WHICH FORCE IS WITH YOU?

A MOTION AND DESIGN LESSON

Target Audience:
Students, ages 8–14

STEM²D Topics:
Science, Technology, Mathematics, Design

STEM²D .org

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Which Force Is With You? A Motion and Design Lesson is part of the STEM²D Student Activity Series. The content and layout were both developed by the Smithsonian Science Education Center as part of Johnson & Johnson's WiSTEM²D initiative (Women in Science, Technology, Engineering, Mathematics, Manufacturing, and Design), using a template provided by FHI 360 and JA Worldwide. This series includes a suite of interactive and fun, hands-on activities for girls (and boys), ages 5-18, globally.

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ACTIVITY DESCRIPTION

In this physical science and engineering activity, students will design, draw, and build K'NEX vehicles to meet specific challenges. They will discover the different forces at play as they run tests on ramps and make engineering design revisions. In addition to data collection, decision-making, and creative engineering design, students use interpersonal skills needed in STEM²D careers such as presenting ideas, negotiating, organizing, and working as a collaborative team. This activity is adapted from the STC curriculum unit *Motion and Design* by the Smithsonian Science Education Center.

ESTIMATED TIME:
This session typically takes one hour to complete.

STUDENT DISCOVERIES

Students will:

- Participate in a team-based learning experience.
- Learn how STEM²D—science, technology, engineering, mathematics, manufacturing, and design—subjects are used in engineering.
- Build important STEM²D skills, such as problem-solving, engineering design, decision-making, data collection, and trial and error.
- Consider STEM²D concepts, including, force, friction, gravity, and velocity.
- Become aware of engineering challenges and in everyday products.
- Recognize that STEM²D offers diverse and exciting career opportunities, including those connected with engineering design.
- Have fun experiencing STEM²D.

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GETTING READY

Materials: Suggested materials preparation prior to the activity with students.

- Activity Leader Checklist
- Tell My Story form
- 2 Ramps *Ramps for testing the cars can be made from anything a K'NEX vehicle can travel down. One ramp should have a smooth surface and another a rough surface.*
- Facilitator's package contains:
    - Masking tape
    - Measuring tape, in meters
    - List of K'NEX pieces in the student bags
- 1 Student K'NEX bag with all the pieces to build a vehicle per group of three to four students
- Handout, *Tips on Using the Building Pieces*, 1 per team
- Graph paper, 1 sheet per team
- 24 Certificates
- Camera (optional)

When considering the ramp setup and space, there needs to be a smooth, ideally uncarpeted space on which the vehicles can travel after descending the ramp. This activity does works on a carpeted surface, as long as the carpet is relatively smooth. The ramps must be the same height, to reduce the number of variables.

Before the time of the activity, the ramp should be set up. Use masking tape to mark 1 m and 2 m beyond the end of the ramp, for the vehicle design tests.

Estimated Materials Cost:

Activity leaders can expect to spend less than $15 (assuming handouts are printed and ramp materials are available) on materials, when completing this activity with 24 students organized into six or seven teams of three to four students.

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ACTIVITY LEADER PREPARATION

1. Read **Spark WiSTEM²D.** This is essential reading for all volunteers interested in working with youth, as it provides important background knowledge about STEM²D, strategies for engaging students, and tips for working with groups of students. Download at STEM2D.org.

2. Review the **Activity Leader Checklist** for details and specific steps for planning and preparing to implement this activity.

3. See the **STEM²D Student Activities Overview** for additional information.

4. Take time to experiment with designing and building a K'NEX car to better understand the challenges facing the students.

STEP-BY-STEP ACTIVITY:

WHICH FORCE IS WITH YOU? A MOTION AND DESIGN LESSON

Welcome and Introductions (15 minutes)

- Greet the students.
- Tell the students your name and your organization/company. Talk about your educational and career path. Use the Tell My Story form as a basis for your remarks. Be prepared to describe your job or a typical day, and provide information about your background including:
    - Your education – focus on secondary and post-secondary classes and courses
    - Current work projects
    - Interests and hobbies
    - Why you love STEM²D, and how your work is connected.
- Ask the students or any volunteers helping today to introduce themselves.
- Use Conversation Starters to learn more about the students and their interests.
- Discuss the opportunities that exist in the local community to support students as they develop their interests and personal experiences.
- Tell the students that your career is only one of the many careers available in STEM²D – science, technology, engineering, mathematics, manu-

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facturing, and design.

