NEXT ENGINEERS

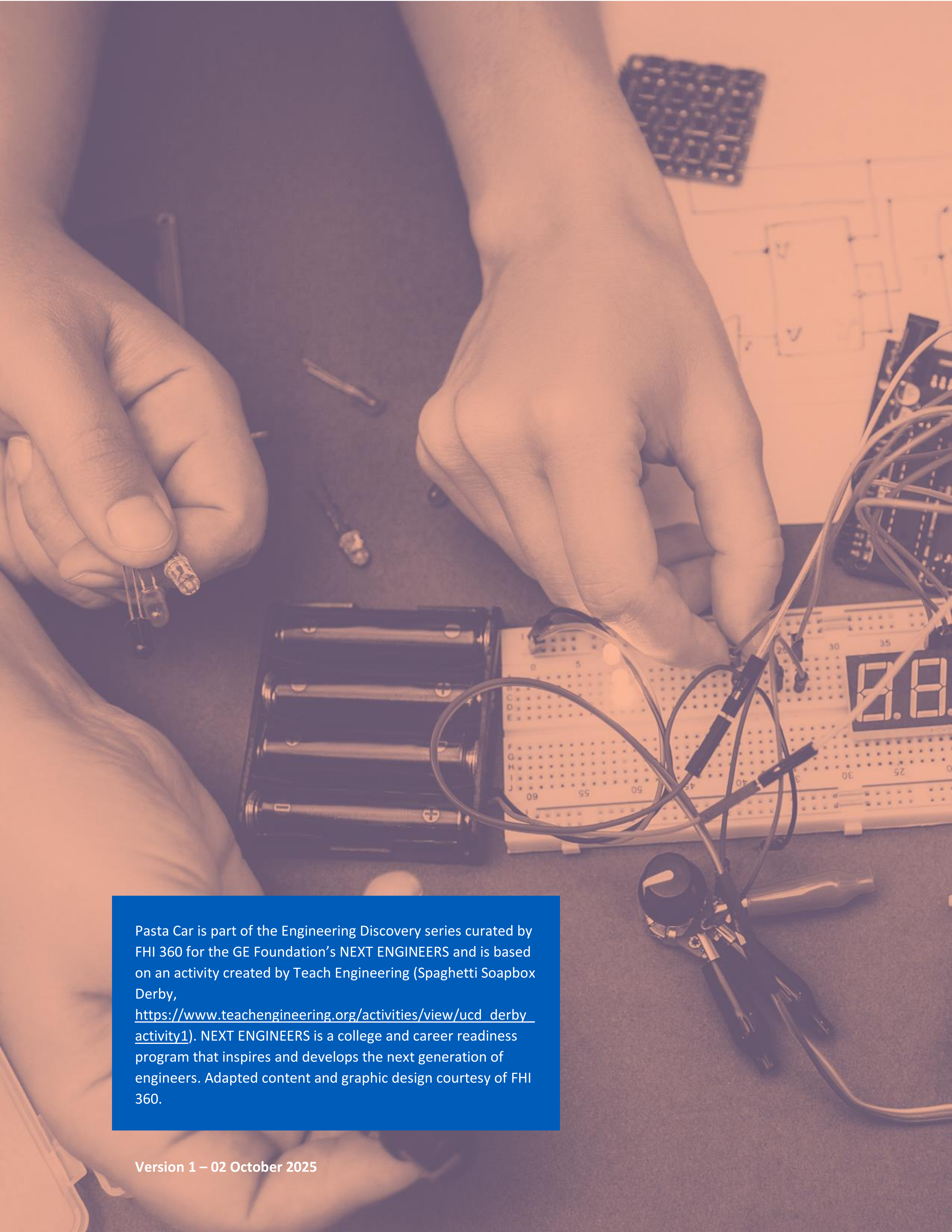
ENGINEERING DISCOVERY

Difficulty Level 1

Pasta Car

Mechanical Engineering
Materials Engineering

NEXT ENGINEERS



Pasta Car is part of the Engineering Discovery series curated by FHI 360 for the GE Foundation's NEXT ENGINEERS and is based on an activity created by Teach Engineering (Spaghetti Soapbox Derby, https://www.teachengineering.org/activities/view/ucd_derby_activity1). NEXT ENGINEERS is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

Version 1 – 02 October 2025

Pasta Car

HANDS-ON ACTIVITY

Time	Ages	Cost	Group size (teams)	Activity type
70 minutes	11 - 18	Low	3 - 4 students	Hands-on Activity
Engineering Areas				
• Mechanical Engineering		Materials Engineering		

Activity Description

Parents are always telling their kids not to play with their food. In this activity, students get to do just that! In teams, students work as engineers to design and build a functional car entirely out of different kinds of pasta…oh, and glue.

