Science Friction!

Science Objectives

- Students will investigate the role of friction in the motion of a hero running across a concrete surface.
- Students will learn about Newton's second and third laws of motion and how they relate to the ability of the hero to run across a concrete surface.

Vocabulary

- force
- Newton's second law
- Newton's third law
- friction
- static friction
- kinetic friction
- coefficient of friction

About the Lesson

- In this lesson, students will explore forces and friction and their effect on the motion of an individual running across a solid surface.
- As a result, students will understand that:
  - Newton's second law states that force is a product of mass of an object and its acceleration.
  - The force of friction is required for an individual to be able to walk or run across a concrete surface.

TI-Nspire™ Navigator™

- Send out the *Science_Friction.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

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

- Science_Friction _Student.pdf

TI-Nspire document

- Science_Friction.tns

Discussion Points and Possible Answers

Have students move to pages 1.2 - 1.6 and read the background information on the student activity sheet and/or .tns file. You may need to review forces and Newton's laws of motion with the class. They should have a solid understanding of the concept of force before moving forward with the activity. The coefficient of friction and its formula are introduced on page 1.4. Ask students to consider what information they can infer from the coefficient of friction. What does a higher coefficient of friction tell us about the relationship between the force of friction and the normal force?

Move to pages 1.7 – 1.11.

Have students answer questions 1 - 2 in the .tns file, activity sheet, or both.

Q1. What is a force?

Answer: a push or a pull

Q2. If the object on page 1.8 has a mass of 1.02 kg, what is its acceleration in m/s^2?

Answer: 10.2 m/s^2

Move to pages 1.12 – 1.13.

Have students use the graph on page 1.12 to answer question 3 in the .tns file, activity sheet, or both.

Tech Tip: To perform a regression, select menu or **Document Tools ( ) > Analyze > Regression > Show Linear (mx + b).**

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Q3. What is the mass of the cart from page 1.12?

Answer: 0.64762 kg

Move to pages 1.14 – 1.18.

Have students answer questions 4 – 8 in the .tns file, activity sheet, or both.

Q4. Newton's third law of motion states that _____.

Answer: C. for every action force, there is an equal and opposite reaction force

Q5. If the sum of all the forces acting on a moving object is zero, the object will _____.

Answer: D. continue moving with constant velocity

Q6. A box is pushed toward the right across a classroom floor. The force of friction on the box is directed toward the _____.

Answer: A. left

Q7. A girl is pulling a box across the floor. The normal force acting on the box is 160 N. Calculate the frictional force on the box if the coefficient of friction between the box and floor is 0.25.

Answer: F_n = 160 N and μ = 0.25. $F_f = \mu \times F_n = (0.25) \times (160\ N) = 40\ N$

Q8. When a 12 N horizontal force is applied to a box on a horizontal tabletop, the box remains at rest. The force of static friction acting on the box is _____.

Answer: C. 12 N

Move to pages 2.1 – 2.8.

Students will read about the villain's plan and the role he wants them to play. Ask them to consider the substances and how they might affect the hero's ability to run across a concrete surface.

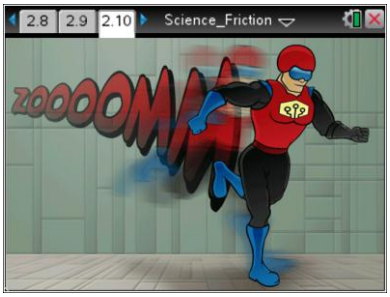
Move to page 2.9.

Have students answer question 9 in the .tns file, activity sheet, or both.

Q9. Which of the three substances do you think will be most effective at stopping or slowing the hero? Why do you think this is the best option?

Sample Answer: Ice will be most effective because there will not be enough friction between the hero's shoes and the ice. This will cause the hero to slip when running.

Move to page 2.10.



Students will use the simulation on page 2.10 to explore the results of each of the following scenarios: no substance sprayed on the concrete, water sprayed on the concrete, oil sprayed on the concrete, and the ice ray spraying a layer of ice on the concrete.

