HESS

Science of Speed

STEM Activities with the Hess Flatbed Truck with Hot Rods

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Baylor College of Medicine

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Contents

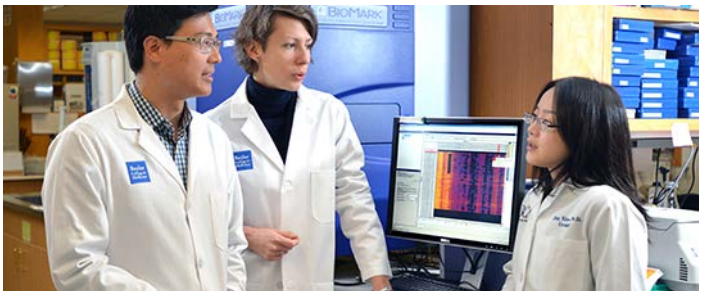
ORDER OF ACTIVITIES AND HESS TOY AVAILABILITY

- The order of the activities may be changed if it will create a more logical progression for the classroom.
- The 2022 Hess Flatbed Truck with Hot Rods is available at www.hesstoytruck.com while supplies last.
- Activity guides for Hess trucks for years 2016 – 2022 are available on the Baylor College of Medicine Bioedonline.org website.

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 other leading healthcare and research institutions. This concentration of expertise has helped support the development of collaborations that advance every aspect of the college's mission.



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With nine affiliated teaching hospitals and partnerships with major institutions, including 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 #20 in the nation among all medical schools based on NIH funding. Twelve departments rank in the top 25, including a ranking of #1 in genetics. US News & World Report Best Medical Schools ranks Baylor in all six program specialty categories, including #1 among medical schools in Texas, #22 among the nation's research-intensive schools, and #16 in the nation for primary care.

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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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BioEd Online℠ and SuperSTAAR℠ 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. At Hess, social responsibility (SR) means maintaining the highest standards of corporate citizenship as we work to deliver the energy the world needs—energy that is fundamental to advancing economic progress and improving living standards. SR, which is one of the six Hess Values, is foundational to the culture of our company and to our engagement with the communities where we operate; it includes protecting the health and safety of our workforce, safeguarding the environment, and creating a long-lasting positive impact on our communities. In 2021, our social investments totaled $15.7 million, with approximately $4.5 million going toward education projects. Above all, we continue to be a company that cares about its people, its impact on the community, its reputation, and doing the right thing. We are proud of our achievements, which include being recognized as one of the 100 Best Corporate Citizens by 3BL for 14 consecutive years, being a member of the Dow Jones Sustainability Index North America for 12 consecutive years, and being included on the 2022 Bloomberg Gender Equality Index and Human Rights Campaign Corporate Equality Index for our diversity, equity, and inclusion performance. Hess has also been recognized as one of America's Most Responsible Companies by Newsweek Magazine and was ranked a Top 50 Employer by *STEM Workforce Diversity Magazine* (13 consecutive years), *Equal Opportunity Magazine* (3 consecutive years), *Minority Engineer Magazine* (4 consecutive years),- *Woman Engineer Magazine* (10 consecutive years) and *Careers & the disABLED Magazine* (11 consecutive years).

The Hess Toy Truck Story

The Hess company was founded in 1933 when Leon Hess bought a secondhand 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 (with batteries included), a concept that endures to this day. The Hess Toy Truck remains a beloved holiday tradition and among the best-selling toys in the country every year, now offered exclusively at www.hesstoytruck.com and at HessToyTruck.com/Stem.

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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 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 generally comprises 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 toys for children or collectors' items for adults. 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 on each day. It is also one of the fastest-growing categories for jobs.

Activities in this guide use the 2022 Hess Flatbed Truck with Hot Rods to explore transportation issues and the way STEM applies to the world of hot rod technology. Plus, the artistic component of hot rod design and decoration incorporates art into STEM, giving us the modified acronym STEAM.

The seven activities contained here are designed for elementary students in grades 3–5, but all activities can be adapted for lower- or higher-grade learners. The order of the activities can be changed as desired. All activities support the Three Dimensions of Science Learning in the Next Generation Science Standards. Some activities include activity pages that can be used for assessment or placed in science notebooks.

The 2022 Hess Flatbed Truck is reminiscent of the original 1933 oil tanker on which the Hess company was founded. The 2022 truck is bright green and white and loaded with chrome accents. The truck is free-wheeling, meaning it has no motor. It features four buttons on the cab roof that activate engine start, horn, hot rod racing sounds, and flashing lights. A hidden loading ramp at the rear enables loading and unloading of the two hot rods that fit in the flatbed.

The two hot rods are identical except for the colors. Both have lights and feature powerful pull-back spring motors. To make a hot rod go, the driver (a student) presses down on the roof while pulling the hot rod back across the floor. The wheels-to-floor friction causes them to rotate backward. A system of gears, connected to the wheels, transfers kinetic energy to the spring by winding it. When the motor clicks, the spring is fully charged with potential energy.

The student driver releases the hot rod and the converts back into kinetic energy, propelling the hot rod in a forward direction. The hot rod motors are powerful enough to enable the hot rods to do wheelies.

STEM Careers

Skilled workers in STEM fields are always in demand, with job openings exceeding the number of prepared candidates. This guide provides powerful, stimulating STEM learning experiences that relate to many STEM fields, such as the example careers listed below. These careers require competency in science, technology, engineering, and mathematics.

EXAMPLE CAREERS

- Artist/Designer
- Automotive Technologist
- Biologist
- Chemist
- Civil Engineer
- Computer Scientist
- Electrical Engineer
- Environmental Scientist
- Geoscientist
- Graphic Designer
- Manufacturing Engineer
- Mechanical Engineer
- Medical Scientist
- Race Car Driver
- Robotics Engineer
- Safety Engineer
- Software Developer
- Structural Engineer
- Technical Writer
- Toy Designer
- Transportation Engineer
- Website Developer

01 How Fast?

Suggested Grades **3–5**

Suggested Grades **3–5**

01 How Fast?

The Question

What is the average speed of the fastest hot rod?

Where's the STEM

Motion is an important science topic. How fast a vehicle moves is based on the **force** applied to the wheels by the engine. The more force, the faster the wheels turn (revolutions per minute, or **RPM**) and the faster the hot rods accelerate. Mathematics is applied when measuring speed. Engineering comes into play in the design of speedometers that report wheel RPM to the instrument panel. In racing, technology determines speeds and winners via various clocking and recording devices.

In this activity, teams of learners will race their two hot rods against each other to determine which hot rod is faster. They will also have to determine the average speed of their fastest hot rod and the (RPM) of its drive wheels.

Materials

PER INVESTIGATION TEAM

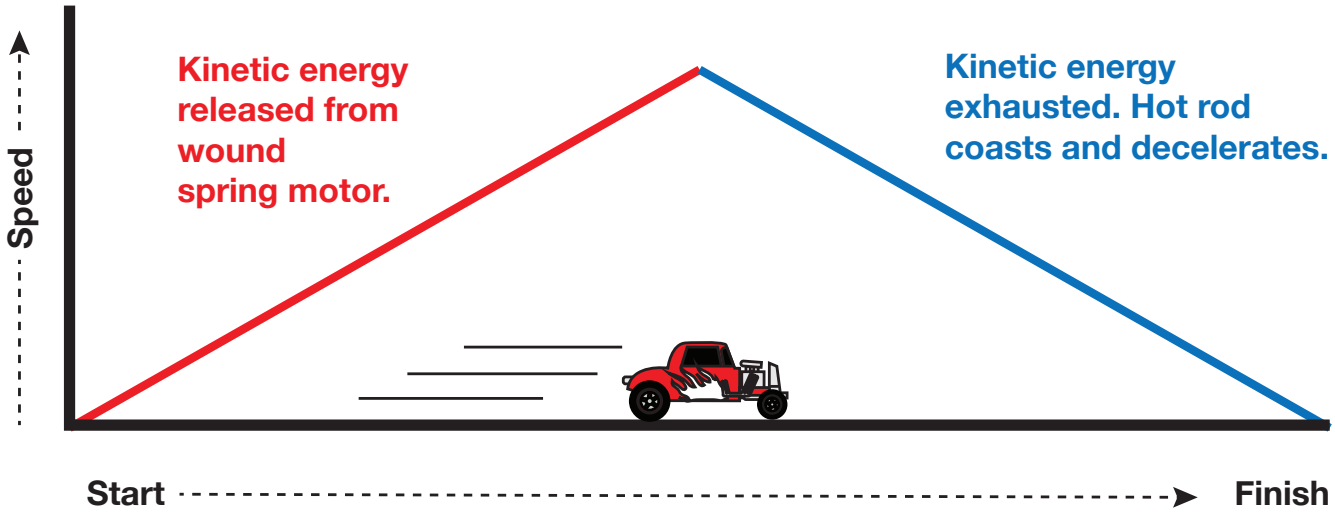
- 2 Hess Hot Rods
- "How Fast" data sheet

FOR THE CLASS

- clear floor space (tile or other hard, smooth floors are best)
- masking tape (or blue painter's tape) to mark the start and finish lines and the track sidelines
- stopwatch or smart phone timer
- small-tip dry-erase markers (for whiteboards)

Management Tips

- Have learners work in teams.
- Teams will need to use a clear floor space about 15 to 20 feet long. If such a space doesn't exist in your classroom, consider moving out to the hallways.
- When applying tape to the floor to mark the start and finish lines, fold over the ends of the tape to facilitate its easy removal from floors. Blue painter's tape is especially easy to remove.
- If learners will be calculating their average speed, have them conduct three trials or "runs." If learners are careful in the setup and release for each run, the measured times should be consistent within a second or two. If one measurement is very different from the others, have the team drop that measurement and conduct one more run.
- The RPM measurement requires placing a small mark with a dry-erase marker on one of the rear hubcaps. The mark should be small but visible to indicate rotations of the wheel. The mark can be easily removed later with dry-erase marker cleaner.
- Provide a data sheet for each team to work on together.



Procedure 1: Which Hot Rod Is Faster?

01 Use tape to mark a test track on the floor. The track should be 15-feet long from the starting line to the finish line. If the test area is wide, such as in a school hall, stretch the tape from wall-to-wall. Several teams can use the test track at the same time. If the area is very wide, you may want to use tape to indicate sidelines for your track.

02 Have teams select a driver for each of their hot rods. Each driver will wind up the hot rod's spring engine (storing up **potential energy**) until the spring clicks. Drivers can hold the rear wheels firmly to avoid prematurely releasing the spring engines. Have the two learners place both hot rods just behind the starting line.

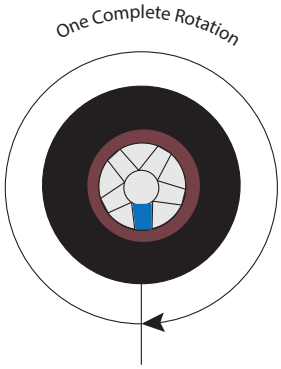
03 After a brief countdown, the hot rods should be released together (with all wheels on the ground). A third team member should serve as the judge of which hot rod crossed the finish line.

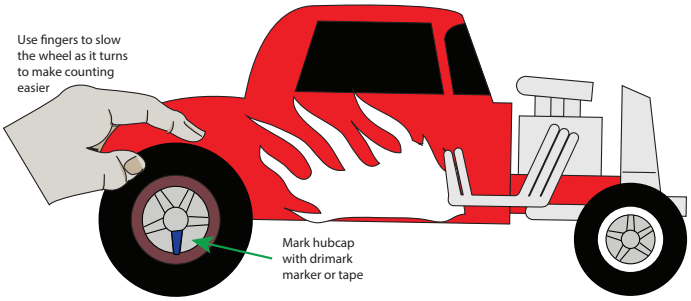
04 Repeat the race twice more (for a total of three runs). The best two out of three determines the fastest hot rod. This hot rod will be used in the next tests.

Procedure 2: How Many RPM?