About the Engineering Design Challenge

Students work as teams of mechanical engineers to design, build, and test vehicles made entirely out of dry pasta. These vehicles must be able to roll down a ramp and then coast freely as far as possible while transporting a passenger. Students must also design and build in the most efficient way possible. Therefore, each vehicle will receive a final score calculated as follows:

$$\text{score} = \frac{\text{coasting distance achieved (cm or in)}}{\text{total cost}}$$

Success Criteria

- The vehicle must coast as far as possible after rolling down a ramp (distance measured perpendicular to the bottom of the ramp – see the **Activity Background** for more details).
- The vehicle must be able to carry a passenger.
- It must be easy to insert and remove the passenger.
- The passenger must not fall out of the vehicle at any point during the journey.

Constraints

- Teams may only use the materials provided.
- Teams must remain within the specified materials budget (suggested budget is 130 - 150).
- Teams must complete the activity in the time allocated.

STUDENT DISCOVERIES

Students will:

- Know more about engineering and engineering careers
- Learn about the Engineering Design Process
- Participate in a team-based learning experience
- Learn about energy conversion and friction
- Have fun experiencing engineering

Materials

Students will need blank paper and pens/pencils with which to design their cars.

The following materials will be required **per team of 3 – 4 students**:

- A glue gun
- A glue stick

The following additional materials must be available for teams to **purchase from a central store** (suggested prices in brackets):

- Spaghetti (3/piece)
- Penne (3/piece)
- Lasagna sheets (flat or 10/sheet)
- Rigatoni (5/piece)
- Rotelle (10/piece)
- Farfalle (optional 4/piece)
- Fusilli (optional 4/piece)
- Glue stick (30/piece)

The following additional materials will be required for the **ramp**, **testing**, and **demonstration**:

- A piece of wood or stiff board (about 35 cm (14 in) x 100 cm (39 in))
- A pile of books, bricks or other stable objects to make a tower about 45 cm (18 in) height
- A measuring tape
- An object to act as the car's passenger (e.g., a Lego mini figure, a Playmobil figure, or even a AA battery with wire arms and legs attached!)
- Your own pasta car or another small demonstration vehicle able to roll down the ramp and then coast freely.

Note: You can make the ramp larger than specified above. However, the ramp should make an angle of between 25^0 and 30^0 with the floor. If possible, find a smooth flat surface for the cars to coast over.

Facilitation Principles

Working with Youth: Facilitation Tips (https://www.nextengineers.org/resource/working-youth-facilitation-tips) is a handy summary of the key facilitation principles that volunteers need to keep in mind when demonstrating any activity with students.

Facilitator Preparation

1. Read the step-by-step instructions.
2. Collect the materials.
3. Practice doing the activity yourself to identify where students may struggle. Bring any pasta cars you have made to show students and even use these to demonstrate how well (or not!) they work.
4. Plan when and how you will share your story and career journey in a relevant and personal way. Try to integrate your story into the activity as much as possible. You can find the following volunteer resources for how to tell your story on the Next Engineers website:

KEY WORDS

- Constraints
- Criteria
- Engineering Design Process (EDP)
- Engineering Habits of Mind (EHM)
- Engineers
- Friction
- Gravitational potential energy
- Iteration
- Kinetic energy
- Momentum
- Prototype

Spaghetti

Penne

   a. ***I'm an Engineer! Storytelling Worksheet*** (https://www.nextengineers.org/resource/im-engineer-storytelling-worksheet)
   b. ***I Work with Great Engineers! Storytelling Worksheet*** (https://www.nextengineers.org/resource/i-work-great-engineers-storytelling-worksheet)
5. Practice asking and answering questions students may ask. See ***Frequently Asked Student Questions*** (https://www.nextengineers.org/resource/frequently-asked-student-questions).
6. Print out copies of the **Student Worksheet** (below) for each group.
7. Set up each group's materials before the start of the activity.

Rigatoni

Step-by-Step Instructions

Time	Instructions	Materials
2 min	**Welcome & Introductions** • Welcome students to the activity and briefly introduce yourself, noting what kind of engineer you are. • Explain briefly how and why you became an engineer. • Ask students if they have ever been told not to play with their food. Say that today will be different. Today they MUST play with their food.	Activity Background
5 min	**Pre-Challenge Exploration** • Hold your pasta car or the demonstration vehicle at the top of the ramp and ask students to explain what will happen if you let go. • Most students will correctly predict that the car will roll down the ramp but ask them to explain why. Take a few answers. • Explain that by holding the car at the top of the ramp, we are actually holding it above the ground. If we let the car go, gravity will pull the car towards the ground. We say that the car has gravitational potential energy - **potential energy** because, although it is not moving yet, it has the potential to do so, and this potential exists because of **gravity**. *The heavier the car is and the higher we raise it off the ground, the more gravitational potential energy it will have.* • Ask students to predict what will happen to the car when it reaches the bottom of the ramp. Again most students will correctly predict that the car will coast along the ground for a while and then stop. Ask them to explain why. Take a few answers.	Ramp Passenger Pasta car or demonstration vehicle

