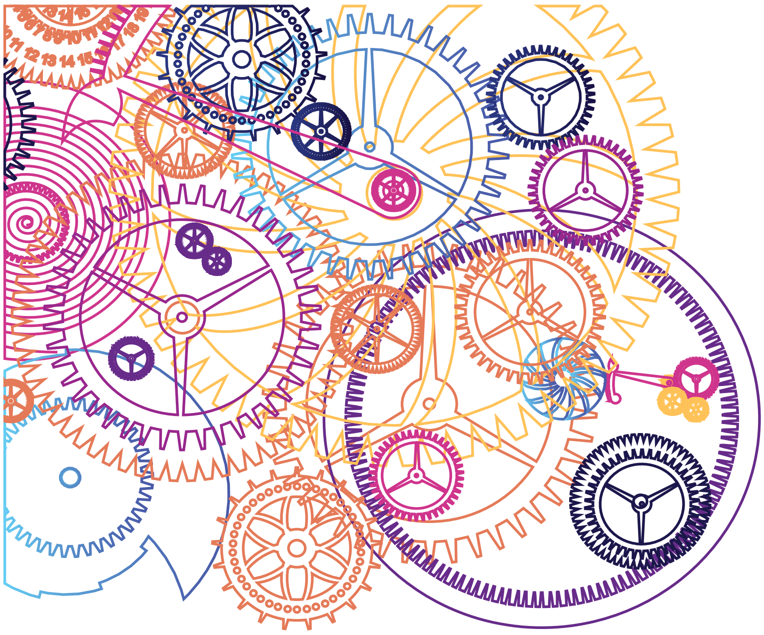
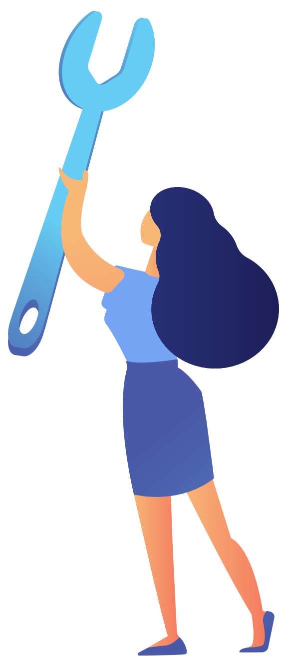


NASA eClips™

Engineering Design

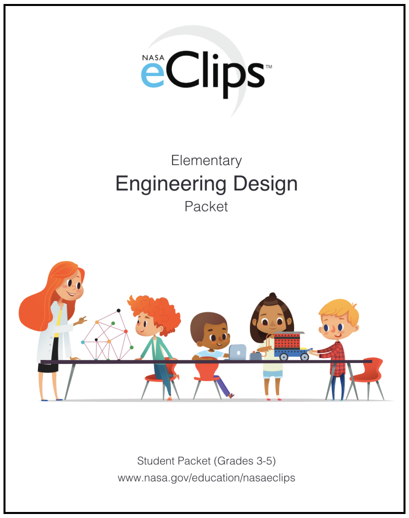
Educator Implementation Guide

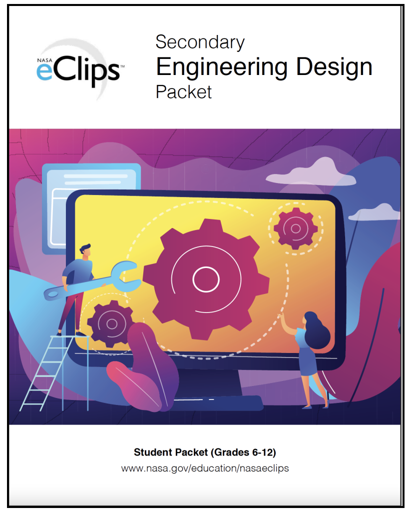


NASA Partner

https://nasaeclips.arc.nasa.gov/

NASA eClips Engineering Design Packets





Engineering design builds authentic context for scientific inquiry. It engages students through hands-on learning and provides nontraditional ways to assess learners' skills and knowledge.

