BioEd℠

ON THE ROAD WITH VEHICLE PERFORMANCE

STEM Activities for Use with the 2018 Hess RV with ATV and Motorbike

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The order of the activities may be changed if it is determined that it will create a more logical progression.

The 2018 Hess RV, ATV and Motorbike is available at www.hesstoytruck.com while supplies last.

To download the previous, 2016 and 2017 Hess Toy Truck STEM guides, visit the following sites.

Force, Motion, Friction and Energy (2016)

http://www.bioedonline.org/lessons-and-more/focus-on-stem/force-motion-friction-and-energy/

Simple and Complex Machines (2017)

http://www.bioedonline.org/lessons-and-more/focus-on-stem/simple-and-compound-machines/

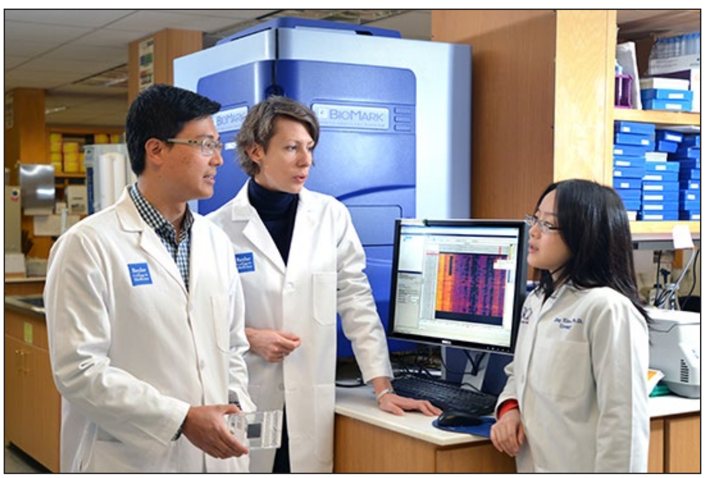
STEM is an acronym used to identify the academic subjects of science, technology, engineering and mathematics. By highlighting the inter-relatedness of these subjects, the STEM acronym encourages schools, districts and educators to integrate STEM content rather than teach each subject separately.

The STEM approach is important for workforce development and economic growth. Many careers are available in STEM-based fields, and forecasts indicate that in the future, there will be more STEM-based jobs than qualified workers to fill them.

BAYLOR COLLEGE OF MEDICINE

Baylor College of Medicine (Baylor) is a health sciences university that creates knowledge and applies science and discoveries to further education, healthcare and community service locally and globally. In addition to its School of Medicine, Baylor includes a Graduate School of Biomedical Sciences, School of Health Professions, and National School of Tropical Medicine.

Located in the heart of the Texas Medical Center, the world's largest health sciences complex, Baylor is surrounded by leading healthcare and research institutions. That concentration of expertise has helped support the development of collaborations that advance every aspect of the College's mission.



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With seven affiliated teaching hospitals and partnerships with major institutions, such as the University of Houston, Rice University and NASA, Baylor has a diversity of resources unparalleled at other academic health centers. The College also partners with community leaders to serve Houston, Texas, and the world through outreach initiatives, innovative healthcare delivery models and research focused on specific community needs. Its educational outreach programs reach students at all levels, from elementary school through college, creating a pipeline of learners interested in science and medicine.

Baylor is ranked by the National Institutes of Health at #1 in Texas, and #21 in the nation among research intensive medical schools. Seven departments rank in the top 20, including a ranking of #1 in genetics. *US News & World Report* ranks Baylor at #1 in Texas, and in the nation at #16 in research, #5 in primary care, and #10 in pediatrics.

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The Center for Educational Outreach at Baylor College of Medicine provides a wide range of educational programs and resources that help prepare and encourage students to pursue careers in medicine and the health sciences. Offerings include teacher professional development and curricular materials that improve the STEM content knowledge and skills of K–12 students. Educators can earn continuing education credits via the Center's face-to-face workshops or online courses, some of which are tailored to meet the needs and requirements of individual schools or school districts.

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Teacher resources. BioEd Online[SM] and SuperSTAAR[SM], are dynamic STEM teacher websites that provide coursework, streaming video presentations, teaching slide sets, inquiry-based classroom activities and complete teaching modules for grades pre-K to 12. BioEd Online materials feature an integrated, hands-on approach to teaching STEM. Each inquiry-based unit is aligned with national and state science education standards.

HESS CORPORATION

Hess Corporation is a leading global independent energy company engaged in the exploration and production of crude oil and natural gas. Social Responsibility is integrated into the way we do business, enhancing our ability to be an effective and trusted energy partner and enabling us to meet the highest standards of corporate citizenship by creating a long-lasting, positive impact on the communities where we do business. Hess is committed to building trusted partnerships with governments, communities, employees, customers and stakeholders to develop programs that can make a measurable and sustainable difference. With over $200 million invested in social programs since 2011, we are helping to create an army of problem solvers that will overcome future complex challenges. Above all, we continue to be a company that cares about its people, its impact on the community, its reputation, and about doing the right thing. We are proud of our achievements, having been recognized 11 consecutive years by *Corporate Responsibility Magazine* as one of the 100 Best Corporate Citizens, along with 9 consecutive years as a member of the Dow Jones Sustainability Indices North America. In addition, Hess has been recognized for the 10th consecutive year as one of the Top 50 Employers, *STEM Workforce Diversity,* Equal Opportunity Publications, Inc.

Mr. Leon Hess (left), shown with the 1964–1965 Hess Tanker Trailer.

© Hess Corporation.

THE HESS TOY TRUCK STORY

The Hess Company was founded in 1933 when Leon Hess bought a second-hand truck and started a business delivering fuel oil to homes in New Jersey. By the time Mr. Hess passed away in 1999, at the age of 85, Hess Corporation had grown into one of the world's largest energy companies including oil exploration, production, storage and more than 1,300 gas stations along the east coast. Not long after opening the first Hess branded gas station in 1960, Leon Hess decided to offer families a fun, high quality and affordable toy for the holidays as a goodwill gesture to customers. With that decision, he created a toy for kids of all ages, the Hess Toy Truck, which has become a hallmark of the holiday season, with a new model released each year. Leon Hess wanted a toy truck made with outstanding craftsmanship and innovative use of electronics. And he wanted to offer it at a price families could afford, and with batteries included, a concept that endures to this day 55 years later. The Hess Toy Truck remains a beloved holiday tradition and among the largest selling toys in the country every year, now offered exclusively at www.hesstoytruck.com.

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HOW IT'S MADE

It takes a long time (and a lot of STEM) to create a Hess Toy Truck. The process of developing each new toy starts two to three years before the truck goes on sale. Some trucks have taken as long as six years to go from concept to market. Initial drawings and feature concepts are reviewed, and the toys begin to evolve. The top two or three designs go to the next round, where they are transformed from drawings to handmade models. The models are evaluated for safety, functionality, playability, durability and value. Eventually, the new Hess Toy Truck is chosen. A Hess Toy Truck is generally comprised of up to 300 small, hard plastic pieces. A tooling, or mold, for each piece must be cut to precise measurements. Once the toolings are made and tested, the pieces are produced and meticulously assembled. Then, as anyone who has unpacked a Hess Toy Truck knows, the final toy is placed—very carefully—into the toy box. ■

TOOLS TO TEACH STEM

Hess Toy Trucks are much more than collectors' items. They are useful teaching tools that offer a variety of practical and fun ways to teach STEM subjects, such as force and motion and simple and complex machines. STEM is the acronym for science, technology, engineering and mathematics. It denotes an integrated approach for developing many products and processes we depend upon each day. It is also one of the fastest growing categories for jobs.

Activities in this guide use the 2018 Hess RV with ATV and Motorbike to explore practical transportation issues, such fuel efficiency, potential and kinetic energy for producing motion, and motorsports. The activities can be used sequentially as a unit or inserted into an existing curriculum. While designed for grades 4–6, they can easily be adapted for upper and lower grades. All activities support the Three Dimensions of Science Learning in the Next Generation Science Standards. Some include student pages that can be used for assessment or placed in science notebooks.

© Hess Corporation.

The 2018 Hess RV with ATV and Motorbike follows a recreational vehicle (RV) theme. It consists of a motorhome-style vehicle with compartments for an all-terrain vehicle (ATV) and a street motorbike. The three vehicles are based on real vehicles used widely on the highways and back roads of the world. They consist of a variety of simple machines, such as wheels and axles, inclined planes, gears, screws and levers. These individual machines are carefully designed to work together to accomplish a variety of functions, such as moving along highways and conquering rough back-country roads.

The 2018 Hess RV with ATV and Motorbike is a vehicle that combines a motorhome with a "toy transport." In the RV world, "transport" usually refers to some sort of trailer that holds motorbikes, ATVs, boats, kayaks or other recreational vehicles. Living quarters, found at the rear of a typical RV cabin, are small and mostly utilitarian. These features are not accessible in the toy RV, so, imagination is necessary to envision their layout and function. The midsection and rear of the 2018 Hess RV feature storage compartments for the toy motorbike and the all-terrain-vehicle. The compartment for the motorbike opens on both left and right sides of the RV. Doors to both compartments serve as off-loading and on-loading ramps. In machine terms, the three ramps are known as inclined planes.

The real-world vehicles modeled in the 2018 Hess RV with ATV and Motorbike exemplify STEM at work. Every one of the thousands of parts used to design and assemble actual RVs, ATVs and motorbikes represent practical applications of science, technology, engineering and mathematics.

STEM CAREERS

Skilled workers for STEM fields are always in demand, with job openings exceeding the number of prepared candidates. In combination with the 2018 Hess RV, ATV and Motorbike, this guide provides powerful, stimulating STEM learning experiences that relate to many STEM fields, such as the "Select Careers" listed below. These careers require competency in science, technology, engineering, math, and art.

SELECT CAREERS	
Automotive Technologist	Mechanical Engineer
Biologist	Medical Scientist
Chemist	Petrophysics Engineer
Civil Engineer	Robotics Engineer
Computer Scientist	Safety Engineer
Drilling Engineer	Software Developer
Electrical Engineer	Structural Engineer
Environmental Scientist	Technical Writer
Geoscientist	Theme Park Designer
Graphic Designer	Toy Designer
Manufacturing Engineer	Transportation Engineer
Marketing Specialist	Website Developer

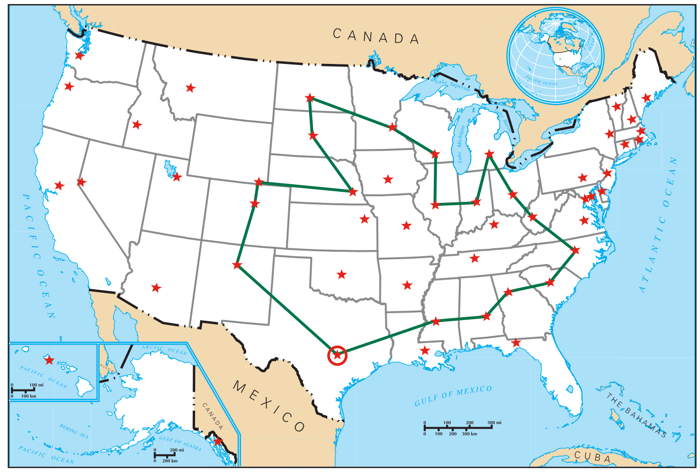
1. Road Trip: Distance vs. Time Restrictions

Year round, highways of the United States are filled with recreation vehicles, or "RVs," of all sizes. Typically, RVs have built-in accommodations for living. The most basic models include sleeping quarters and simple kitchens. Some larger RVs, better described as motorhomes, feature beds, kitchens, full bathrooms, and amenities like televisions, game rooms, water heaters and air conditioning. Some even have slide-out walls that increase the interior space when parked.

