Towing the Load with the Hess Tow Truck Rescue Team

STEM Activities for Use with the 2019 Hess Tow Truck Rescue Team

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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 2019 Hess Tow Trucks is available at www.hesstoytruck.com while supplies last.

To download the previous, 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/

On the Road with Vehicle Performance **(2018)**

http://www.bioedonline.org/lessons-and-more/focus-on-stem/on-the-road-with-vehicle-performance/

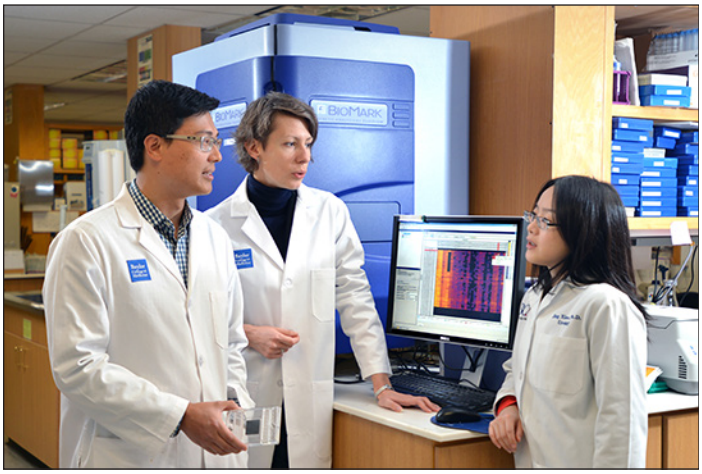
STEM is an acronym used to identify the academic subjects of science, technology, engineering and mathematics.
By highlighting the inter-relatedness of these subjects, the STEM acronym encourages schools, districts and educators to integrate STEM content rather than teach each subject separately.

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℠ and SuperSTAAR℠, 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 12 consecutive years by *Corporate Responsibility Magazine* as one of the 100 Best Corporate Citizens, along with 10 consecutive years as a member of the Dow Jones Sustainability Indices North America. In addition, Hess has been recognized for the 11th consecutive year as one of the Top 50 Employers, *STEM Workforce Diversity,* Equal Opportunity Publications, Inc.

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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. ■

TOWING THE LOAD WITH THE HESS TOW TRUCK RESCUE TEAM
© Baylor College of Medicine.

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 2019 Hess Tow Truck Rescue Team to explore practical transportation issues, such as fuel efficiency, force and motion, levers, road surfaces, and map skills as they relate to tow trucks. 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 higher 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.

The 2019 Hess Tow Truck Rescue Team consists of a large tow truck and a smaller tow truck that can ride in the bed of the larger truck. Both are based on real vehicles used widely on city streets, country roads and highways to rescue stranded vehicles. 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 lifting the front end of a disabled vehicle and towing it to a repair shop or junkyard if needed.

Each of the 2019 Hess tow trucks has special features that enhance its utility. The large truck has a tiltable and extendable towing boom with hooks for attaching to a disabled vehicle. It also has a flat bed that can carry automobiles completely off the ground. A third towing feature is an extendable T-shaped low tow bar. The large truck has a full compliment of lights and realistic sounds. It does not have a functioning motor and must be propelled by hand. The smaller tow truck also has an extendable boom and lights. It features a push-forward friction motor that stores potential energy in a geared flywheel system.

STEM CAREERS

Skilled workers for STEM fields are always in demand, with job openings exceeding the number of prepared candidates. In combination with the 2019 Hess Tow Truck Rescue Team, 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
Biologist
Chemist
Civil Engineer
Computer Scientist
Drilling Engineer
Electrical Engineer
Environmental Scientist
Geoscientist
Graphic Designer
Manufacturing Engineer
Marketing Specialist
Mechanical Engineer
Medical Scientist
Petrophysics Engineer
Robotics Engineer
Safety Engineer
Software Developer
Structural Engineer
Technical Writer
Theme Park Designer
Toy Designer
Transportation Engineer
Website Developer

1. Tow Truck Primer

Automobiles, trucks, recreational vehicles, fire engines, and busses all have one thing in common. They eventually break down or become damaged in an accident. In either case, they become unable to move under their own power. When the inevitable happens, their drivers need help. That's what the 2019 Hess Toy Trucks are all about. The 2019 Hess Toy Truck Rescue Team includes one larger and one smaller tow truck, a kind of rescue vehicle. Other names for two truck include wrecker, breakdown truck, recovery vehicle, and breakdown lorry.

Tow trucks provide an important transportation service. They come to a disabled vehicle, latch on to it and take it to a place where it can be repaired or recycled if it is beyond repair.

The larger Hess Toy Truck is designed for towing both automobiles and large vehicles like buses or semi-truck tractors. It has an extendable hydraulic (simulated) boom or crane with a hook at its end for lifting the vehicle to be towed. The large truck also features a deployable ramp (an inclined plane leading to a fixed flatbed). Many modern automobiles, especially four-wheel-drive vehicles, can become damaged if towed. Rather than towing, the disabled auto is pulled up the ramp with a winch and anchored to the floor of the flatbed for transportation.

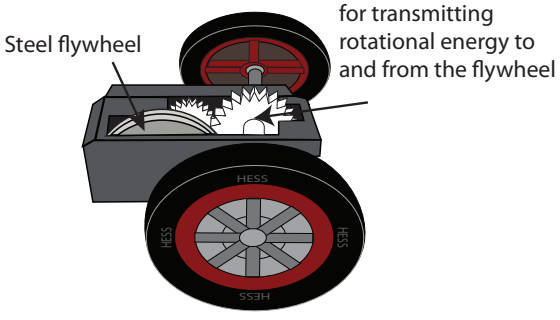
2019 large and small Toy Tow Trucks showing towing booms and low tow extended.

The larger Hess Toy tow truck also features an extendable low tow platform (also known as a T-bar or Wheel-lift). The truck boom lifts one end of a vehicle to be towed and places its wheels in slots in the "T" bar to hold them above the road surface. The smaller Hess Toy Truck is suitable for towing automobiles and small pickup trucks. It is especially useful for rescuing cars that have run off the road into a ditch. The small truck actually fits on to the flatbed of the larger truck so that it can be transported to an incident site where multiple vehicles need towing. The small tow truck also has an extendable hydraulic boom and hook.

Both of these Hess Toy Trucks are propelled along the floor by pushing on the rear of the trucks. The large truck has six wheels that all spin freely. A good push will propel it a long distance on a tile floor.

The smaller truck has the addition of a push forward friction motor. Pressing down on the truck while giving it a push forward will spin up the motor. Four internal gears transmit this force to a pair of steel disks, called a flywheel, that temporarily store kinetic energy. When the truck is released, the stored kinetic energy, now called potential energy, is transmitted back to the rear wheels, propelling the truck.

Gear Case for Small Hess Toy Tow Truck



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THE QUESTION

What can you tow?

MATERIALS

Per team of students

- 2019 Hess Toy Tow Trucks
- Toy trucks and cars for towing (see management tips)
- String, rubber bands, paper clips, etc. (see management tips)
- Masking tape
- Copy of Towing Practice Report Form

MANAGEMENT TIPS

In this activity, student teams will use the Hess Toy Tow Trucks to discover how the vehicles work. They will pretend that one or the other truck has broken down and needs a tow. The second truck will do the towing. After mastering the towing procedures, teams can try towing other toy vehicles. Depending upon the kind and size of the "broken down" vehicles they are trying to tow, the same procedures may not work in all cases. Teams will then have to come up with another way of joining the tow truck to the towed vehicle. For example, the 2018 Hess Toy Truck includes a recreational vehicle and an all-terrain vehicle. If it is available to your class, use that for the first towing activity. Considering where vacationers may take these vehicles, it is possible they will get stuck and need to be towed. The RV doesn't fit the hooks and it is too large for the large truck flatbed or low tow. Teams will use various materials to design a way of making the tow connection. If previous Hess trucks are not available, toy trucks and automobiles from other toy manufacturers can be used.

Provide a station in your classroom for different supplies (rubber bands, string, etc.) which teams can select to join the large or the small tow truck for towing. Remind teams that any strategies they devise to hook the tow trucks to the towed vehicles must not to do anything to permanently alter or damage the Hess trucks or other vehicles being towed. Before doing this activity, ask your students if they have toy trucks or toy automobiles at home. If so, ask if they can bring those toys to class. The vehicles to be towed should be approximately the same size as or smaller than the Hess Toy Tow Trucks.

The propulsion gear case for the small Hess Toy Tow Truck can be easily removed for demonstration purposes. The access panel on the bottom is held in place by two small Phillips head screws. Remove the screws and lift the access panel. The gear case and wheels lift easily from the mount on the truck bottom. Reverse this procedure to reassemble the truck. It is strongly suggested that only the teacher remove the mechanism. The screws are small and not easily replaced if lost.

PROCEDURE

1. Have teams familiarize themselves with the two 2019 Hess Toy Tow Trucks. Begin with the larger truck. Show teams how to deploy the boom. It must be pushed upwards manually by slipping a fingertip under the boom at its rear end. The boom rises to approximately a 45-degree angle to the truck's flatbed and locks in position. Teams should extend the boom and push down and pull the hooks to complete the extension. To return the boom to its stowed position, the hooks must be folded back into the boom, the extensions pushed back, and pressure applied to the boom rear end. When enough force is applied to boom end, the boom will make a loud click and drop back into the flatbed. Teams should also try out the ramp and the low tow.

2. Have teams familiarize themselves with the small truck. Its boom arm also extends, but the angle of the arm is fixed. It does not lie down in the truck bed. Teams should also try out the friction motor by placing the truck on the floor and applying a small amount of downward pressure on the truck while simultaneously pushing it forward and releasing it.

3. After teams are completely familiar with the two tow trucks, tell them that they will practice towing. They should pretend that the smaller tow truck has broken down and needs to be towed to a repair shop. As teams try different towing configurations, they should take notes on the Towing Practice Report Form.

Continued

4. Continue the towing practice by using the smaller tow truck to try to pull the big tow truck. Teams will discover that the small tow truck's hook will latch on to the front of the big truck but the truck's weight is too much for the small truck. Like a lever, the front end of the small truck will pop off the ground into a wheelie position. A different method for attachment is needed. Have teams use the materials at the supply station to attach the small tow truck to the "disabled" large tow truck. Can they use the small truck's friction motor to tow the larger truck?