TIPS FOR WORKING WITH STUDENTS

- **Be prepared** by practicing the activity beforehand. Being prepared is the best start to leading confidently and having fun.
- **Facilitate like an engineer** by reflecting during and after each session. What worked? What could be improved? How could you do things differently next time?
- **Teamwork is critical** in engineering so encourage it among students. Make sure no one dominates and everyone gets to play.
- **Give one instruction at a time** to keep a large group on task and doing what you need them to do.
- **Give regular time updates** to keep students on track.

	• Explain that the gravitational potential energy gets converted into kinetic energy (the energy of motion) as the car rolls down the ramp. *The more gravitational potential energy it had at the top, the more kinetic energy it will have at the bottom.* • Once the car gets to the bottom of the ramp, it has enough kinetic energy to keep moving. However, this kinetic energy is gradually converted to sound and heat because of friction and so the car loses its kinetic energy and eventually stops. *The more kinetic energy it started with and the less friction there is, the further the car will coast.* • Demonstrate how your own pasta car (if possible) or your demonstration vehicle coasts after rolling down the ramp you have created.	
3 min	**Challenge Overview** • Explain to the group that their challenge will be to design and build their own vehicle entirely out of pasta able to carry a passenger that coasts as far as possible after rolling down the ramp. Show the group the passenger they must carry and the different kinds of pasta they can build with and the cost of each. • Describe the rest of the criteria and constraints: ○ It must be easy to insert and remove the passenger. ○ The passenger cannot fall out during the journey. ○ Teams may only use the materials provided. ○ Teams cannot exceed their budget (be sure to tell teams what their exact budget is). ○ Teams must complete the challenge in the time given • Explain that the coasting distance will be measured perpendicular (at 90^0) to the bottom of the ramp and that teams also need to build as efficiently as possible. Each team will receive a final score calculated as follows: $\text{score} = \frac{\text{coasting distance achieved (cm or in)}}{\text{total cost}}$	Pasta Car Passenger Pasta

TIPS FOR MAKING CONNECTIONS

- **Give constructive feedback** to help students grow and improve.
- **Ask open-ended questions** to better understand what and how students are thinking.
- **Be respectful** by listening actively and responding openly and authentically. Give students your undivided attention and the respect you want them to give you.
- **Be honest** about what you know. Say if you don't know something. Encourage students to keep trying by sharing some of your own failures and the lessons you learned.

TOP TIP

Don't allow teams to buy materials from the central store until they have produced a sketch of their car that details what pasta pieces will be used where.

	Finally, note that teams will not be allowed to buy anything from the central store until they have produced a design sketch of their pasta car.	
50 min	**Engineering Design Challenge** • Divide the group into teams and hand each team a copy of the **Student Worksheet** and the **Engineering Design Process Summary**. • Tell teams that they have 50 minutes in which to design, test, and re-design their pasta cars and do an official test to obtain their final score. • As teams work, circulate around the room encouraging them and answering any questions they might have. • Have teams consider what affect the mass of their pasta car has on its coasting performance. Also have them consider the effects of friction and how this might be reduced as well as the importance of their cars travelling in a straight line. • Encourage teams to plan their cars well so that they spend as little as possible at the central store while also testing early and often. • As teams are ready, allow them to perform ramp tests and obtain their final score. • After about 40 minutes, encourage teams to come forward and do a final ramp test to get their final score.	Building Materials Student Worksheet Engineering Design Process Summary
10 min	**Reflection and Closing** • Give teams about five minutes to discuss the reflection questions in the **Student Worksheet**. • After this time, bring the group back together to discuss their answers, paying particular attention to what students learned about engineering and the engineering design process.	Student Worksheet

TOP TIP

When doing the ramp tests, place the back wheels of the pasta car over the back of the ramp and then gently push it forward.

Rotelle

Lasagne

Extension

This activity can be extended or modified in the following ways:

- Increase the size and/or mass of the passenger (bigger and heavier passengers will require larger and more robust vehicles).
- Reduce the budget teams have available.
- Reduce the amount of time teams have to design and build.
- Introduce a minimum coasting distance the cars must achieve.
- Increase the slope of the ramp (this will increase the forces the car is subject to at the bottom of the ramp, requiring the car to be suitably sturdy and strong).