- Explain that STEM²D careers are **high-demand**, **high-growth careers** and are predicted to remain in demand over the next 10 years.
- Some STEM²D careers do not require a college degree and offer young people exciting, high-paying opportunities. Stress the importance of gaining mathematics skills and engineering practices to succeed in any STEM²D career.

CONVERSATION STARTERS: *CAREER PLANNING*

- When you consider your future, what are you most excited about?
- Do you see yourself working with others, for a large company, with your friends, for yourself? Why or why not?
- What does the perfect work day look like to you? Are you outdoors? Are you working alone, or with others? Do you solve problems? Do you fix or build things?

LEARNING ACTIVITY

Instructions:

Divide the class into teams of three or four students each. (When working with younger grade levels, ask the teacher in advance to divide the students into teams.)

Send a prebuilt K'NEX vehicle down a ramp and discuss the forces at work. Student understanding and age should determine the detail of the discussion.

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Background Information on Forces:

FORCE: a push or a pull on an object

- This can cause an object to go faster, slow down, or for its motion to change direction or remain the same.

FRICTION: the force of one object rubbing against another

- In some cases, we want to prevent friction so it's easier to move.
- Friction is also helpful when we want things to be controlled and stop.

GRAVITY: a force between Earth and an object that pulls everything toward Earth

- Earth's gravitational pull is what keeps someone on the ground and what causes objects to fall.
- The more massive something is, the stronger its gravitational pull is.

Taking into consideration time, age, and logistics, it is up to the facilitator to determine how many challenges the students should complete.

Possible design challenges:

1. Design a vehicle that moves at least 1 meter beyond the end of the ramp.
2. Design a vehicle that moves at least 1 m but not more than 2 m beyond the end of the ramp.
3. Design a vehicle that can carry a load at least 1 m beyond the end of the ramp.
4. Design a vehicle that can carry a load at least 1 m but less than 2 m beyond the end of the ramp.

Pass out a bag of K'NEX pieces from which each team will build their vehicle, and graph paper.

Let the students know how much time they have to complete their challenge(s).

Each team should:

- Understand the required challenge(s). *Design and build a vehicle that will move at least 1 meter beyond the end of the ramp.*
- Sketch a vehicle design on the graph paper to meet the challenge(s).

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This should be a two-dimensional design with front and side views.

- Build the vehicle using the K'NEX pieces and *Tips on Using the Building Pieces.*
- Test the vehicle by releasing it and letting it roll down the ramp, observing what happens. (Both rough and smooth surface ramps may be used.) Measure and record the distance the vehicle moves from the bottom of the ramp to the stop position. If using both rough and smooth ramps, test the vehicle on both surfaces. Was there a difference?
- Discuss what worked and what didn't. Redesign the vehicle to improve its performance.
- Move on to the next challenge, redesigning the vehicle to meet the goal of the new challenge.
- When all required challenges have been completed, take the vehicle apart and return all pieces to the bag.

Reporting Results:

Have each team pick one person to report the work of their engineering team. Have them mention the problems they encountered and how they overcame them.

Remind the students that this is how professional engineers and scientists go through the designing, building, and testing process when preparing products for manufacturing and marketing.

Give positive feedback after each team presentation and encourage the other teams to applaud their work.

This is a good time to take pictures of each team with their vehicle.

Collect the bag of K'NEX pieces from each team.

Student Reflection (10 minutes)

Have the students reflect on this activity by answering the following questions:

- What did you learn about designing a vehicle?
- Was it fun? What made it fun?
- Who are you going to tell about today's activity? Why?
- What did you learn from testing your vehicle?
- What was your biggest challenge in completing the challenges?
- Might you consider a career in engineering design? Explain.