5. Optional. If other toy trucks and automobiles are available, have teams try towing them. If the tow truck hooks, flatbed, or low tow do not work, have teams devise new ways to attach the tow truck to them.

WRAP IT UP

Hold a class discussion and have teams report on their towing successes. How did they arrange to tow vehicles when the hooks, flatbed, and low tow did not work? Have teams demonstrate their solutions.

One towing challenge teams may face is inertia, or the resistance of matter to a change in motion. If towing with the low tow on the large truck is required, the towed vehicle's inertia will cause it to resist the forward motion and its tires may roll off the T slots.

It is necessary to start towing slowly to keep the wheels in place. However, this may cause another, competing problem: stopping. The inertia of the towed vehicle may cause its wheels to roll forward off the T slots and slam into the rear of the tow truck. Discuss the problems caused by inertia of the towed vehicle and what can be done to tow vehicles safely. Be sure to include friction in the discussion. How does friction assist or interfere with the ability of the tow trucks to tow their load?

EXTENSIONS

Have students investigate the different types of tow trucks on the internet. Different sites have their own classification systems for tow trucks ("4 kinds," "10 kinds," etc.). One site lists the following.

- Hook and chain
- Wheel-lift tow truck
- Flatbed tow truck
- Lift flatbed tow truck
- Boom trucks
- Integrated tow trucks

Ask students to try to classify the 2019 Hess Toy Tow Trucks using the above system. Note: The large tow truck will fit into several classifications. ■

Towing Practice Report Form

Team Names: _____ _____

_____ _____

Practice Tow 1 - Small truck disabled. Large truck towing.

Were you able to tow the vehicle? Check one. Yes ☐ No ☐

If no, explain why.

How did you attach the vehicle for towing? Describe below. Include a diagram of your method.

Which towing method worked best? Check one. Hooks ☐ Flatbed ☐ Low Tow ☐

Explain why this method worked best.

Practice Tow 2 - Large truck disabled. Small truck towing.

Were you able to tow the vehicle? Check one. Yes ☐ No ☐

If no, explain why.

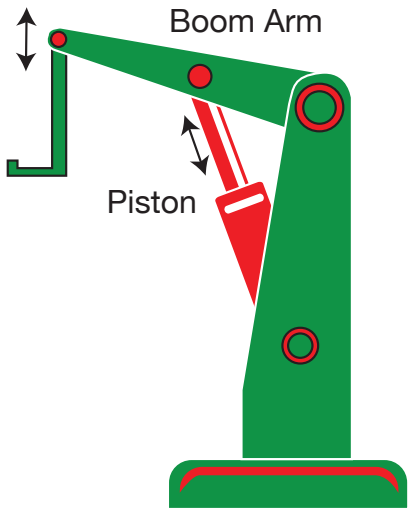
How did you attach the vehicle for towing? Describe below. Include a diagram of your method.

Practice Tow 3 - Other disabled vehicles. Small or large truck towing.

If other vehicles are available for towing, describe your results on the back of this page.

2. Powering the Boom

The booms on real tow trucks are powered by a hydraulic system, in which fluid transmits a force. Hydraulic systems consist of fluid-filled cylinders, pistons and hoses that permit the fluid to move. To raise the boom arm, fluid from the main cylinder is pumped into a smaller, secondary cylinder with a piston attached to the boom. The piston is pushed upward by the fluid. This, in turn, lifts the boom arm and an automobile attached to it. To lower the arm, the fluid is sent back to the main cylinder, causing the piston to retract and bring the arm back down.



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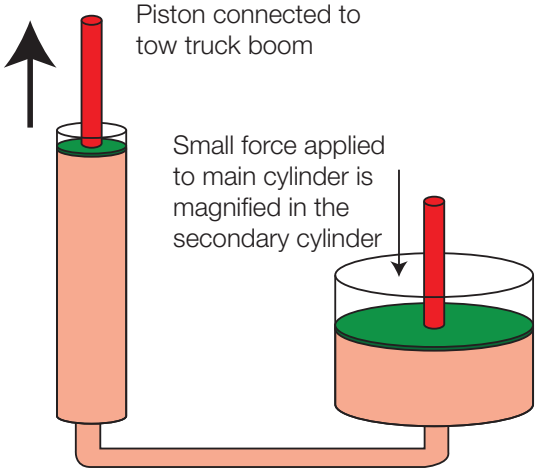
The booms ("arms") on the 2019 Hess Toy Tow Trucks only simulate hydraulic systems with manual manipulation. The boom on the large truck is lifted and stowed back down manually. The small truck boom also lifts manually. Both booms have extensions that can be pulled so that the ends of the booms clear the rear of the trucks to attach to the vehicle being towed.

This schematic of a hydraulic system shows the main and secondary cylinders, pistons, and connecting tube. The hydraulic fluid is dyed red.

The boom arm on this hydraulic lift system goes up when the piston in the secondary cylinder extends. Fluid from the main cylinder (not shown) pushes the piston outward. If the fluid is sent back to the main cylinder, the piston retracts and the boom arm lowers.



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THE QUESTION

How do booms on tow trucks lift a disabled vehicle for towing?

MATERIALS

Per team of students

- 2 plastic rulers with center holes or wood strips that have been drilled with holes. See management tips.
- Two 10 ml syringes without needles. See management tips for more information.
- 30 centimeters of aquarium air hose tubing
- 1, 1-inch brass paper fastener or bolt and nut to fit holes
- Masking tape
- 1 meter of string
- Scissors
- Toy car
- Copy of the Hydraulic Boom Construction Plan

MANAGEMENT TIPS

Wooden sticks can replace the plastic ruler boom support and boom arm (see diagram). Sticks will be more durable than the rulers. They should be about 30 centimeters (12 inches) in length. Smaller or larger sticks are acceptable. Holes large enough for the paper fastener or bolt and nut must be drilled through the sticks. Refer to the diagrams for hole placement.

If using rulers for the boom support and boom arm, join them with the brass paper fastener. The tines of the fastener should be bent open to keep the rulers attached while allowing the rulers to pivot. A piece of masking tape to secure the tines in the open position is a good idea.

Plastic syringes are available at local pharmacies, online, and from school science supply companies. Order ten, 25-milliliter Leur lock syringes. The tips of Leur lock syringes fit the inside diameter of aquarium air hose.

PROCEDURE

1. Ask your students if they know how booms on tow trucks operate and what a hydraulic system is. Some students may know about these things if family members or friends are mechanics or just like to repair cars at home. Automobile brakes, power steering, lift systems for low-rider cars, and ride comfort and stability systems employ hydraulics. In tow trucks, the boom arm raises and lowers with hydraulics. Tell your teams they will be building a working hydraulic boom system.

2. Provide materials for the teams. Keep the masking tape in a central location where teams must go for strips of tape. (A central tape location can limit over-use of tape.)

3. Give each team a copy of the hydraulic system diagram to use as a construction plan.

4. When teams are ready to add the two syringes and hose to their hydraulic system, assist them in filling the syringes and hose with water. Follow the instructions below.
   - Attach the hose to one syringe.
   - Push the syringe plunger all the way to the bottom of the cylinder.
   - Dip the other hose end into a sink or a plastic tub partially filled with water. While keeping the open end of the tube under water, pull the plunger out from the cylinder until it just reaches the end. Do not pull it all the way out. Remove the hose from the water.
   - Push the plunger on the second syringe all the way down and attach the water hose to it. The hydraulic system is ready to attach to the boom.

5. Test the hydraulic system by depressing the plunger on the water-filled syringe. Water will travel through the hose and push the other syringe plunger out.

6. Have each team attach the syringes to the boom arm as shown, and test the system by pushing on the plunger shown on the left side of the diagram.

Continued

7. After teams have several minutes to test their hydraulic boom system, challenge them to find ways to improve it. (Improvements might include eliminating air bubbles in the hydraulic lines, changing the placement of the lifting syringe, changing the length of the boom arm by connecting the rulers or sticks with different holes, etc.) Have students list their improvements and report on the outcomes.

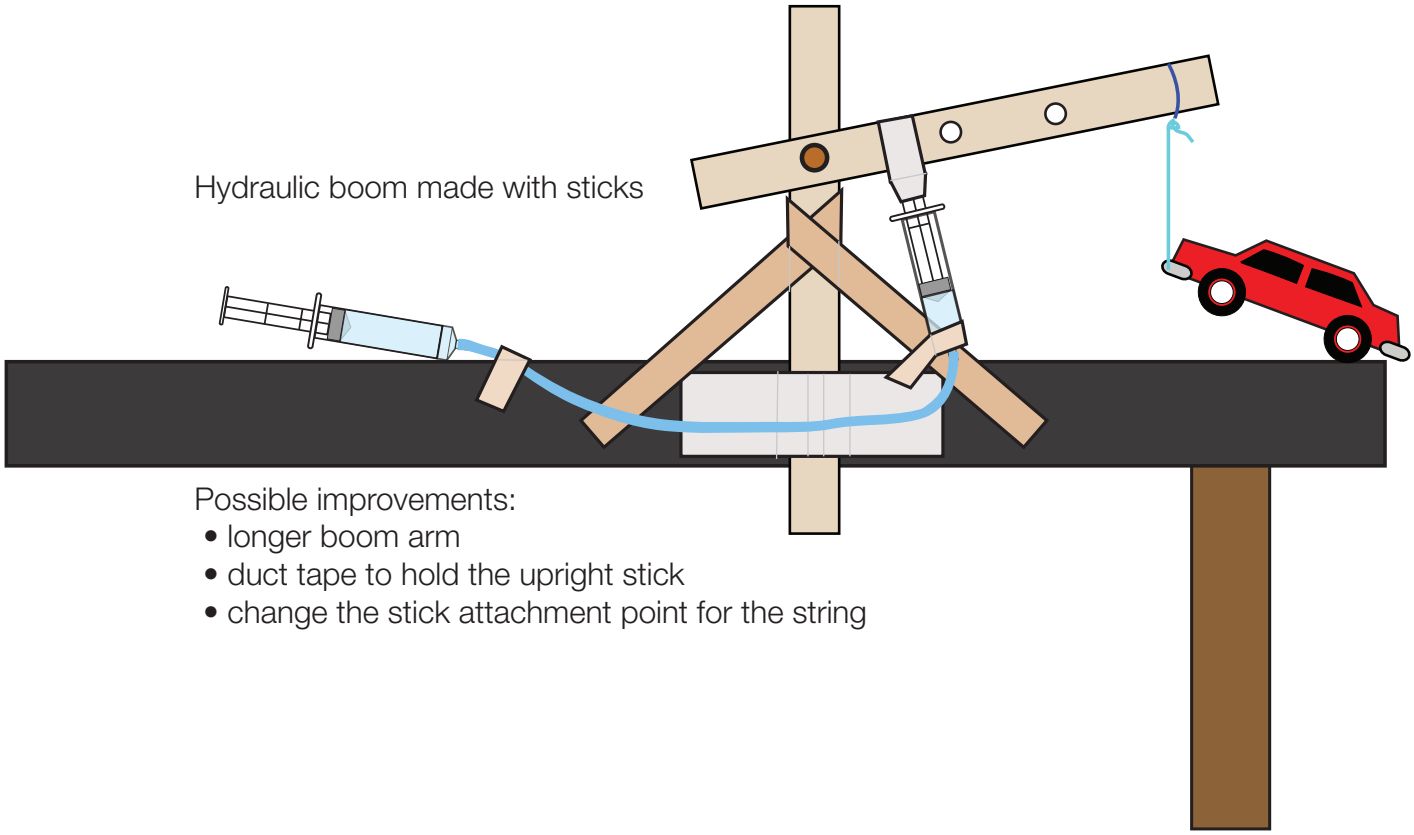
WRAP IT UP

Have teams share their ideas and successes for improving their hydraulic systems.