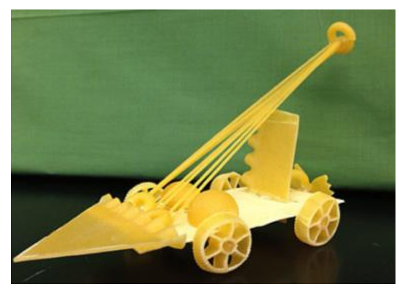
Key Words

- **Friction**: The force of resistance that one surface or object experiences when moving over or sliding past another.
- **Gravitational Potential Energy**: The potential energy an object has by virtue of its position above the surface of the earth.
- **Kinetic Energy**: The energy an object has by virtue of its motion.
- **Momentum**: the quantity of motion of a moving body or mass in motion, calculated as the body's mass multiplies by its velocity.

- **Constraints:** Limitations of materials, time, budget, size of team, etc.
- **Criteria:** Conditions that the design must satisfy to be considered successful.
- **Engineering Design Process (EDP):** The iterative process of researching, designing, prototyping, and testing engineers use to solve problems and design solutions.
- **Engineering Habits of Mind (EHM):** Six unique ways that engineers think.
- **Engineers:** Inventors and problem-solvers of the world. Twenty-five major specialties are recognized in engineering (have a look at the infographic at https://tryengineering.org/wp-content/uploads/18-EA-381-InfographicEngineering_R2-6.pdf).
- **Iteration:** The process of repeated design, testing, and redesign.
- **Prototype:** A working model of the solution to be tested.

Activity Background

Everyone intuitively knows what will happen when a rolling object like a ball or a toy car is allowed to roll down an incline onto a smooth flat surface. As the object rolls down the incline it gains in speed. When it reaches the bottom of the ramp it will coast along the floor and eventually come to a stop.



Pasta race car is used under fair use https://www.lovemylibrary.ca/event/pasta-cars/

If you want to maximize the distance over which the ball or car will coast for a given ramp, it is helpful to know some of the simple physics involved.

To begin with, to lift any object off the ground requires energy (or for work to be done). This energy is needed to overcome gravity. The heavier the object and the higher it is lifted the more energy is needed. If you let go of the object, it will fall back to the ground because of gravity.

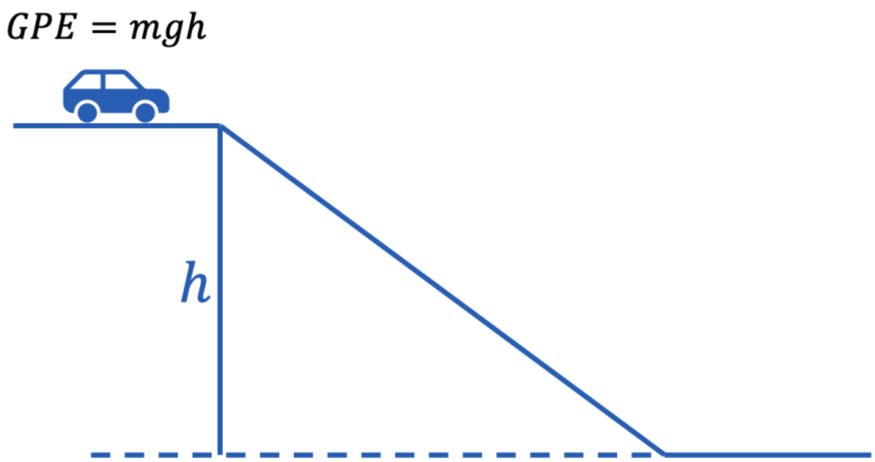
Therefore, if you expend energy lifting an object off the ground, you can get this energy back if you drop the object again. You can think of this like depositing energy into the object and then withdrawing it again.

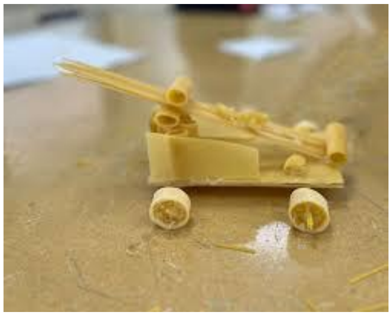
The energy you deposit into an object by lifting it off the ground is called **gravitational potential energy**. It is potential energy because it is stored - it only gets released if you drop the object. It is gravitational potential energy because it exists because of gravity.