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After a few minutes, ask the students to share their thoughts.

Thank the students for participating.

EXTENDED LEARNING

1. Develop other design challenges for the vehicles, changing the length of the ramps, the payload, the surface texture, etc.
2. Design and build vehicles out of common materials to meet a challenge.
3. Visit a product design or manufacturing facility to see how products are designed, built, and tested.

Keywords:

DESIGN: a plan or drawing produced to show the look and function or workings of something before it is built or made

FORCE: a push or a pull on an object

FRICTION: the force of one object rubbing against another

GRAVITY: a force between Earth and an object that pulls everything toward Earth

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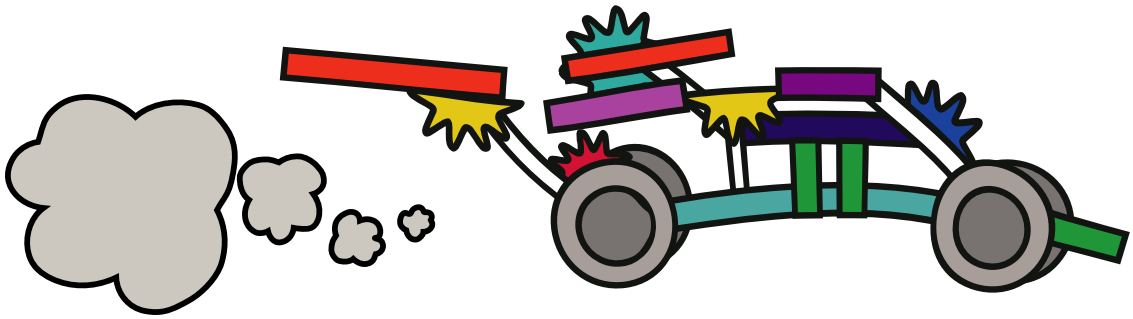
ACTIVITY LEADER REFLECTIONS

After the activity, take a few minutes to reflect on the following:

- What went well and what could be improved?
- What would you do differently next time?
- How comfortable did you feel leading the learning experience?
- Do you have a better understanding of the STEM^{2}D concepts?
- How useful was the information presented in the **Spark WiSTEM^{2}D**?
- Will you volunteer for this type of experience again?

RESOURCES AND REFERENCES

1. **STC Curriculum**
2. **Smithsonian Science Education Center: ScienceEducation.si.edu**



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ACTIVITY LEADER CHECKLIST:

DID YOU . . .

- ☐ Read Spark WiSTEM²D? This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with female students. Download at www.STEM2D.org.

- ☐ Visit the implementation site and observe the young people? (optional) If visiting, take note of the following:
  - ☐ How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems with managing the class of young people?
  - ☐ What does the site do to make each student feel important and at ease?
  - ☐ How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
  - ☐ How can you engage the site representative in your presentation?
- ☐ Meet with and finalize the logistics with the Site Representative?
  - ☐ Confirm the date, time, and location of the activity?
  - ☐ Confirm the number of students attending? Knowing this will help you decide how to group the students into teams, as well as the appropriate materials to purchase.
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the Tell My Story Form, which will prepare you to talk about your educational and career path with the students?
  - ☐ If teams are needed for this activity, please ask the teacher in advance to organize the students into teams.
- ☐ Practice your presentation, including the hands-on, minds-on activity? Be sure to:
  - ☐ Do the activity; make sure you can explain the concepts to students, if needed, and that you know the correct answers.
- ☐ Obtain the required materials (see the Materials and Estimated Materials Costs sections) and, if asked for in the Getting Ready section, photocopy the Student Handouts and Materials Testing Sheets. In addition:
  - ☐ Organize the materials to ensure each team has everything listed in the Materials section—keep in mind some materials are shared among the teams.
- ☐ Prepare the space? Specifically:
  - ☐ Make sure tables and chairs are arranged to accommodate teams of students.
  - ☐ Bring a camera, if desired, to take photographs.
- ☐ Obtain and collect permission slips and photo release forms for conducting the activity if applicable?
- ☐ Have fun!