EXTENSIONS

The boom arm is a lever. It has a fulcrum, an input arm, and an output arm. The hydraulic system provides the force that makes the lever move. Investigate levers with your students. Ideas for investigations can be found in Lesson 2, "Lifting Forces," of the 2017 Hess Toy Truck guide, Simple and Compound Machines. www.bioedonline.org/lessons-and-more/simple-and-compound-machines/ ■

Hydraulic boom made with sticks



Possible improvements:

- longer boom arm
- duct tape to hold the upright stick
- change the stick attachment point for the string

Hydraulic Boom Construction Plans

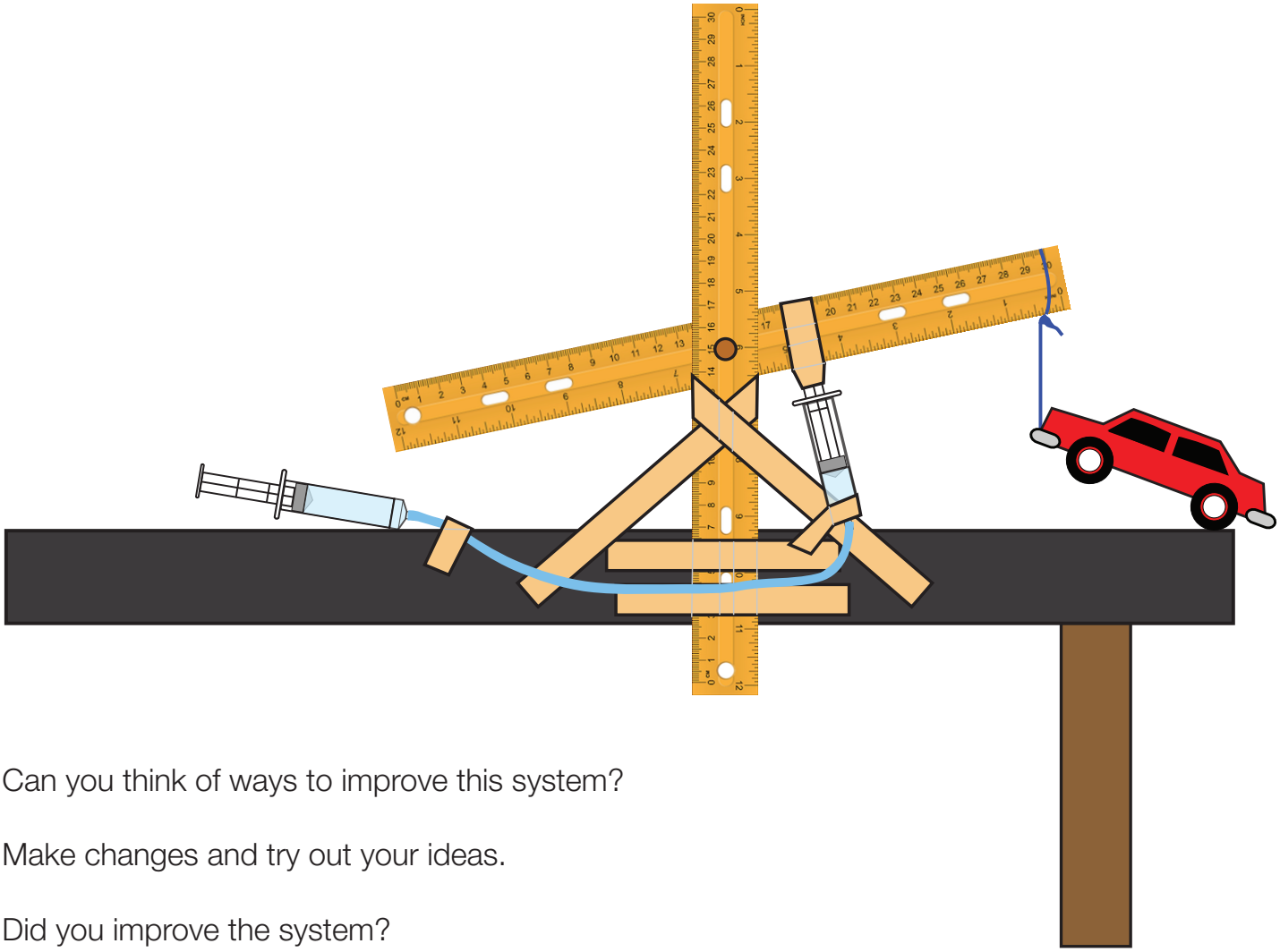
Start construction by taping the upright support to the table edge. Add two diagonal pieces of tape to stabilize the support.

Push a brass paper fastener through the holes in the rulers to hold them together and spread the tines on the back side to keep it in place.

Obtain the water-filled syringes from your teacher and attach as shown.

Press the syringe plunger on the left. What happens to the plunger on the right?

Attach a car with string and watch what happens when you operate the hydraulic boom.



Can you think of ways to improve this system?

Make changes and try out your ideas.

Did you improve the system?

Describe what you did and how it improved the system on the back of this page.

3. Stuck In a Rut

It happens to nearly every driver. The road ahead is covered with ice. Or maybe it has been raining and there are patches of slick oil coating the driving surface. Strong crosswinds are blowing. A dense fog or a snow whiteout makes the road disappear. An oncoming car swerves into your lane and you must take evasive action. These are just some of the ways even a good driver can get into trouble, like running off the road into a ditch, skidding into soft soil or sand, or smacking into a deep snowdrift. Being stuck in a rut is no fun, and it takes a tow truck to pull your vehicle out.

For tow truck operators, bad weather and bad traffic conditions lead to more business. Their trucks are up to the job of rescuing stuck cars, and the charge for getting customers unstuck can range into the hundreds of dollars. Tow trucks have lots of super powers. They have cranes for picking up or pulling a stuck vehicle out of mud or snow, or dragging it up an embankment. In addition, tow trucks have heavy-duty wheels with knobby tires.

The large Hess Toy Tow Truck has dual axles (four wheels) in the rear to support heavyweight vehicles. The small truck has a single axle (two wheels), sufficient for the smaller jobs. The tires on both trucks have the necessary traction or (i.e. friction) to keep them out of trouble.

In this activity, the traction of the small tow truck will be put to the test at several stations that are covered with various materials to simulate different road surfaces.

THE QUESTION

Which road surface provides the greatest traction for the small tow truck? Which surface offers the least traction?

MATERIALS

Per team of students

- Small 2019 Hess Toy Tow Truck
- Meter stick or yardstick
- 3 student instruction and data sheets for each team member

For the class

- Materials for constructing several test tracks with different road surfaces
  - Wax paper
  - Plastic wrap
  - 5, 8X10-inch sheets of coarse sandpaper (60 to 80 grit) cut in half lengthwise
  - Bare smooth surface tile floor
  - Masking tape
- Additional materials
  - 3 water spray bottles (set to spray a water mist)
  - Towels for mop-up

MANAGEMENT TIPS

Lay out four simulated road surfaces on an open area of a tile floor with a smooth surface. Each test surface should be the same length (8 to 10 feet). Use lengths of wax paper, plastic wrap, and sand paper to create test tracks. Anchor the tracks to the floor using masking tape. Also, mark a distance on the bare floor to create a smooth hard surface track. Save the water spray bottles for when each team has run its vehicle over dry surfaces. In the second part of the activity, teams will give a light coating of water to the wax paper, plastic wrap, and bare tile floor tracks. Make sure the spray bottles are set for misting. Do not conduct the water spray test with the sandpaper track.

The student data sheets call for the averaging of 4 driving test distances. If possible, have teams measure distances in centimeters for easier averaging. If students have not yet learned about averages, have them look at their four measurements and pick the one closest to the middle of all the measurements.

PROCEDURE Part One – Dry Weather

1. Set up four stations on the classroom floor where teams will test the traction of their small tow trucks. Each track should be the same length (8 to 10 feet long) and marked with a masking tape line from behind which the truck will start. Use tape to hold down the corners of the coarse sand paper. Run the cut sand paper sheets end to end for the length of the track.

Continued

2. Have teams examine their small tow trucks. Ask, "What are the most important parts of the trucks?" Have teams discuss possible answers and make a list. Answers may include:
   - engine
   - boom or crane
   - headlights and safety lights
   - tires

3. Ask each team to name one thing from their list and write it on the board. Go through the completed list and discuss each item. Why is it important? What does it do? How could it help the tow truck operator free a stuck vehicle? Focus the discussion on the tires. For the truck to do its job, the tires must provide lots of traction. Traction is another word for friction. If the wheels don't grab the road surface or dirt, sand, or snow, the tow truck won't be able to pull out the stuck vehicle. Worse, the tow truck could slide into a ditch and need a tow itself.