Based on the images in the simulation, the students will see that the hero is able to run across the concrete and water successfully and that he will slip and fall on both oil and ice.

Tech Tip: To access the Directions again, select menu or **Document Tools ( ) > Science Friction > Directions.**

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Move to pages 2.11 – 2.12.

Have students answer questions 10 - 11 in the .tns file, activity sheet, or both**.**

Q10. What do you think caused the hero to slip and fall when you sprayed the concrete with oil and the ice ray?

Sample Answer: The oil and ice reduced the friction between the hero's boot and the surface, causing him to slip.

Q11. The water, oil, and ice changed the magnitude of the _____.

Answer: C. coefficient of friction

Move to pages 2.13 – 2.14.

After the students have answered questions 10 and 11, have them discuss their answers. What role does friction play in the hero's ability to run across a solid surface? What forces are acting on the hero's foot when he makes contact with the concrete or the material that is coating the concrete? This is a good opportunity to discuss why friction isn't always a bad thing, even though we usually think of it as a force that slows the motion of an object.

Students will read more about the coefficient of friction on page 2.13 and the values for the coefficients of kinetic friction between different surfaces in the table on page 2.14. Ask them what they can infer from these values if they know that the hero was wearing rubber soled boots.

Move to pages 2.15 – 2.20.
Have students answer questions 12 – 16 in the .tns file, the activity sheet, or both.

Q12. Rank the surfaces in order of the maximum possible static friction force each is able to apply to the hero's foot while he is running.

Answer: A. dry concrete, wet concrete, ice

Q13. If the hero has a mass of 90 kg, find the maximum static friction force for dry concrete (use the maximum value for coefficent of static friction from the table on page 2.14).

Answer: $F_n = 90 \text{ kg} * 9.8 \text{ m/s}^2 = 882 \text{ N}$
$F_{s,max} = (0.85)*(882 \text{ N}) = 749.7 \text{ N}$

Q14. If the hero has a mass of 90 kg, find the maximum static friction force for an iced surface.

Answer: $F_n = 90 \text{ kg} * 9.8 \text{ m/s}^2 = 882 \text{ N}$
$F_{s,max} = (0.15)*(882 \text{ N}) = 132.3 \text{ N}$

Q15. How does Newton's third law apply to an individual running on a surface?

Sample Answer: Newton's third law states that for each force, there is an equal and opposite reaction force. When you run on a surface, you exert a force onto the surface, and it exerts a force back on you.

Q16. Use your own words to describe why friction is necessary for the hero to be able to walk or run across a solid surface.

Sample Answer: Friction is necessary in order for anyone to walk or run. When walking on a surface, an individual's foot applies a force that pushes backwards on the surface. The friction between the person's foot and the surface produces an equal and opposite force back on the foot, causing the person to move forward. Without friction, the foot pushes backwards against a surface and slips.

Move to pages 3.1 – 3.2.

Have students answer question 17 in the .tns file, activity sheet, or both.

Q17. Using your tool belt loaded with oil or an ice ray, you were able to halt the hero's progress and accomplish the villain's dastardly mission. Can you think of a strategy the hero could use to defeat the oil or ice obstacle?

Sample Answer: One option for the hero is to attempt to slide across the ice rather than trying to run. By using this option, he would be able to use the reduced coefficient of friction as an advantage. He could use his arms to steer him as he slides across the ice.

On page 3.2, students will read more about civil engineering. This would provide a good starting point for a class discussion about engineering careers and the types of courses that engineers would take to prepare them to solve problems in everyday life.

TI-Nspire Navigator Opportunities

Make a student a Live Presenter to show how to move the points on the interactive graph. Throughout the activity, monitor student progress. At the end of the activity, collect the .tns file 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 could consist of questions/problems on the chapter test or a performance assessment involving students diagraming the forces acting on a stationary or moving object or determining the speed of an object using the slope from a graph.