It is common to see larger RVs towing cars or trailers carrying one or more motorbikes. These smaller vehicles are used to get around when the RV is parked at a resort or a campground.

RVs serve as homes away from home for many tourists who appreciate having familiar surroundings as they travel. Other RV owners use their vehicles year-round to travel from state to state, visiting scenic locations, national parks and monuments. A widespread network of RV campgrounds across the country offers parking spots with water and electricity hookups.

In this activity, teams of students will imagine themselves as tourists who have rented a 2018 Hess RV for 14 days—the motor vacation of a lifetime! Their goal is to visit as many state capitals as possible and end up back where they started on Day 1. Teams will receive a blank US map, on which the locations of state capitals are marked with red stars. They will also receive logbook pages to record their starting points, distances traveled, driving times and capitals visited.



Example route

THE QUESTION

Using the 2018 Hess RV, how many state capitals can the team visit in 14 days while abiding by the "rules of the road"?

MATERIALS

Per team of students

- 2018 Hess RV
- Computer with access to Google Maps (www.google.com/maps). See "Management Tips" for alternate option.
- Trip Logbook (to be created by student teams)
- One copy of each of the four student pages

MANAGEMENT TIPS

Prior to class, launch Google Maps on student computers. If using Google Maps is not practical, routes can be plotted on paper maps. Go to the USGS National Atlas website and print maps for your state and as many surrounding state maps as needed. Have students plot their route from capitol to capitol by following major highways. Have them measure distances with the miles scale found on the map. To determine the number of driving hours, have students divide the distance traveled by 45 miles per hour (MPH), an average speed for RVs.

Continued

PROCEDURE

1. Organize teams of two to four students. Have them examine their 2018 Hess RVs. As a class, discuss the RV's features. Why would it be a fun travel vehicle? What advantages does it offer the traveler?

2. Explain the purpose of the activity. Teams will plan a 14-day road trip to visit as many state capitals as possible. Starting at the capital of the state in which they live, teams will plot their routes to other state capitals on a map of the U.S. They will have to follow drive time rules as described on the "Trip Planning" page.

3. Each team will create and keep a travel logbook. The book will consist of instructions, log pages, and a state outline map.

4. As a class, review the trip plan instructions. Explain how to use the log pages and how to draw a route path on the outline map. Remind teams that they must end their 14-day trips at the capital where they began. Route lines may cross each other.

5. Demonstrate how to use Google Maps (see "Management Tips," p. 1, for alternate option to using Google Maps). When the program is open, the upper left corner of the screen displays a menu followed by the words, "Search Google Maps." Next to that is a blue diamond with a right turn arrow in its center. Click on the arrow. Two blanks will appear. Enter the starting point (first capital) in the first space and name of the destination capital in the second. Be sure to include state names. Google Maps will calculate the best route, distance, and estimated time required to travel from one capital to another.

6. The following are tips and special instructions.
   - In some cases, teams may be able to visit more than one capital in a single day. However, the total drive time *must not* exceed 12 hours for any day.
   - If it takes more than 12 hours to reach the next capital, teams must stop, record 12 hours on the first day, and then record any additional hours required to reach the capital on the second day.
   - For students in Hawaii, Alaska, and U.S. Territories, select a capital in one of the contiguous 48 states where all teams will begin their trips.

WRAP IT UP

Have teams report to the class how many state capitals they were able to visit during their trips. Compare maps teams drew. Have teams talk about how they decided what route to take. Were their routes circular? Did their routes cross themselves? What route planning strategies did they use?

EXTENSIONS

- The daily 12-hour time limit for the road trip is based partly on regulations established for driving long-distance commercial vehicles (18-wheelers, or semi-trucks). Have students use the Internet (including the U.S. Department of Transportation website) to investigate rules regarding how long truck drivers can drive before resting. RV drivers are not required to follow these rules. They may be able to drive safely for more hours providing there is more than one driver on board. Multiple drivers periodically trade places to ensure that no driver gets overly tired.
- Have student teams use the Internet to research the capitals they visited and make a list of one or two interesting things about each city. ■

Trip Planning

Traveler name

Traveler name

Traveler name

Traveler name

INSTRUCTIONS

1. Begin the trip at your state's capital. Circle the capital's star on the map. Write the name of your state and capital city as the starting point in your Travelog book.

2. As a team, choose any state adjacent to yours and plan a drive to its capital. Use the Google Maps program on a computer to determine how far that capital is from your starting point and how many hours it will take to drive there.

   Rule 1. You may drive no more than 12 hours in a single day.
   Rule 2. You must abide by local speed limits. (Google Maps will use local speed limits to plot the best route to your destination and determine how long it will take to get there.)

   Rule 3. If your capital destination is nearby, you may be able to continue to another capital. As long as you stay within your daily 12-hour driving limit, *go for it!*

3. Draw a line on the map below showing the path you travel from one state capital to the next.

4. On your Travel Logbook sheet, write the day number for each part of trip. Record the state and capital names, distance, and hours/minutes driven in that Day's box. If you visit more than one state capital in a day, list the information about it in the blank box beneath the first, and record the same day number.

5. *Important!* Your trip must be completed in 14 days, and your route must circle back to arrive in your home state's capital (where you started) on Day 14.

Travel Logbook: 1

Traveler's Name

Traveler's Name

Traveler's Name

Traveler's Name

INSTRUCTIONS

Begin recording information for the first city you will travel to in Column 1, Day 1. For Day 2, record the information in the box underneath Day 1, and so on. If you reach two or more capitals in one day, record the same day number for each.

What city and state is your starting point?__________

Column 1

DAY 1

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

Column 2

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

Travel Logbook: 2

Traveler's Name ____________________ Traveler's Name ____________________

Traveler's Name ____________________ Traveler's Name ____________________

INSTRUCTIONS

Continue recording your trip using the first box in Column 3 on this sheet. When all the boxes in Column 3 are complete, begin recording in Column 4. Your last recorded box must be at the same location as where you began your trip (starting point). If you have not finished your trip, continue recording on the sheet named, "Travel Logbook: 3."

Column 3

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

Column 4

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

DAY ☐
State
Capital City
Distance traveled in miles
Hours : Minutes

Travel Logbook: 3

Traveler's Name

Traveler's Name

Traveler's Name

Traveler's Name

INSTRUCTIONS

Continue recording your trip using the first box in Column 5 on this sheet. When all the boxes in Column 5 are complete, begin recording in Column 6. Your last recorded box must be at the same location as where you began your trip (starting point).

Column 5

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

Column 6

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

DAY

State

Capital City

Distance traveled in miles

Hours : Minutes

2. RV-ing: Energy Efficiency vs. Vehicle Mass

There are many kinds of recreation vehicles (RVs) on the market today, but generally, they fall into two large categories: motorhomes and towable RVs. The 2018 Hess RV is a Class A motorhome. Class A motorhomes can be 40 feet long and include interior amenities such as kitchens, living rooms, full bathrooms, multiple bedrooms and expandable walls that provide extra floor space. They are rectangular in shape, with a squared front and rear giving the overall appearance of a large bus.

© Hess Corporation.

Smaller varieties of motorhomes include Class B motorhomes, essentially large vans with an expandable rear section to provide living quarters. Class C motorhomes have living quarters mounted on top of an existing truck. Then, there are the towable RVs such as trailers, campers and flatbed haulers for things such as ATVs and motorbikes.

One consideration for all RV owners is the cost of operating their vehicles. Fuel expense and gas mileage top the list. The largest Class A motorhomes get about 8 to 13 miles per gallon (MPG). Smaller RVs may get up to 20 MPG. An RV vacation trip can include several hundred miles of driving or more. The futher the destination, the greater the fuel expense.

RV owners also must include weight in their cost calculatiions. Heavier vehicles require more gasoline to operate, and large RVs can carry a lot of food, water, personal items, extra furniture, flatbed haulers, etc. They also hold many gallons of fuel. Most Class A motorhomes have have 100- to 150-gallon capacity fuel tanks. Gasoline weighs just over 6 pounds per gallon, so a Class A motorhome with a full tank is carrying 600 to 900 pounds of fuel! The extra weight lowers the fuel efficiency.

The reason heavier vehicles take more fuel to operate is a simple matter of physics. The amount of force needed to change the motion of an object depends upon its inertia. Inertia is a property of all objects. It is the resistance to a change of motion of an object and depends upon the object's mass. In other words, the more mass in an object, the greater its inertia and its resistance to a change in motion. This concept is addressed in Isaac Newton's First Law of Motion. The law states that an unbalanced force is needed to change an object's motion. Since the force propelling the RV comes from the combustion of fuel, more fuel has to be burned to accelerate a heavier vehicle to highway speeds than to accelerate a lighter vehicle to the same speeds. Of course, there are other factors at work. Heavier vehicles tend to have a bigger cross section and this leads to greater friction or drag with the air, causing more fuel to be consumed. Heavier vehicles also put more pressure on the tires which can become slightly flatter and wider, increasing friction with the road surface.

Additional information about inertia and force and motion can be found in the 2016 Hess Toy Truck guide, *Force, Motion, Friction and Energy*. The guide is available for free download at http://www.bioedonline.org/lessons-and-more/focus-on-stem/force-motion-friction-and-energy/

In this activity, students will experiment with vehicle mass verses energy efficiency. Student teams will use a fixed force to propel the 2018 Hess RV across the floor. They will compare the distance traveled by an empty vehicle RV with that of a fully loaded (much heavier) RV. The distance the RV travels will be an approximate measure of fuel efficiency.

THE QUESTION

How does vehicle mass affect fuel efficiency?

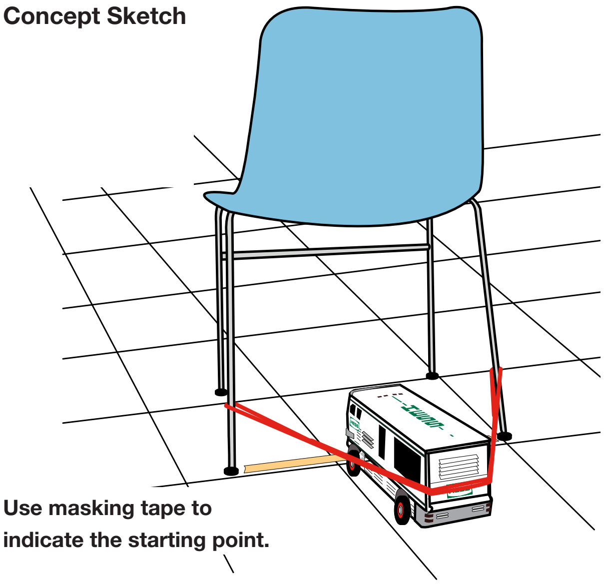
Continued

MATERIALS

Per Student Team of 4

- 2018 Hess RV with ATV and Motorbike
- 6 size #64 large rubber bands (smaller rubber bands can be used, but may have to be doubled to produce enough force)
- 4 copies of the "RV Data Sheet" page
- Non-rolling 4-legged chair
- Sandwich-sized sealable plastic bags holding weights/ cargo, such as metal washers, hex nuts, marbles, etc. Use doubled bags for sand or water.
- Strip of 15-cm masking tape (starting line)
- Yardstick, meterstick, or tape measure

Concept Sketch



Use masking tape to indicate the starting point.

SAFETY NOTICE

In Step 6, have one team member from each team sit on the chair sideways to anchor it to the floor.

PROCEDURE

1. Ask students what they know about vehicles and gas mileage. Why is it important to know gas mileage? Encourage students to consider fuel cost and environmental issues. What are some things that affect mileage? Examples might include vehicle weight and shape, engine size, cargo weight, terrain, wind resistance, etc.