4. Announce that teams will conduct an evaluation of the tire traction of their tow trucks. Each member of the team will drive the truck along the four different tracks. Teams will measure how far the trucks travel along the tracks and beyond. The smoothness or roughness of the test track surfaces will affect tire friction. If friction of the tires with the road surface is low, the trucks will lose some of their kinetic energy and not travel as far.

5. Provide teams with the Stuck In a Rut instruction sheet, dry weather and wet weather data sheets, and the question sheet. Have the teams rotate through the various test track stations as they become available.

PROCEDURE Part Two – Wet Weather

1. After all teams have tested their trucks on the wax paper and the plastic wrap, provide the spray water bottles. Have the teams spray the entire length of these tracks with a light film of water and test their Hess Toy Tow Trucks again. *Do not spray the sandpaper track! Teams should evaluate tow truck performance on the two dry surfaces, compared with the same two surfaces after a "rainfall."

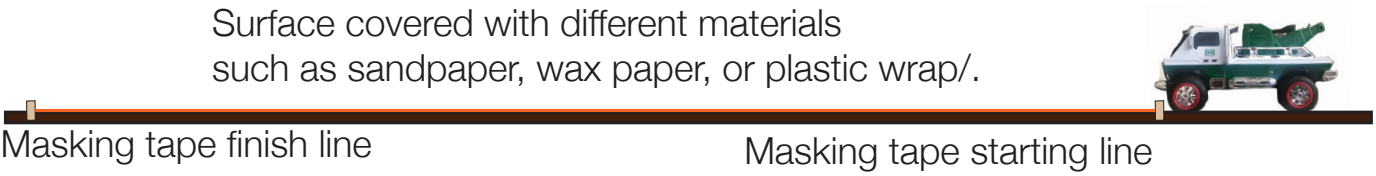
2. At the completion of the water test, teams should thoroughly dry the track surfaces for the next team.

WRAP IT UP

- Conduct a class discussion on the team's investigation results. *On what surface material did the tow truck have the best traction? On what surface material did the truck have the least traction? How do you know?*
- Have students report the findings from their data sheets. *What effect did water have on the truck's traction? Why are the results of this investigation important to tow truck operators?*
- When on a job, the surface on which the truck is operating may cause the truck to slide rather than pull out the disabled vehicle. Knowing this, the operator will position the truck in the best location and direction to accomplish the job. *Can anything be done to increase the traction of the tow truck tire?*

EXTENSIONS

- Have teams try towing each other's small tow truck over the same test surfaces. Compare the distance the small Hess Toy Tow Truck travels with another vehicle attached with the distance the truck traveled with no tow.
- Have teams practice towing each other's small tow truck over various surfaces, such as carpet, tile flooring, concrete, or asphalt. ■



Stuck In a Rut

INSTRUCTIONS

Several test tracks are placed around the room. Each track simulates a different road surface. Several tracks are covered with a surface material that represents a slick driving surface or a very rough gravel surface. Your team will start at one track and test how much traction your tow truck has on that surface. When you have completed your tests on that track and recorded your results on the data sheet, your team will move on to the next available station and test your truck's traction there.

HOW TO CONDUCT THE TESTS

1. Take your small Hess Toy Tow Truck to the first available track. Have your team's first "driver" spin the motor, immediately place the tow truck's front wheels on the tape line, and then release the truck.
2. Observe the truck and measure how far it travels. Record the distance in the appropriate box below and have the next team member be the "driver." Average the distance measurements for all four test runs over each surface.
3. Answer the questions in each section. Then, repeat the process on "Wet Weather" tracks. Finally, as a team, answer the questions on the Stuck In a Rut reporting page.4. After all team members have "driven" the truck on the track and recorded the traveling distance each time, go to the next available track and begin again.
5. When all teams have completed their "dry weather" tests, begin "wet weather" tests. The test procedure is essentially the same, but your team will first spray a mist of water over the track's entire length. After running each test, dry off the track for the following team to use.

Important: Do not conduct wet weather tests on the sandpaper track.

Stuck In a Rut - Dry Weather Tests

Name: _____

Instructions: Take your small hess truck to the first track that is available. Have your first driver spin the motor and immediately place the front wheels on the tape line and release it. Observe the truck's drive and measure how far it truck travels. Record the distance below and have the next team member repeat the procedure. Average the distance measurements. Answer the questions on the attached page.

Wax Paper Track

	Test 1	Test 2	Test 3	Test 4	Average Distance
Distance truck rolled along the road:					

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Plastic Wrap Track

	Test 1	Test 2	Test 3	Test 4	Average Distance
Distance truck rolled along the road:					

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Sand Paper Track

	Test 1	Test 2	Test 3	Test 4	Average Distance
Distance truck rolled along the road:					

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Tile Floor Track

	Test 1	Test 2	Test 3	Test 4	Average Distance
Distance truck rolled along the road:					

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Stuck In a Rut - Wet Weather Tests

Wax Paper Track with Water Coating

	Test 1	Test 2	Test 3	Test 4	Average Distance
Distance truck rolled along the road:					

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Plastic Wrap Track with Water Coating

	Test 1	Test 2	Test 3	Test 4	Average Distance
Distance truck rolled along the road:					

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Tile Floor Track with Water Coating

	Test 1	Test 2	Test 3	Test 4	Average Distance
Distance truck rolled along the road:					

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Stuck In a Rut

Name: _____

Using your data from the investigation, answer these questions.

Which surface material provided the best traction for the truck?
Explain your answer.

Which surface material provided the least traction for the truck?
Explain your answer.

How did the presence of water on stations 1, 2, and 3 affect traction?

If you were the tow truck operator, what could you do to increase traction on terrible road conditions such as ice, snow, mud, or flood waters.

4. Help Wanted – Tow Truck Driver

Tow truck drivers are always in demand. As more and more vehicles hit the roads, more and more accidents occur. Sometimes, drivers lose control and end up in the ditch, or heavy rain and snowfall causes havoc. Tow truck drivers are needed to solve many different transportation problems.

Being a tow truck driver is much more than just driving around looking for a vehicle to tow. Tow truck drivers need a solid understanding of transportation mechanics, science, and mathematics. They also must have a strong knowledge of transportation safety and good communication skills to deal with distraught drivers, law enforcement officers, fire fighters, and emergency medical technicians. Tow truck drivers also must be excellent drivers and have a current commercial driver license (CDL) for the state in which they operate. Tow truck driver jobs start at an annual salary of $25,000 to $30,000, and can rise over $100,000 for the most experienced and best drivers.

In this activity, students will try to pass the driving test to earn a Hess Tow Truck license, needed to operate the 2019 Hess Toy Tow Trucks.

THE QUESTION

Can you pass the Hess tow truck driver test?

MATERIALS

Per team of students

- 2019 Hess large and small toy tow trucks
- Cleared floor space (about 3 x 4 meters for test course)
- Masking tape
- Several thick books or blocks
- One Driver Test Report page per student
- Blank CDL licenses
- 1 meter of string

MANAGEMENT TIPS

- If space is available, set up more than one driver's test course, consisting of the three driving challenges, so that more than one team at a time can take the driving test. If room is available for only one course, three teams can use the course at a time and rotate through the tests.
- Thick books or blocks are used for lining the street for Test 1.
- Use masking tape to set up the square for Test 2. To facilitate easy removal after the activity, fold over a few centimeters of tape on one end to make a pull-tab.
- More books or blocks can be used to outline an intersection for Test 3.
- In Tests 1 and 3, bumping the books or blocks automatically results in failure of the tests and the driver must try again.
- The objective is for each student to pass the driver's test and earn a CDL. Multiple tries may be necessary, but if a student passes the test on the first attempt, that student is finished for that test, and the next student takes the test.

PROCEDURE

1. Explain the purpose of the activity. Each member of the team is applying for a commercial driver's license (CDL) to qualify for a tow truck driver job. To get the license, each team member must pass a driver's test consisting of three tow truck challenges. As each team member takes the tests, his or her teammates will serve as license examiners.
   Test 1: Holding the road.
   Test 2: Stopping at an accident scene.
   Test 3: Turning a corner with a vehicle in tow.

2. Holding the Road
   Make curbs with thick books or blocks on the floor to outline a street on which the large truck will travel. The street should run straight and be about 3 to 4 meters long and about 30 centimeters wide. It is not necessary to make the curbs continuous. Books or blocks every 50 centimeters will be sufficient. Also, place a masking tape strip at the front end of the street (start line) and at the far end (finish line). The challenge is for the driver to give the large 2019 Hess tow truck a push and have it run the length of the street from behind the

Continued

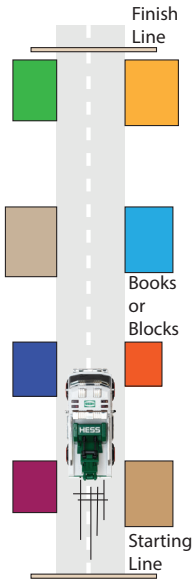
starting line and cross the finish line without bumping into any books or blocks.

3. Stopping at an Accident Scene
   In a clear area of the floor, use masking tape to mark a square measuring one meter by one meter. The square represents an accident scene. Place a tape starting line 3 to 4 meters away from the square. Team members will use the small 2019 Hess toy truck for this test. Each team member will power up the small truck engine by pushing it along the floor and then releasing it. The objective is to give the small truck just enough kinetic energy to roll forward and stop within the tape square.

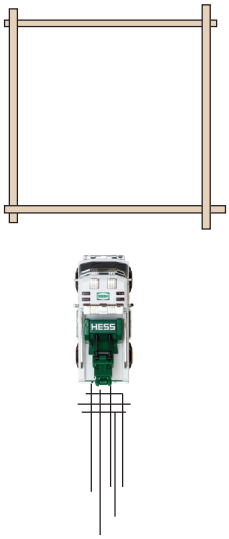
4. Turning a Corner with a Vehicle in Tow
   Use books or blocks to outline a street intersection. The books or blocks will form curbs. The curbs should be 50 centimeters across from each other. Place the large and small 2019 Hess Tow Trucks between the curbs before the intersection. The small truck will be the towed vehicle. The objective is for the student driver to push the big truck with the small truck in tow around a corner without losing the tow or bumping into the curbs. The boom hooks of the large truck will latch on to the front bumper of the small truck. However, the tow will be lost if the student driver makes too sharp of a turn.