Visit the [NASA eClips Engineering] page to explore NASA-inspired engineering design challenges, STEM activities, and STEM careers.

Using the NASA eClips Engineering Design Packet

The Engineering Design Process (EDP) is outlined within the Elementary and Secondary NASA eClips Engineering Design Packets. The learner packets include an age-appropriate:

- graphic of the EDP steps;
- problem scenario and related research page (to be added by the educator);
- interactive learner pages for each engineering design process step; and
- learner checklist.

Table of Contents

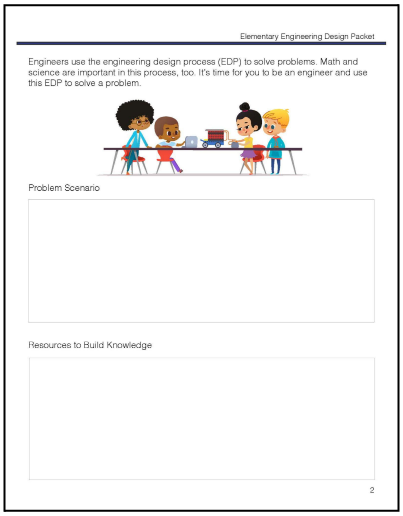
Partner

The material contained in this document is based upon work supported by the National Aeronautics and Space Administration (NASA) grant or cooperative agreement. Any opinions, findings, and conclusions or recommendations expressed are those of the author and do not necessarily reflect the views of NASA.

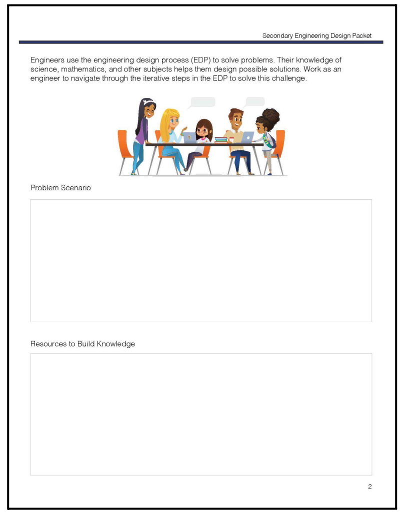
The implementation guide and engineering design packets reflect input from the NASA eClips Educator and Technical Advisory Boards and educators in a pilot study.

Problem Scenario and Related Research

Educators develop a problem scenario and identify related research to build background knowledge for youth. ***These sections must be added to the engineering design packet by the educator before beginning the process.***



Elementary Engineering Design Packet



Secondary Engineering Design Packet

Problem Scenario: The problem scenario should have an authentic context and relate to a real-world issue or problem. An open-ended problem is best because it offers numerous possible solutions. An integrative challenge provides opportunities for learners to apply content knowledge and skills from math, science, language arts, history/social studies, and the arts.

The problem scenario should identify a client (**who** has a problem or need), **what** problem needs a solution, and **why** it is important to solve the problem.

One approach you may use to develop the problem scenario is to follow GRASPS, a model used for performance assessments and project-based learning. Each letter of the acronym GRASPS can be used to guide the development of the problem scenario.

Goal: State the goal within the context of the scenario.

Role: Identify the role the learner will assume.

Audience: Describe the target audience.

Situation: Explain what is involved in the challenge.

Product*, **P**erformance and **P**urpose: Tell the learner what should be created or developed.

Standards & Criteria for Success: Provide the requirements or attributes of the product that need to be met in order for the learner to successfully meet the challenge.

*In this guide, the **product** refers to the product, system, or process developed during the engineering design process.

Problem Scenario Example:

Almost one-fourth of the water used each day is used in the bathroom. The flow of water from a showerhead ranges from 2.5 to 5.0 gallons per minute.

- (Situation) Limited amounts of usable water are available on Earth and many do not have access to enough clean water.
- (Role and Audience) You are an environmental engineer and have been asked to help local families reduce and limit how much water is used in the bathroom.
- (Goal and Product) Work as a team to design and build a water clock that can be used to time a five-minute shower.
- (Standards & Criteria for Success) The shower clock must attach to the shower head and use water from the shower in its design.

