can download the files for activity 9520 at education.ti.com/exchange.*

Classroom Management

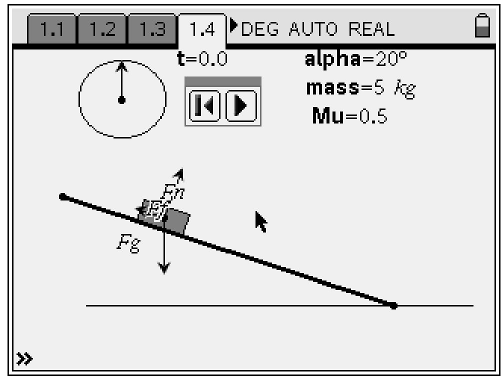
- *This activity is designed to be* ***teacher-led*** *with students following along on their handhelds. You may use the following pages to present the material to the class and encourage discussion. Note that the majority of the ideas and concepts are presented only in* ***this*** *document, so you 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 System Info > Graphs & Geometry Settings. 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 is the coefficient of friction related to the motion of an object down the plane?

Students will use an animation to explore the relationship between coefficient of friction and acceleration.

Step 1: Students should open the file **PhysBR_week07_incl_planes.tns** and read the first three pages. Page 1.4 contains an animation of a block sitting on an inclined plane. The mass of the block (**mass**) should be set at 5 kg, the angle of the plane (**alpha**) should be set at 20°, and the coefficient of friction (**Mu**) should be set at 0.4. The time (**t**) should be set to 0.0. If the time is not set to 0.0, students should reset the animation by pressing the reset (**|◂**) button. Note: Make sure students do not alter or delete the *Calculator* or *Lists & Spreadsheet* applications at the end of the .tns file. These applications contain information required to make the animations function correctly.



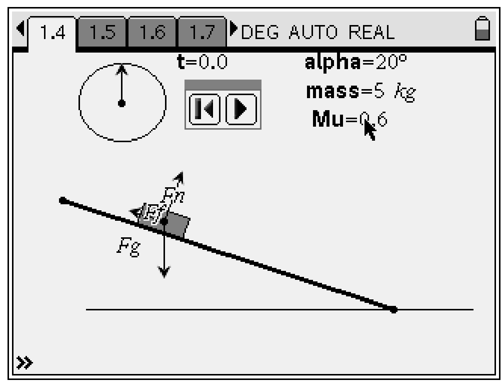
Step 2: Next, students should vary the coefficient of friction. They should first just vary the coefficient of friction and observe how the frictional force (*Ff*) on the block changes. They should not play the animation. They should then answer questions 1 and 2.

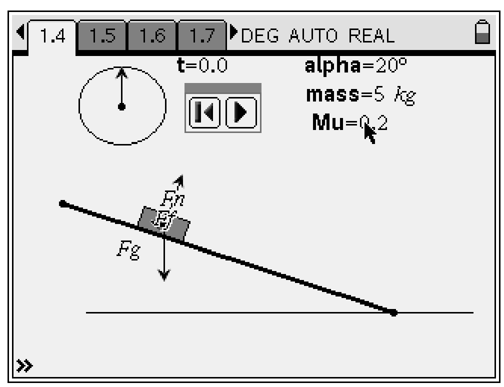
Q1. How does changing the coefficient of friction affect the force of friction (*Ff*) on the block?

A. *As the coefficient of friction increases, the frictional force on the block increases.*

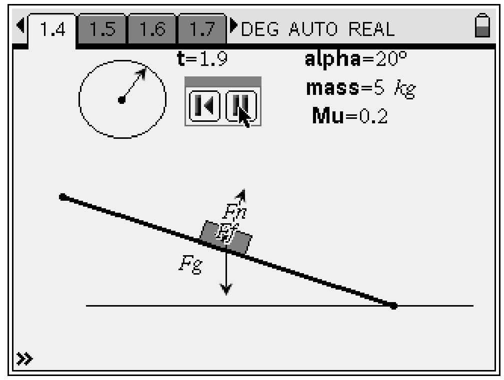
Q2. Predict how the acceleration of the block will change as the coefficient of friction changes. Explain your answer.