2. Tell students they will investigate the relationship between a vehicle's weight and the energy needed to propel it along a road. This will be a controlled experiment, with two independent variables. The first variable force: the same amount of force must be used to propel the 2018 Hess RV in every test run. The second variable is weight: over the course of multiple trials, students will compare the distances traveled by their RVs, when loaded with more or less weight. The dependent variable is how far the RV travels.

3. Have teams loop together 6 large rubber bands to make an elastic that will exert a force on the RV. If needed, demonstrate how to loop the bands together.

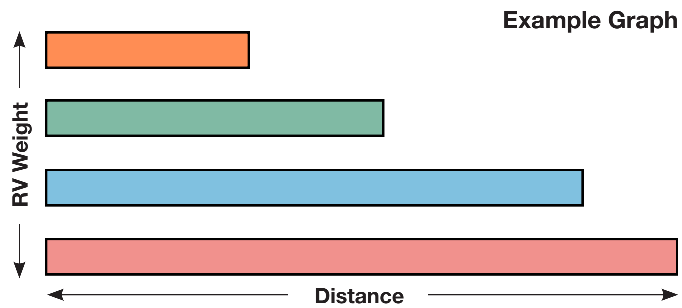
4. Select (or create) clear floorspace in a hallway or classroom, in which teams can conduct the investigation. Smooth lineoleum floors work best. Place non-rolling 4-legged chairs, one for each team, at one end of the floorspace. Station teams at each individual chair.

5. If they have not already done so, have teams remove the ATV and motorbike from the 2018 Hess RV. Instruct students to insert the back legs of their chairs through the loops at either end of their rubber band elastics, (see "Concept Sketch" above.) The elastic bands should be at the same height on each chair leg for all trials. Use masking tape to secure the bands in place. Put a strip of tape on the floor to serve as a "starting line." This is an experimental control that will ensure the same force is used for each run.

6. For the first trial, the RV should be empty. Have one team member sit on the chair to keep it in position. Another team member or members should align the midpoint of the elastic with the Hess logo on the RV's rear door. Instruct students to pull back on the RV (like a slingshot) and stretch the elastic until the front of the RV is at the starting line. Do a short countdown and have students release the RV. The RV will roll across the floor until friction causes it to stop.

7. Direct teams to measure and record how far, in centimeters or inches, the empty RV rolled along the floor. Many tile floors are made from 12-in. x 12-inch tiles. The

Continued



number of tiles the RV traveled may provide an easy distance measurement. Teams should repeat the test three times and average the distances on their RV MPG data sheet. Repeating and averaging helps to reduce errors induced in pulling back the RV or in releasing it.

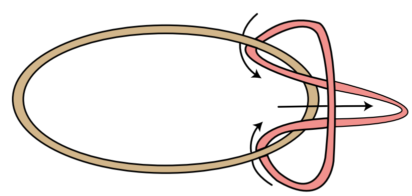
8. Have teams repeat the same experiment, but this time with the ATV and motorbike loaded into the toy RV. Remind students to pull the RV and rubber bands back the exact distance as before, releasing, measuring and recording the distance traveled and averaging the totals.
9. Finally, have teams remove the ATV and motorbike from the RV, and replace them with heavy weights. Once again, have teams propel the RV and average the distance traveled over three runs.

WRAP IT UP

Have teams complete their data sheets. Hold a class discussion in which teams report on their results. Students should explain why their RVs traveled different distances when empty vs. when full. Discuss their results in terms of fuel costs for lighter and heavier vehicles. Make sure students understand that fuel efficiency is related to the force needed to propel their RVs. Since the propelling force was always the same for each test run, how far their RVs traveled was an approximate measure of fuel efficiency.

EXTENSIONS

- Have students measure how far the RV travels on short pile carpet or other surfaces to study the effect of road friction on how far it travels. Do not change the mass of the vehicle but be sure to control the force applied.
- Have students use a scale to weigh the empty 2018 Hess RV, a partially filled RV, and a fully loaded RV. After multiple trials at each weight, have teams construct a graph to show the distance traveled in relation to the RV's weight. The graph could look something like the one shown to the upper left.
- To make a long elastic piece from rubber bands, insert one rubber band into another. Pull one end and tuck it through the other end as shown in the diagram. Pull the tucked end and the other rubber band to form a tight knot. Repeat the procedure to add rubber bands. Continue until all rubber bands are linked together.



Note: If using smaller rubber bands, link more together so that the elastic can be doubled if necessary to propel the 2018 Hess RV.

RV Fuel/Energy Efficiency Data Sheet

Fuel Efficiency Engineer ____________________

Fuel Efficiency Engineer ____________________

Fuel Efficiency Engineer ____________________

Fuel Efficiency Engineer ____________________

INSTRUCTIONS

You will be testing the fuel/energy efficiency of the 2018 Hess RV using three configurations. Fuel efficiency is also known as the number of miles per gallon a vehicle averages, or MPG. The configurations are as follow.

1. **Empty RV.** Remove the ATV and Motorbike from the 2018 Hess RV so that it is empty.
2. Following the instructions provided by your teacher, and use the rubber band elastic to propel the empty RV across the floor for your first run. Record the distance the RV traveled. Check only one of the boxes below to indicate you are calculating using inches or centimeters.

   ☐ **Inches** ☐ **Centimeters**

   Make two more runs and record the results each time. Add the three numbers together to obtain the total, then divide the total by three to find the average distance the empty RV traveled.
3. **RV with ATV and Motorbike.** Place the ATV and Motorbike back into their RV storage compartments. Repeat Step 1 using this new configuration, and record your results.
4. **Replace ATV and Motorbike with Weights.** Remove the ATV and Motorbike from their storage compartments in the RV. Replace the toys with heavy weights, marbles and other objects. Repeat Step 1 using this alternate configuration, and record your results. Average the distance traveled as before.
5. Explain your results on the back of this sheet, and answer the following questions. How do the final results for each configuration relate to the fuel efficiency of all vehicles (miles per gallon and operating costs)?

	Empty RV	RV with ATV and Motorbike	RV Only with Very Heavy Weights
Test Run 1			
Test Run 2			
Test Run 3			
Total			
Average Distance	______	______	______

CHALLENGE

Using the 2018 Hess RV as a model, plan for a 500-mile trip. If the empty RV gets 18 miles per gallon (MPG), how many gallons of gasoline will it take to complete the trip? If gas costs $2.79 per gallon, what will the trip cost?

Repeat your calculations assuming you are driving a fully-loaded RV that gets 12 MPG. How many gallons will it take for the same trip and what will it cost? Do your calculations on the back of this page.

3. Off-Roading: Angles and Slopes

The 2018 Hess ATV is based on an off-road vehicle—but it designed for fun on concrete, lineoleum, and smooth types of flooring. Avoid using on sand, mud or anything that might damage its inner workings.

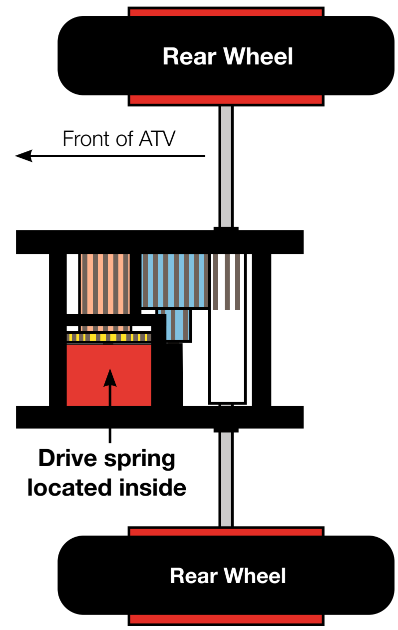
An actual ATV can be designed as a single driver vehicle with a powerful engine and large wheels with deep treads that provide traction on unpacked surfaces. Oversized fenders protect the driver from mud, water and sand spray kicked up by the wheels. A roll bar system over the cockpit keeps the driver safe during inevitable rollovers.

© Hess Corporation.

The 2018 Hess ATV has working head and taillights, red safety lights, and interior lights—but the most important part is its propulsion system. The ATV's pull-back motor uses a wind-up/gear system to store potential energy that converts to kinetic energy. Roll the ATV backwards several times on a smooth surface to wind the spring. While rolling backward, gears connected to the ATV's rear wheels capture the kinetic energy and step up the number of rotations to wind the spring. The ATV spring is fully wound, meaning that the spring has stored all the potential energy it can hold, when a clicking sound is heard. At that point, release the ATV. The spring will start unwinding, converting the potential energy back to kinetic energy, which is transmitted through the gears to power the rear wheels. This gives the ATV a fast start.

The gears are colored in the diagram (right) to make it easier to tell tell them apart. In the actual gearbox, all the gears are white in color. The important thing to know is that pulling the ATV backwards causes the gears to transmit kenetic energy to the red box where a coil spring is located. When the spring is tightly wound, it stores potential energy that is reconverted to kinetic energy that travels through the gears back to the ATV's rear wheels.

ATV Gear Box and Spring



(Bottom view)

This activity begins with a demonstration of how the ATV stores potential energy and converts it to kinetic energy Then, students will evaluate the 2018 Hess ATV's hill-climbing ability.

THE QUESTION

What is the maximum angle at which the 2018 Hess ATV can operate safely?

MATERIALS

Teacher (see "Potential/Kinetic Energy Demonstrator," p. 12)

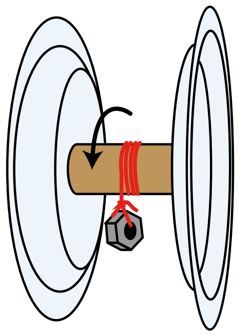
- 2 feet of string
- 2 stiff paper or Styrofoam™ dinner plates
- Center tube from toilet paper roll or paper towel roll
- Hot glue gun and glue
- Tape
- Weights, such as a large hex nut or several metal washers

Per student team

- 2018 Hess ATV
- 2 or 3 sheets of cardstock

Continued

Potential/Kinetic Energy Demonstrator



The 2018 Hess ATV's potential/kinetic energy propulsion system can be demonstrated with a simple rolling device, the Potential/Kinetic Demonstrator. Unlike the ATV's motor, this device does not have a spring to store potential energy. However, it effectively illustrates how kinetic energy converts to potential energy as it is rolled backwards (winding the string and raising the weight). It then illustrates how the potential energy converts back to kinetic energy when the demonstrator is released and it rolls forward.

1. Use hot glue to glue the ends of the paper tube to the middle of the plate bottoms, as shown in the illustration. This forms an axle. Be sure the tube ends are centered on the plates.
2. Tie one end of the string to the weight or weights.
3. Securely tape the other end of the string to the middle of the axle.
4. Place the completed demonstrator on a hard surface, such as a tabletop or tile floor. Roll the device along the surface so that the string winds around the axle and the weight is raised to the center.
5. Release the demonstrator. Gravity will pull the weight(s) down, causing the wheels to roll across the surface. If the demonstrator doesn't roll, add more hex nuts, washers or other weight to the string.

- Flat sheet of cardboard (approximately 2-ft x 3-ft, or used science fair display board
- Masking tape
- Protractor
- Stacks of books to elevate the cardboard

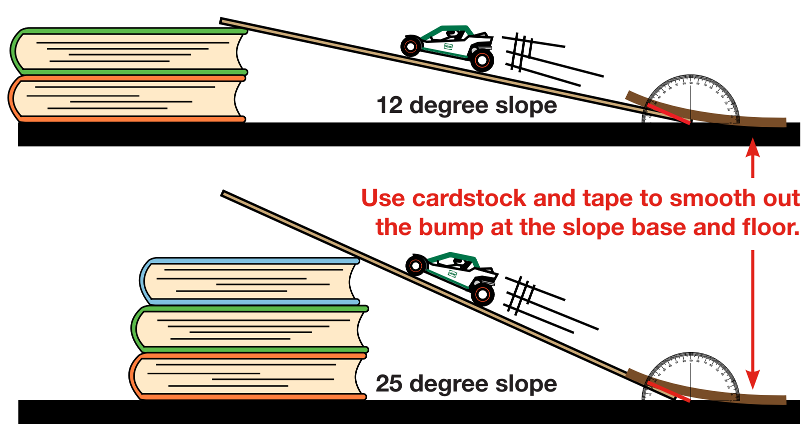
PROCEDURE

1. Use the Potential/Kinetic Demonstrator to illustrate how kinetic energy converts to potential energy (see "Potential/Kinetic Energy Demonstrator," above).