01 Explain the term RPM to your learners. RPM refers to how many times wheels revolve (turns in a complete circle) in a minute's time. Learners may be familiar with the **tachometer** in the instrument panel of cars. Automotive tachometers measure the rotational speed of an engine. The numbers on the dial are in thousands of rotations per minute. The Hess Hot Rods do not have tachometers, but it is possible to determine the RPM by observing the drive wheels in the rear.

02 Mark one of the rear wheels of each team's fastest hot rod (using a dry-erase marker on one of the of the shiny "spokes"). As an alternative, apply a small bit of masking tape to the black rubber tire.





Demonstrate how to count RPM. Fully wind up the spring motor. With a finger placed on one of the back wheels as a brake, slowly allow the motor to turn the other wheel. Each complete circle of the marker counts as 1. The number of rotations ends when the spring motor runs out of energy. It may take a couple of tries for learners to get this right.

03 Have learners fully wind up the spring motors of both hot rods. With the hot rods in the air, hold the rear wheels to keep them from turning. Use a stopwatch or smart phone to time how long (in seconds) the wheels turn when released.

04 Using their answers for steps 3 and 4, learners will follow the instructions on Part 2 of the data sheet to determine the RPM of their hot rods.

Procedure 3: Average Speed

01 Using their fastest hot rod, have each team determine its average speed. Teams should place their hot rod on the taped racetrack and time (in seconds) how long it takes for the hot rod to travel across the finish line 10 feet away.

02 Teams should repeat step 1 three times.

03 Have teams enter the speed data on the data sheet and follow the directions on part 3 to determine average speed.

Wrap It Up

Speed and **velocity** are useful terms for learners to know. Speed is a measure of how fast something is traveling (distance divided by time). Miles per hour (**MPH**) and feet per second (**FPS**) are common measurements of speed. Velocity, is a measure of both speed and direction. Traveling 100 MPH is a measure of speed. Traveling 100 MPH east is velocity. In this investigation, learners measure only speed.

Acceleration is another useful motion term. Acceleration is defined as a change in velocity. A vehicle is accelerating when it is going faster and faster. When a vehicle is going slower and slower, this is referred to as deceleration. Acceleration also occurs when a vehicle is traveling around a curve. While its speed may be constant, its direction is changing. Remember, velocity is both speed and direction.

ASK TEAMS TO SHARE THEIR RESULTS

- How many times did the rear wheels spin when the motor was wound and then slowly released?
- How many RPM does your hot rod have? *About 240*.
- What is the hot rod speed in feet per second? *About 5 FPS. Learners may estimate that the hot rods are very fast. However, when they do the math as explained on the data sheet, the answer will be somewhere around 3.2–3.7 MPH.*
- What is the relationship of RPM and the speed of the hot rod? *The greater the RPM, the greater the acceleration, average speed, and distance the hot rod travels.*

As an additional challenge, have teams determine hot rod speed over different surfaces, such as carpet, tiles that been misted with water, asphalt on a playground, and concrete, etc. If learners detect differences in speed, ask them to account for them. *Friction on different surfaces. Wet tiles are slippery and the hot rod wheels might have less traction and slower speeds*.

01 How Fast?

Data Sheet

Team Names

_____ _____

_____ _____

Part 1: The Fastest Hot Rod

Calculate the RPM of your fastest hot rod by following the steps on the right

	RED	GREEN
Race 1	☐	☐
Race 2	☐	☐
Race 3	☐	☐

WINNER

1. Go to the race track. Have one team member drive the red hot rod and another team member the green hot rod.
2. The drivers will fully wind the spring motors and place the hot rods at one end of the race track with the front wheels just behind the starting line.
3. Have another team member stand at the finish line to judge which hot rod crosses the finish line first.
4. If you have a fourth team member, that member does a countdown and calls "go." If you do not have a fourth team member, the judge does the countdown.
5. Run three races and record the results to the left. Two out of three wins determines the fastest hot rod.

Part 2: How Many RPM?

Calculate the RPM of your fastest hot rod by following the steps on the right

A	B	C	D
☐	☐	☐	☐

1. How many wheel revolutions did you count? Put the answer in box A.
2. How many seconds did the spring engine spin the wheels before they stopped? Put the answer in box B.
3. Divide the number in box B by 60 seconds. Put the answer in box C.
4. Multiply the number in Box A times the number in box C. Put the answer in box D.
5. Draw a circle around box D. This is the RPM that would show on a tachometer if your car's motor ran for 60 seconds.

01 How Fast? - Continued

Data Sheet

Part 3: What is the average speed of your hot rod?

1. Determine the number of seconds your hot rod takes to travel from start to finish on the race track. Record the seconds in the "Seconds" column. Repeat two more times and record.
2. Add the numbers in the "Seconds" column and write the answer in the "Total" box.
3. Divide "Total" by 3. Record your answers in the "Average" box.
4. Divide the average number into 15 (the length of the track). That will give you a feet per second (FPS) speed.
5. How fast in miles per hour is your hot rod? Guess! There are 3,600 seconds in an hour. Multiply your FPS by 3,600. Then divide that number by 5,280 (the number of feet in a mile). This will give you miles per hour (MPH). Do your calculations below.

Trial	Seconds
1	
2	
3	

Total

Average

FPS

CALCULATIONS

02 Drag Racing: Four Wheels Down vs. Wheelies

Suggested Grades **K–5**

Suggested Grades **K–5**

02 Drag Racing: Four Wheels Down vs. Wheelies

The Question

Which hot rod is the fastest in a drag race?

(Note: This activity should follow the "How Fast?" activity. Each team should determine which hot rod is their fastest and use that hot rod for drag racing.)

Where's the STEM

Drag racing began in 1930s in the dry desert lakebeds of California. People were obsessed with speed and tinkered with their cars to get the maximum power. Tinkered-with cars routinely reached speeds of over 100 miles per hour on the smooth lakebeds.

Following World War II, drag races were often conducted on unused military roads. Cars raced a distance of ¼ mile. These were casual races in which cars and drivers just showed up to compete against one another.

Over the next ten to twenty years, drag racing became more organized, with physical barriers and regulations imposed to ensure safety.

Drag racing hot rods are an example of STEM at work. Understanding force and motion, energy in different fuel mixes, technology of materials, engineering of engines, aerodynamic auto body design, measurement instrumentation, and much more is what determines race winners and losers.

While hot rods like those included with the 2022 Hess Flatbed Truck are still raced, drag racing cars have evolved in many ways. Instead of short and wide cars like the vintage styled Hess Hot Rods, the fastest drag race cars are now long and narrow with engines at their rear.

In this activity, teams will race their hot rods against those of other teams. Teams will pick their hot rod for the competition, then determine which strategy will move their car the fastest: having all four wheels on the track or doing **wheelies**.

Materials

PER INVESTIGATION TEAM

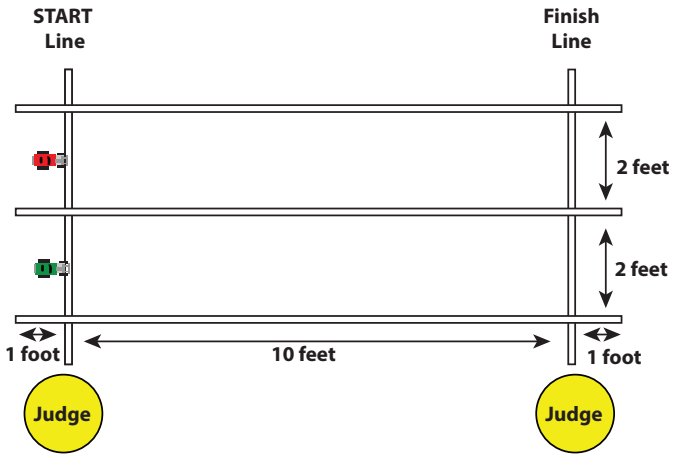
- fastest Hess 2022 Hot Rod as determined in the "How Fast?" activity

FOR THE CLASS

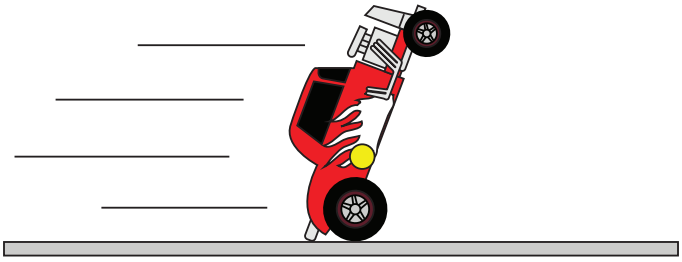
- clear, smooth floor about 20 feet across
- masking tape or blue painter's tape
- measuring tape

Management Tips

- Lay out a racetrack on the floor with masking tape (or blue painter's tape for easy removal). Refer to the diagram below for details on layout and distances.



- Set up a race schedule for elimination matches. Pick which teams compete in the initial races.The winners of the first races will compete against each other and so on until the grand winner is determined.To involve more learners, you also can consider having the cars that lost during the first round compete in a separate set of elimination matches.
- Pick two learners not racing to serve as judges, one at the start line and the other at the finish line. The start line judge will give the "ready, set, go" and call "foul" if one hot rod takes off before the "go" call.The finish line judge will determine the winner either visually or with a video taken on a smart phone.
- The hot rods work with all four wheels on the ground, but they can also do wheelies. Wheelies occur when the acceleration of a car is so great that the front wheels leave the ground. To make a wheelie with the hot rods, wind up the engine spring and set the hot rods on their rear wheels with the rear bumper touching the floor, then let go. Demonstrate how to do a wheelie.



Procedure

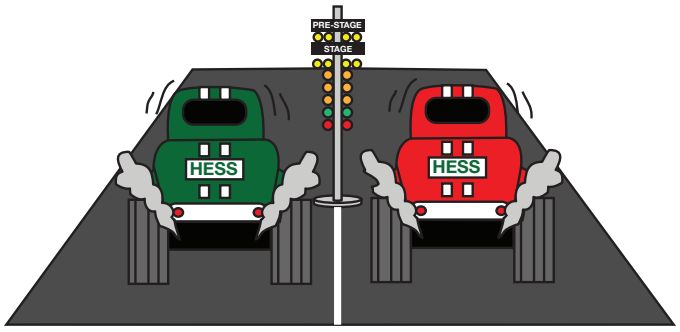
01 After introducing the competition, have teams do some trial runs on the racetrack. Remind teams to be consistent in how they add energy to the spring motor, how they aim the hot rod, and how they release it. Also have teams practice doing wheelies.

02 Set up a series of elimination races. Pair up teams and race three times. The team that wins at least two of the three races will move on in the competition.

03 Pick two learners from other teams to serve as judges as described in the Management Tips.

04 Run the races until all teams are eliminated except the grand-winning team.

05 Have teams run additional races with their hot rods doing wheelies. For wheelie races, have the drivers place the rear wheels directly on the start line. Is a wheelie faster than a hot rod with all four wheels on the track? Have them try wheelies vs. four wheels on the track. Note: If a hot rod doing a wheelie veers off track, consider it a false start and try again.