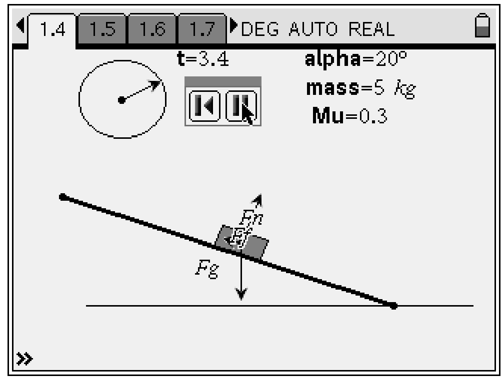
A. *Student answers will vary.*





Step 3: Next, students should study the effects of the coefficient of friction on the acceleration of the block. They should again vary the coefficient of friction. Each time they change the coefficient of friction, they should reset the animation and then play it. Their goal should be to identify the smallest coefficient of friction that will prevent the block from sliding down the plant. If the coefficient of friction is sufficiently small for the block to move, the block will begin to slide down the plane after students press the play button. The block will accelerate as it slides. After students have experimented with the coefficient of friction, they should answer questions 3–7.





Q3. Describe the motion of the block when it slid down the plane.

A. *As the block slid down the plane, it accelerated.*

Q4. How does the coefficient of friction affect the block's motion down the plane? Was your prediction from question 2 correct? If not, explain any errors in your reasoning.

A. *Student answers will vary. Students should recognize that larger coefficients of friction produces smaller accelerations. Encourage students to use metacognitive thinking to identify any errors in their reasoning.*

Q5. What was the minimum coefficient of friction required to keep the block from sliding down the inclined plane?

A. *approximately 0.36*

Q6. Calculate to two decimal places the minimum coefficient of friction required to keep the block from sliding down the inclined plane.

A. *0.36; Remind students that at the "equilibrium" value of* μ*—the minimum value required to keep the block from sliding—the frictional force is exactly equal to the force parallel to the inclined plane. If* θ *is the angle of the inclined plane,* m *is the mass of the block, and* g *is the acceleration due to gravity near Earth's surface, then the force parallel to the inclined plane is equal to mg(sin θ). The frictional force is equal to* μN, *where* N *is the normal force. The normal force, in turn, is equal to mg(cos θ). Setting the frictional force equal to the parallel component of the gravitational force yields the following:*

$$mg(\sin\theta) = \mu mg(\cos\theta)$$

$$\mu = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

Therefore, the value of μ *is tan(20º) = 0.36.*

Q7. Calculate the frictional force on the block for the coefficient of friction you calculated in question 6.

A. *16.76 N; the frictional force (*Ff*) is equal to* μN, *or μmg(cos θ). Substituting the given values yields the following:*
Ff = (0.364)(5 kg)(9.8 m/s^2*)(cos 20º) = 16.76 N*

Suggestions for Extension Activities: If you wish, you may have students try to identify quantitative relationships between coefficient of friction and acceleration. They can vary the coefficient of friction and use the animation timer to determine how long it takes for the block to slide down the ramp in each case.

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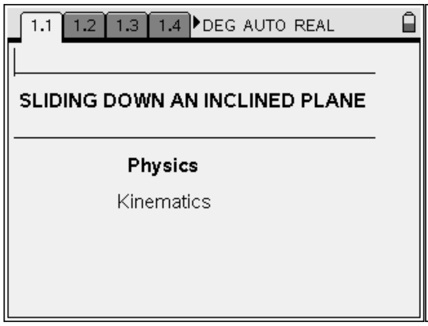
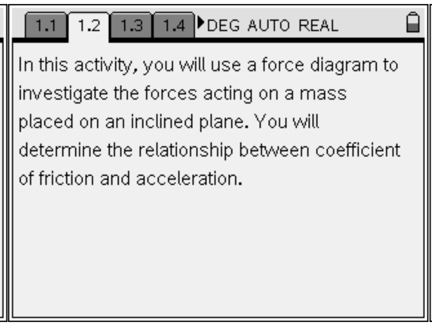
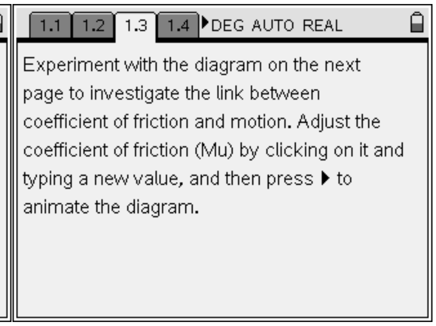
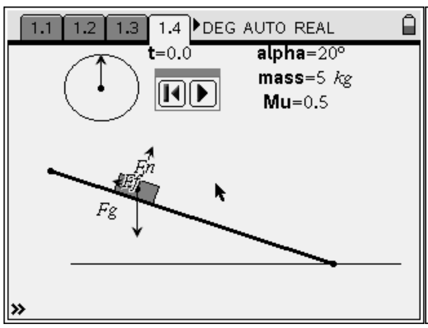
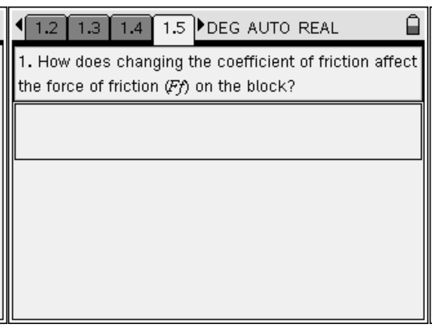
(Student)TI-Nspire File: *PhysBR_week07_incl_planes.tns*