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“Tell My Story” Form

This form will help volunteers serving as activity leaders prepare to talk about their STEM²D interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

Company: _____

When/Why did you become interested in STEM²D? _____

_____

_____

What do you hope young people, especially girls, will get out of this activity? _____

_____

FUN FACT

Share a little about your background. Ideas:

- Share a memory from childhood where you first had your “spark” or “interest” in STEM.
- Detail your journey; highlight what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most? _____

How did you know you wanted to pursue a STEM²D career?

_____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why to the students.*

_____

What your current position entails. *Be sure to include how you use STEM²D on a typical work day.*

_____

_____

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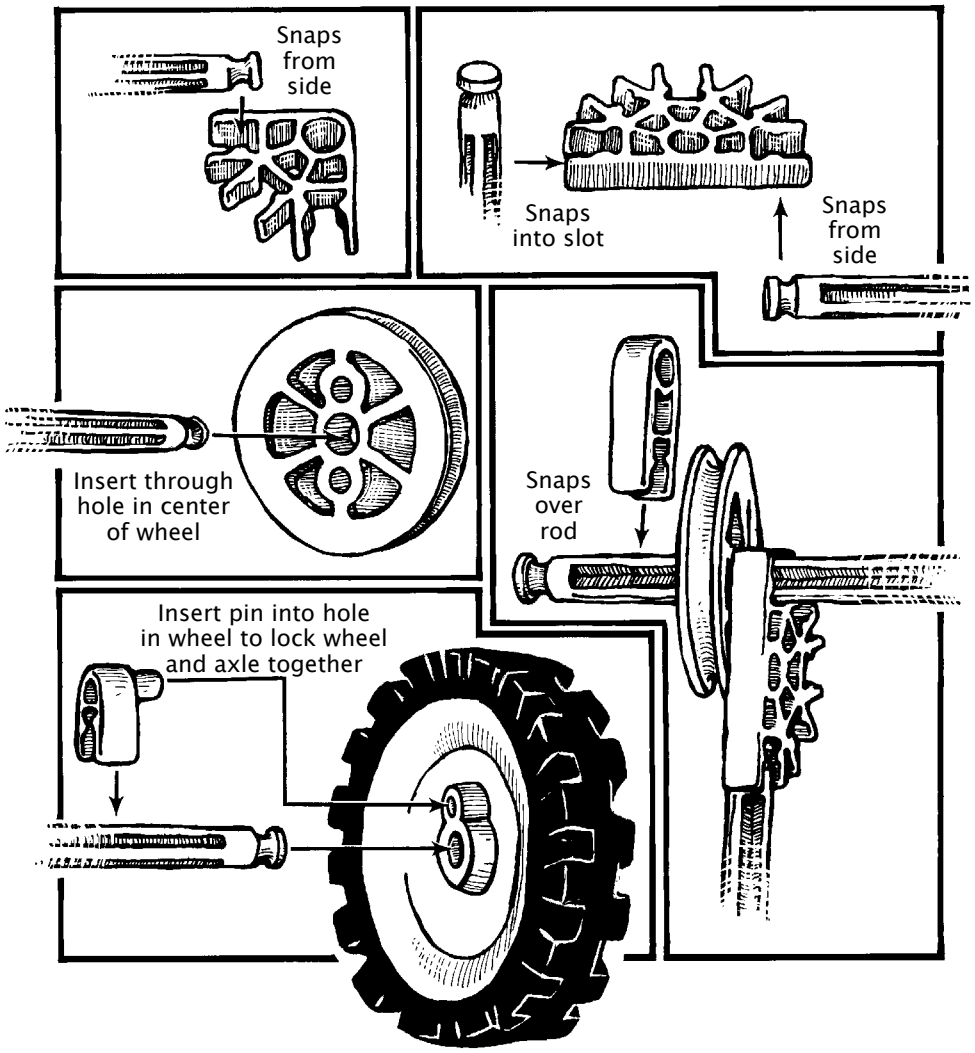
Tips on Using the Building Pieces