Wrap It Up

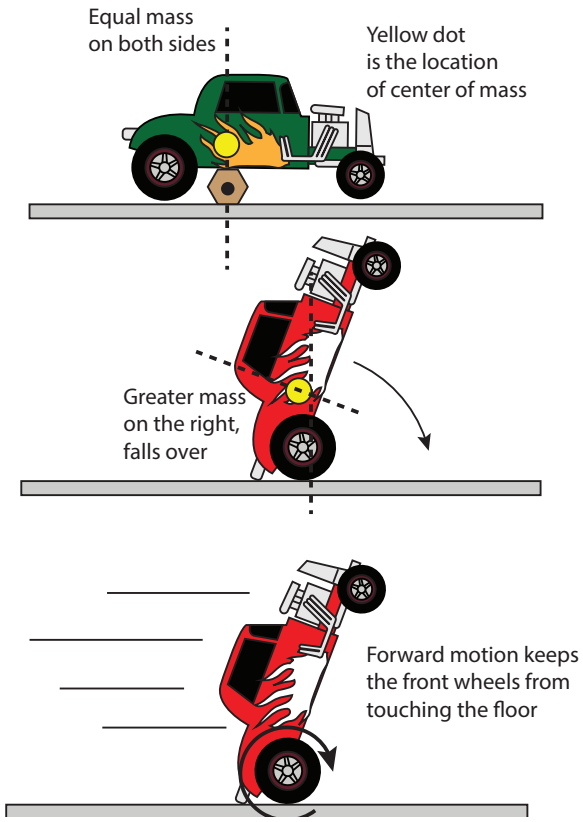
Since all of the hot rods have the same gear and spring mechanism for propulsion, they should all be alike on the racetrack. So, why were some hot rods consistent race winners? Winning a race may depend more on driving skill than on hot rod power.

When the start line judge says "go," a momentary delay in the hot rod release could lead to coming in second. How the hot rod is aimed and released could also make a big difference, as could not fully charging up the motor with potential energy.

Why are the hot rods able to do wheelies?
The **center of mass** of the hot rod is directly below the side windows. Place a fat pencil or a ruler on its edge on a tabletop. Balance the hot rod on the pencil or ruler edge so that none of the four wheels touch the tabletop. When the hot rod is perfectly balanced, the center of mass is directly above the pencil or ruler edge.

When the hot rod is set on its back wheels with its rear bumper resting on the racetrack, the center of mass is now just to the front of the forward edge of the wheels. As a result, it is out of balance and will drop to all four wheels if you let go. However, when the engine is charged with potential energy and the hot rod is tipped up on its back wheels and bumper and then released, the hot rod is propelled forward as inertia comes into play.

Inertia is the tendency of all matter to resist a change in motion. The inertia of the front end of the car resists moving forward and flopping down when the car accelerates. This keeps it in the wheelie position while the car races away. However, when the hot rod stops accelerating, **gravity** takes over and pulls the front wheels down.



What is the difference between the speed of the hot rod with all four wheels on the ground and the speed of the hot rod doing a wheelie?

One possible difference is that the hot rod's rear bumper drags on the ground surface during a wheelie, and this friction could reduce the speed. Another possibility is that a wheelie's upright position exposes more of the hot rod's surface area as it moves forward, increasing **drag** with the air.

Why do wheelies cause some of the hot rods to go off course?

Like all automobiles, the wheels that steer the hot rod are located in the front. With the front wheels off the ground, the driver is unable to use the steering wheel to drive a straight course. Any small bump in the track can send the hot rod off course. Differences in the traction of the two rear wheels can also be a problem.

03 Breakdown

Suggested Grades **3–5**

Suggested Grades **3–5**

03 Breakdown

The Question

What do you do when your truck breaks down?

Where's the STEM?

No matter how well a real vehicle is designed and built, there will come a time when it breaks down (unlike a Hess toy vehicle, of course). Many breakdowns are the result of poor maintenance—not changing the oil on time, not replacing belts or chains when worn, not checking the cooling system, and not fixing or replacing a hundred other parts and systems when worn or broken.

Cars and trucks have become more and more advanced compared to vehicles manufactured just a few years ago. Furthermore, computers now control many internal systems in vehicles. Correspondingly, vehicle repair has become more complex. Modern repair technicians must be skilled in all the STEM (science, technology, engineering, and mathematics) disciplines.

Of course, repairing a broken-down or malfunctioning vehicle usually requires taking it to the repair shop where those highly skilled technicians work. In this activity, we imagine that the Hess truck breaks down and teams must get it to the local repair shop. Unfortunately, the nearest repair shop doesn't have a tow vehicle that can handle such a large truck.

The only option the teams have is using the two hot rods. By winding the spring motors, potential energy is stored in the springs. When the hot rods are attached to the truck with string or when they push the truck, potential energy is converted to **kinetic energy** and the truck advances along the road.

Keep in mind that big trucks have a large **mass**, and this makes them difficult to start rolling when pushed or pulled. The reason for this difficulty is inertia, which is a property of all matter that resists a change in motion. In other words, it takes a force to start the truck rolling.

Teams are challenged to figure out the best towing or pushing arrangement for getting the truck to the repair shop.

Materials

PER INVESTIGATION TEAM

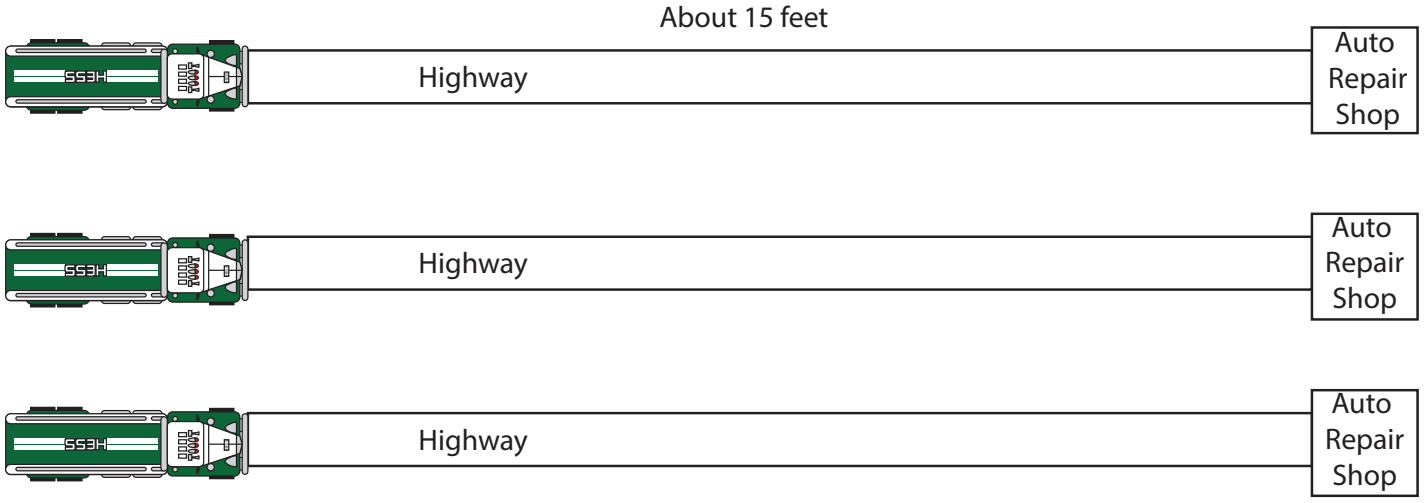
- 2022 Hess Flatbed Truck with Hot Rods
- 6 feet of string

FOR THE CLASS

- clear, smooth floor space, about 10 feet wide and 20 feet across
- masking tape (or blue painter's tape for easier removal)
- measuring tape
- scissors for cutting string

Management Tips

- Use tape to lay out the floor space, as shown below, to allow three teams to compete at a time.



- Cut string into 6-foot lengths for each team and place scissors in a common location. Teams may want to cut their strings into smaller pieces.
- Make sure teams understand that force is a push or a pull. This may help them with their strategy for getting the truck to the repair shop.

Procedure

01 After explaining that trucks eventually break down and need repair, explain the activity:
Your truck broke down and cannot transport the hot rods to compete in a hot rod race. There is an auto repair shop 10 miles away. It doesn't have a tow truck powerful enough to tow the truck to the shop. If you can get it there, the shop can repair it. How can you make that happen?
What type of force will it take to move the large truck, a push or pull?

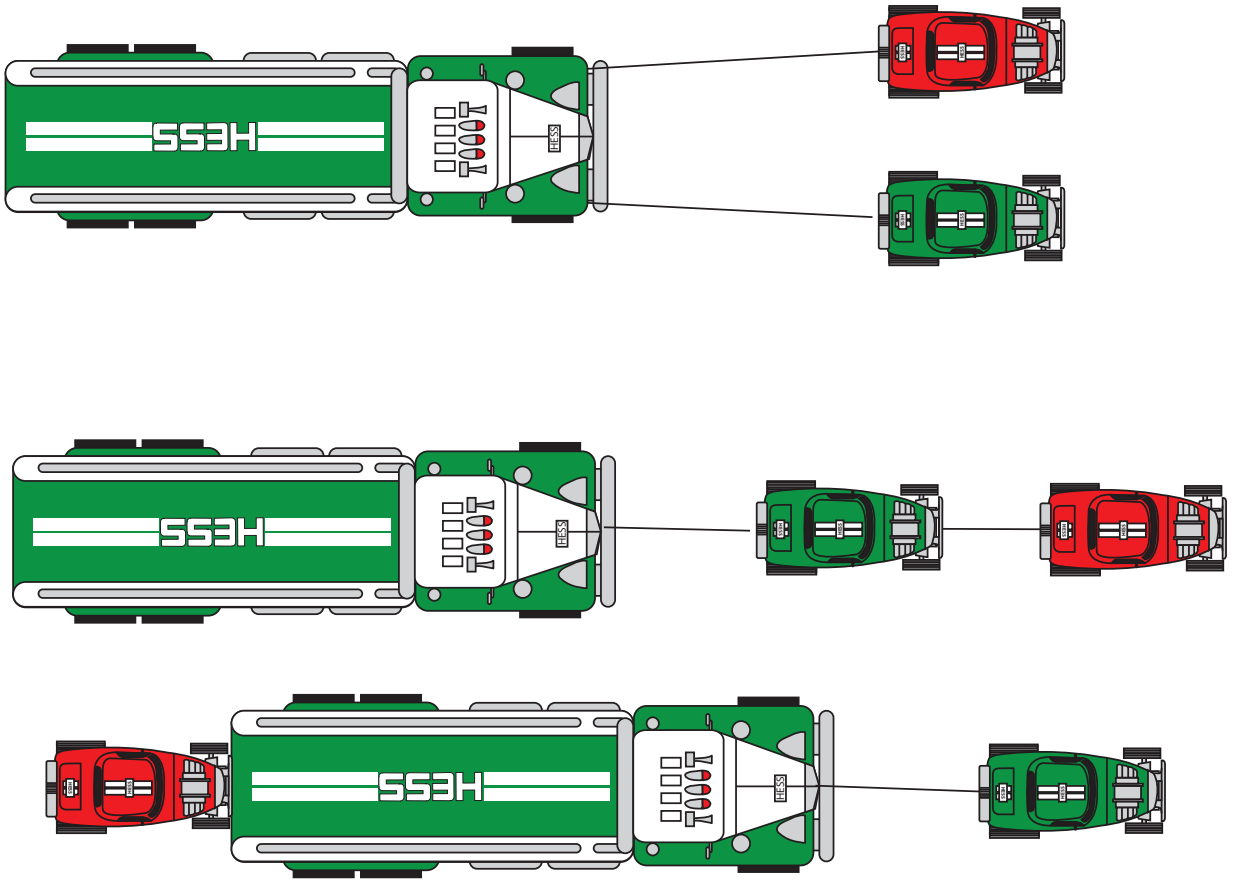
You have the Hess Flatbed Truck with Hot Rods, and you have string. When you come up with a solution, set up your truck on the starting point on your highway. Other teams will be trying to reach the repair shop at the same time. You must stay in your highway lane and not interfere with the other teams. Good luck!

Give teams at least 15 to 20 minutes to come up with and test a solution to the towing problem. You may want to assign the challenge on one day and have teams test their solutions on a second day.

02 When three teams are ready, have them start towing or pushing. Tell them that their truck must remain behind the starting line but their hot rods can be positioned across the line at the start. Use a stopwatch or smart phone to time how long each towing solution takes to reach the repair shop. The times for each team can be used to compare which towing solution is the best.

03 If the truck stops before the repair shop, allow teams to wind up their hot rod motors as needed to continue the transport.