We can calculate the amount of gravitational potential energy an object has using this equation:

$$\text{GPE} = mgh$$

- *m* is the mass of the object in kg
- *g* is the acceleration due to gravity which is taken as 9.8 m/s^2 on Earth
- *h* is the object's vertical height above the ground in m





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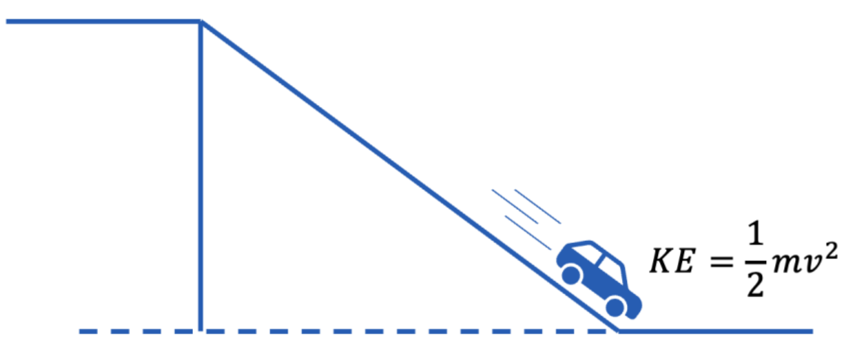
If you drop the object it accelerates towards the ground because of gravity, gaining in speed. Therefore, its gravitational potential energy gets converted into another kind of energy called **kinetic energy**, or the energy of motion. By the time it reaches the ground again, all of its potential energy has been converted into kinetic energy.

We can calculate the amount of kinetic energy an object has using this equation:

$$\text{KE} = \frac{1}{2}mv^2$$

- *m* is the mass of the object in kg
- *v* is the velocity (the speed) of the object in m/s



Pasta motor cycle is used under fair use https://www.rbth.com/multimedia/2012/12/19/tiny_masterpieces_theres_more_to_pasta_than_just_cooking_21261

The same holds true when a car rolls down a ramp. It has gravitational potential energy at the top of the ramp which gets converted into kinetic energy as it rolls down. We can say that the

$$\text{GPE}_{\text{top of ramp}} = \text{KE}_{\text{bottom of ramp}}$$

Therefore, the higher the ramp or the heavier the car, the more gravitational potential energy the car will have at the top of the ramp and, thus, the greater will be its kinetic energy at the bottom of the ramp. However, the heavier the car, the more force it will experience as it leaves the ramp and hits the ground. This will mean that the car will need to be stiffer and stronger.

While it might be easy to just stick more pasta onto the car to increase its mass and hence its kinetic energy, it matters where this additional mass is added. If mass is added to only one end of the car, the car will become unbalanced. In general, it is best to keep the car's center of gravity between the axles with an even distribution of mass over each axle. You can check where the center of gravity is by trying to balance the car on your finger.

However, increasing the mass of the vehicle means that the axles and wheels need to carry more mass and, therefore, be stronger.

The conversion of energy, for example from potential to kinetic, is never perfect. Some energy is always lost, especially as heat. In the case of a car rolling down a ramp, quite a bit of energy is lost as heat due to friction. Friction is the force of resistance that one surface or object experiences when moving over or sliding past another. The wheels moving over the ramp, the axles spinning in their holes, and the car pushing through the air are all sources of friction.

The effects of friction are especially visible when the car starts to coast. At this point, there is no force pushing or pulling the car forward. The only force acting on the car is friction and so the car gradually loses all of its kinetic energy until it finally comes to a stop.

If you want the car to coast further, you either need to make sure it has more kinetic energy at the bottom of the ramp or you need to reduce the amount of friction it experiences, or both.

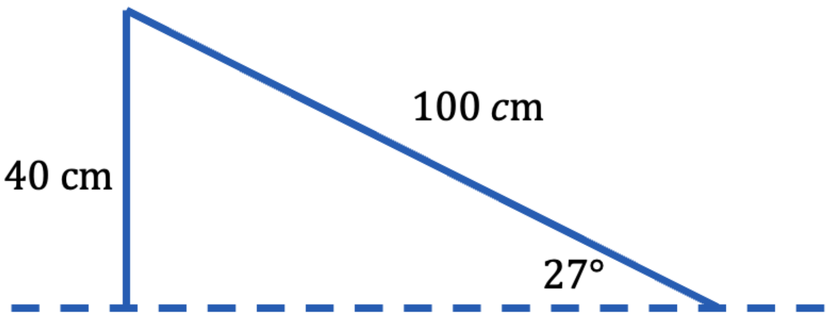
Adding extra mass to increase kinetic energy is, however, also likely to increase friction within the system. There will be more force pushing the axles onto the car body and more friction between the wheels and the ground. Here, as in all of engineering, is a trade-off.