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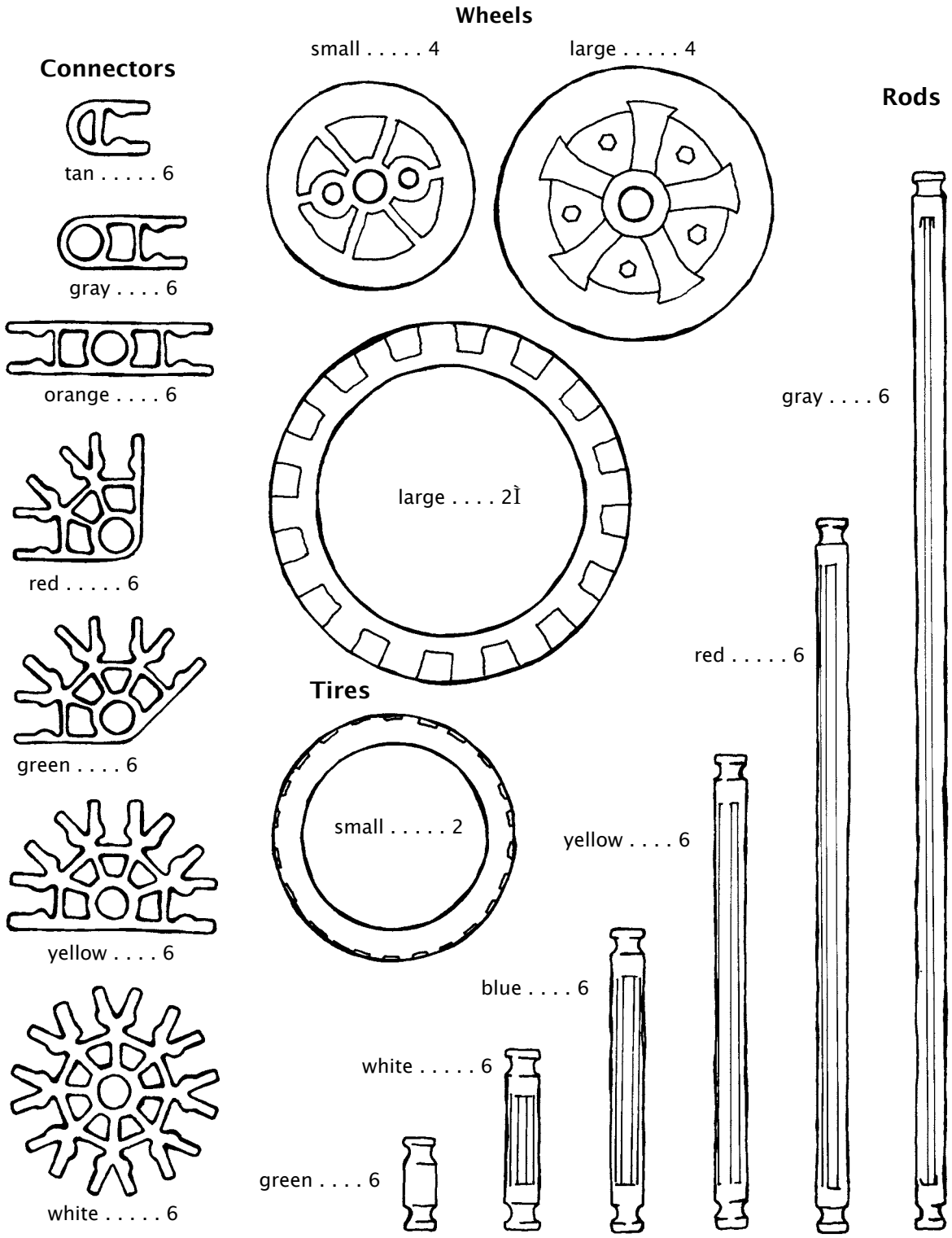
Building Pieces for Each Group



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