2. Distribute the 2018 Hess ATVs. Demonstrate how to wind up the toy. Allow teams a few minutes to practice and to explore some of the ATV's capabilities.

   TIP: To be fully wound, the 2018 Hess ATV must be rolled backward on a hard surface until a clicking sound is heard. Clicking means that the ATV spring then is fully loaded with potential energy. The spring can be wound using one long pull or by several short pulls. It is important to keep the rear wheels from spinning when the ATV is repositioned to the planned starting point. To prevent the rear wheels from turning, pull the car backward and then press a finger on one wheel to hold the wheels in place.

3. Challenge teams to determine what the highest angle of a slope that the ATV is able to climb. Place a stack of books on the floor and lean one end of the cardboard sheet on top of the stack (see illustrations below). This creates a "hill" or slope for the ATV. The slope angle can be adjusted by sliding the books toward or away from



Continued

the base of the slope. Instruct teams to tape cardstock to the base of the cardboard slope and the floor to smooth the bump where the floor and cardboard meet.

4. Have teams test climbing abilities by powering up their ATVs, and starting them from about a foot behind the bottom of the slope. Each team should test its ATV several times, adjusting the slope angle with each trial to determine the maximum angle that the ATV can climb. Every test should start from the exact same place. Have teams use a piece of masking tape to mark the starting line. During the tests, have teams use their protractors to determine the maximum angle of the hill slope the ATV can fully climb.

   Note: The ATV accelerates very easily on a smooth level surface. It only has to overcome its inertia (resistance to motion changes) to begin rolling. When climbing up an incline, the ATV has to overcome gravity acting on the ATV's weight as well. If the slope is too steep, the ATV will roll on to it but then stop because it is trying to lift too much of its own weight. This is one of the properties of inclined planes. The steeper the slope the more effort it takes to raise the ATV. Think of how it feels when walking uphill. A gentle slope is easy. A steep slope takes lots of effort.

WRAP IT UP

Ask student teams to report on their results. Is there agreement among teams about the maximum slope angle that the ATV can climb? If teams were writing a safety manual for the ATV, what angle should they recommend as the maximum safe slope (e.g., average angle? highest angle? lowest angle?) Discuss their ideas about ATV safety. Ask, "What is the highest angle that is safe to climb without accident?" "What angle do you think the ATV manufacturer should include in the manual for safe operation, to avoid lawsuits?"

EXTENSION

- Ask teams to explain why the ATV stops part way up the slope when the angle is too great. Why doesn't the ATV roll backward?

  Note: The momentum of the ATV approaching the hill enabled it to start the climb. However, there isn't enough kinetic energy in the spring to carry the ATV to the top because it has to carry some of its weight to do so. This causes, the ATV to stop. Rolling backward would have started the spring winding again, thus propelling the ATV forward. Instead, the ATV reached a point of equilibrium wherever it came to rest on the slope. The remaining kinetic energy was not enough to push it further uphill, but there was too much potential energy remaining in the spring to permit the ATV to roll down. Students should have noticed that when they plucked the ATV from the middle of the slope, the wheels began spinning again as the last of the potential energy stored in the spring was used up.

- Ask if any team tried this investigation by starting the ATV in the wheelie position. What happened? If any teams haven' tried this, have them do so and observe if the climbing results are different.

  Note: To do a wheelie, the ATV drive system should be fully charged with potential energy. Set the ATV down on just its rear wheels and release. ■

4. Gearing Up For Motorbike Racing

The 2018 Hess Toy Truck Motorbike is based on a multifunction motorcycle design suitable for urban street conditions, cross-country touring, and to a limited extent, off roading. The toy runs best on smooth, level surfaces and should not be used on sand or dirt that could damage its inner workings.

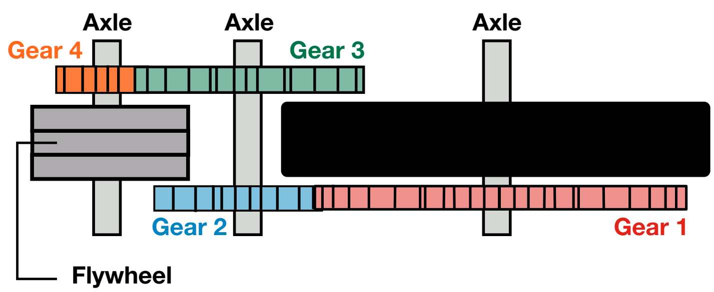
© Hess Corporation.

The 2018 Hess motorbike has an interesting power system. There are no windup springs or electric motors inside. Instead, it is powered by a geared flywheel. To work, the motorbike is pushed forward over a flat surface while being held. Friction with the surface causes the both wheels to spin and gain kinetic energy. The rear wheel is connected by internal gears that increase the rotation rate and transfer the kinetic energy to the flywheel, which spins very rapidly. When the motorbike is released, the kinetic energy of the flywheel is transmitted back to the motorbike's rear wheel, propelling the motorbike forward and making a motor-like whining sound.

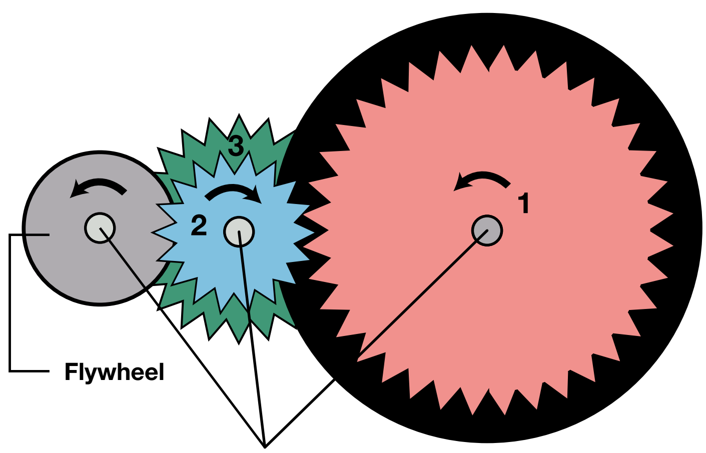
As indicated in the illustration to the right, the motorbike's gears are arranged in two step-up systems. The rear wheel is directly connected to Gear 1 along the rear wheel axle. Pushing the motorbike to the left causes the wheel and Gear 1 to rotate counterclockwise. The teeth of this gear mesh with the those of Gear 2 (blue). Gear 1 has 36 teeth. Gear 2 has 18 teeth. With every single rotation of Gear 1, Gear 2 rotates twice. Thus, the gear arrangement "steps up" (doubles) the rotational speed from Gear 1 to Gear 2.

As you can see, Gear 2 (blue) is directly connected to Gear 3 (green) by the axle. As a result, Gear 3 also rotates twice with each rotation of Gear 1. Gear 3 has 20 teeth which mesh with Gear 4 (orange, seen in "Bottom View"). Because Gear 4 has 10 teeth, it rotates twice for every rotation of Gear 3.

Bottom view



Side view



Gear 1 = 36 teeth
Gear 2 = 18 teeth
Gear 3 = 20 teeth
Gear 4 = 10 teeth (not shown in side view)

To summarize, each rotation of Gear 1 causes Gear 2 to rotate twice. Because Gear 3 rotates with Gear 2, it also rotates twice for each rotation of Gear 1. Two rotations of Gears 2 and 3 cause Gear 4 to rotate 4 times. Thus,

Continued

Gear Puzzle Answer Key (see Step 2)

1. **Counterclockwise.** Gear 1 rotates clockwise. This causes Gear 2 to rotate counterclockwise. Gear 2 causes Gear 3 to rotate clockwise. Gear 3 causes Gear 4 to rotate counterclockwise.

2. **Three times.** The large gear has 36 teeth. The small gear has 12 (one-third as many). Rotating the large gear once causes the small gear to rotate 3 times (36 divided by 12 equals 3 rotations).

3. **Two-thirds of one full rotation.** The small gear has 20 teeth. The large gear has 30. Rotating the small gear once causes the larger gear to complete 2/3 of a full rotation (20 divided by 30 equals 2/3 of a rotation).

4. **Clockwise.** Gear 1 rotates clockwise, which causes Gear 2 to rotate counterclockwise. Because Gear 3 is attached to Gear 2, it also rotates in a counterclockwise direction. Gear 3 causes Gear 4 to rotate clockwise.

5. **Nine times.** Gear 1 has 30 teeth; Gear 2 has 10. One rotation of Gear 1 causes Gear 2 to rotate 3 times (30 divided by 10 equals 3).

   Gear 3 is attached to Gear 2, so it also rotates 3 times. Gear 3 has 30 teeth; Gear 4 has 10. Thus, the three rotations of Gear 3 causes Gear 4 to rotate 9 times (30 divided by 10 equals 3 rotations).

Summary. Gear 1 causes Gear 2 to rotate 3 times. Gear 3 also rotates 3 times, causing Gear 4 to rotate 9 times.

this step-up system increases rotational speed 4 times, from a single rotation of Gear 1, to four rotations of Gear 4 (1 x 2 x 2 = 4).

There is one more part to this system. The axle for Gear 4 also holds a solid metal cylinder, known as a flywheel. The purpose of the step-up gear system is to rotate the flywheel very fast, thereby loading the flywheel with kinetic energy.

Note: Energy added to the flywheel is classed as kinetic because the flywheel is continuously spinning. This system differs from the system described in Activity 3, used to power the ATV, which stores potential energy by winding a spring. When the motorbike is released, the spin of the flywheel transmits its kinetic energy back to the rear wheel, accelerating the motorbike across the floor. After the motorbike has had a good run, possibly including a wheelie, friction brings it to a stop.

In this activity, students learn how to "power-up" and drive the motorbike across the floor. When students become accomplished drivers, teams race against each other across a measured course to determine a grand champion. The activity concludes with a puzzle requiring students to determine the rotational directions of gear systems, and calculate changes in rotational speeds through those systems.

THE QUESTIONS

How does the motorbike's gear system work, and who are the best "riders"?

MATERIALS

Teacher

- Clear area on a smooth floor (about 10-ft x 15-ft)
- Masking tape
- Meterstick
- Soft barriers to "catch" the motorbikes

Per Student Team of 4

- 2018 Hess Motorbike
- Copy of "2018 Hess Flat-track Motorbike Race" and "Qualification Heats and Final Results" pages
- Metersticks or tape measures

Continued

Per student

- Copy of the “Gear Puzzle” page (see Step 2)

Optional

- STEM kit with gears
- Treat or prize for the winning team

PROCEDURE

1. Use one 2018 Hess Motorbike to introduce the activity. Show the motorbike and demonstrate how it works, possibly by propeling it across a table.

   Tip: Identify a volunteer student to catch the motorbike, or set up foam or other soft barrier at the end of the table to ensure the bike is not damaged. Press the motorbike on the tabletop and quickly push it forward to spin the rear wheel. Let it go.

2. Discuss the STEM aspects of the motorbike: wheels, gears, friction, kinetic energy. Explain how gears are used to build up kinetic energy, which enables the motor bike to race across a smooth surface.

   Distribute copies of the “Gear Puzzle” page and have each student complete his or her own copy (see “Answer Key,” p. 15). If you have STEM kits with gears, let students work with the gears to learn more about the operation and advantages of using multiple gears. Illustrate the relationships between gear size, rotational speed and direction.