Generally, though, friction in a system like a pasta car can be reduced by ensuring that the wheels spin as freely as possible with as little wobble as possible by making sure that the:

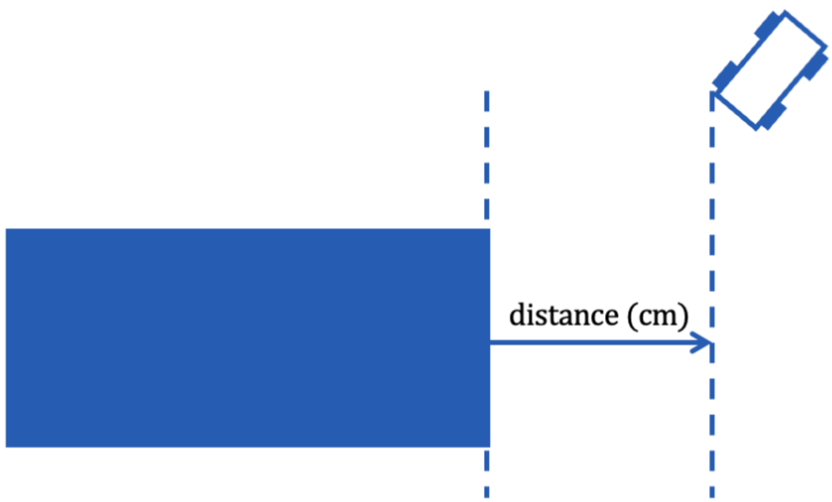
- Axles are straight and parallel to each other
- Wheels don't rub against the sides of the car
- Wheels are perpendicular to the axis
- Axles are attached as close as possible to the center of the wheels

In addition, the car can be made as aerodynamic as possible although at the speeds at which the car is likely to travel and at its size, friction at the wheels will be far greater than friction through the air.

As noted above, while a 1 m (39 in) long ramp with the top about 45 cm (18 in) off the ground is suggested, you can create whatever size ramp you like. These ramp dimensions will create a ramp with at a 27^0 to the ground. Whatever size your ramp, make sure that the ramp angle is between 25^0 and 30^0.



When measuring the coasting distance, make sure that you measure this distance as perpendicular to the end of the ramp. This will incentivize teams to prioritize that their cars travel as straight as possible.



Additional Resources

- ***Gravitational Potential Energy*** (1:58) https://www.youtube.com/watch?v=28MQF0RNl3g
- ***KINETIC ENERGY*** (3:23) https://www.youtube.com/watch?v=1YeBgtH589c
- ***Gravitational Potential and Kinetic Energy*** (2:03) https://www.youtube.com/watch?v=MYwqb8m0jkM
- ***MSC-Pasta Cars*** (3:40) https://www.youtube.com/watch?v=JKt0w94rPGc

References

This activity is based on **Spaghetti Soapbox Derby** originally created by **Teach Engineering** and available at: https://www.teachengineering.org/activities/view/ucd_derby_activity1.

Visit the **Teach Engineering** (https://www.teachengineering.org/) website for a host of other great engineering activities and resources.

ncwit.org
TEACH ENGINEERING

Pasta Car

STUDENT WORKSHEET

NOTES

Challenge Overview

Did your mom ever tell you not to play with your food? Well, here's your chance. You are part of a team of engineers who have been given the challenge of designing and building a car made entirely out of pasta…oh, and hot glue. You will let your car roll down a ramp to see just how far it can coast along the ground.

However, your pasta car must also be able to carry a passenger. It must be easy to get this passenger into and out of your car and they cannot fall out during the journey.

To make things even more interesting, you will need to build as efficiently as possible. Your team will get a final score calculated as follows:

$$\text{score} = \frac{\text{coasting distance achieved (cm or in)}}{\text{total cost}}$$

Success Criteria

- Your pasta car must coast as far as possible after rolling down a ramp (note that the distance your car coasts will be measured perpendicular (at 90^0) to the end of the ramp)
- Your pasta car must be able to carry a passenger.
- It must be easy to insert and remove the passenger.
- The passenger must not fall out of the vehicle at any point during the journey.

Constraints

- You may only use the materials provided.
- You must remain within the specified materials budget (your facilitator will tell you what budget you have).
- You must complete the activity in the time allocated.

Total Time: 50 minutes

Research & Planning (2 minutes)

Basically, you need to build a car that can coast as far as possible will also safely carrying a passenger. Here are some questions to get you started. Think about the pre-challenge investigation the facilitator led as you answer these questions.

- Every pasta car will roll down the same ramp (i.e., it will roll from the same height). What factor will increase the kinetic energy your pasta car will have at the bottom of the ramp?
- Once your car starts coasting, what force will slow it down and make it stop?
- How do you think you can reduce the friction your car experiences?

Design Phase (3 minutes)

Before you start building anything, share ideas about how you might design and build your pasta car with your team. The more ideas, the better. Remember that crazy ideas are allowed. They are often the launchpad to the winning idea!