A few possible towing/pushing designs:



Wrap It Up

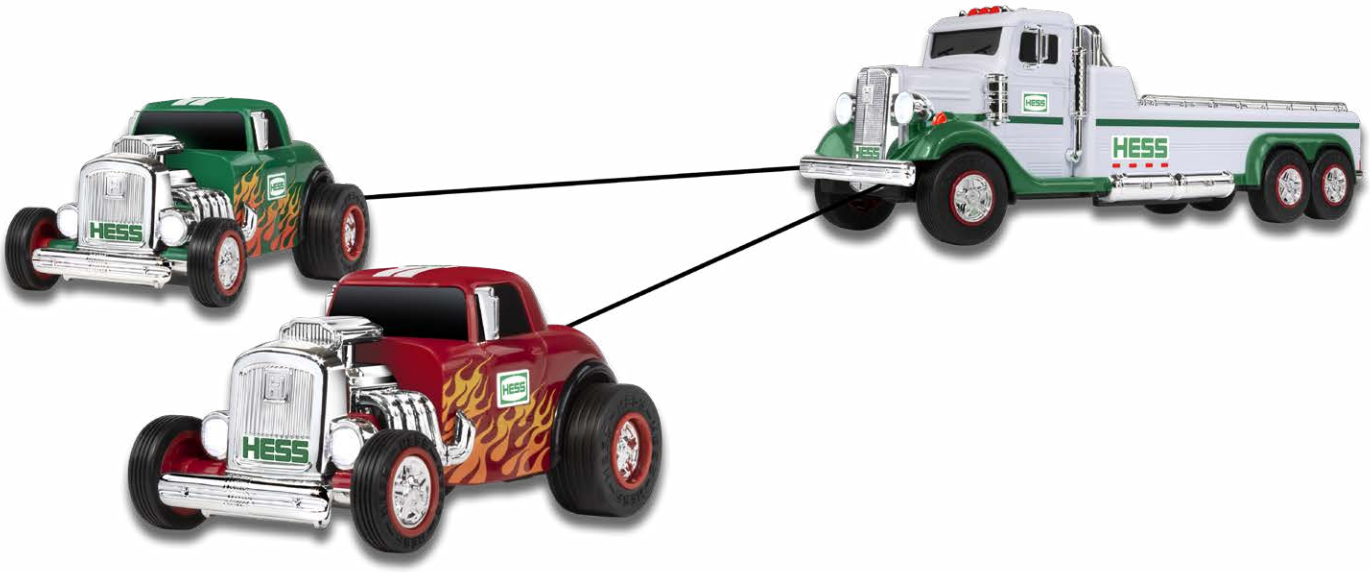
After teams complete their towing, have them analyze their performance.

- Did you try pulling, pushing, or both?
- Did your truck start rolling immediately, or did it need a small tap to start it?
- What worked and what didn't work?
- What part did friction play in your towing design?

  The more mass the truck has, the more force it takes to get it moving. Once the truck is rolling, it takes another force to stop it. One such force is friction. Friction occurs when two surfaces rub against each other. With trucks, one of the greatest sources of friction is the contact of the tires and the road. Friction with the floor eventually stopped the trucks when the hot rods ran out of stored energy in their spring motors.

  Another source of friction is air that the truck hits as it is moving. This is called drag. Drag slows the truck. The faster the truck moves, the greater the drag. Relate this to what learners have observed of actual big trucks traveling on highways. Many trucks have large shells over their cabs to help reduce drag by directing air over the truck rather than into the flat surface of the trailer.

- Which towing solution was the most effective in towing the flatbed truck to the repair station in the shortest time?
- For an extra challenge, ask learners to repeat the towing test with extra weight in the flatbed, such as a few pebbles. How does the increased mass affect the time it takes to get to the repair shop?



04 Crash Test

Suggested Grades **3–8**

Suggested Grades **3–8**

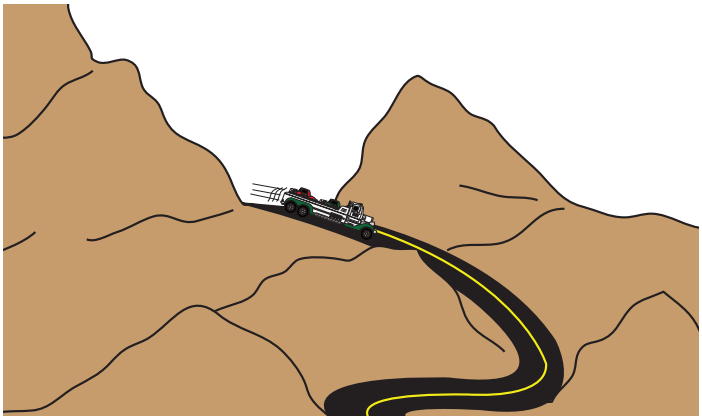
04 Crash Test

The Question

How do you stop a runaway truck coming down a steep mountain road?

Where's the STEM

Mountain roads offer major challenges for highway engineers. Trucks and cars traveling cross-country encounter potentially dangerous conditions when trying to cross mountain passes (low points in mountain ranges). Mountain passes can be very steep and curvy and descend for many miles. Gravity pulls hard on vehicles, causing them to accelerate to unsafe speeds. Maintaining a safe downhill speed puts extreme stress on brakes and engines.



When constructing roads, highway engineers must survey mountain passes to pick the best route. This requires careful mathematical measurement of the steepness of the valley below the pass where the road will go. It also requires understanding the science of geology to determine how road wear and tear affects the subsurface of rock and soil. Will the surface collapse? The cliff side of sharp turns requires safety railings, crash barriers, and other barriers or technologies. Understanding **forces and motion** in relation to gravity helps to determine speed limits and how much the road surface should be tilted (banked) to keep vehicles from flying off the outer edge of curves.

In some mountain passes, the steepness is so great that truck-escape road sidings are built. A truck whose brakes have failed will accelerate so much that it will fly off the road on the next curve. To help prevent accidents in this scenario, an escape ramp may be built for the truck driver to steer into. The ramp consists of deep layers of gravel and an uphill slope. The truck wheels sink into the gravel, which exerts a counterforce to the truck's motion. The uphill slope of the ramp provides further slowing (due to gravity), bringing the truck to a safe stop. Other escape technologies include collapsing barriers and rows of cables stretched across the ramp that the truck plows into.

In this activity, teams of learners will design, build, and test a crash barrier for safely stopping runaway trucks.

Materials

PER INVESTIGATION TEAM

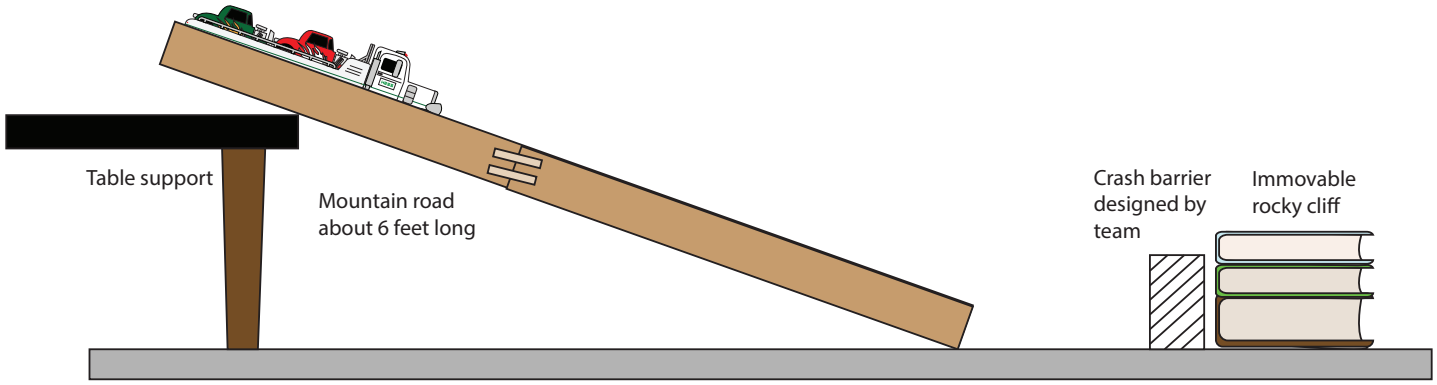
- 2022 Hess Flatbed Truck with Hot Rods
- scissors
- clear plastic tape
- goggles

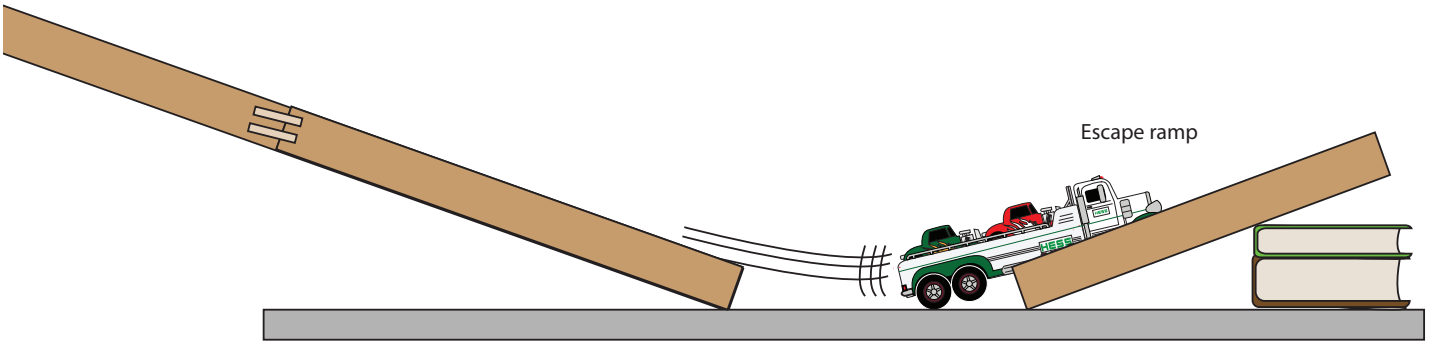
FOR THE CLASS

- supplies (cardstock paper, cardboard from a used science fair presentation or any large cardboard box, aluminum foil, string, rubber bands, etc.)
- inclined plane, representing a steep mountain road (see Management Tips for details)
- heavy pile of thick books, representing a rocky cliff
- masking tape

Management Tips

- The cardboard will be cut to make a mountain road. Fold up the edges of the road to keep the truck from slipping off the sides.
- Make two road segments and join them end-to-end with some overlap to lengthen the road to about 6 feet in length.
- Use masking tape to firmly attach the upper end of the road to a table and to anchor the lower end to the floor.
- Tape the midpoint segments securely to avoid sagging. If the ramp still sags, challenge learners to figure out how to prevent the sagging.
- Use a marker to show where the rear wheels of the flatbed truck should be placed.
- Invite learners to bring materials from home that their team might use for their crash-barrier design.





Procedure

01 Discuss the runaway truck problem. Why is it a major safety issue for mountain roads or steep hills? Runaway trucks will accelerate so much that they crash when they can't make curves. They could also plow into the rear of cars ahead of then on the road or simply lose control of their vehicle.

02 Challenge teams to build a crash barrier, escape ramp, or some other form of protection for the Hess Flatbed Truck (the barrier is intended to slow down and absorb the impact so the truck doesn't hit the wall). Show the mountain road made of cardboard pieces totaling about 6 feet in length (see Management Tips) and point out the cliff wall made of stacked books that the truck will crash into unless an effective crash barrier or other technology protects it.

03 Each team will plan and design a crash barrier, ramp, or some other solution for protecting the truck, using the suggested materials and any materials team members bring in from home.

04 Allow teams one class period for constructing their crash barriers. Crash barriers should be no thicker than 6 inches (a very thick barrier would work, but when scaled up to life size, it would become very expensive and impractical).

05 When all barrier constructions have been completed, they will be ready for testing. Team members should wear goggles for testing. As long as the truck runs into the team-made barriers, it should not be "damaged" (missing the barrier won't actually hurt the Hess Flatbed Truck—they are built to last—although the hot rods may come loose from the flatbed in a sudden stop).