5. While each team member is taking the driving test, the other team members will be license examiners, watching to make sure the trucks do not rub or hit the curbs. Hitting the curb (Test 1 and 2) or missing the square (Test 2) will cause the driver to repeat the test until success is achieved. The driver examiners will check off the test form for the driver. After the driver passes the test, another team member will take the test and the first driver will become a driving test examiner. Encourage team members to share with each other any tips they have for passing the three tests.

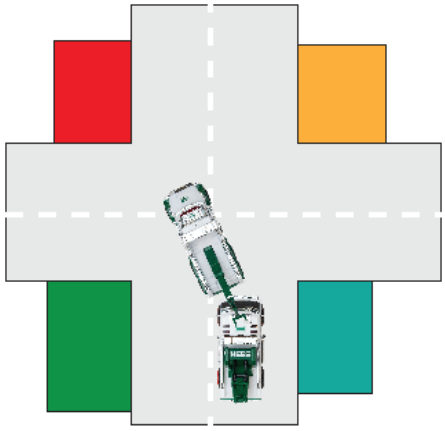
Commercial Driver License Driving Test Courses



Holding the Road



Stopping at Accident Scene



Turning Corner with Tow

Continued

WRAP IT UP

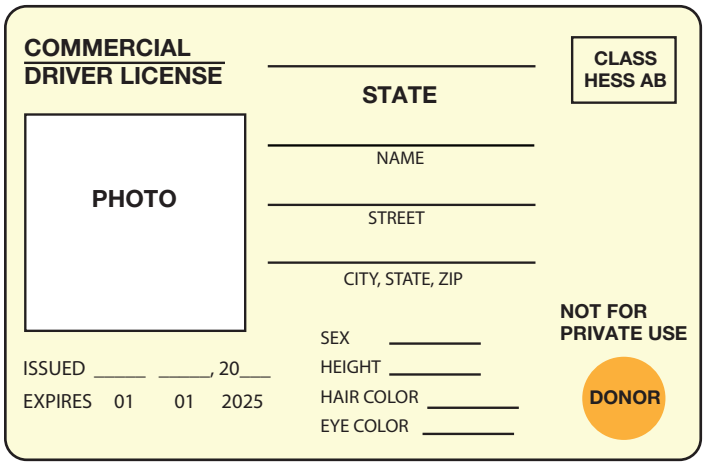
At the conclusion of the driving test, distribute blank commercial driver licenses to the class. Students should fill in their information. If possible print small pictures of each student for pasting into the indicated space for photos.

Ask students which test was the hardest and which the easiest. What made a test hard? What did you do to meet the driving challenges?

Ask if anyone has seen an accident scene with one or more tow trucks and drivers at work. Have them share their observations. Did they notice any special safety procedures, such as putting down orange safety cones or wearing orange or bright yellow vests?

EXTENSIONS

- Have students try backing up the large truck with the small truck in tow. Have them turn the large truck slightly to one side or the other and observe which direction the small truck goes.
- Have students learn about the requirements for receiving a commercial driver's license in the state in which they live. Use a search engine and the phrase, "commercial driver's license for [state name].



If possible, print the license on cardstock paper.

The driver license test form has room for recording multiple attempts. One passing test for each test is sufficient for each student. ■

Commercial Driver License Test Form

Applicant Name: _____

Test 1: Holding the Road

	Attempts				
Pass	☐	☐	☐	☐	☐
Fail	☐	☐	☐	☐	☐

Test 2: Stopping at Accident Scene

	Attempts				
Pass	☐	☐	☐	☐	☐
Fail	☐	☐	☐	☐	☐

Test 3: Turning Corner with Vehicle in Tow

	Attempts				
Pass	☐	☐	☐	☐	☐
Fail	☐	☐	☐	☐	☐

The Applicant Has Passed Driver Test

Yes ☐ **No** ☐

Driver Test Examiner Names

_____

_____

_____

Continued

COMMERCIAL DRIVER LICENSE

CLASS HESS AB

STATE

NAME

STREET

CITY, STATE, ZIP

PHOTO

ISSUED ______ ______, 20___

EXPIRES 01 01 2025

SEX ________

HEIGHT ________

HAIR COLOR ________

EYE COLOR ________

NOT FOR PRIVATE USE

DONOR

COMMERCIAL DRIVER LICENSE

CLASS HESS AB

STATE

NAME

STREET

CITY, STATE, ZIP

PHOTO

ISSUED ______ ______, 20___

EXPIRES 01 01 2025

SEX ________

HEIGHT ________

HAIR COLOR ________

EYE COLOR ________

NOT FOR PRIVATE USE

DONOR

COMMERCIAL DRIVER LICENSE

CLASS HESS AB

STATE

NAME

STREET

CITY, STATE, ZIP

PHOTO

ISSUED ______ ______, 20___

EXPIRES 01 01 2025

SEX ________

HEIGHT ________

HAIR COLOR ________

EYE COLOR ________

NOT FOR PRIVATE USE

DONOR

COMMERCIAL DRIVER LICENSE

CLASS HESS AB

STATE

NAME

STREET

CITY, STATE, ZIP

PHOTO

ISSUED ______ ______, 20___

EXPIRES 01 01 2025

SEX ________

HEIGHT ________

HAIR COLOR ________

EYE COLOR ________

NOT FOR PRIVATE USE

DONOR

COMMERCIAL DRIVER LICENSE

CLASS HESS AB

STATE

NAME

STREET

CITY, STATE, ZIP

PHOTO

ISSUED ______ ______, 20___

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COMMERCIAL DRIVER LICENSE

CLASS HESS AB

STATE

NAME

STREET

CITY, STATE, ZIP

PHOTO

ISSUED ______ ______, 20___

EXPIRES 01 01 2025

SEX ________

HEIGHT ________

HAIR COLOR ________

EYE COLOR ________

NOT FOR PRIVATE USE

DONOR

Continued

Commercial Driver License
Test Form

Applicant
Name: ____________________________

Test 1: Holding the Road

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 2: Stopping at Accident Scene

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 3: Turning Corner with Vehicle in Tow

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

The Applicant Has Passed Driver Test

Yes ☐ **No** ☐

Driver Test Examiner Names

____

____

____

Commercial Driver License
Test Form

Applicant
Name: ____________________________

Test 1: Holding the Road

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 2: Stopping at Accident Scene

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 3: Turning Corner with Vehicle in Tow

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

The Applicant Has Passed Driver Test

Yes ☐ **No** ☐

Driver Test Examiner Names

____

____

____

Commercial Driver License
Test Form

Applicant
Name: ____________________________

Test 1: Holding the Road

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 2: Stopping at Accident Scene

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 3: Turning Corner with Vehicle in Tow

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

The Applicant Has Passed Driver Test

Yes ☐ **No** ☐

Driver Test Examiner Names

____

____

____

Commercial Driver License
Test Form

Applicant
Name: ____________________________

Test 1: Holding the Road

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 2: Stopping at Accident Scene

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 3: Turning Corner with Vehicle in Tow

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

The Applicant Has Passed Driver Test

Yes ☐ **No** ☐

Driver Test Examiner Names

____

____

____

Commercial Driver License
Test Form

Applicant
Name: ____________________________

Test 1: Holding the Road

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 2: Stopping at Accident Scene

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 3: Turning Corner with Vehicle in Tow

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

The Applicant Has Passed Driver Test

Yes ☐ **No** ☐

Driver Test Examiner Names

____

____

____

Commercial Driver License
Test Form

Applicant
Name: ____________________________

Test 1: Holding the Road

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 2: Stopping at Accident Scene

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

Test 3: Turning Corner with Vehicle in Tow

Attempts

Pass ☐ ☐ ☐ ☐ ☐

Fail ☐ ☐ ☐ ☐ ☐

The Applicant Has Passed Driver Test

Yes ☐ **No** ☐

Driver Test Examiner Names

____

____

____

5. Hess Towing Inc.

There is much more to towing than knowing how tow trucks work and having a Commercial Driver's License. First, tow truck operators need to be a part of a towing company that is qualified to conduct business in the region it is located. Towing companies can consist of just one individual (sole proprietor) or a business with several employees.

Before opening for business, the company must complete a state application form to obtain a towing operator permit. The application requires the company to describe its tow trucks and their towing capabilities. Knowing the trucks and capabilities is a matter of both safety and towing efficiency (clearing the road of a disabled vehicle as soon as possible). An unqualified driver might improperly attach the disabled vehicle and then lose it while transporting it to a garage or wrecker yard. This could lead to further damage to the towed vehicle or serious injuries to nearby people and property. The towing permit ensures that the company and employees are ready to safely conduct business.

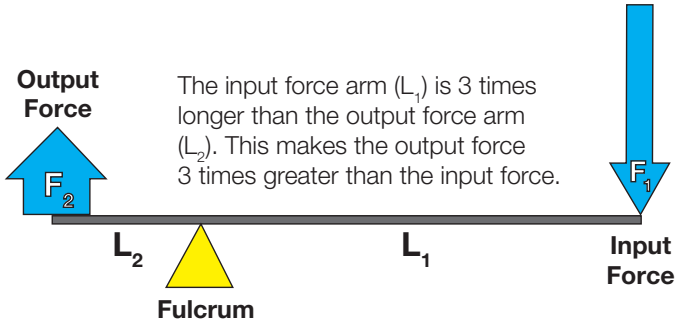
In this activity, teams of students will perform a detailed examination of their Hess Toy Tow Trucks and complete the towing application form. The most important parts of this activity are:

- To understand how tow trucks and their load are actually a simple machine called a lever.
- To measure and calculate, using the lever principle, how much each truck can lift and safely transport.

Tow Trucks and Levers

The tow truck and its load (damaged vehicle) is a simple machine—a lever. In its simplest form, a lever is a rigid bar, resting on a pivot called a fulcrum. It is used to lift something heavy.

Levers change the magnitude and direction of the input force. By pressing down on the long end of the bar, the short end lifts the weight.