3. Divide the class into student teams of four. Have student teams practice “driving” the motorbike on a smooth tile floor. Through practice students will learn the best way to spin-up the motorbike engine to race it.

4. Inform student teams that the 2018 Hess Flat-track Motorbike Race is about to take place. Review the rules found on the “2018 Hess Flat-track Motorbike Race” (p. 17), to explain how the competition will work.

5. Draw a race score sheet on a white board (see “Qualification Heats and Final Results,” p. 18). Record team names and points each each team earns to determine the teams for the final race.

6. Have students compete in smaller and smaller groups until the groups are narrowed down to two. Conduct the final three races to determine the team winner.

WRAP IT UP

Have students discuss what they learned during the motorbike competition. What strategies did they employ to get the fastest, straightest rides?

EXTENSIONS

- Try running the races with the 2018 Hess Motorbike in wheelie mode.
- A single gear is a simple machine. Two or more gears working together become complex machines. Download *Simple and Complex Machines* (designed for use with the 2017 Hess Dump Truck and Loader), to explore ideas and hands-on activities. Free downloadable copies are available at:

  http://www.bioedonline.org/lessons-and-more/focus-on-stem/simple-and-compound-machines/

2018 Hess Flat-track Motorbike Race

Team Name

Racer 1 (Team Captain)

Racer 3

Racer 2

Racer 4

INSTRUCTIONS

1. As a team, create a team name, and pick a team captain. Record the information above.

2. After learning about how the 2018 Hess Motorbike gear system works, try driving the motorbike on a flat, smooth floor. Remember what you learned about “gearing up” for speed.

3. Continue to practice with the motorbike until your teacher tells you to stop.

MOTORBIKE RACING RULES

1. Your team will be competing in the 2018 Hess Flat-track Motorbike Race. This competition will consist of several qualification heats (races).

2. **Round 1:** You will pit your team against three other teams. The first rider in each heat to cross the finish line earns 3 points for his or her team. The 2nd place rider earns 2 points and the 3rd place rider earns 1 point.

   Regardless of the number of teams, no points are awarded to riders in 4th place or lower.

3. Your teacher will referee the race. Each team captain will record his or her team’s scores on the “Qualification Heats and Final Results” page. Be sure to share your team’s results with your teacher.

4. Once the first heat (race) is completed, team captains should have their teams proceed to the next heat, continuing races until everyone on each team has competed against each other.

   Note: If you have more than three or four teams, hold additional heats for the remaining teams so that all teams can compete in Round 1.

5. When all teams have competed Round 1, total the scores for each team. Select the two teams with the highest points. Team captains from the two teams will then select their best riders (highest points earned) from their respective teams to compete in the finals.

   Note: If there are several teams tied for the top slots, hold elimination matches to reduce the number of finalists down to two teams.

6. **Round 2:** The two riders will compete in three head-to-head heats. The team/rider that wins two or more races is the Grand Champion!

Qualification Heats and Final Results

Round 1

POINTS

	Team Name	Team Name	Team Name	Team Name	Team Name	Team Name	Team Name	Team Name
Heat 1 Racer 1								
Heat 2 Racer 2								
Heat 3 Racer 3								
Heat 4 Racer 4								
TOTAL POINTS	______	______	______	______	______	______	______	______

Round 2

	Team name	Team name
Heat 1		
Heat 2		
Heat 3		
TOTAL POINTS	______	______

Gear Puzzle

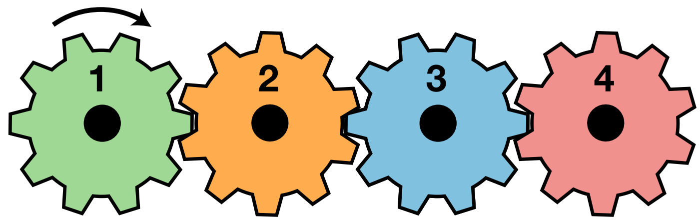
____
Mechanical Engineer

INSTRUCTIONS

Gears are a form of a complex machine. When two or more gears are side by side, they can accomplish work. Turning one gear causes the other gear to move. Gears can magnify force or increase or decrease rotation speed. Try to figure out what each gear set below accomplishes.

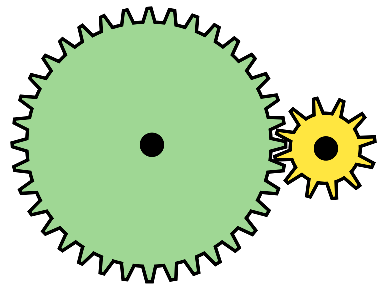
1. When Gear 1 turns clockwise, in what direction does Gear 4 turn?

____



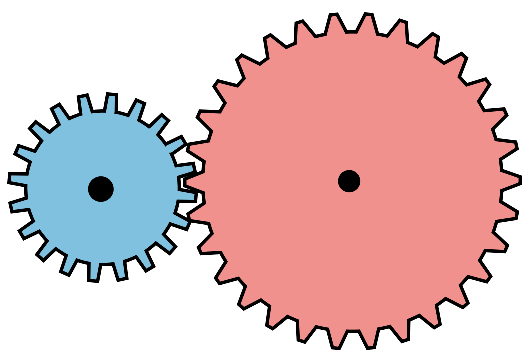
2. When the big gear rotates one time, how many times does the small gear rotate?

____



3. When the small gear rotates one time, how many times does the big gear rotate?

____

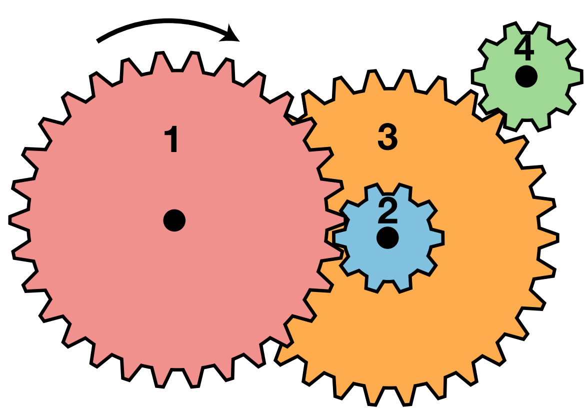


4. When Gear 1 rotates clockwise, in what direction does Gear 4 turn? (Hint: Gear 2 and Gear 3 are joined and rotate together.)

____

5. When Gear 1 rotates one time, how many times does Gear 4 rotate? (Hint: Gear 3 has 30 teeth.)

____



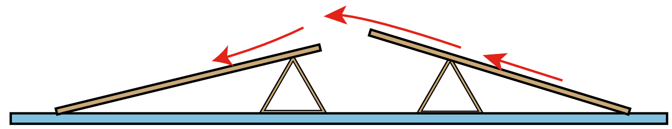
5. ATV: Design and Test an Obstacle Course

ATVs, or all-terrain vehicles, are an important category of recreational vehicle. They are fun, and provide relatively comfortable access to rugged, remote places that most vehicles cannot reach.

Though based on a real ATV, the 2018 Hess ATV is designed to be used only on hard surfaces and carpet. Damage may occur if it is run over sand or though water. The ATV fits into a large compartment at the back of the 2018 Hess RV. When the toy RV stops, its entire rear wall can be lowered to serve as an exit ramp for the ATV. Then, the fun begins!

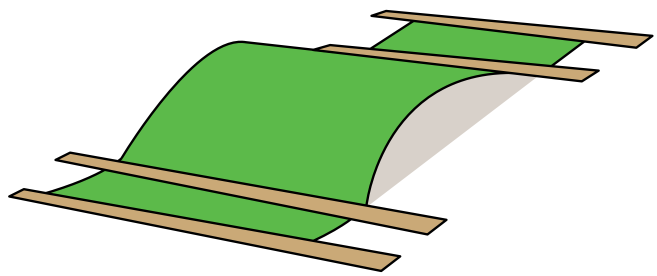
In this activity, student teams engage in an unusual ATV adventure. Rather than driving on an established ATV track, teams will design and construct their own trails with obstacles of their choice. They then will challenge other teams to drive each others' trails.

Construction Ideas



Cardboard Jump Ramp
Triangular-shaped supports made from folded cardboard

Cardboard or Cardstock Rumble Strips



Cardstock Hill

Cardboard Bridge

THE QUESTION

How can we design a challenging obstacle course for the 2018 Hess ATV?

MATERIALS

Per team of students

- Copy of "Design an ATV Adventure Trail" page
- Corrugated cardboard, used poster board, cardstock paper for constructing inclined planes
- Glue or tape
- Marker
- Masking tape
- Scissors or other cutting tools
- Clear floor space: 2-ft x 10-ft of floor space
- Variety of materials collected by teams for constructing their trails (no sand or fine particles)

PROCEDURE

1. Divide the class into teams. Introduce the ATV Adventure Trail project to the class. Explain that every team will design and construct its own ATV trail to challenge the driving skills of other teams. Once teams come up with a trail name, each team will brainstorm to come up with ideas for its trail. Once on paper, teams build the trail from materials provided, or items that they supply themselves.

Continued

2. Explain the rules for designing the ATV obstacle course.

   - The trail must be no larger than 2-ft x 10-ft.
   - There must be at least two bumps or other obstacles that will challenge an ATV. The trail may include as many bumps and obstacles as desired, but all features must be driveable. *If a team is unable to navigate its own ATV to the end of the trail, the trail is unacceptable and must be redesigned.*
   - The trail must be a straight line. No curves are allowed because the ATV toys do not have steering capabilities.
   - To be successful, an ATV must drive the entire trail, from one end to the other.

3. Distribute copies of the student sheet. Point out to students that each square on the design page represents an area of one square foot. Teams should list their trail challenges, and show where they will be placed. Possible trail challenges include low and high hills, ruts, bumps, bridges, jumps, etc. Materials requried to construct the trail also should be listed.

4. Review team designs for completeness and reasonable navigation.

5. Allow one or more class periods for teams to construct their trails. When the adventure trails are complete, have half of the teams invite the other teams to use their 2018 Hess ATV to drive their trails. Each member of the invited team should have a chance to try the trail. Reverse the process so that all teams have a chance to test all trails.

WRAP IT UP

Have teams show and describe their adventure trails to the class and discuss challenges they faced and the solutions they created to make their trails successful. Remind teams that their trails were required to feature two or more bumps or obstacles and be driveable from the start to the end to be successful. Have teams vote on the most challenging course.

EXTENSIONS

- Check the Internet for appropriate videos showing ATVs riding motocross courses. Some of the videos will have onboard cameras to give a driver's eye view of competitions. Be sure to check for inappropriate advertising or other content before showing the videos to your students. Search with the following terms "ATV" and "motocross." ■

Design and Test an ATV Adventure Trail

____

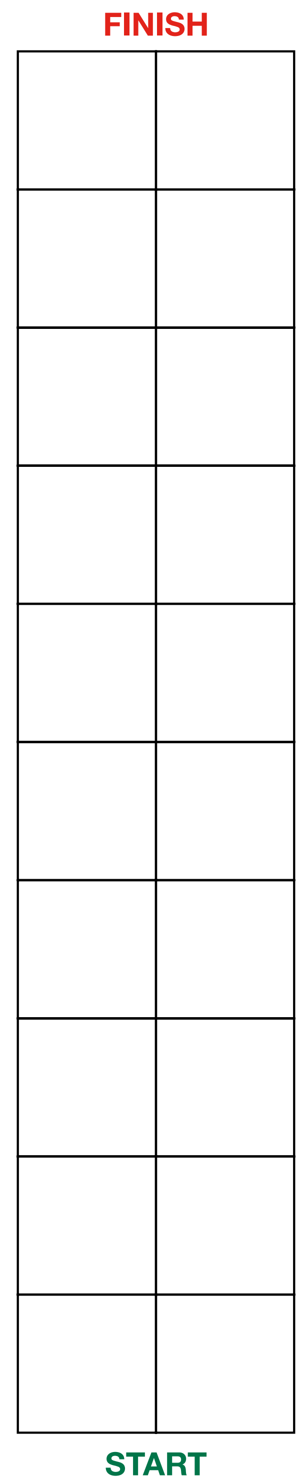
Trail Name

______________________________ Theme Park Designer

______________________________ Theme Park Designer

______________________________ Theme Park Designer

______________________________ Theme Park Designer



INSTRUCTIONS

Your team will design and construct a straight-line ATV obstacle trail. The actual trail must be no larger than 2-ft x 10-ft, and have at least two bumps or other obstacles on the course. To be a successful trail, the 2018 Hess ATV must be able to drive the entire trail from start to finish. A scaled, blank map to use for designing the trail is shown to the right. Each square on the map equals 1 foot. Once all trails are completed, all teams will test each others trails.