Resources to Build Knowledge: This section is used to develop learners' science, math, social studies, language arts, or arts knowledge to build context that will be needed to solve the problem. Add additional resources to help youth develop their background knowledge.

Engineering Design Process

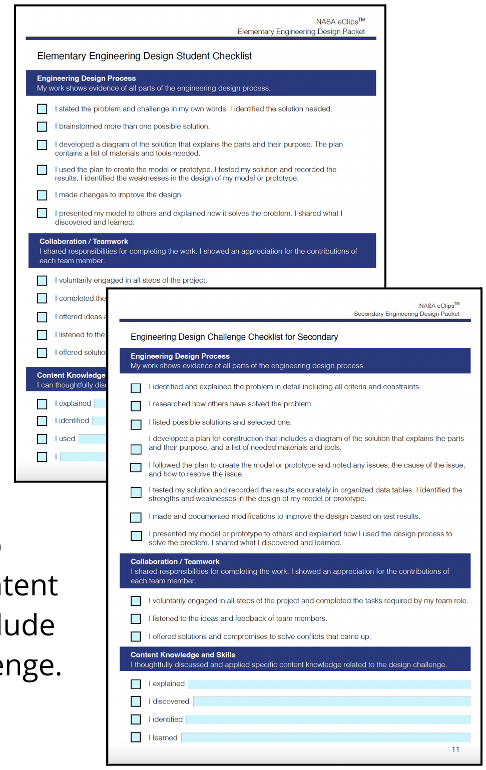
The engineering design process (EDP) is an iterative process that engineers use to solve problems. Engineers ***ask*** questions, ***imagine*** solutions, ***plan*** designs, ***create, test*** and ***refine*** models or prototypes, and ***share*** their ideas with others.

Requirements (***criteria***), limitations (***constraints***), and materials are defined within this process. The process guides learners to work together to develop a model or prototype to solve the problem. Sometimes the model or prototype is a specific ***product***, while other times it may be a particular ***process***. There is no one right or wrong answer – no instructions or recipes. It is important to help learners understand and expect that designs may fail, but failures lead to new understandings.

Learners become engineers and use the EDP to solve the problem defined within the problem scenario. Learners also apply what they have learned in science, math, and other disciplines as they work through this process. As a facilitator, guide learners through each part of the EDP by asking questions and empowering each team.

Learner Assessment: Checklist and Rubric

The Engineering Design Packet and EDP can be used for learner performance assessment. The EDP is an iterative process that helps learners apply and integrate content knowledge and skills. The checklist and rubric are assessment tools that document how learners access and use information. They also track the growth of learners' collaboration, critical thinking and problem solving skills.


NASA eClips™
Elementary Engineering Design Packet

Elementary Engineering Design Student Checklist

Engineering Design Process
My work shows evidence of all parts of the engineering design process.

- ☐ I stated the problem and challenge in my own words. I identified the solution needed.
- ☐ I brainstormed more than one possible solution.
- ☐ I developed a diagram of the solution that explains the parts and their purpose. The plan contains a list of materials and tools needed.
- ☐ I used the plan to create the model or prototype. I tested my solution and recorded the results. I identified the weaknesses in the design of my model or prototype.
- ☐ I made changes to improve the design.
- ☐ I presented my model to others and explained how it solves the problem. I shared what I discovered and learned.

Collaboration / Teamwork
I shared responsibilities for completing the work. I showed an appreciation for the contributions of each team member.

- ☐ I voluntarily engaged in all steps of the project.
- ☐ I completed the
- ☐ I offered ideas
- ☐ I listened to the
- ☐ I offered solutio

Content Knowledge
I can thoughtfully dis

- ☐ I explained
- ☐ I identified
- ☐ I used
- ☐ I

NASA eClips™
Secondary Engineering Design Packet

Engineering Design Challenge Checklist for Secondary

Engineering Design Process
My work shows evidence of all parts of the engineering design process.