06 One at a time, while other teams observe, have teams place their crash barrier, ramp, or other crash-prevention solution directly in front of the book cliff wall (see diagram for placement). The goal is to safely slow the truck without losing the hot rods!

07 The team will place and hold its truck, with the hot rods loaded, at the top of the road. After a short countdown, the runaway truck is released to see what happens.

Runaway Truck Ramp sign in Colorado (photo by Travis Kelleher)


Runaway Truck Ramp, Route 30, PA in the mountains.
https://www.publicdomainpictures.net/en/view-image.php?image=6876&picture=runaway-truck-ramp

Wrap It Up

Have teams write a test summary and answer questions like the ones below:

- Did the hot rods remain on the truck bed?
- What happened to the crash barrier—was it damaged, or can it be used again?
- Did the truck have a sudden hard stop or did it stop more slowly with collapsible cushioning provided by the barrier?
- Did the crash make a loud or a soft sound?
- What could be done to improve the barrier?
- Is there a difference between the truck with the hot rods loaded in the flatbed versus the truck with an empty flatbed?

Use the stopwatch on a smart phone to time how long it takes for the truck to reach the crash barrier or ramp—because this will only take few seconds, it might be a good idea to have learners practice timing with the hot rods to help improve timing accuracy.

Measure (in inches or centimeters) the length of the mountain road from the front bumper of the truck to the barrier or ramp. Divide the number of seconds into the length of the track. This will give the average speed of the truck in inches or centimeters per second.

Try it again, but first change the angle of the mountain road to make it steeper and then again to make it less steep than the first trial. Is there a difference in the average speeds? Why or why not?

For added excitement, place a raw egg in a sandwich bag. Remove the hot rods and place the bagged egg against the wall just behind the truck cab. Do the crash again and see if the eggshell survives.

Look on the Internet for videos of truck escape ramps being used in actual driving situations where truck brakes have failed. The following YouTube video provided by Business Insider, reviews the science behind truck escape ramps:

https://www.youtube.com/watch?v=jp7N9NgSTlQ

05 Hollywood Hot Rods

Suggested Grades **5–8**

Suggested Grades **5–8**

05 Hollywood Hot Rods

The Question

What "impossible" stunts can your hot rod do?

Where's the STEM

Hot rods check every box in the STEM world. They are combinations of antique and modern automobile technology. The builders of hot rods need functional knowledge of science, technology, engineering, and mathematics.

While many hot rods are built for show and weekend jaunts on the road, others are built for performance—high speed, control, and balance. Some rods can be used for racing while others are designed for stunts. Hot rods can be modified to do stunts including jumping over old busses and trucks, riding around on two side wheels, and performing rear wheelies, high-speed doughnuts, and complex jumps with flips. Often, these stunts are carefully staged and captured on film for exciting movie chase scenes.

By Trekphiler - Own work, CC BY 3.0,
https://commons.wikimedia.org/w/index.php?curid=4502977

In this activity, teams will imagine that they are stunt coordinators for a movie production and design "impossible" stunts with their hot rods.

Materials

PER INVESTIGATION TEAM

- 2022 Hess Flatbed Truck with Hot Rods
- two 6 x 28 poster board strips (see Management Tips)
- scissors
- clear plastic tape or masking tape
- rulers
- ballpoint pens

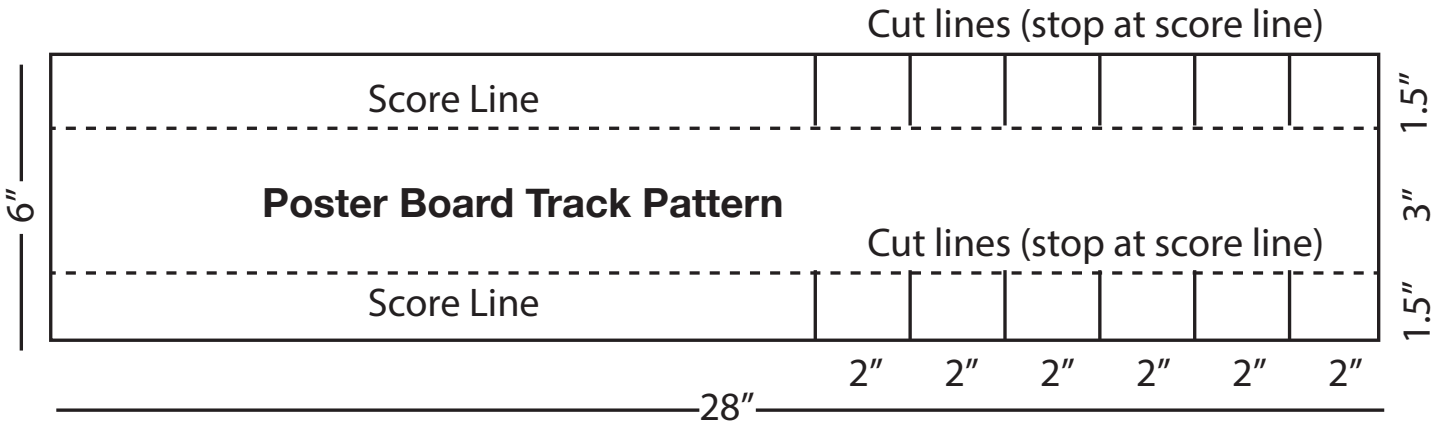
FOR THE CLASS

- a clear space for testing the stunts

Management Tips

- Use poster board strips to create tracks for the hot rods. You can save time by precutting and marking the strips in advance. Cut 6-inch-wide strips the long direction of the poster board. A standard sheet will yield 3 strips plus an extra narrower strip that can be used for construction supports, etc. Cardboard can be substituted for poster board but it is much harder to cut.
- The 6-inch strips will be used for tracks on which the hot rods will run. Fold up the long sides of each strip 1.5 inches to make the guardrails. To make folding easy and precise, use a ballpoint pen and press hard to score the paper along each side. A yardstick will help in this step. Refer to the diagram below on how to measure, cut, score, fold, the strips.

Note: The tracks may be difficult for students to make on their own. If so, have an adult prepare the strips for students ahead of time. The pattern below is for a jump ramp with a curve at one end. Loop tracks will require cut lines every 2 inches along the entire length of the track.



Procedure

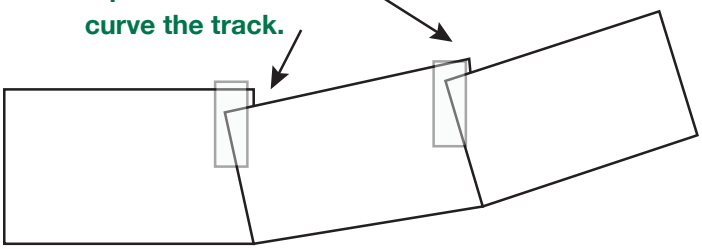
01 Ask learners to describe movies they have seen that feature wild action scenes with cars jumping, flipping in the air and landing on their wheels, and other seemingly impossible stunts. Tell students that they will be a part of a Hollywood movie stunt teams. The director wants really exciting stunts. It will be up to the teams to design and build whatever structures are needed to create stunts and then perform the stunts with their hot rods.

02 Teams will need to construct ramps or other apparatus from poster board for their hot rod stunts. Hold up a prepared piece of poster board with fold lines and tab cut lines.

03 Demonstrate how to make a curved track for a hot rod stunt such as jump ramp enabling a hot rod to jump over the Hess Flatbed Truck.

- Fold up the long sides. These will serve as walls to guide the hot rods on track.
- Show how the track can be bent. Point out how the tabs on the walls overlap to make a curve.
- Start with two adjacent tabs on one wall and tape them together as shown below. Do the same on the opposite side.

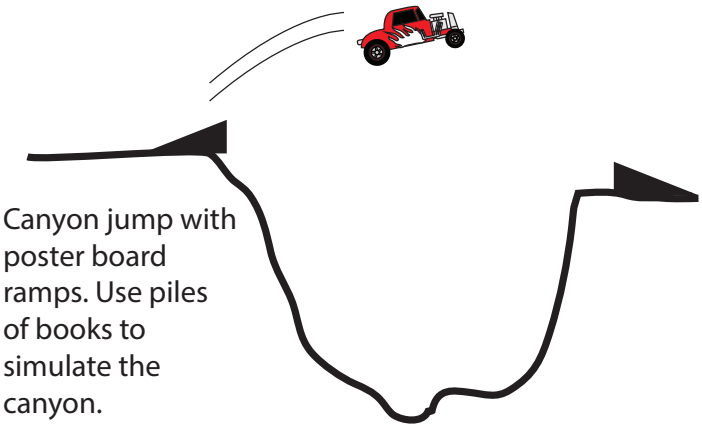
Overlap upper corners and tape on both sides to curve the track.



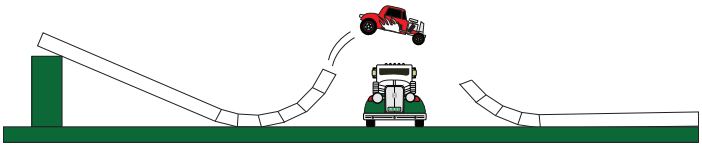
- Repeat the overlapping and taping until all tabs are properly joined. The track will be curved.

Note: The amount of overlap will determine the shape of the curve.

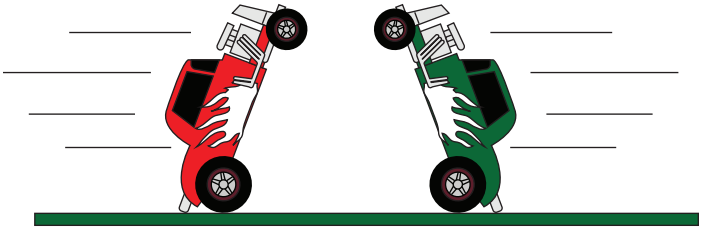
A few ideas for stunts to perform:

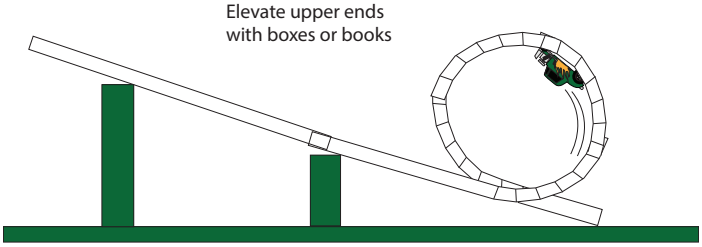


Canyon jump with poster board ramps. Use piles of books to simulate the canyon.



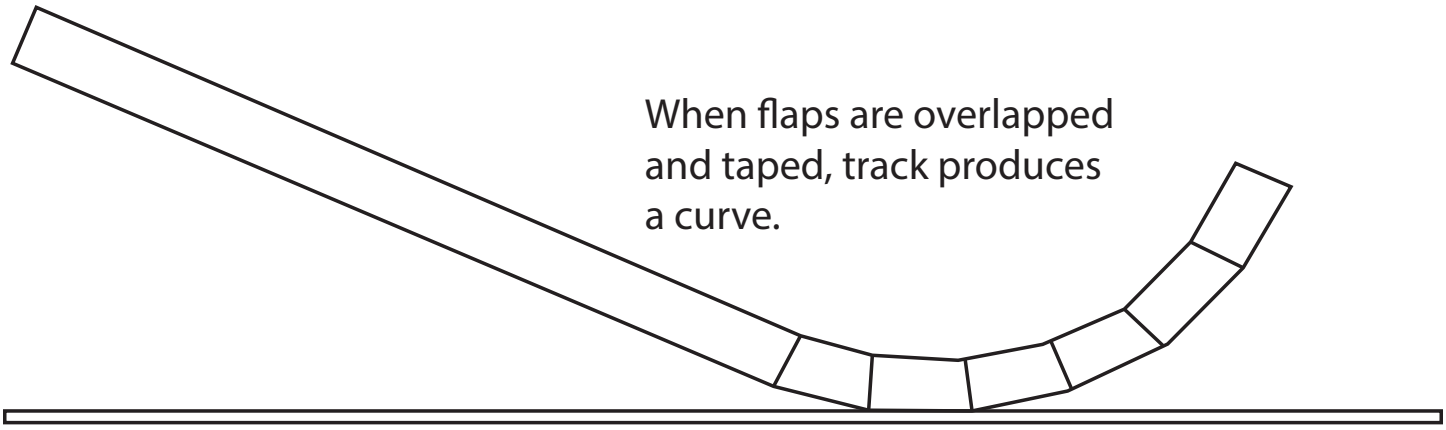
Wheelie Crash





Procedure - Continued

04 Set the curved track you just constructed on a tabletop. Raise the straight end of the track a few inches and show how the hot rod rolls down the track. Do it again, but this time wind up the hot rod engine to give it greater acceleration.