1. List the challenges you will build on your trail (below) and show on the map (right) where they will be placed.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

   f. ______________________________

   g. ______________________________

2. List the objects and materials you will need need to build your challenges.

   - ______________________________
   - ______________________________
   - ______________________________
   - ______________________________
   - ______________________________
   - ______________________________
   - ______________________________

6. Vehicle Stability: Two Wheels vs. Four Wheels

An ATV and motorbike provide RV owners with a lot of vacation versatility. When the RV reaches a campground, the two additional vehicles can be unloaded for adventures. An ATV enables a driver to explore the roughest forest and mountain roads. Depending on its style, motorbike allows a rider to zoom along local paved roads or uneven surfaces.

With the 2018 Hess RV with ATV and Motorbike, the ATV can drive over rough surfaces, but the motorbike runs best along a smooth surface. The ATV is a four-wheel-drive vehicle with a wide wheel base for forward and lateral stability that helps to prevent it from flipping or rolling over. In the real-world, even when ATVs have the protective roll cage, rolling is dangerous for drivers and can damage the ATV.

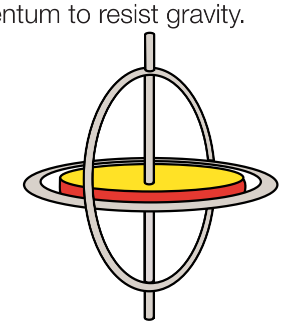
© Hess Corporation.

Being a two-wheeled vehicle, a motorbike doesn't have four-wheeled stability like an ATV. When standing still, it will fall over if it is not supported. That is why most motorbikes have a kickstand. Resting on an extended kickstand, the bike leans over slightly, but remains upright. When the motorbike is in motion, the kickstand is folded up away from the street surface. The 2018 Hess Motorbike's kickstand consists of two small fixed downward pegs on the underside lid of the battery compartment. Because there are two pegs, the motorbike can lean to the right or the left and remain upright.

When a real motorbike is moving, stability is accomplished by the gyroscopic action of its spinning wheels. A spinning wheel resists changes to the plane along which the wheel is spinning. For a simple example of this effect, roll a coin across a table top. The coin remains upright as long as it is rolling (spinning). When it stops rolling, the coin flops over due to the effects of gravity. This effect of gyroscopic action makes it easy to remain upright while riding a bicycle or a motorbike. When the 2018 Hess Motorbike is in motion, its spinning wheels keep it stable by serving as gyroscopes. When the bike is stopped, however, that stability is gone. That's where the kickstands become handy.

Scientists refer to the rotational properties of a spinning wheel as angular momentum. Angular momentum is a product of the wheel's rotational inertia, multiplied by its rotational velocity. Isaac Newton's Law of Inertia (First Law of Motion) states that objects at rest tend to remain at rest, while objects in motion tend to remain in motion unless acted upon by some external force. In terms of the Hess Motorbike, this means that once its wheels are rotating, they will continue to rotate along the same plane unless an external force (leaning by the rider to one side or ther other) changes the orientation of the plane.

Such a change in rotational direction brings Newton's Third Law of Motion into play. A modern statement of this Law is that every action force is accompanied by an equal and opposite reaction force. When the motorbike's wheels are not rotating, they have no angular momentum to resist gravity. Therefore, the motorbike tips over easily. As long as the wheels are rotating, angular momentum serves as a reaction force to keep the moterbike upright.


Toy Gyroscope

Angular momentum can easily be felt when working with an actual

Continued

gyroscope. This activity allows students to investigate the stability of the motorbike and the ATV, and includes optional plans to make two different types of gyroscopes for observations.

THE QUESTION

Which vehicle, the 2018 Hess ATV or the Hess Motorbike provides the greatest stability and why?

MATERIALS

Per team of students

- 2018 Hess ATV and Motorbike
- Books to elevate one end the cardboard sheet to form an inclined plane
- Copy of “Stability: 2 Wheels vs. 4 Wheels” (p. 26)
- Protractor
- Sheet of cardboard such as a used science fair

Optional

- Inexpensive toy gyroscopes
- To make two different types of gyroscropes, refer to “Demonstration Gyroscopes” (Step 8, and p. 27)

PROCEDURE

1. Distribute copies of “Stability: 2 Wheels vs. 4 Wheels,” page so teams can take notes as they conduct the investigation.

2. Have teams investigate the maximum slope at which the ATV can remain on all four of its wheels. In other words, at what angle is the slope too great, causing the ATV to flip over? Designate one student from each team to hold the cardboard sheet; another to measure the slope angle with the protractor; a third student to record the angles; and a fourth student to place and catch the ATV.

   Note: This part of the activity is similar to Activity 3, but it goes beyond in that teams determine the destruct mode. At what slope angle does the ATV lose all stability and flip over? (This is what the ATV safety roll bar is for.)

3. Instruct teams to begin with their ATV pointing uphill. Remind students who are placing the ATV on the cardboard sheet that the rear wheels need a small amount of winding to prevent the ATV from rolling back down the slope. The internal spring motor system will keep the ATV in place until the maximum angle is found.

4. The student holding the cardboard sheet should gradually tilt the cardboard upward (increasing the angle) until the ATV flips backward. The student with the protractor should measure the angle at that moment and call out the number for the team’s recorder.

5. Repeat the procedure for the ATV when it is sideways on the slope as if it is being driven across the slope.

6. Have teams review their results and recommend the maximum safe angle at which the ATV can climb a hill or traverse around inclined terrain. Discuss the concept of safety margins. If the ATV tips over at 75 degrees, what should the safety margin be? 60 degrees? 50 degrees? Have the students decide but be prepared to justify their decision.

7 Repeat steps 2–5 for the motorbike. The motorbike does not have a spring motor system like the ATV. Consequently, the motorbike can roll forward or backward and will not remain on the slope. Have students spin the motorbike’s flywheel motor and then place it on the incline. Have them observe the motorbike’s stability while climbing different slope angles. The flywheel system doesn’t need to be spun up for checking across the slope stability.

8. Make one or more gyroscopes to demonstrate how angular momentum makes rotating wheels stable (see “Demonstration Gyroscopes,” p. 27).

WRAP IT UP

If you obtained gyroscopes for this activity, have students describe what they felt when the gyroscope wheels were spinning and they used a force to change its rotational plane (action/reaction).

If you made a bicycle wheel gyroscope, ask what happened when the spinning wheel was supported from one handle (the wheel turned). This is what happens when a motorbike rider leans from one side to the other. It causes the motorbike to turn. The same effect applies to riding a bicycle.

EXTENSION

- Student drivers may notice that the 2018 Hess ATV, as well as the Motorbike, are capable of doing wheelies. To do a wheelie with the ATV, fully wind the spring motor and tilt the ATV backwards, then set it down on its rear wheels and release. It will travel some distance before the front end drops to the road surface. The Motorbike's flywheel engine has to be spun up and then placed on the road surface with its front wheel off the ground. It too will travel some distance before the front end drops. Sometimes, the toy does a wheelie on its own if it is not set down with both wheels touching the road surface the same.
- Have students try to balance the ATV on its two rear wheels and the Motorbike on its rear wheel without first powering the engines. Will the vehicles balance? Students will discover the answer is no. Both vehicles have too much mass toward their front to be able to balance. However, when the vehicles are powered up, their rear ends race along preventing the front ends from landing. When the vehicles begin to slow because they are running out of kinetic energy, the rear ends no longer keep up and the front ends drop.
- Have students conduct research on the Internet to explore other uses for gyroscopes besides helping to stabilize a motorbike while the wheels are rotating.

Stability: 2 Wheels vs. 4 Wheels

Toy Designer ________________ Toy Designer ________________

Toy Designer ________________ Toy Designer ________________

INSTRUCTIONS

Your team will operate as toy designers. Your job is to test the stability of two toy vehicles to ensure they work properly before they are mass produced and sold on the market. Follow the steps below and record your answers in the boxes. If you need more room, use the back of this sheet.

2018 Hess Motorbike: 2 Wheels

1. Place the motorbike on a table top and stand it upright. Is it stable? Describe how it stands up.
2. Can you balance the motorbike on just its two wheels? Why or why not?
3. Spin the wheels by pressing the wheels onto the table top and move it quickly in a straight line. Let it go. Is it stable? Why or why not? Describe.

2018 Hess ATV: 4 Wheels

4. Place the ATV on a table top and stand it upright. Describe how it stands up below. Is it stable?
5. Place the ATV on one end of a sheet of cardboard, with its nose pointing at the other end. Tilt the other end of the cardboard to make a slope. Gradually tilt it to make a steeper angle. At what angle does the ATV fall backward, flipping over? Describe.
6. Place the ATV sideways on the cardboard sheet and tilt the cardboard up. At what angle does the ATV rollover? What is the recommended angle for the steepest slope the ATV should climb without rolling over?

7. Describe the different ways the motorbike and the ATV achieve stability.

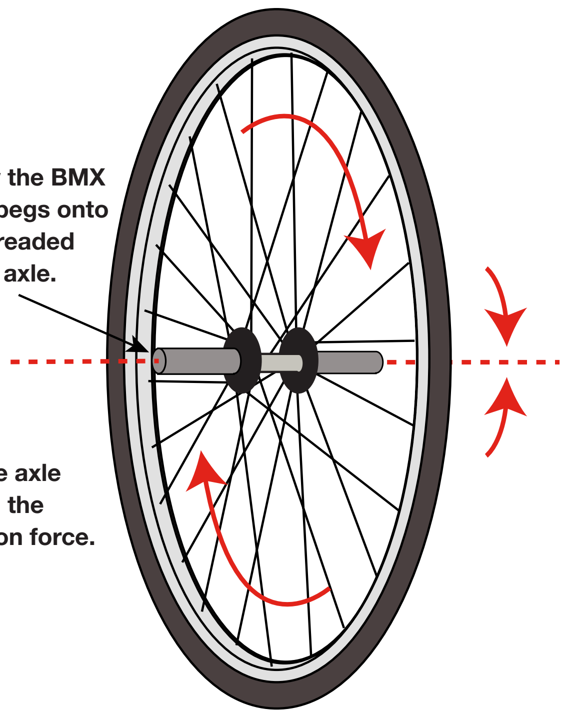
Demonstration Gyroscopes

There are two easy ways make simple gyroscopes with used CDs (right). A larger and more dramatic gyroscope can be made from a bicycle wheel (left). Toy gyroscopes also work well for demonstration the stability principle. Start with the wheel still and have students feel how easy it is to tilt and turn the gyroscope. Next, spin the gyroscope as fast as possible and have students feel the action/reaction forces when they try to tilt and turn the gyroscope.