- ☐ I identified and explained the problem in detail including all criteria and constraints.
- ☐ I researched how others have solved the problem.
- ☐ I listed possible solutions and selected one.
- ☐ I developed a plan for construction that includes a diagram of the solution that explains the parts and their purpose, and a list of needed materials and tools.
- ☐ I followed the plan to create the model or prototype and noted any issues, the cause of the issue, and how to resolve the issue.
- ☐ I tested my solution and recorded the results accurately in organized data tables. I identified the strengths and weaknesses in the design of my model or prototype.
- ☐ I made and documented modifications to improve the design based on test results.
- ☐ I presented my model or prototype to others and explained how I used the design process to solve the problem. I shared what I discovered and learned.

Collaboration / Teamwork
I shared responsibilities for completing the work. I showed an appreciation for the contributions of each team member.

- ☐ I voluntarily engaged in all steps of the project and completed the tasks required by my team role.
- ☐ I listened to the ideas and feedback of team members.
- ☐ I offered solutions and compromises to solve conflicts that came up.

Content Knowledge and Skills
I thoughtfully discussed and applied specific content knowledge related to the design challenge.

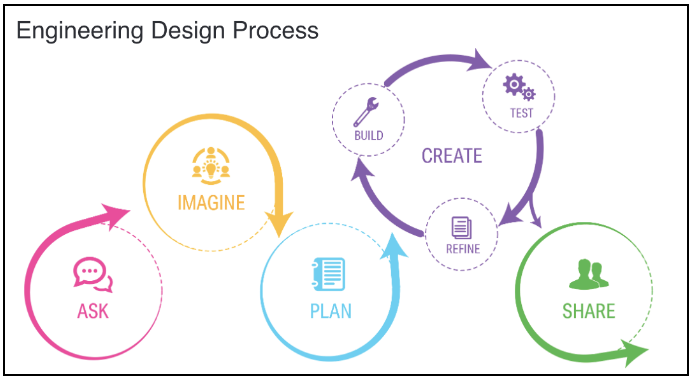
- ☐ I explained
- ☐ I discovered
- ☐ I identified
- ☐ I learned

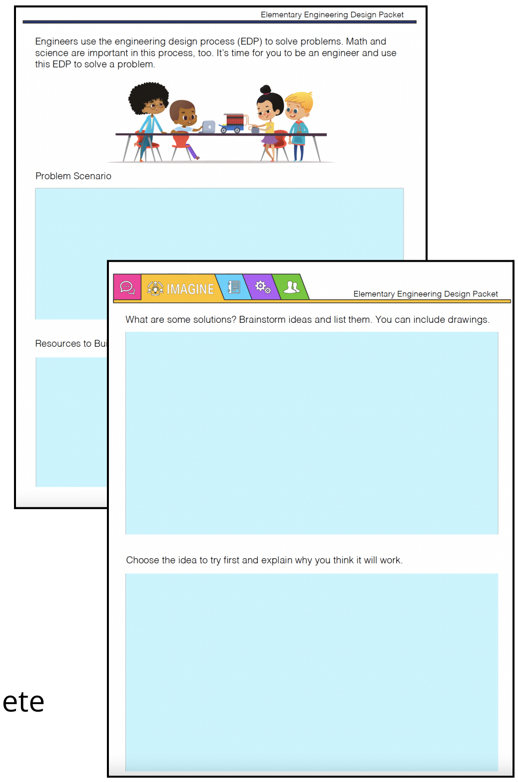
11

Checklist: A checklist is included in the ***learner packet*** to help guide learner's work and self-assessment. Review the checklist with learners ***before, during, and after*** their work to focus their efforts during each phase of the EDP.

Rubric: A rubric is ***included in this implementation guide*** to help educators assess learners' mastery of content and skills. The Content Knowledge and Skills section of the rubric can be modified to include learning targets and performance indicators specific to the challenge.

Guiding Learners Through the Engineering Design Process (Grades 3 - 5)





- **Ask**

  During this stage of the design process, learners demonstrate their understanding of the problem, criteria, constraints, and resources.