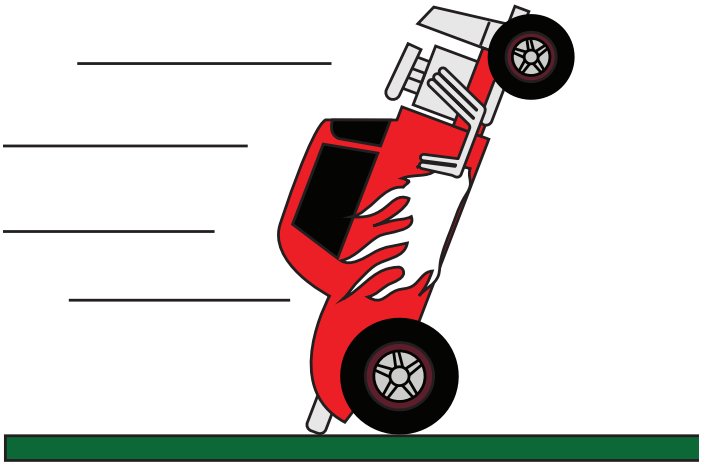
05 Turn the teams loose to create a Hollywood hot rod stunt. Give them two prepared poster board strips and tape to make their stunt track. (If older students are making their own tracks, provide two pre-marked strips, scissors, and tape. Demonstrate how to construct the strips.)

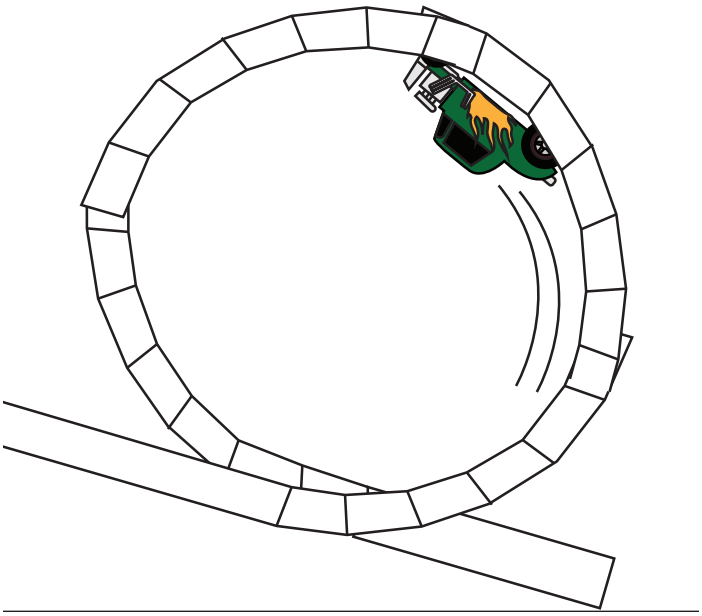
- Set a time for teams to plan their stunt, construct their apparatus, test, and modify the apparatus if needed.
- When teams are ready, have them demonstrate their stunts. If smart phones with video capabilities are available, have teams make short movies.
- Talk about how picking the right camera angles can intensify the excitement of the shot.
- Teachers—consider sharing the movies on social media for Hess fans to see. Tag **@HessToyTruck** and use the hashtag **#HessHotrods**.

Wrap It Up

Ask teams to consider the following:

- What were the challenges you encountered in designing your stunt? Describe.
- How important was it to get the right angles or curve of the track to have a successful stunt?
- What problems did you encounter in your design and how did you solve them?
- What did you learn from this problem solving?
- Why is it useful to test your ideas with model cars rather than full-size hot rods? *Hot rod stunts involve traveling at high speeds. Slight mistakes in angles and curves can cause a hot rod to jump the track. Testing stunts with models gives the team the chance of correcting problems before the stunt is tried with a real driver and a real hot rod. Failures with a model provide a chance to learn and perfect designs.*





When executing stunts, it is important to understand basic STEM concepts such as force and motion, inertia, friction, and gravity. For example, the stunt driver has to reach the correct speed to safely make a jump. Too slow and the hot rod falls short of the landing zone. Too fast and the hot rod overshoots the landing zone. In both cases the driver and the hot rod can be injured.

Invite students from another class to visit, and have teams demonstrate the stunts they created and share what they learned. As an added attraction, have the students in the visiting class vote on which team stunt is the most exciting: "**Hess Hot Rod Stunt Award**."

Consider sharing the awards on social media for Hess fans to see. Tag **@HessToyTruck** and use the hashtag **#HessHotrods**.

06 Hot Rod Jump

Suggested Grades **3–5**

Suggested Grades **3–5**

06 Hot Rod Jump

The Question

What slope angle achieves the greatest jump distance?

Where's the STEM

Many sports rely on inclined planes, which are surfaces with one end higher than the other. Ski hills, ski jumps, and snowboard and skateboard ramps all rely on inclined planes that demonstrate principles of force and motion.

Ski jumpers, snowboarders, or daredevils who race motorcycles or cars like hot rods start out at the top of an inclined plane that curves and flattens out at the bottom.

The force of gravity accelerates the jumper down the plane. The flat lower end of the inclined plane changes the velocity of the jumper by changing the direction from downward to horizontal flight.

The jumper's air path is controlled by both gravity and lift created by the position of the jumper's body or hot rod speeding through the air. These two forces work to extend the distance of the flight.

To protect jumpers, the height of the starting point of the inclined plane, the length of the run, the distance and shape of the landing zone, and the acceleration of gravity are all calculated mathematically. Too high a jump and too steep a slope can lead to jumper injuries. Just like ski jumpers and snowboarders, the drivers of hot rods and motorcycles depend on the force of gravity to achieve a spectacular jump.

In this investigation, teams will determine the best angle for an inclined plane (jump ramp) to give Hess Hot Rods a long jump but a safe landing.

Materials

PER INVESTIGATION TEAM

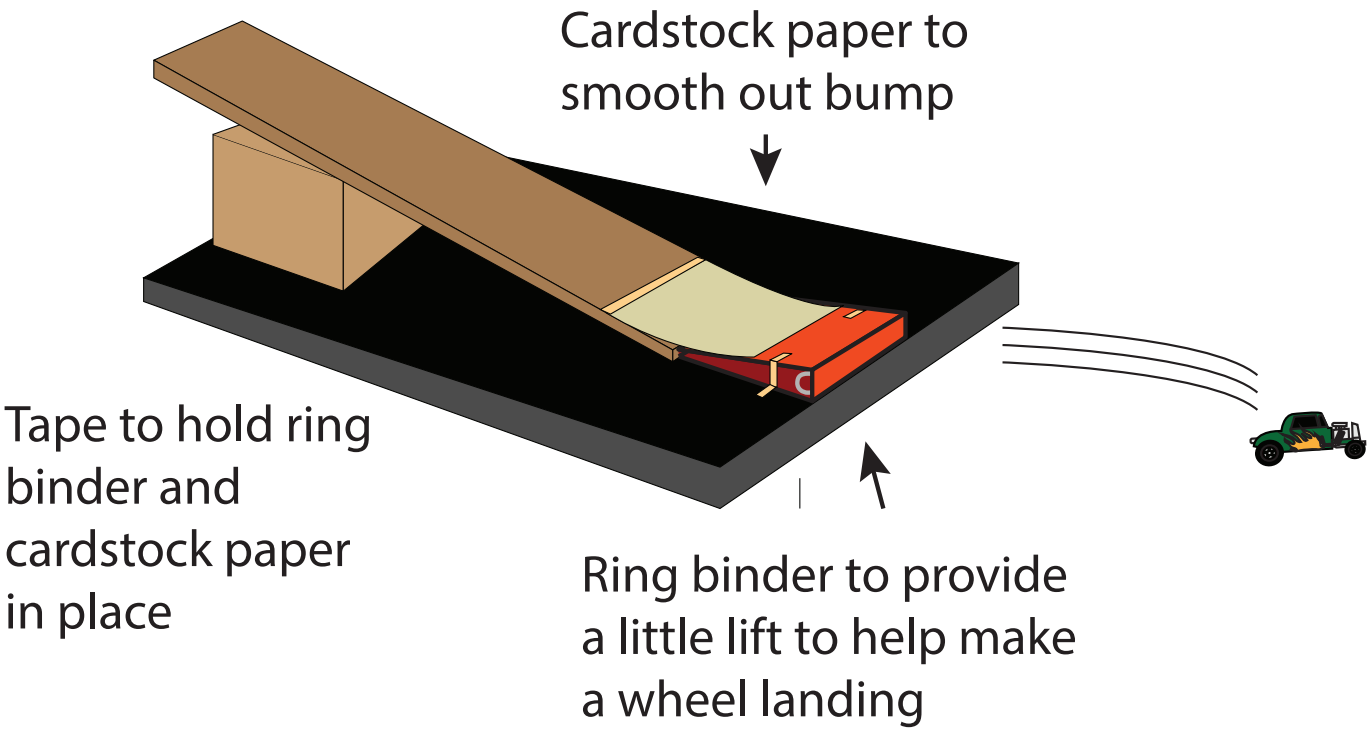
- Hess Hot Rod
- paper protractor printed on cardstock paper (see pattern)
- yardstick or tape measure
- "How Far" data sheet

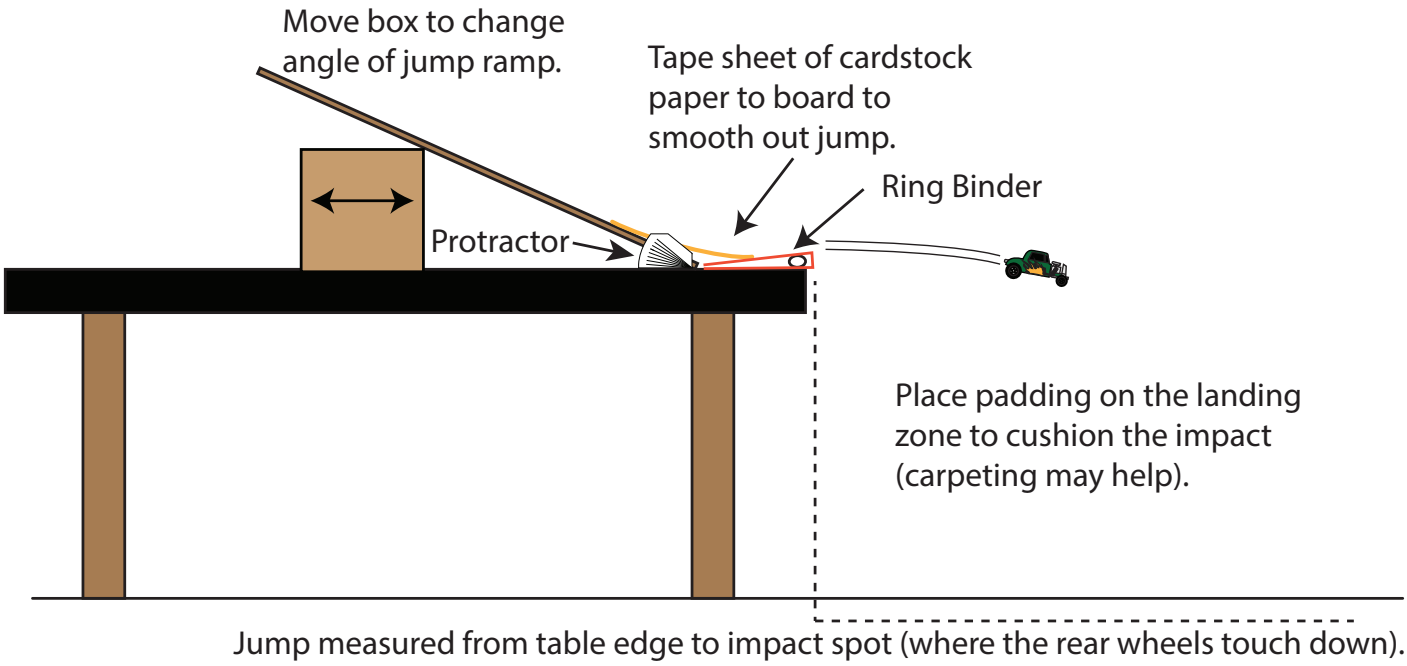
FOR THE CLASS

- inclined plane for jump ramp structure (see Management Tips for details)
- empty ring binder for each jump structure made
- several sheets of cardstock paper
- masking tape