Bicycle Wheel Gyroscope

Materials

- 2 bicycle BMX stunt pegs from a bicycle shop
- Bicycle front wheel from old bike, or a used wheel from a bicycle shop



This is actually very easy project to do. First, you need to obtain the front wheel from a bicycle. Someone you know probably has an unused beginner bicycle or an old bike no longer needed. Remove the front wheel from the bicycle by loosening the nuts holding the threaded wheel axle on the fork. Take the two stunt pegs and screw them onto the threaded axle—done!

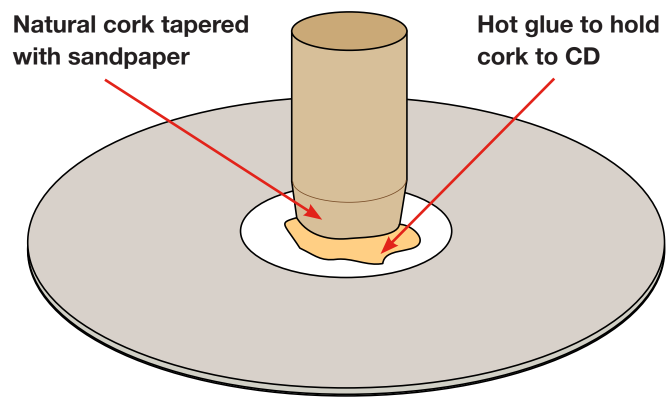
While holding the two stunt pegs (now handles), have a volunteer spin the bicycle wheel very rapidly. Tilt the handles from side to side with an action force and feel the reaction force resisting it. Try spinning the wheel again and support it just by one handle. Feel how the wheel tries to turn around your supporting hand. Compare this to what happens when the wheel is not spinning.

CD Gyroscope

Materials

- 1–3 old CDs
- Natural cork stopper, sand paper and hot glue OR a #1 solid rubber stopper and a flat-headed push pin

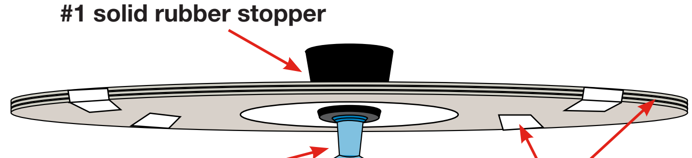
The CD gyroscope can be made from a single CD. As an interesting experiment, tape two or three CDs together to increase the mass of the disk. How will this affect the performance of the CD gyroscope?



Natural cork with one CD

If using the natural cork, taper one end with sand paper so that it fits into the hole of the CD. Secure it with hot glue.

If using a rubber stopper (see illustration below), push it into the CD hole and twist to hold it with friction. Push the push tack into the bottom of the stopper. Twirl the upper end of the stopper to spin the CD on a smooth, level surface. Observe how the spinning CD is stable along one plane (until friction slows and stops the spinning).



7. RV: Custom Designing Interior Spaces

A typical RV has space for a living compartment behind the driver's cab. There is a wall behind the seats with a passage way leading to the rear. The size of this space is based on the overall size of the RV. In the U.S., individual states set laws specifying the maximum size of RVs that can operate on their highways. There are small variations from state to state, but generally RVs can be no larger than 8.5 feet wide, 40 feet in length, and 13 feet in height. In life-size dimensions, the 2018 Hess RV would be approximately 8.5 feet wide, 28 feet in length, and 12 feet in height.

© Hess Corporation.

The 2018 Hess RV has a bulkhead wall that separates the driver's cab from the space allotted to the motorbike. A second bulkhead wall separates the motorbike space from the allotted space for the ATV. The driver's cab and the space directly behind it is a little bit under one third the entire length of the vehicle. In the 2018 Hess RV, this space is not accessible because it contains electrical components that make the toy's lights work. In a true-to-life version of the Hess toy, this space would be accessible and the area behind the seats available for a variety of uses. Allowing for the thickness of the walls of a life-size RV, the space between the driver's cab seats and the bulkhead separating the motorbike compartment would be 7.5 feet wide, 5 feet in length, and 7.5 feet in height.

In a full-size RV, this space could be used for living quarters, or for storing camping gear, luggage, or something else. Depending on the chosen purpose, this space could be designed and fitted with shelves, furniture, appliances, bedding, etc. Equipping the interior to fit specific needs provides an interesting engineering challenge.

THE QUESTIONS

What should the vacant space immediately behind the 2018 Hess RV's cab seats be used for, and what features should it contain?

MATERIALS

Per team of students

- 2018 Hess RV
- 4 copies of "Designing Efficient Interior Living Spaces"
- Ruler
- Pencils or markers for each team member

PROCEDURE

1. Have teams work together to examine the 2018 Hess RV and measure its size: width, length, and height. The RV's scale is 1 inch on the RV equals 2.5 feet on the real vehicle. Teams should multiply their measurements (in inches) of the toy RV by 2.5 to obtain the size (in feet) of a real RV. For this activity, have students round the dimensions. Answers are provided below.

   2018 Hess RV
   Width = 3.5 inches
   Length = 11 inches
   Height = 4.75 inches

   Calculated Dimensions
   Width = 8.75 feet
   Length = 27.5 feet
   Height =11.875 feet

   Rounded Dimensions
   Width = 8.5 feet
   Length = 28 feet
   Height = 12 feet

   Point out and describe the size of the vacant space

Continued

between the cab seats and the bulkhead (wall) of the Motorbike compartment. Write the usable dimensions of this space on the board (dimensions allow for wall thicknesses).

Vacant Space

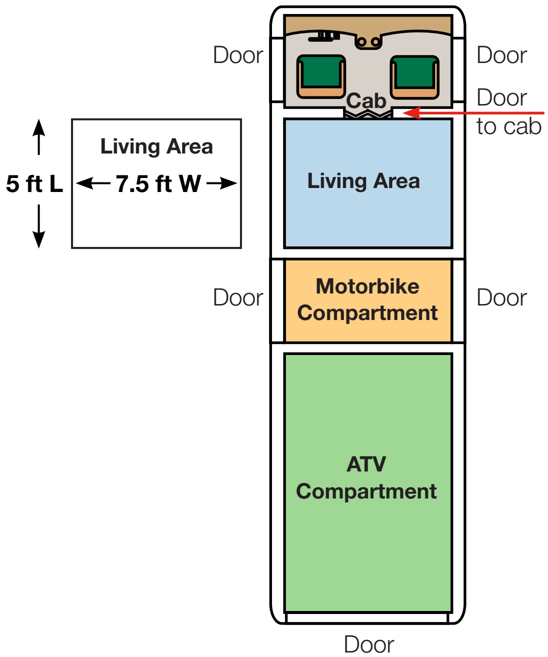
Width = 7.5 feet

Length = 5 feet ("Living Area")

Height = 7.5 feet

The diagram below shows the general floor plan of the 2018 Hess RV.

Model RV Interior Layout



2. Tell teams that they must decide on a use for this living area, and then design the interior to serve that purpose. What features (furniture, appliances, bins, shelves, etc.) will be needed? Students can view motorhomes being offered for sale on the Internet to get ideas about the possible function, features and interior design of the vacant space for their Hess RVs.

3. Each team should draft a floor plan of its design. Teams also may wish to make 3D side view sketches of their interior designs (see illustration, p. 30).

4. Have teams present their design ideas, floor plans, and sketches to the class. If possible, scan team drawings and insert them into presentation software, such as PowerPoint® or Keynote®.

WRAP IT UP

Discuss challenges that arose while teams were deciding how to use the space and design the interior. Did they have ideas for space-saving features (fold-up furniture, multifunction storage, inflatable furniture, etc.)? Was there any discussion of lighting, outlets, etc.? Challenge students to identify ways in which they applied science, technology, engineering, and mathematics (STEM) to their designs.

EXTENSION

If time is available, have teams construct 3D models of their designs. Their models and the features they place inside can be much larger than what would be possible in the 2018 Hess RV. Rectangles of cardboard or poster board can be cut and taped together to model the vacant space, and then filled with appropriately sized "furniture" or other items.

Models should be built to scale. Using the dimensions from Step 2, the model should have the same proportions (5 feet width, 7.5 feet in length, 7.5 feet in height). Have teams calculate the floor space and the total volume available for the amenities they put inside.

Floor area = Width x Length

Volume = Width x Length x Height

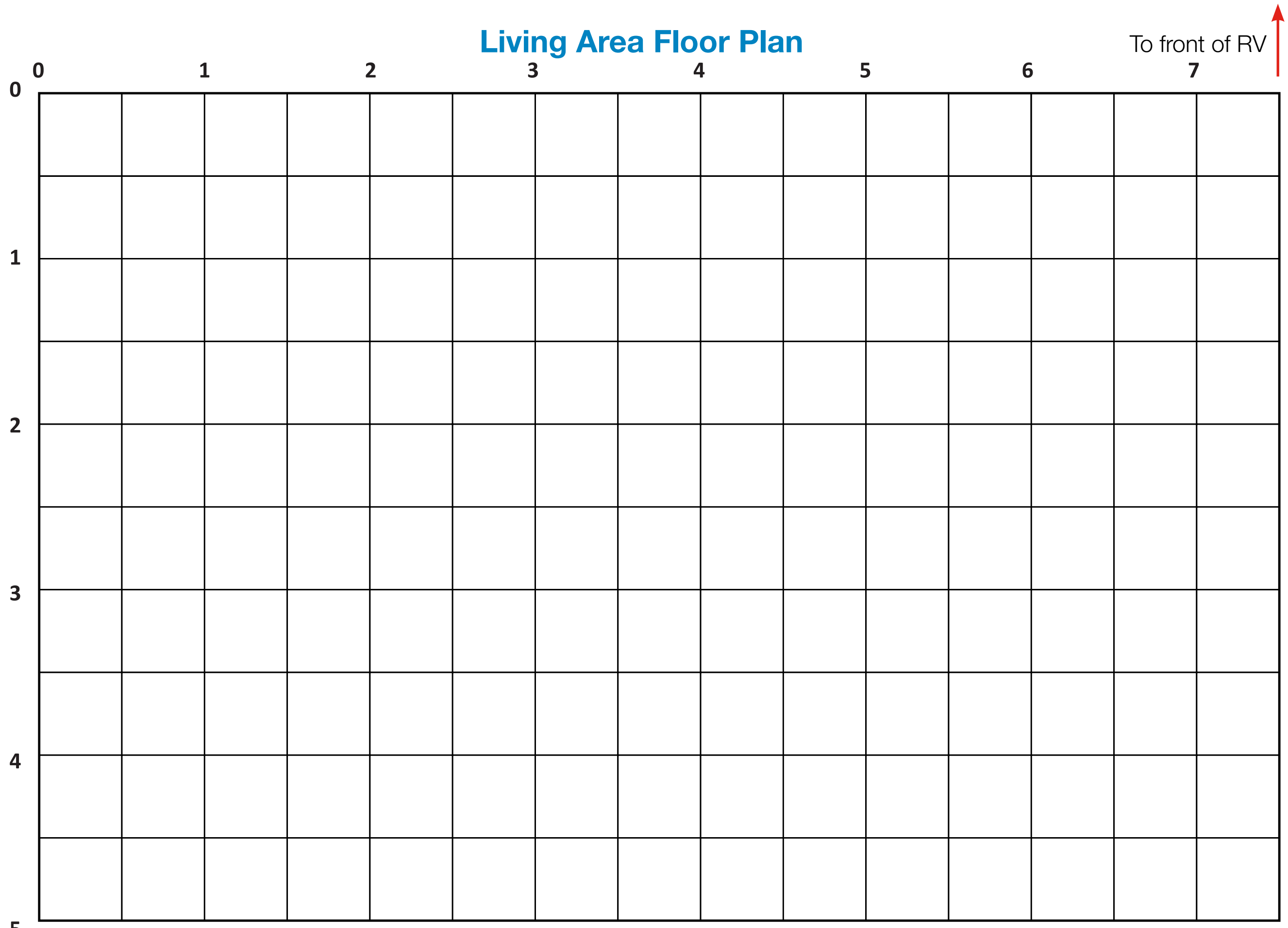
Teams should also calculate the scale of their model. What does 1 inch on their model equal in real life?