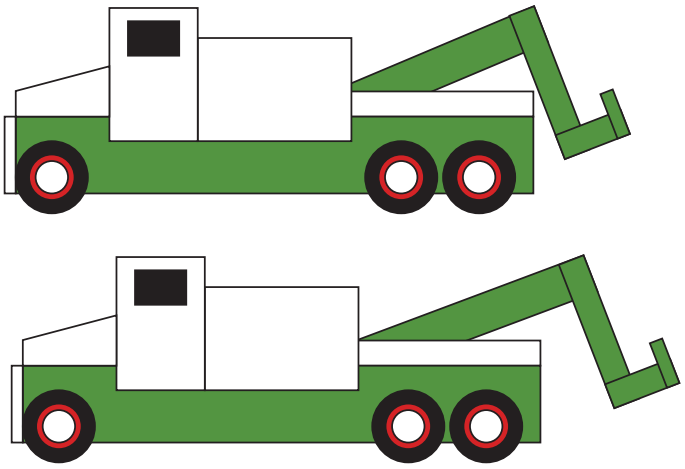
If both ends of the bar are the same length, the lifting force will be the same as the downward force. However, if the length of the L_1 is twice as long as the length of L_2, the lifting force will be doubled. If it is three times as long, the lifting force will be tripled.

The rear wheels of the tow truck together constitute the fulcrum. The truck frame acts as a part of the rigid bar. The boom overhang of the truck is the other end of the bar. The front end of the tow truck exerts a downward force because of its weight. The front end of the towed vehicle also exerts a downward force because of its weight.

It is essential for tow truck operators to understand the lever relationship between the tow truck and towed vehicle. If the load is too heavy, the front end of the tow truck will lift off the road. With front wheels off the ground, the tow truck can't be steered and braking power will be greatly reduced. For safety purposes, the weight of the towed vehicle should be no more than one half the tow truck's actual lifting force. For example, if the lifting force of the tow truck is 10,000 pounds, the towed vehicle weight should be no more than 5,000 pounds. This safety factor means that the tow truck's front wheels will remain firmly on the road so that steering and brakes work.

Continued

One approach to towing a heavy vehicle is to shorten the boom length to reduce the overhang (L_2) length. This enables a heavier vehicle to be lifted by the boom without sacrificing safety.



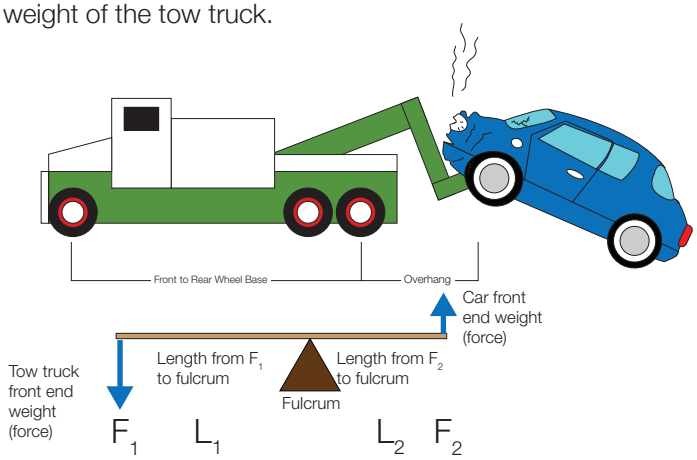
A simple formula enables tow truck operators to calculate how much weight their truck can safely lift and transport. The formula is "force x length = force x length." Here is the formula.

$$F_1 \times L_1 = F_2 \times L_2$$

If you know three of the four factors, the fourth factor can be calculated. The fourth factor for tow truck operators is F2, the safe weight the truck boom can lift. To determine F2, the formula is rewritten to this.

$$\frac{F_1 \times L_1}{L_2} = F_2$$

Finally, the result is divided in half to arrive at the safe lifting weight of the tow truck.



THE QUESTION

How much weight can your tow trucks lift and tow safely?

MATERIALS

Per team of students

- 2019 Hess large and small toy tow trucks
- 12-inch ruler
- Tow truck operator application form
- Maximum towing weight work sheet

Per Class

- Electronic or balance beam scale – more than one preferred (a postal scale will work if it is capable of measuring two pounds or more)

MANAGEMENT TIPS

- Because most or all state licensing agencies function primarily in British system units, this activity will require British system measurements. If your measurement scales only use metric units, conversions of grams to pounds will be necessary. If your students are not familiar with decimal numbers, you will have to assist them in conversions. The factor for converting grams into pounds is 0.0022. Multiply the number of grams times this factor to yield the equivalent measure in British system pounds.
- Place the scale or scales students will use for weight determination in an easy-to-reach location. If necessary, review the use of laboratory scales with your students.
- It is suggested that you do not review the application form with your students before they start filling it in. Figuring out forms correctly is a valuable lifetime skill. Be available to answer specific questions.
- When discussing how a tow truck—together with the disabled vehicle it is towing—make up a lever, mention seesaws. Most students will have experienced riding on a seesaw. It has a long beam and a pivot point called a fulcrum. The two riders sitting on opposite ends of the seesaw are like the front end of the tow truck and the front end of the tow vehicle. The truck body and boom are like the seesaw's long beam. The truck's rear tires act as the fulcrum. (See diagram above.)
- The maximum towing weight worksheet is optional. It breaks down the safe towing weight formula into small multiplication and division steps and helps students who have not had introductory algebra.

Continued

PROCEDURE

1. Have teams try towing the small truck with the large truck. Can they do it? Why or why not? Have them reverse the two trucks and try to tow the large truck with the small truck. Can they do it? Why or why not? Explain that a tow truck with a tow is a lever. Too much weight on the boom causes the front end of the tow truck to leave the road.

2. Describe the purpose of the activity. Teams will complete an application form for a towing operator license. Knowing their trucks and how much they can tow is a big part of the application process.

3. Distribute application forms to the teams and point out the resources available to them.

4. Show how the truck weight measurements should be made. Refer to the diagrams that follow. If unit conversions for weight become necessary, explain how they will be made (calculator, computer, hand calculation). If students suggest weighing whole trucks and dividing the weight by two, point out that weight distribution in vehicles is not uniform. Because of the engine, the truck is heavier in the front than in the rear.

5. Have teams turn in their completed applications to you. Play the role of a licensing agency official and reject incomplete forms or forms with mistakes. (This is a real world experience.)

WRAP IT UP

Discuss the importance of knowing the towing weight capacity for each truck. Ask, "Why is the maximum towing weight divided by 2?" Dividing by 2 is a safety factor. It makes sure that the front wheels of the tow truck remain firmly on the ground during transport. Ask, "Is there any way to increase the maximum towing weight safely?" The length of the boom can be shortened. This decreases the overhang length, which enables the tow truck to lift a heavier vehicle.

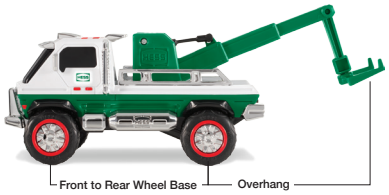
Another way of increasing the maximum weight is to increase the front-end weight of the truck. For example, adding several hundred pounds of sand bags to the truck cabin will increase the front-end weight. This is not recommended. Besides interfering with the driver, extra weight stresses the truck frame, causing extra wear.

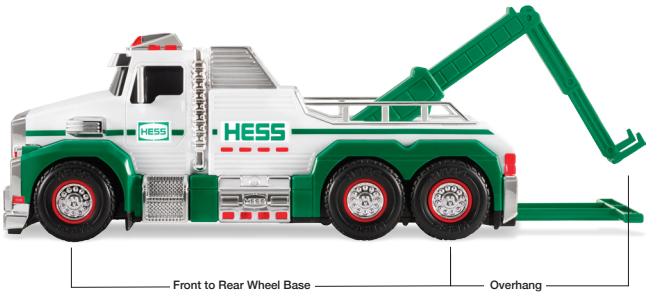
EXTENSIONS

Obtain several toy vehicles of sizes comparable to the sizes of the trucks. Have teams determine if they can tow these vehicles and decide which Hess Toy Tow Truck will be best to use. Teams should first weigh the tow vehicles and then try to tow them. If tow truck's front wheels lift up, that team miscalculated. If teams determine that either truck is able to make the tow, ask which truck is the most economical to use. (The heavier the truck, the more fuel it needs to operate.)

How to Measure Wheelbase and Overhang

The overhang starts at the center of the rear wheels. When vehicle is attached to the boom, the center point of the rear wheels act like a fulcrum of a lever. If the tow truck operator tries to lift too much weight, the lever causes the front wheels of the tow truck to lift off the ground.





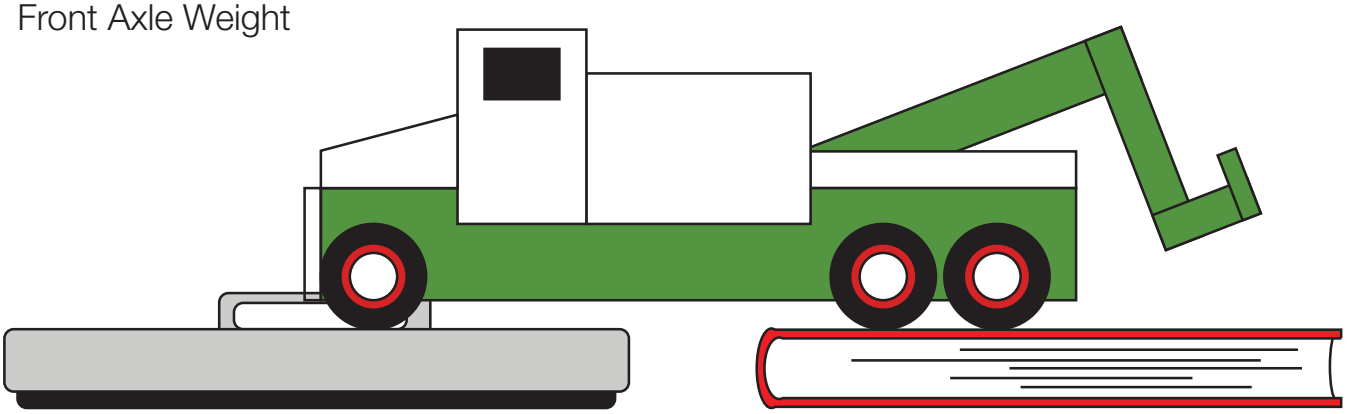
In both tow trucks, the length of the boom arm can be changed. Shortening the boom arm length decreases the overhang and increases how much the truck can lift with the boom.