Management Tips

- More than one jump ramp is recommended so that several teams can participate at the same time. The inclined plane that makes up the jump can be made from stiff cardboard about 8 inches wide and 4 feet long. If possible, the corrugations should run parallel to the long direction of the cardboard for maximum strength. A stronger and longer-lasting inclined plane can be made from a 4-foot length of 1-inch x 8-inch board. Boards can be obtained at home improvement stores or lumberyards. Retailers are usually willing to cut longer boards to the length you need. (The inclined plane used in the crash test activity can also be used.)
- Set up the jumps before class. Elevate the upper end of each jump with a small box or pile of thick books.
- Anchor the lower plane edge to the tabletop with masking tape to keep it from sliding.
- Lay the folded ring binder with the opening facing the plane as shown on diagram. Because the hot rod front wheels are small, any bumps that the wheels encounter would be like hitting a curb. The lower end of the inclined plane creates a small bump to the tabletop. To smooth out the transition between the inclined plane and the ring binder, tape the upper end of the cardstock to the lower end of the jump (see diagram). Also tape the binder to the table to secure it.
- Protect the hot rods when they land by padding a tile floor with cloth towels or a small blanket. If the floor is carpeted, the carpet should provide sufficient protection.
- Have teams construct their protractors and show them how to use them to measure the inclined-plane angle.





Procedure

01 Introduce the investigation to the teams. Show them how the jump angle can be changed by sliding the box support inward (increases the angle) or backward (decreases the angle). Remind teams to start the hot rod at the same place on the inclined plane for each jump run. A strip of tape indicating the starting line will help ensure consistency.

02 Provide teams with the data sheet, which includes directions.

Wrap It Up

Gravity accelerates the hot rod as it rolls down the jump ramp. It also accelerates the hot rod when it becomes airborne. Once airborne, the hot rod goes in two directions at once: it goes forward and downward at the same time. The ramp will channel the hot rod straight down the ramp and then change its motion to a slightly upward direction. However, when the hot rod leaves the support of the ramp, its path becomes an arc that ends at the floor. The main reason the arc occurs is that gravity causes the car to move faster and faster as it falls while continuing to travel in a forward direction.

If time permits, have learners with smart phones take a video of several jumps to record the flight path of the hot rod. Have the videographers determine the best distance from the jump ramp and the best height above the floor to record a complete jump. When the floor is reached, the downward motion stops but the forward motion may continue if the hot rod lands on its wheels or crashes and slides across the floor.

The relationship between the jump ramp angle and the jump distance is a simple one. The higher the upper end of the ramp above the tabletop, the greater the vertical distance the car travels. A high angle produces a greater acceleration of the hot rod than a low angle. There is one problem with this relationship: a really steep ramp angle may result in a crash at the bottom of the ramp where the ramp angle curves to a near horizontal direction.

HAVE TEAMS SHARE THEIR JUMP RESULTS

- How far did your hot rod jump (Part 1 Average)?
- How did the jump distance change from just letting gravity accelerate the hot rod as opposed to gravity plus a fully wound motor?
- What is the relationship between the angle of the inclined plane and how far the hot rod jumped?
- What was the shape of the flight path during the jump?

06 How Far?

Data Sheet

Team Names

_____ _____

_____ _____

Part 1: Practice Jumps

1	2	3	Average

To get the average, total the three jump distances. Then divide that number by 3. The answer is the average jump.

(Jump 1 + Jump 2 + Jump 3 = total
total : 3 = average)

1. Place your hot rod at the upper end of the jump ramp (inclined plane). It is important that every jump starts in the same place.
2. Aim the hot rod straight down the jump ramp. Do not wind the motor.
3. Release the hot rod so that it rolls freely down the ramp.
4. Measure in inches or centimeters how far the hot rod jumps from the edge of the ramp.
5. Record the distance for three jumps.
6. Follow the directions for determining the average distance.

Part 2: Powered Jumps

1	2	3	Average

1. Repeat the steps above but this time wind up the hot rod motor.
2. Did the motor increase the jump distance? Explain what happened in the box below.

Part 3: Jump Ramp Angles and Jump Distance

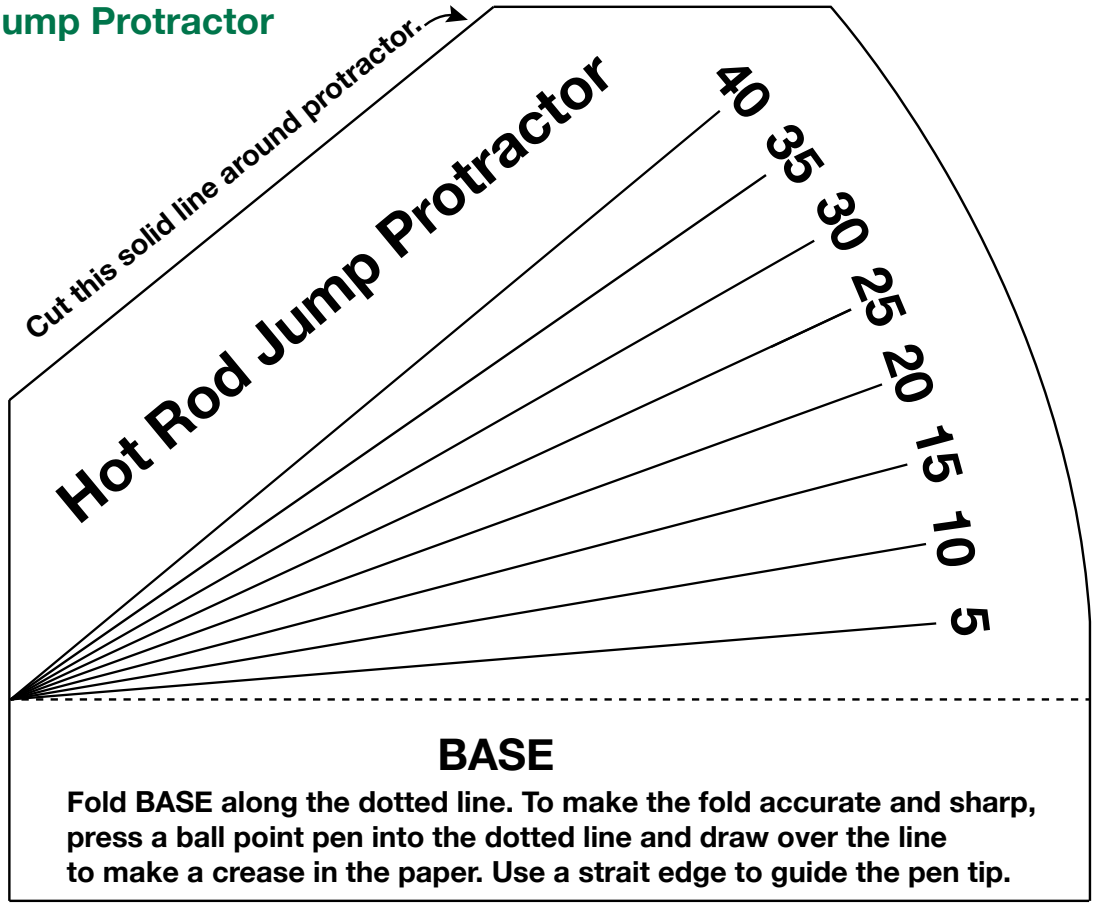
Initial Angle	Initial Angle + 10 degrees	Initial Angle - 10 degrees
Jump Distances		

1. Use the protractor to measure the initial angle of the jump ramp with the table. Wind up the motor and measure how far the hot rod jumps. Record the jump angle and distance.
2. Repeat, but raise the jump angle by +10 degrees. Record the angle and the jump distance.
3. Repeat, but lower the angle to -10 degrees below the initial angle. Record the angle and jump distance.
4. Did the jump distance change with the different angles?

Group Discussion and Jump Results

Discuss your results with your team and describe how the jump distance changed as the angles of the inclined plane changed.

Hot Rod Jump Protractor



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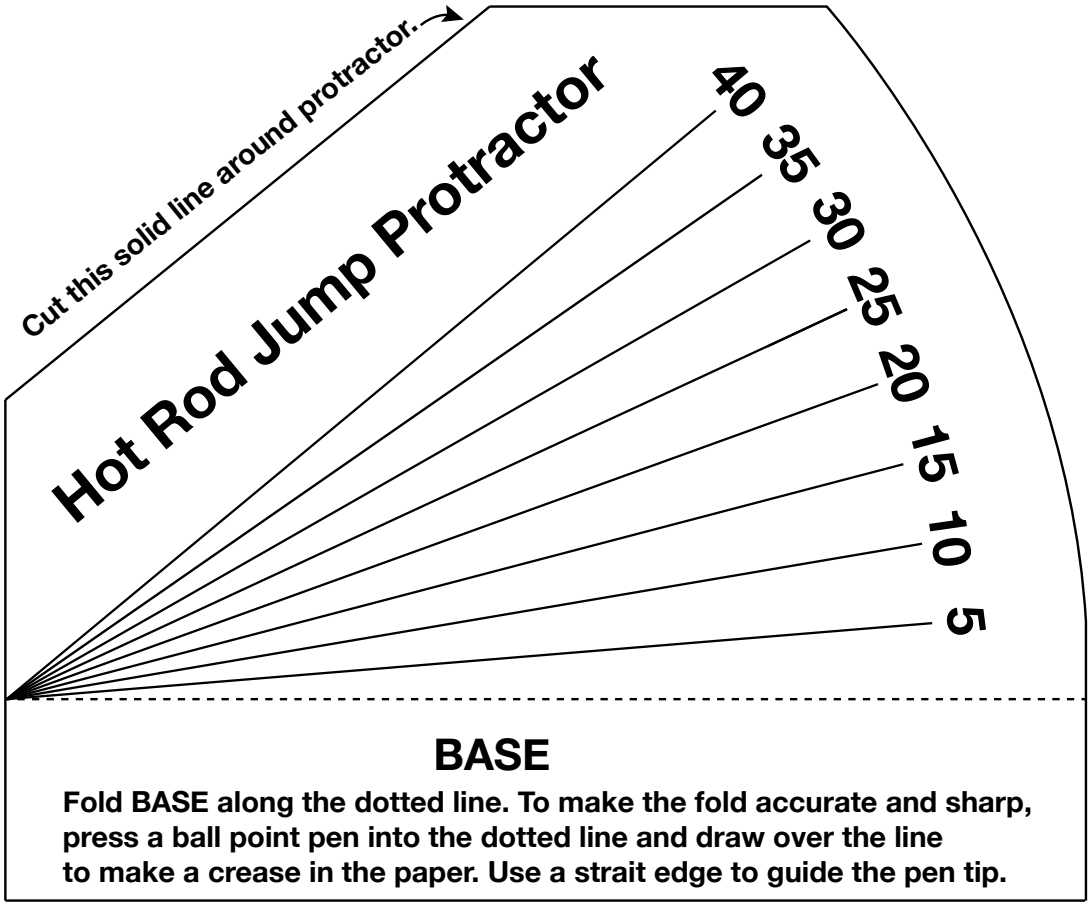


Fold BASE along the dotted line. To make the fold accurate and sharp, press a ball point pen into the dotted line and draw over the line to make a crease in the paper. Use a strait edge to guide the pen tip.

