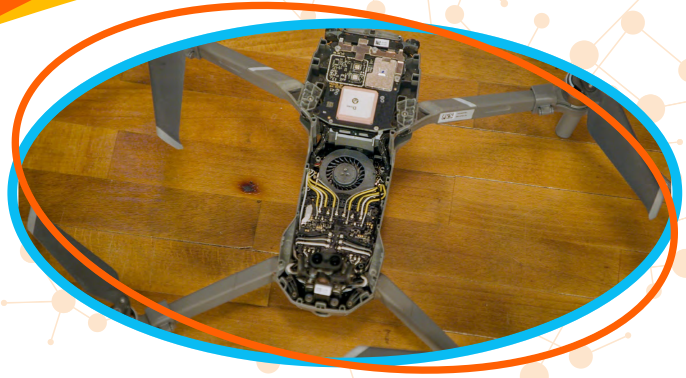
GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.



# LESSON PLAN

## ENGINEERING DESIGN PROCESS
## GRADES 6-8

## SUMMARY

Students will develop ideas and a model of a mechanical system to solve an engineering design problem, using criteria and constraints to guide the process.

## NEXT GENERATION SCIENCE STANDARDS CORRELATION

**MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

| Science & Engineering Practices | Connections to Classroom Activity |
|---|---|
| **Defining Problems** | • In the explore activity, students write a problem statement and list the criteria and constraints using a T-chart, the NASA article, and the scenario mission. |
| **Developing and Using Models** | • In the explain and extension activity, students develop models of their design solution. |

| Disciplinary Core Ideas | Connections to Classroom Activity |
|---|---|
| **ETS1.A. Defining and Delimiting Engineering Problems**<br>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification | • In the explore activity, students write a problem statement and list the criteria and constraints using a T-chart, the NASA article, and the scenario mission. |

| | |
|---|---|
| of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.<br>**ETS1.B. Developing Possible Solutions**<br>There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. | • Students choose a design idea to develop further with their partners using criteria and constraints to help them make the decision.<br>• Students share how their design ideas meet the criteria and constraints when they share their models and discuss how they can be used to evaluate competing designs. |
| **Cross Cutting Concepts** | **Connections to Classroom Activity** |
| **Patterns** | • During the elaborate activity, students look for patterns of similarities and differences between the models of design solutions. |
| **Systems and System Models** | • During the elaborate activity, students develop models to explain how their design solutions work and how it will be controlled or powered.<br>• During the extension activity, students share their prototypes with the class and describe the limitations of what they were able to represent. |

## DURATION

90 min.

## MATERIALS

- Poster paper
- Markers or colored pencils
- Recycled materials (for extension activity)

## ENGAGE

Have students read the NASA article about the 2020 Perseverance Rover Mission to Mars that is also carrying along the Ingenuity Mars Helicopter.

https://www.nasa.gov/feature/jpl/6-things-to-know-about-nasas-ingenuity-mars-helicopter/

Ask students to gather information from the article about the first aircraft to attempt a controlled flight on another planet and record that information in their notebooks. After enough time has passed, ask students to move into pairs to share the information they found in the article.

While students are talking to their partners, facilitate the discussion by asking guiding questions such as the following:

- What criteria or requirements for success did engineers use to guide the design and development of Ingenuity?
- What constraints or limitations were placed on the design and development of Ingenuity?
- What is the role of Ingenuity on this mission?
- How did engineers test Ingenuity on Earth before the mission?

## EXPLORE

Tell the class that they have all been hired by NASA to begin developing ideas for Ingenuity II. Write or project the scenario of the next mission for students to see on the board.

**Scenario**
You have been hired by NASA to begin developing ideas for the second mission that will carry Ingenuity II, which will be used to collect samples from places that are difficult to reach with a rover vehicle. The mechanism that needs to be developed must function while attached to Ingenuity II and withstand the environment on Mars. The samples must be placed into a container system that can be closed to avoid contamination and spillage. The samples must also be returned to the spacecraft for analysis.

Begin by having students define the problem they are trying to solve for this next mission to Mars. Ask students to write a problem statement in their science notebooks that defines the problem in one or two sentences.

