

**The Ramp (and Friction) PhET Simulation Lab****Introduction:**

When an object is dragged across a horizontal surface, the force of friction that must be overcome depends on the normal force as  $F_f = \mu F_n$  and the normal force is given by  $F_n = F_g$ . When the surface becomes an inclined plane, the normal force changes and when the normal force changes, so does the friction. In this lab, you will change the angle of an inclined plane and observe how weight is resolved into its components ( $F_n$  and  $F_g$ ) using the basic trig functions.

**The Ramp****Procedure:** Play with the Sims  $\Rightarrow$  Physics  $\Rightarrow$  Motion  $\Rightarrow$  The Ramp **Run Now!**

- Be sure to stay in the Introduction part of the simulation. *More features* will be used later when we investigate energy. Start by playing with the cabinet some. Have fun, really... Now... back to work.

- Move the cabinet up and down the ramp by dragging it with your mouse.
- Move the ramp to an angle of zero (horizontal) and draw a free body diagram of the cabinet here:

- On a horizontal plane, the normal force is \_\_\_\_\_ to the weight.
- The cabinet has a mass of 100kg. It therefore has a normal force of \_\_\_\_\_ N and a friction force (on the horizontal plane) of \_\_\_\_\_  $\mu = 0.30$

- Reset** the ramp and draw a free body diagram of the cabinet in the box here:

- The force down the plane and normal force are components of \_\_\_\_\_.

- Before we add an applied force on the ramp, there is a force of \_\_\_\_\_ that acts against the force down the plane (Force parallel).

- When we apply a force to get the cabinet moving, the friction force acts in the \_\_\_\_\_ direction as movement of the cabinet.

- Slowly** increase angle (0.1 degrees at a time) of the ramp until the cabinet starts to move on its own. What angle is this? \_\_\_\_\_ =  $\theta$

- At this point, the force down the plane is \_\_\_\_\_ than the force of friction.

- Since the ramp is now at an angle, the normal force is \_\_\_\_\_ than the weight.

- At the angle above, the normal force equals \_\_\_\_\_ N. (hint: what trig function?)

- At the angle above, the force down the plane equals \_\_\_\_\_ N. (trig function?)

- Using the formula for friction above, the force of friction is \_\_\_\_\_ N.

- If the plane-cabinet were frictionless, what angle would be required for the cabinet to move?

- Why? \_\_\_\_\_

Calculate first, then test each object in the table below with the simulation on a horizontal plane.

Object      Mass      Weight      Normal Force       $\mu$ , Coef of Friction      Friction Force to Overcome

Dog				0.10	
Crate				0.70	
Piano				0.40	
Refrigerator				0.50	

**Conclusion Calculations:****GRADED**

$$g = 9.8 \text{ m/s}^2$$

# Phet Lab Answers The Ramp

**N Colangelo**



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## **Table of Contents Phet Lab Answers The Ramp**

1. Understanding the eBook Phet Lab Answers The Ramp
  - The Rise of Digital Reading Phet Lab Answers The Ramp
  - Advantages of eBooks Over Traditional Books
2. Identifying Phet Lab Answers The Ramp
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Phet Lab Answers The Ramp
  - User-Friendly Interface
4. Exploring eBook Recommendations from Phet Lab Answers The Ramp
  - Personalized Recommendations
  - Phet Lab Answers The Ramp User Reviews and Ratings
  - Phet Lab Answers The Ramp and Bestseller Lists
5. Accessing Phet Lab Answers The Ramp Free and Paid eBooks
  - Phet Lab Answers The Ramp Public Domain eBooks
  - Phet Lab Answers The Ramp eBook Subscription Services
  - Phet Lab Answers The Ramp Budget-Friendly Options
6. Navigating Phet Lab Answers The Ramp eBook Formats

- ePub, PDF, MOBI, and More
- Phet Lab Answers The Ramp Compatibility with Devices
- Phet Lab Answers The Ramp Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Phet Lab Answers The Ramp
  - Highlighting and Note-Taking Phet Lab Answers The Ramp
  - Interactive Elements Phet Lab Answers The Ramp
- 8. Staying Engaged with Phet Lab Answers The Ramp
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Phet Lab Answers The Ramp
- 9. Balancing eBooks and Physical Books Phet Lab Answers The Ramp
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Phet Lab Answers The Ramp
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Phet Lab Answers The Ramp
  - Setting Reading Goals Phet Lab Answers The Ramp
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Phet Lab Answers The Ramp
  - Fact-Checking eBook Content of Phet Lab Answers The Ramp
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks
- 14. Embracing eBook Trends
  - Integration of Multimedia Elements
  - Interactive and Gamified eBooks

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