07 Best in Show

Suggested Grades **3–8**

Suggested Grades **3–8**

07 Best in Show

The Question

Which hot rod is "Best in Show?"

Where's the STEM?

With this lesson, we can add the arts to STEM, turning it into STEAM.

Not all hot rods are used for racing. Many hot rods are meant only for driving around on nice weekend days or for exhibiting at car shows where they are lined up for people to examine and admire.

So how are hot rods built? Many hot rod builders start out with an old car that has a decent frame and body but is probably rusty and dented. Dents are pounded out and rust is sanded off. Hoods are removed and a new or rebuilt engine with lots of fancy chrome parts is mounted in the engine compartment. Add new brakes, glass, headlights, and paint, and you have a fancy new hot rod!

Besides making their hot rods lighter and faster, "hot-rodders" add a personal touch with accessories. Their hot rods are an expression of their personalities and their scientific, technologic, engineering, and mathematical skills. Their personality comes through with the rod design and the paint job. That's the product they take to the hot rod show.

In this activity, learners will design a unique and personal paint job for a 2022 Hess Hot Rod, beginning with a line-drawing outline. Making plans, sketches, and measurements are some of the things a hot-rodder would do before getting out the spray-paint gun. If the paint job doesn't look good on paper, it won't look good on the actual hot rod.

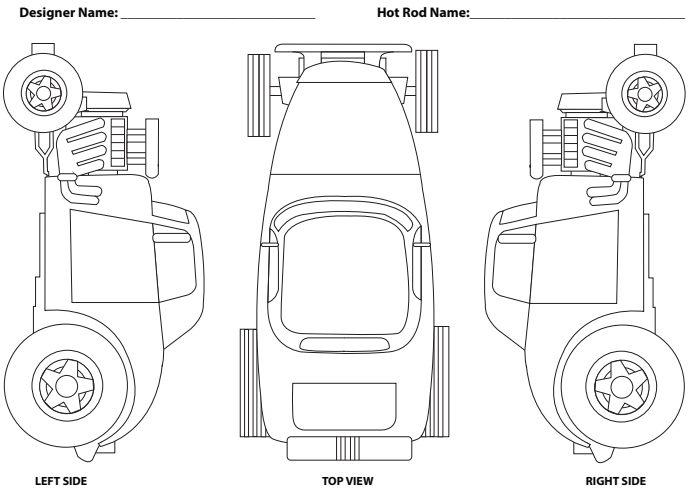
Materials

PER INDIVIDUAL LEARNER

- copies of the black-and-white line drawings of the Hess Hot Rods (2 or 3 per learner)
- pencil with good eraser
- access to the Hess Hot Rods for comparison and to identify the parts on the line drawings

FOR THE CLASS

- lots of colored marker pens (or other media) placed in a central location
- display space for finished designs



Management Tips

- Talk with your learners about the proper use of the marker pens: don't press too hard, secure the cap to the pen so they don't dry out, and return markers to the supply box.
- Distribute the line-drawing copies one at a time as needed.

Procedure

01 Ask if any of the learners have attended an antique or hot rod auto show. If any have attended such shows, ask them to describe to the rest of the class what it was like. Ask questions, e.g., Were any of the cars painted with artistic designs? What did they look like?

02 Draw learners' attention to the Hess Hot Rods. Both are painted with a flaming design on the right and left side panels. Ask learners if they can think of other designs that might look good on these cars.

03 Distribute blank copies of the Hess Hot Rod line drawings to each learner. Have learners compare the Hess Hot Rod to the line drawings. The drawings show the right and left sides and a top view.

04 Challenge your learners to come up with their own art designs for a hot rod based on the hot rod's shape.

05 Display the finished hot rod designs. If desired, have learners vote for their favorite hot rod paint job.

06 Consider sharing the designs on social media for Hess fans to see. Tag **@HessToyTruck** and use the hashtag **#HessHotrods**.

Wrap It Up

Discuss the challenges learners had in designing their hot rod paint job.

- Why did you choose your design?
- What inspired your decision?
- Were there any messages written or pictured in the designs?
- What color combinations were used?
- Based on your design, what might you name the hot rod?

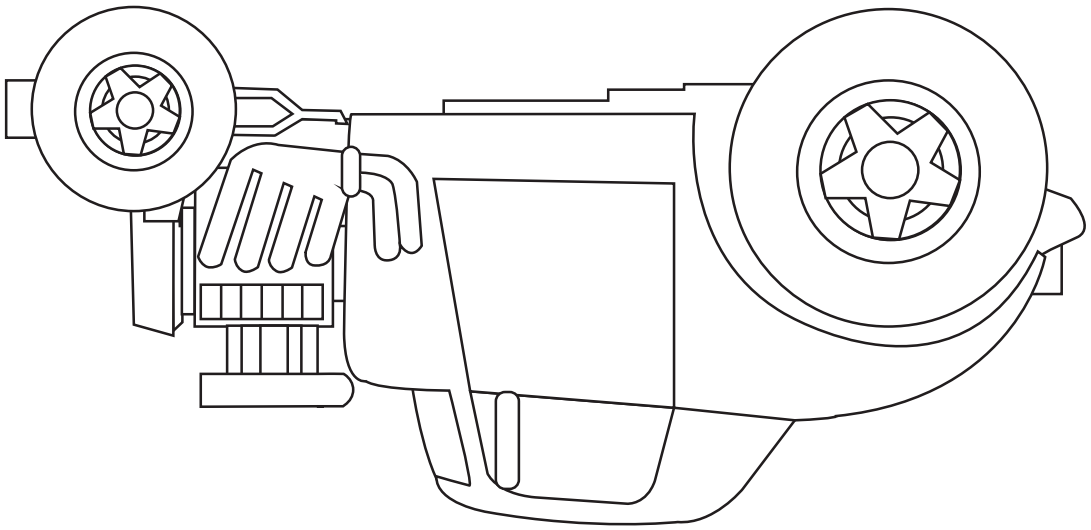
Follow the activity by having teams of learners design a hot rod from scratch. Team members should work together to make large and small decisions about the overall design, such as

- length, width, and height
- two door or four door
- exposed or covered engines
- body style, e.g., sedan, coupe, sports car, station wagon, hatchback, convertible, sport-utility vehicle (SUV), minivan, or pickup truck

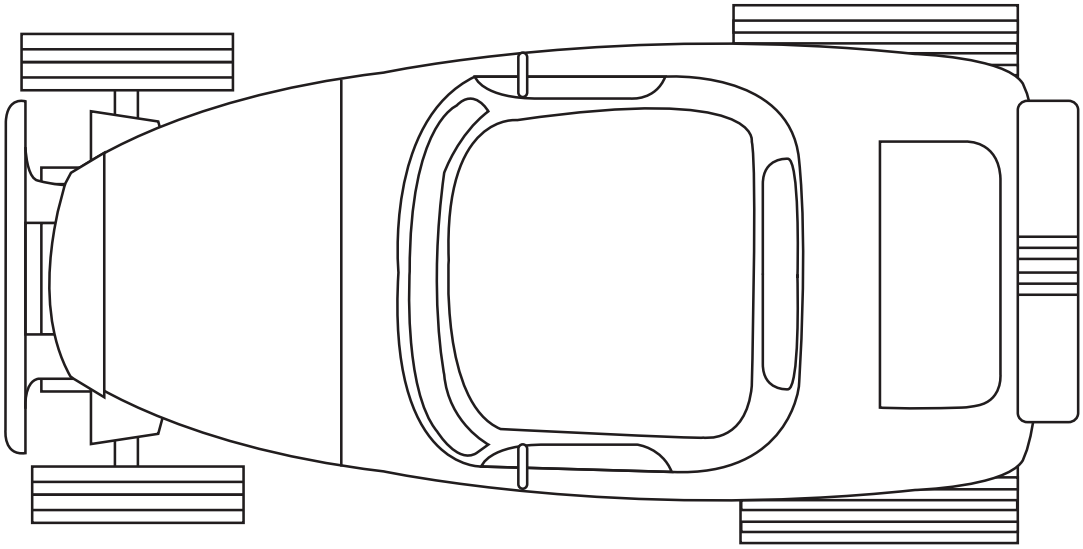
Hess Hot Rod Line Drawings

Hot Rod Name: _____

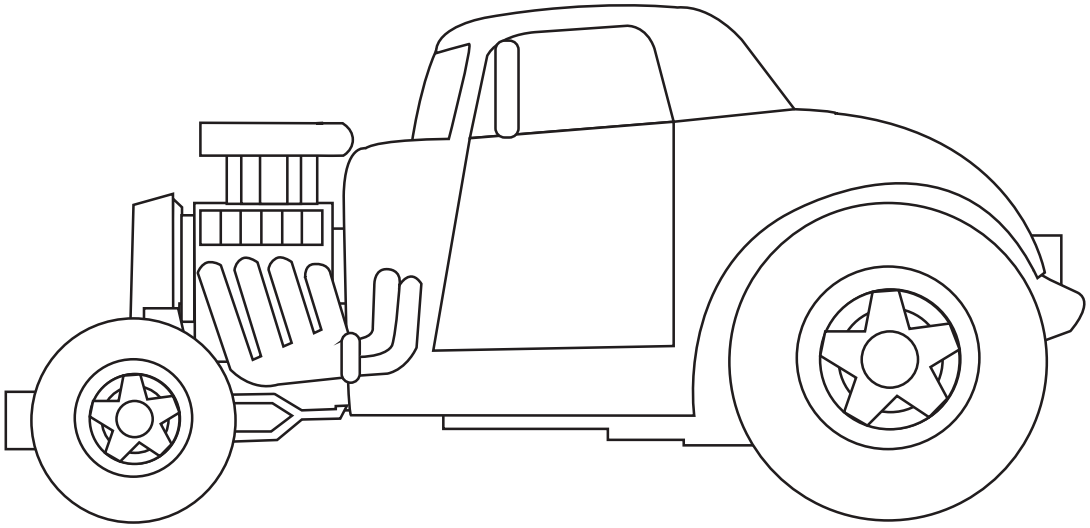
Designer Name: _____



RIGHT SIDE



TOP VIEW



LEFT SIDE

/// Glossary

Terms

ACCELERATION
The rate at which an object gains speed.

CENTER OF MASS
The point on an object where its mass is evenly distributed so that the object is able to balance.

DRAG
The force of friction on the surface of an object that works against its forward motion.

FORCE
Any interaction that, without interference, changes the motion of an object; force has both magnitude and direction.

FPS/FEET PER SECOND
The speed of a moving object as measured by the number of feet it travels in one second.

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

INERTIA
The property of matter to remain at rest or in motion unless acted upon by an a force that causes a change in an object's state of motion.

KINETIC ENERGY
The energy an object possesses due to its motion.

MASS
The amount of matter contained in an object.

MPH/MILES PER HOUR
The speed of a moving object as measured by the number of miles it travels in an hour.

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

RPM/REVOLUTIONS PER MINUTE
The revolution of an object measured in rotations per minute.

SPEED
The rate at which an object moves as measured by distance divided by time.

TACHOMETER
An instrument for measuring revolutions.

VELOCITY
The speed of an object in a given direction.

WHEELIE
A stunt in which the front wheels of an automobile are made to lift off the ground so that the automobile is balanced on the rear wheels as it moves forward.