Draw or sketch some of your ideas on paper. Have a look at what pasta is on sale.

Here are some questions to help get you started:

- How big do you think your car should be? What are the benefits of a big or small car?
- What will you use for the body of the car?
- What will you use for the wheels and axles?
- How can you ensure that your wheels spin freely?
- What can you do to make sure that your pasta car travels as straight as possible down the ramp and while coasting?
- How long will your wheelbase (the distance between the front and back axles) be? Should your car be longer or shorter?
- How heavy do you think you should make your car? Can you make it too heavy?
- If you do add extra mass to your car, where do you think you should add it – the front, the back, the middle?
- Where do you think you should place the passenger?
- How can you keep the passenger from falling out during the journey?

Remember that engineers always sketch their ideas. This helps them communicate and test their thinking before committing to building anything. Make sure that you make a few design sketches of the basic approach you intend to take. Beware that you will not be allowed to buy any materials from the central store until you have a fairly detailed sketch of what you plan to build. Don’t worry; you can also change course if your original idea does not work as planned.

Build it! Test it! (40 minutes)

Now it’s time to build and test your pasta car. It’s a good idea to test early and often so that you can make changes and improvements along the way. Also, be sure to watch what other teams are doing and consider the aspects of different designs that might be an improvement on your team's plan.

You may decide to completely change your design during the build phase if you need to. Failure is part of the process and how we learn what works and what does not.

AT HOME

When you get home today, why not tell your family about the pasta car you designed and built? Tell them about how you worked in a team to design, build, and test your car, what score your team achieved, and what you learned about engineering.

After telling your family about today’s activity, tell them what you liked/didn’t like about it and what you would change or add to the activity.

If you like, you can also discuss some of the reflection questions with them.

When you are ready to start testing your car down the ramp, let your facilitator know. Let it roll down the ramp and then measure how far it coasts while taking note of its general performance. For example, does it roll down the ramp straight or not.

Here are some questions you should ask yourself after each test:

- Does our pasta car roll straight?
- Does the passenger fall out at any stage of the journey?
- How smoothly does our car leave the bottom of the ramp?
- Is there a difference in performance when the car rolls down 'forwards' or 'backwards'? Why might this be? What is the mass distribution like?
- Do the wheels wobble when the car moves? Can we reduce the amount of wobble?

Remember, if something goes wrong or your design does not work quite as you expected, this is just an opportunity to improve. Learn, redesign, and retest.

Reflection

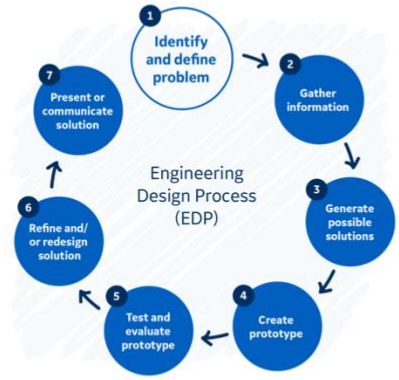
As a team, discuss the following questions:

1. How similar was your original design to the actual pasta car your team built?
2. If you found you needed to make changes during the construction phase, why did you decide to make these changes?
3. Which pasta car that another team built was the most effective or interesting to you? Why?
4. If you could have used one additional material, what would you choose and why?
5. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?
6. What did you learn about engineering?
7. How do you think the activity relates to a career in engineering?

The Engineering Design Process

STUDENT HANDOUT

The engineering design process (EDP[1]) is the key process engineers follow when they solve problems and design solutions.



1. Identify and define the problem

Engineers start by asking lots of questions. What problem must be solved? Who has the problem? What do we want to accomplish? What are the project requirements? What are the limitations? What is the goal? Through this process, engineers start to identify the **criteria** (the conditions the solution must satisfy to be considered successful) and the **constraints** (the limitations they need to design within).

2. Gather information

Engineers dig deep into the problem by collecting **information and data** about the problem and any existing solutions that might be adaptable. They talk to people from many different backgrounds and specialties to assist with this research.

3. Generate possible solutions

Now the fun really starts! Engineers start to **brainstorm** ideas and develop as many solutions as possible, sometimes even crazy ones. This is the time for wild ideas and deferred judgment. It is important to build on the ideas of others while staying focused on the core problem and keeping the criteria and constraints in mind. For example, if there is a budget, can the potential solution be developed within that budget?

4. Create a prototype

Engineers choose one or more of the most promising solutions to **prototype**. A prototype is a working model to be tested.

5. Test and evaluate the prototype

Most prototypes **fail**, but that is good. It tells engineers which ideas they should focus on. Engineers also need to decide if the design really does solve the original problem.