Continued

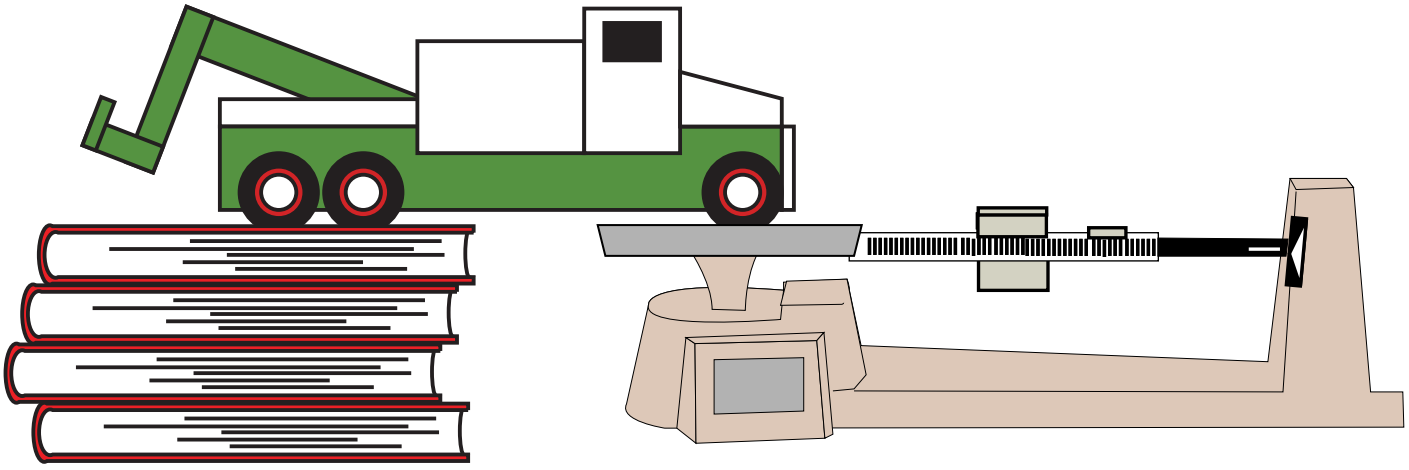
How to Measure the Front Axle Weight of the Trucks and Disabled Vehicles

Place the front wheels of the tow truck on the scale platform. Use a book or book pile to enable the truck to remain horizontal during weighing. Record the weight as F_1. Do the same for the disabled vehicle. Record the weight as F_2.

Front Axle Weight



Use a book to level the truck for weighing.



Towing/Recovery Vehicle Business Application

Page 1

Business Name: _____

Owner/Employees:

_____ CDL Y N
President

_____ CDL Y N
Office Manager

_____ CDL Y N
Driver

_____ CDL Y N
Driver

Number of Tow Trucks: ☐

Vehicle Specifications

Truck 1

☐ Light Duty Wrecker (for passenger cars, pickup trucks, small trailers, etc.)
☐ Heavy Duty Wrecker (for large trucks, tractor trailers)

Vehicle Year: _____ Make: _____ Number of axles: _____

Vehicle Total Weight: _____ lbs

Wheel Base Length: _____ in

Vehicle Front Weight: _____ lbs

Wheel Base Width: _____ in

Boom Overhang Length: _____ in

What is the maximum weight this truck can lift and tow? _____ lbs
(Use the towing capacity formula for calculating this answer)

Describe the safety features of this truck in the space below:

State Towing Company Application Form 01-5789-C. All other versions of this form are obsolete

Towing/Recovery Vehicle Business Application

Page 2

Business Name: _____

Vehicle Specifications

Truck 2

☐ Light Duty Wrecker (for passenger cars, pickup trucks, small trailers, etc.)
☐ Heavy Duty Wrecker (for large trucks, tractor trailers)

Vehicle Year: _____ Make: _____ Number of axles: _____

Vehicle Total Weight: _____ lbs

Wheel Base Length: _____ in

Vehicle Front Weight: _____ lbs

Wheel Base Width: _____ in

Boom Overhang Length: _____ in

What is the maximum weight this truck can lift and tow? _____ lbs
(Use the towing capacity formula for calculating this answer)

Describe the safety features of this truck in the space below:

State Towing Company Application Form 01-5789-C. All other versions of this form are obsolete

Maximum Towing Weight Worksheet

Name: _____

Large Tow Truck Data **(enter the following information)**

A. Wheel Base Length: _____ B. Overhang Length: _____

C. Truck Front End Weight: _____

D. Multiply A times C : _____

E: Divide D by B: _____

F. Divide E by 2: _____ (This is your maximum safe towing weight. Use this number on your Towing/Recovery Vehicle Business Application.)

Small Tow Truck Data **(enter the following information)**

A. Wheel Base Length: _____ B. Overhang Length: _____

C. Truck Front End Weight: _____

D. Multiply A times C : _____

E: Divide D by B: _____

F. Divide E by 2: _____ (This is your maximum safe towing weight. Use this number on your Towing/Recovery Vehicle Business Application.)

6. The Race is On

When a serious traffic accident occurs, help is needed from a tow truck wrecker service. Police responding to the accident may ask the driver or drivers if they wish to call a particular towing company. If not, a police dispatcher will call one or more licensed and approved companies to respond. Towing companies are contacted on a rotating basis to distribute towing jobs fairly.

When a towing job comes in, the tow company dispatcher must know where the company's tow trucks are located at that moment and pick the truck nearest the accident scene. A call to the driver starts the tow process.

Despite the best efforts of tow truck drivers, it may take a long time to get to the accident scene. Quite often, accidents occur during morning or afternoon rush hours. That means there may be heavy traffic to get around. If the accident occurs on a limited access road, such as a freeway, the accident will cause a backup that makes it difficult to arrive quickly.

Knowing how to maneuver in heavy traffic, and knowing the roads and short cuts greatly aids the driver in getting to the job. Towing the vehicle to a repair shop or junkyard completes the tow and makes the tow truck and driver available for another job. The more jobs a tow operator can complete in a day, the more money the driver and company can earn.

In this activity, the tow truck companies formed in the previous activity will practice map-reading skills and then compete to be the quickest tow truck to arrive at a simulated accident.

THE QUESTION

What is the fastest route to the accident site?

MATERIALS

Per team of students

- Map page
- 30 cm of string
- Colored marker

MANAGEMENT TIPS

- Project a copy of the map of Hess City on the screen before starting part one of the activity. Review the map legend and discuss the meaning of the symbols. If you have saved the pdf file of this curriculum guide on your computer, you can scroll to the map page when you are ready to project it.
- Demonstrate how to measure distances on the map using a string. Lay one end of the string on the starting point and stretch the string to the ending point. Pinch the string at the ending point and lay the string on the map scale to determine how long the measurement is in miles. The string permits easy measuring of zigzag or curved streets.

PROCEDURE

1. Distribute copies of the street map to each team. Instruct teams to make no marks on the map until told to do so.

2. Project a copy of the map on the screen, point out its features, and discuss the meaning of the map symbols.

3. Tell the teams to meet and pretend that a traffic accident occurred at site 1. Have them discuss and figure out the best and fastest way to get to the site. It is important to avoid construction zones and areas of slow traffic. When the teams decide the best path, they can mark the route on the map.

Continued

4. When teams have plotted their route from the starting point to the accident, have them measure its distance using the string and map scale. Direct teams to write the distance to the accident in the space indicated.

5. After arriving at the first site, teams should plot a route from traffic accident site 1 to site 2 and then another route from site 2 to site 3. Some students may observe that if this were a real accident, the tow truck would have to bring crashed vehicle to a repair shop or junkyard before going on to another site. Tell them it's a great observation but that step is being skipped for just today. In real life, other tow trucks would be called to work the second and third accident scenes.

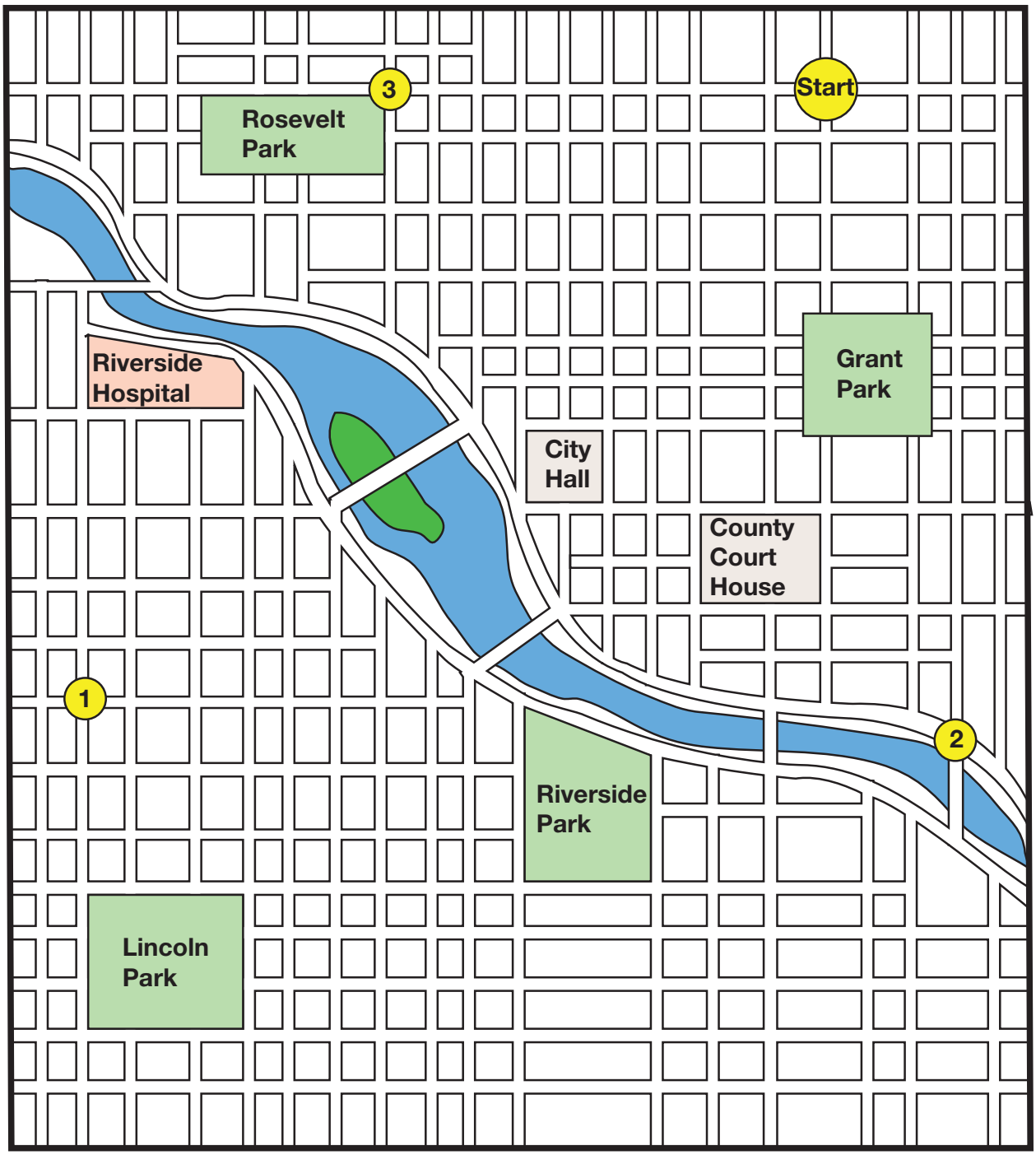
WRAP IT UP

- Review the routes each team chose to reach the accident sites on the Hess City paper map. How did teams decide their routes? What considerations were important to them?
- Compare the distances each tow truck team followed to the three accident sites. What were the best routes?