When teams are ready, have them present their ideas to the rest of the class. They should show their models and talk about its virtues. If students have skill with presentation software, such as PowerPoint® or Keynote®, they can make their that way.

Designing Efficient Interior Living Spaces

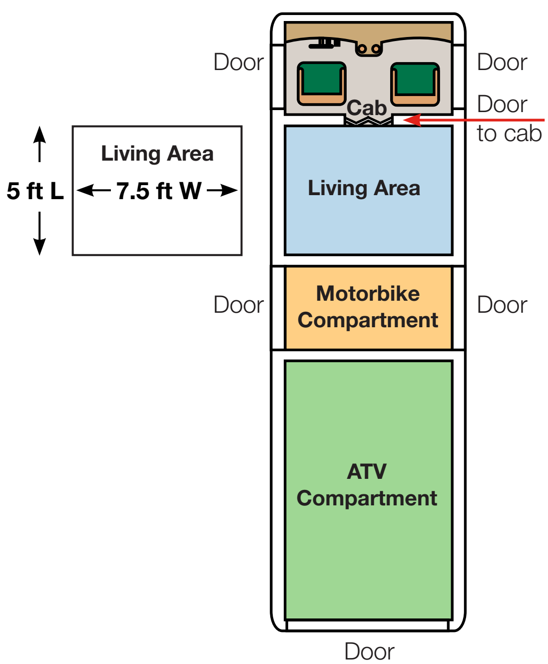
Team Name

Living Area Floor Plan

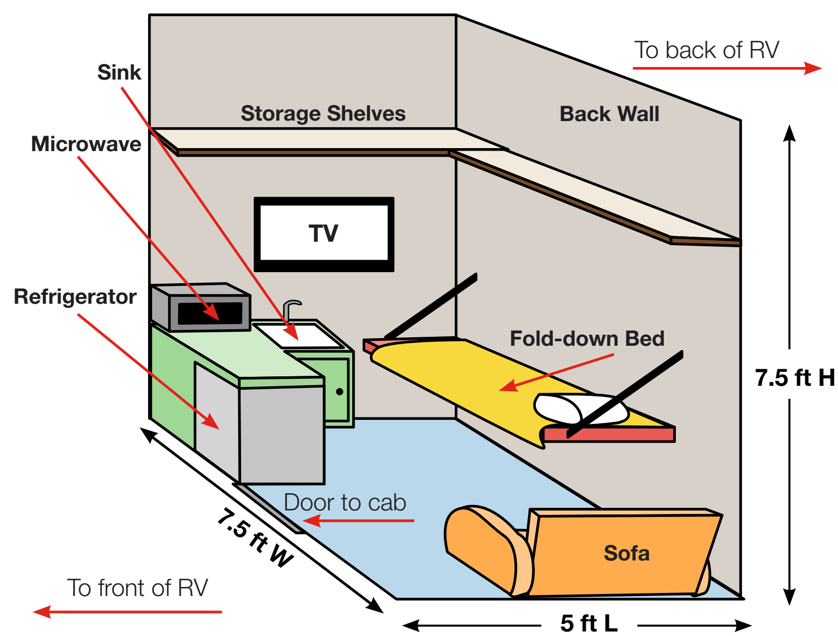


Scale: Each square represents 6-in. x 6-in.

Model RV Interior Layout

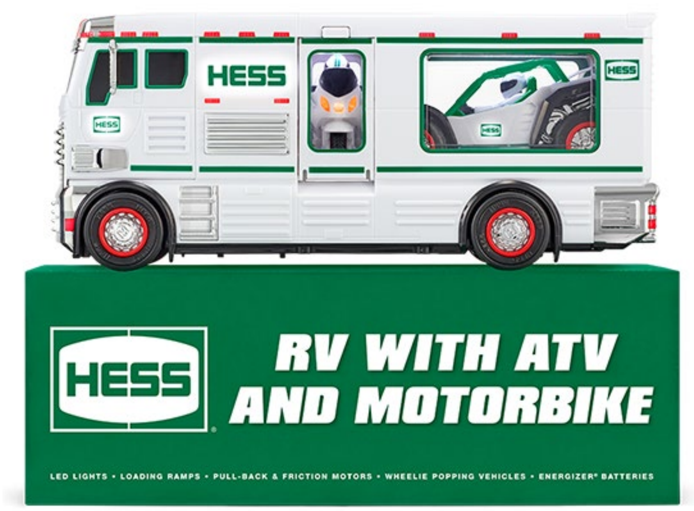


Cut-away of Model Living Area



8. Online Ad Campaign: 2018 Hess RV with ATV and Motorbike

While less common than automobile dealerships, there are recreational vehicle dealers across the country, often located at the edges of cities, where the open road begins. RV dealership lots are packed with motorhomes and trailers of many sizes, makes and costs. Depending on option packages, basic trailer-type RVs might cost $10,000 to $30,000. Large, fully equipped RVs (full motorhomes) can cost well over $200,000. The most luxurious models, custom built to meet individual needs and specifications, can cost far more. RVs are big business!



© Hess Corporation.

The 2018 Hess RV with ATV and Motorbike combines design features of a small motorhome with the convenience of built-in compartments for vehicular storage. This is different from standard RVs where an ATV and/or motorbike must be towed by the RV using a separate trailer. The interior space offers custom options for individuals and families.

In this activity, students will act as marketers and web designers as they create an Internet web page promoting the new 2018 Hess RV with ATV and Motorbike. (The advertisement won't be an actual Internet website but a simulated website using presentation software such as PowerPoint® or Keynote®.)

THE QUESTION

Using the 2018 Hess RV with ATV and Motorbike as a model for an actual RV, how should it be described and marketed to entice potential customers via a web page?

MATERIALS

Per team of students

- 2018 Hess RV with ATV and Motorbike
- Cell phone with camera
- Computer access to presentation software, such as PowerPoint® or Keynote®, and for research on the Internet

Option (see Step 4, p. 32)

- Art supplies, including colored markers and paper
- Calculators
- Glue and tape
- Large sheets of paper to make newspaper-sized ads
- Scissors

PROCEDURE

1. Divide the class into teams.

2. Explain that each team will roll-play as the advertising department of an RV superstore. Each team will design an Internet ad announcing the store's special deal on a 2018 Hess RV with ATV and Motorbike. The objective is to convince customers to visit the store and purchase the RV.

3. Hold a class discussion to identify key elements to be included in advertising and building a website (see "The 4Ps of Marketing," p. 32). List student ideas on the board. Possible questions to ask include the following.

    - What is the name of the Supercenter?
    - Opening day? Hours?
    - How will students describe and illustrate the 2018 Hess RV with ATV and Motorbike? What features and benefits should be emphasized?

Continued

The 4Ps of Marketing

A marketing strategy, the 4Ps of Marketing often are used to plan for a successful new product offering.

P = Product
What is a good description of the product? What makes it unique? Keep the description short and to the point.

P = Price
How much should we charge the customers for this product? What is included in or with the product—or not—such as batteries, gift message, product box, shipping box, shipping charges, etc.)?

P = Promote
How should the product be promoted or advertised? Promotion includes things like advertising, social media and email marketing, video marketing, etc.

P = Place
Where should the product be sold? Today, even if a product is not actually sold on the web, often potential clients are engaged there first. What will make a client come to the store? Location?

- How much will the RV cost? The manufacturer's price is $32,995. The RV Supercenter must add to that price in order to pay for expenses such as employee salaries, building costs (electricity, water, heating, furniture, etc.), product shipping to the center, and still make a profit for the Supercenter to flourish.

4. If students are not familiar with programs such as PowerPoint®, Keynote®, or other presentation software, demonstrate the software's basis functions and acquaint teams with how to create an advertisement on the slides. Permit each team to design/create up to three slides for its ad. If students have the required skill set, encourage them to use background music and videos. Students can write scripts for the narrators to read.

   Option: As an alternative to simulated Internet websites for their supercenters, students can use large sheets of paper and art supplies to create full-page newspaper ads.

WRAP IT UP

When teams have completed their advertisements, have them present their ads to the rest of the class. Point out the good features of each advertising teams presentation.

EXTENSION

- Most people take out a loan to buy expensive items such as cars, boats, etc. Have students calculate the total cost for each RV purchase including loan interest. Using $32.995 as the base cost, what might the final cost be, and how much would the monthly payments come to? How many years will it take to pay off the loan? (The Internet has many loan interest calculators, offered by banks and various loan companies, that can be used to calculate monthly payments and the total cost of the loan.)
- Have each marketing team present its ad to students in a different class. Base on a show of hands, determine which team's advertisement is most convincing. Would the student "audience" be most likely to purchase a 2018 Hess RV with ATV and Motorbike from the RV Supercenter or elsewhere?

GLOSSARY

4Ps of Marketing — The 4Ps of Marketing is a strategy often used to plan for a successful new product offering.

Angular Momentum — Momentum is the product of the mass of an object times its velocity in a straight line (linear). Angular momentum is the rotational equivalent of linear momentum.

ATV — Acronym for All Terrain Vehicle.

Center of Gravity — The balance point of an object.

Center of Mass — The point of an object where its mass is evenly distributed so that the object is able to balance.

Centrifugal Force — A motion- based effect that feels like an outward pulling force when an object moving in a straight line is made to follow a curved path. Inertial, pseudo or apparent force.

Complex Machine — A collection of two or more simple machines that work together for a common purpose.

Elastic — A material that can change its shape and back.

Flywheel — A massive spinning wheel or disk used for storage of kinetic energy.

Force — Any interaction which, without interference, changes the motion of an object; has both magnitude and direction.

Friction — Force resisting motion or movement.

Gears — A set of wheels and axles that have teeth to interlock with each other to transmit force and movement.

Gravity — An attractive force acting between all matter. The magnitude of this force acting between objects decreases with distance.

Inclined Plane — A simple machine with a sloped surface or ramp for moving objects. Roads climbing or descending hills are inclined planes.

Inertia — The property of matter to remain at rest or in motion unless acted upon by an unbalanced force.

Kinetic Energy — The energy an object possesses due to its motion.

Marketing — Promoting and selling and distributing products or services. May include moving goods from producer to consumer.

Mass — The amount of matter contained in an object.

Mechanical Energy — Energy in motion. Also known as kinetic energy.

MPG — Acronym for Miles Per Gallon; a measure of the energy efficiency of vehicles.

MPH —Acronym for Miles Per Hour; the number of miles a moving vehicle travels in 1 hour.

Momentum — The product of the mass a moving object multiplied by its velocity, e.g., a heavy truck is harder to stop than a lightweight car traveling at the same velocity because its momentum is greater.

Newton's First Law of Motion —Objects at rest and objects in motion stay at rest or in motion unless acted upon by an unbalanced force.

Newton's Third Law of Motion — For every action there is an opposite and equal reaction.

Potential Energy — The energy possessed by an object due to its position (elevation), interior stresses (wound spring, stretched rubber band, etc.), electric charge, etc.

Propel — To push something forward.

Protractor — A measuring device for determining angles.

RV — Acronym for Recreational Vehicle.

Slope — A surface where one end or side is at a higher level than another; a rising or falling surface. The angle of an inclined plane with respect to the horizontal.

Simple Machine — A mechanical device that changes the direction and (or) the magnitude of force; in general, six simple machines as defined by Renaissance scientists; in combination may be used to make compound machines.

STEM — Acronym for Science, Technology, Engineering and Mathematics

Volume — The amount of space solids, liquids, or gas take up.

Weight — The force of gravity acting on an object. Weight is usually measured in ounces and pounds.

Wheel and Axle — A simple machine consisting of a circular disk and a shaft about which the disk rotates.