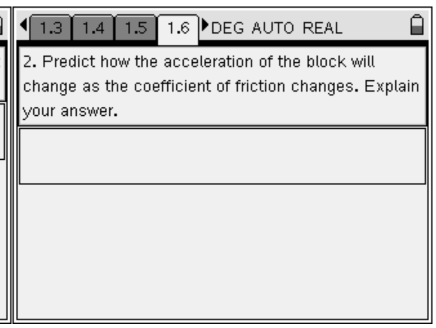


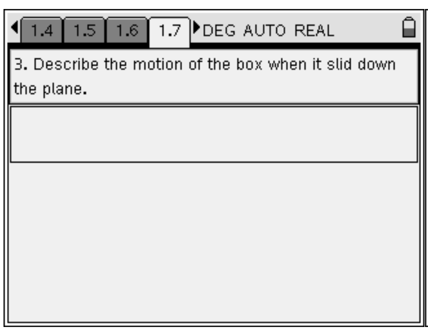


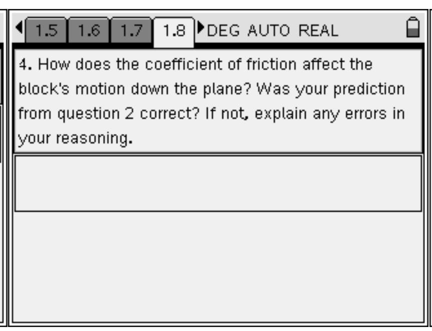


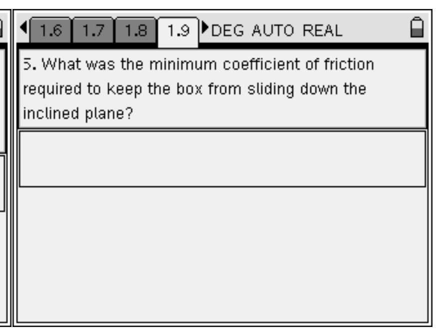


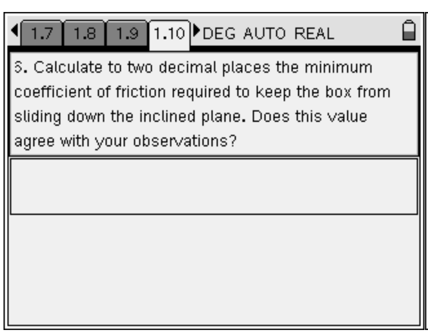


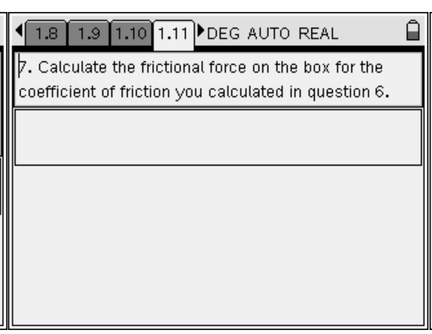


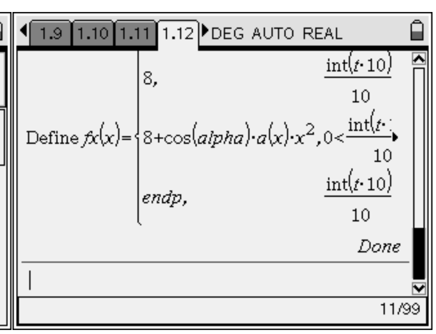


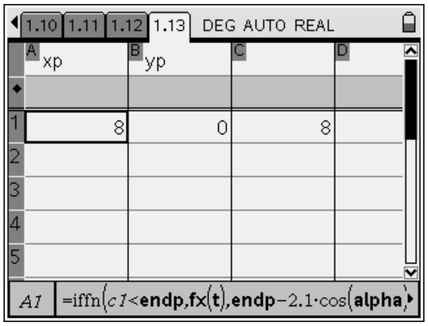











1.10 1.11 1.12 1.13 DEG AUTO REAL
A xp
B yp
C
D
1 8 0 8
2
3
4
5
A1 =iffn(c1<endp,fx(t),endp−2.1·cos(alpha