EXTENSIONS

- Have teams convert their travel distances to time. Assuming an average speed of 30 miles per hour, how long will it take to travel to each accident scene? (Multiply the distance in tenths of a mile times 2 to determine the travel time in minutes.)
- Lay out a series of intersecting roads on an open space of the floor. Use masking tape to mark the roads. Have students try to follow the route using the large and the small Hess Toy Tow Trucks. Students should push the large truck or power up the small truck motor so that the truck stops at intersections where a direction change should be made. If the trucks stop too soon or roll past the intersections, students have to try again. Use a stopwatch or a smart phone timer to time how long it takes to travel the course.
- Map reading skills are useful even in the age of global positioning satellites and Internet-based map applications. Locate a map of the school's city or town on the Internet and use that map for route challenges similar to those in part 1 of this activity. Actual (folded) city and state highway maps are fun to view and have many useful bits of information. Point out symbols, road types, distance markers, directions, map grids, and mileage calculators. ■

HESS City



One Mile

0 1/2 1

Tow Truck Travel Distance

N

Start to accident 1 _____ miles

Accident 1 to accident 2 _____ miles

Accident 2 to accident 3 _____ miles

7. The Cost of Doing Business

A successful business is a complicated venture. It takes a great deal of planning and preparation before an "Open for Business" sign can be hung on the door. In the tow truck/wrecker business, many decisions must be made, and tasks accomplished, before the first tow. Decisions and tasks include obtaining a business location, purchasing trucks and needed tools and supplies, applying for permits and licenses, hiring drivers and an office manager/dispatcher, conducting safety training, etc.

Once the business opens, there is time card reporting, paychecks to be issued, taxes to be paid, and supplies and equipment replacements to be purchased. In the area of consumable supplies, the largest expense for a tow company is fuel to operate the trucks. Tow trucks use a lot of fuel and when they attach a disabled vehicle to the boom or low tow, the fuel cost goes up.

In this activity, teams will indirectly investigate fuel costs (MPG or miles per gallon) by operating their trucks under different road conditions. Teams will roll their large tow trucks down an inclined plane. The momentum of the trucks by the time they reach the bottom will carry the trucks across the chosen surface. The friction of the surface will affect how far the trucks roll. How far they roll will provide a rough estimate of what the MPG of the truck is over that surface. The farther the truck rolls, the better the MPG.

THE QUESTION

How does the road surface affect fuel efficiency?

MATERIALS

Per team of students

- 2019 Hess large toy tow trucks
- 1 or more inclined plains (4 to 6-foot long x 8 inch wide, smooth surface wood board from a home improvement store or lumberyard. If the board is longer, store or lumberyard personnel can cut it for you.)
- Cardboard box for each inclined plane (to raise and support the upper end of the plane)
- Tape measure or meter stick
- Student data page

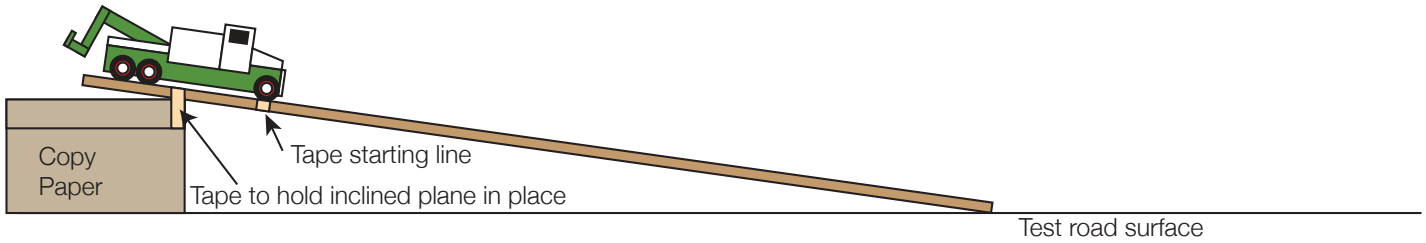
For the Class

- Different road surface materials
  - Tile floor
  - Carpet floor
  - Sand (see tips)
  - Aquarium gravel (see tips)
- Paper or plastic painter drop cloth
- Masking tape

MANAGEMENT TIPS

- Place a tapeline across the inclined plane board about one foot from the top. The front wheels of the trucks should be placed on the tapeline to control for the variable of the speed of the truck when it reaches the road surface.
- Place a cardboard box at the upper end of the inclined plane and use tape to secure it to the box. If the plane moves, the angle of the plane will change and so will the speed of the truck when it reaches the bottom of the plane.
- Having more than one inclined plane setup will enable teams to complete the activity more quickly.
- Both sand and gravel should be contained with a large piece of paper or plastic painter drop cloth. Place a rectangular piece of drop cloth approximately 3 feet wide x 12 feet long on an open space on the floor and tape its edges to keep it smooth. Set up the inclined plane at one end of the road. Spread sand or gravel in a 12-inch-wide road along the middle of the drop cloth, starting at the lower end of the inclined plane. When cleaning up the activity, fold in the edges of the drop cloth to contain the sand or gravel.
- If necessary, tire tracks in the sand and gravel should be smoothed out after each team has completed its runs.
- The distance a truck rolls is measured from the lower end of the inclined plane. Measure the total distance the truck rolls even if it rolls past the end of the test surface.

Continued



PROCEDURE

1. Begin the activity with a class discussion. Ask students, "What does MPG mean?" (miles per gallon) "Why is knowing the MPG of your Hess tow truck important to your towing business?" Explain that knowing how much to charge customers for a towing job depends in part upon how much fuel it takes to get the job done. The cost of gasoline or diesel fuel is an expense that must be included when calculating what to charge.

2. Explain that the purpose of the inclined plane is to provide kinetic energy to the truck for rolling across the different road surfaces. Starting with wheels on the tapeline makes sure the trucks are traveling at the same speed every time they reach the test road surface.

3. Instruct teams to complete three test runs of their trucks over every road surface, and to measure and record on their data sheet how far their trucks roll each time.

4. Set up a rotation plan so that each team can test its truck on each road surface.

WRAP IT UP

Have teams report their results of the road tests. Ask, "Why were there three runs for each road surface, and why were the results averaged?" "On which road surface did the truck roll farthest?" "What caused the differences in rolling distance between each road surface?" "Which road surface would cause the tow truck to use the most fuel for a towing job?"

Relate the distance the trucks traveled on each road surface to fuel efficiency. Students will have observed that the trucks rolled the shortest distance on the roughest surface. This means that the trucks will require more fuel to travel the same distance on a rough surface as they would on a smooth road surface. Compare the results here to the results of the "Stuck in A Rut" activity.

EXTENSIONS

- Have teams use masking tape to firmly attach the large truck boom to the small tow truck. Place both trucks on the inclined plane and see what effect the presence of a towed vehicle has on how far the large tow truck rolls.
- Invite teams to come up with ideas for different road surfaces to test and then test them. ■

The Cost of Doing Business

Name:

_____

Instructions: Take your large Hess Tow Truck to the inclined plane. Place the front wheels on the tape line at the upper end of the inclined plane. Aim the truck downward and release it. Observe and measure how the truck travels along the simulated road and how far it travels. Do this three times. Record your data below and average the distance measurement. Answer the questions.

Inclined Plane 1

Road Surface Material: _____

	Test 1	Test 2	Test 3	Average Distance
Distance truck rolled along the road:				

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Inclined Plane 2

Road Surface Material: _____

	Test 1	Test 2	Test 3	Average Distance
Distance truck rolled along the road:				

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Inclined Plane 3

Road Surface Material: _____

	Test 1	Test 2	Test 3	Average Distance
Distance truck rolled along the road:				

Describe the truck's ride along the road. (smooth, bumpy, etc.) _____

Which road surface would require the tow truck to use more energy (fuel) to travel? Write and explain your answer on the back of this sheet.

The Cost of Doing Business

Press them to calculate the cost of operating their truck based on assumptions:

$3.25 per gallon cost of fuel

Fuel efficiency 10 miles per gallon

25 miles round trip on each call on average

150 calls/jobs per year

What is the other big cost (labor). Can they calculate labor costs as well? Give assumptions for hourly wages of a truck driver. How much does that cost per mile driven?

GLOSSARY

Boom - The large mechanical arm of a tow truck for attaching and lifting disabled vehicles or for pulling vehicles from a ditch.

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

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.

Fulcrum – The pivot point for a lever.

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.

Hydraulic System – A system to transmit force with fluids from one piston to another through hoses.

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.

Lever – A simple machine consisting of a straight bar resting on a pivot point (fulcrum) that magnifies force and direction.

Low Tow – T-shaped bar that extends from a tow truck to securely place the front tires of a disabled automobile for towing.

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.

Piston – A flat plate fitted within a cylinder that rises and falls with the movement of fluids in a hydraulic system.

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

Baylor College of Medicine and Hess Corporation dedicate the 2019 Hess Toy Truck STEM Guide to our friend and colleague, Martha Young (1956-2019). With tireless dedication to education, she encouraged thousands of children to learn through fun and exciting classroom activities. In many ways, Martha brought the Hess STEM curriculum guide from concept to reality. For that we are all eternally grateful. She will be deeply missed.