6. Refine and/or redesign the solution

After learning through testing, engineers **redesign and retest** until they have the best solution possible – one that balances the criteria and constraints.

7. Present or communicate the solution

Finally, engineers reach a point where they are satisfied with their solution. It does not need to be perfect, but it should '**satisfice**' - meet the criteria within the constraints. Engineers now communicate their solution to others.

[1] Adapted from https://www.teachengineering.org/design/designprocess

Pasta Car Volunteer Guide

This guide highlights some important information, questions, and principles to help you support teams in this challenge. Start by watching a video that explains some of the *Principles for Supporting Young Engineers* (9:40) and then *An Introduction to the Design Challenges* (6:08). You can also read about some general *facilitation tips* when working with youth.

The design challenge

In this activity, students work in teams to design, build, and test cars made entirely out of dry pasta. While safely carrying a passenger, these cars must roll down a ramp and then coast as far as possible. However, teams also need to consider material efficiency. They will need to buy all the pasta they use from a central store with a limited budget. Each team will then get a score calculated as follows:

$$\text{score} = \frac{\text{coasting distance achieved (cm or in)}}{\text{total cost}}$$

- Success criteria
  - The vehicle must coast as far as possible after rolling down a ramp.
  - The vehicle must be able to carry a passenger.
  - It must be easy to insert and remove the passenger.
  - The passenger must not fall out of the vehicle at any point during the journey.
- Constraints
  - Teams may only use the materials provided.
  - Teams must remain within the specified materials budget (suggested budget is 130 - 150).
  - Teams must complete the activity in the time allocated.

Possible design solutions

The three key challenges in this activity are to create a vehicle that:

1. Has an optimal and balanced mass to maximize the amount of kinetic energy it has at the bottom of the slope
2. Is able to roll as straight as possible, both down the ramp and while coasting
3. Minimizes friction - especially between the axle and the body and between the wheels and the ground

Very light cars are unlikely to have enough kinetic energy to coast very far. However, the heavier the car becomes, the greater the friction it will experience and the more robust it will need to be. Leaving the bottom of the ramp can cause

FACILITATION NOTE

This challenge is customizable in terms of the exact passenger the cars need to carry, the budget teams are allowed to spend, and the size and slope of the ramp. Therefore, it is a good idea to check with the lead facilitator as to what specific criteria and constraints they have decided to impose.

FACILITATION NOTE

An important factor some teams may overlook is the size of the car. Cars with a longer wheel base tend to roll straighter. Any misalignment between the front and rear wheels is more accentuated the shorter the wheel base.

poorly constructed cars to break. Heavier cars will also tend to roll straighter due to their increased momentum.

Key design questions

Encourage teams to pause and share their ideas before jumping straight into building. The more ideas, the better—and crazy ideas are welcome! Also, remind them that they will need to produce a sketch of their design before they can buy materials from the central store.

Here are some questions you can ask to help their design process:

- How big will you make your car? Are there benefits to a bigger or smaller car, especially in terms of the distance between the axles?
- What will you use for the body of your car?
- What will you use for the wheels and axles? How will you connect the wheels to the axles? How long will you make your axles?
- How long will your wheelbase (the distance between the front and back axles) be? What effect does the wheelbase have on the car's performance? Are longer cars better?
- How can you make sure that your wheels spin freely with as little friction and wobble as possible?
- What can you do to make sure that your pasta car travels as straight as possible down the ramp and while coasting?
- How heavy do you think you should make your car? Can you make it too heavy?
- If you do add extra mass to your car, where do you think you should add it – the front, the back, or the middle?
- Where do you think you should place the passenger?
- How will you keep the passenger from falling out during the journey?

FACILITATION NOTE

Strongly encourage teams to draw their design ideas on paper first.

If possible, explain why engineers draw sketches of their designs before they build by relating your own experience.

Also emphasize that teams will be unable to buy any materials until they have a fairly detailed sketch.

Key testing questions

As teams build, encourage them to test early and often. They can test how far their cars coast on the ground just by giving it a push, but they will also need to do some tests on the ramp. In particular, they need to check that their passenger does not fall out of the car - especially as the car hits the ground.

Here are some questions you may ask while teams test and iterate:

- Does your pasta car roll straight? If not, in which direction does it turn? Why do you think this is?
- Does the passenger fall out at any stage of the journey? How can they be better secured while still making it easy to get them in and out?
- How smoothly does your car leave the bottom of the ramp? Does this cause your car to lose lots of energy?
- Is there a difference in performance when the car rolls 'forwards' or 'backwards'? Why might this be?
- How have you distributed the car's mass? Is it evenly distributed or concentrated? What are the benefits in each case?
- Do the wheels wobble when the car moves? How can you reduce the amount of wobble?