Ask students to create a T-chart in their notebook under the defined problem. Label the left side of the T-chart *Criteria* and right side of the T-chart *Constraints*. Ask students to use the scenario provided and the NASA article to list the criteria and constraints for this design problem.

Display on the board and discuss the meanings of *criteria* and *constraints* to support students in understanding these terms. Explain that *design criteria* are the requirements for success of an engineering solution, and *design constraints* are the limitations placed on an engineering solution.

Have students work with a partner to create a list of criteria and constraints to complete the T-chart. After working in pairs, ask students to share with the class and come to a consensus on the criteria and constraints for this engineering design challenge. Allow students to revise the lists in their notebooks.

Some criteria that students might list are as follows:

- Must be lightweight
- Must be able to withstand 130°F temperatures
- Must collect small samples of materials such as sand or dirt
- Must be able to bring back samples to spacecraft for analysis

Some constraints that students might list are as follows:

- Must have a closed system in which to place the samples
- Must be controlled autonomously (on its own without an engineer) and cannot be controlled by a joystick
- Must use power from the existing solar cells and battery system
- Must be attached to Ingenuity II

Give students time to individually begin brainstorming design solution ideas in their notebooks. Brainstorms can be sketches, labeled diagrams, or ideas written as notes. Tell students that during the brainstorming process, all ideas are accepted and documented without judgement.

After brainstorming, students may use online or print resources to gather information that may support or enhance their brainstormed ideas. Have students document these ideas in their notebooks and provide a reference when appropriate.

*End of Day 1*

# EXPLAIN

## WATCH THE GENERATION GENIUS ENGINEERING DESIGN PROCESS VIDEO AS A GROUP

After watching the video, facilitate a class discussion on the steps of the engineering design process that were completed the day before.

Guiding questions to help facilitate this discussion include the following:

- What is the first phase of the engineering design process explained in the video?
  Answer: Defining the engineering problem
- What did we do to help define the problem?
  Answer: Listed criteria and constraints and wrote a problem statement
- What is the second phase of the engineering design process explained in the video?
  Answer: Develop possible solutions
- What did we do to begin developing ideas for a design solution?
  Answer: Brainstorm and research

Ask students to work again with their partner and explain the design ideas each person brainstormed, researched, and wrote in their notebook the day before. Tell students to hold all judgement and to only listen while their partner shares his or her ideas. After both students have shared their ideas, ask them to choose one idea that they will develop further together. Students should make this choice unanimously, agreeing on the one design idea that best meets the most criteria and constraints.

# ELABORATE

Provide students with poster paper and markers or colored pencils to draw a model of the idea they have chosen. Tell students they may continue to use online or print resources to help them more fully develop their idea together. The model will need to provide an explanation of how this design solution works and how the mechanism will be powered or controlled.

Tell students to also include how their design solution meets the criteria and constraints on the poster.

Have students present their models to the class or hang the posters around the room so students can participate in a gallery walk. While models are being shared or viewed, ask students to look for and note the patterns of similarities and differences between the designs.

To close the lesson, facilitate a discussion about how engineers might use the list of criteria and constraints to evaluate the competing designs and decide on the design that best meets the requirements.

Guiding questions to help facilitate this discussion might be the following:

- Should all of the criteria and constraints be used to decide on the best design solution to this problem?
- What might be a systematic process for evaluating the competing design solutions?
- What patterns of similarities and differences between the designs did you notice?
- How might features from multiple designs be combined to create a solution that is better than any of its predecessors?
- How might we figure out if these models will actually fulfill all of the criteria and constraints listed on the posters?

## EVALUATE

There are multiple ways to assess your students' understanding of this topic. The exit ticket is an opportunity for students to use the science ideas they built in the lesson in a new context. Alternatively, you can use the Kahoot! quiz (which provides downloadable scores at the end of the game) and/or the paper quiz. All these resources are located right below the video in the assessment section.

## EXTENSION

Have students bring in or provide recycled materials to build a prototype of their optimized design solution. Only the mechanism(s) they design to attach to Ingenuity II need(s) to be built. Facilitate a class discussion about the agreed on criteria and constraints that all prototypes must be able to demonstrate or model after being built with the resources available.

After the prototypes are complete, have students share them with the class and describe the limitations of what they were able to represent.