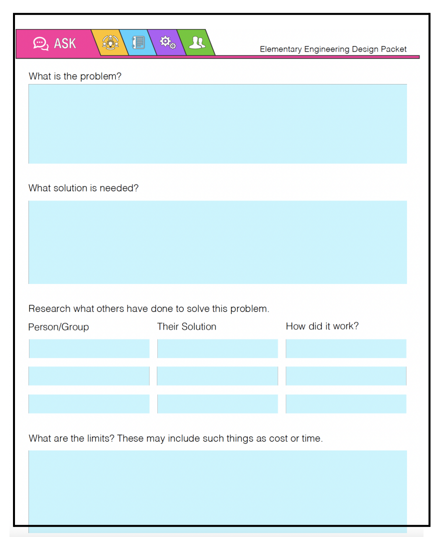
  Facilitate discussions and provide opportunities for learners to:

  - ask questions about the design challenge;
  - explore the materials available for use;
  - learn how their products will be tested; and
  - review the *Elementary Engineering Design Challenge Learner Checklist.*

  Use these questions as a pre-assessment:

  - What do you already know about the topic?
  - What do you need to learn to successfully complete this challenge?

  Use related resources to build background knowledge, fill any gaps in understanding, or correct any misconceptions learners may have.



- **Imagine**

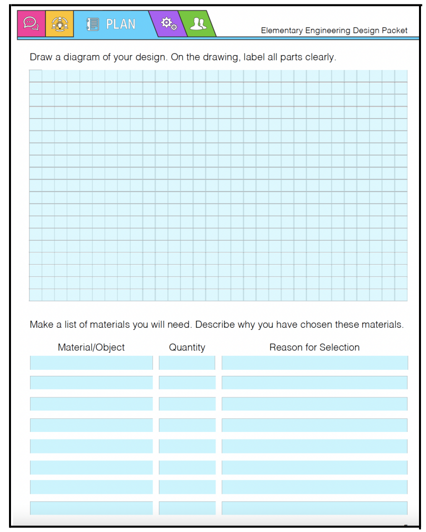
  In this stage of the design process learners use their creativity and knowledge to *imagine and brainstorm* solutions. Encourage learners to apply what they've learned during their research. Allow learners time to complete this step independently before working with a team.

  Questions to guide learners through this stage:

  - What have you learned in _____ that will help you design a solution?

- How will your design show that you know ___________?
- How will your design solve the problem?
- Have you thought about how to _______________?

Ask learners to share ideas with their team members. Remind learners to be respectful of all members by allowing each member the time to share their design without interruption or negative comments. Guide learners to practice active listening.


PLAN
Elementary Engineering Design Packet
Draw a diagram of your design. On the drawing, label all parts clearly.
Make a list of materials you will need. Describe why you have chosen these materials.

Material/Object	Quantity	Reason for Selection

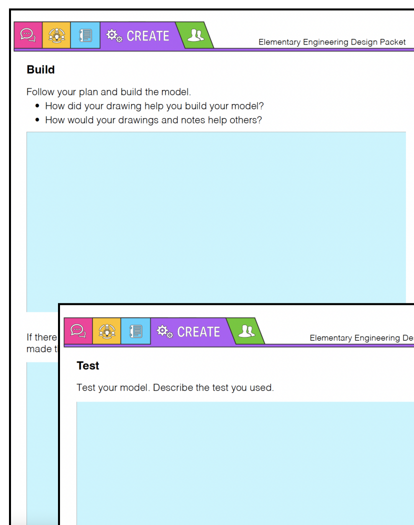
- **Plan**

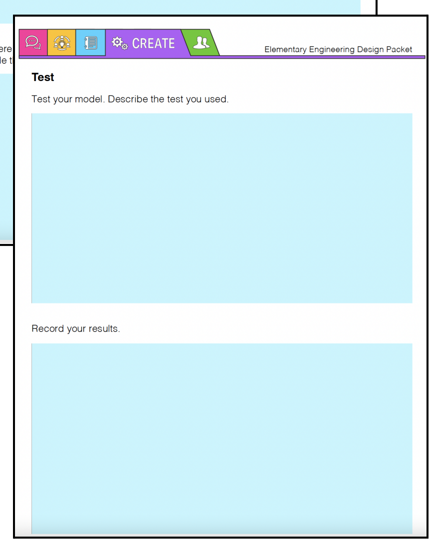
  Teams select one design to develop further. A diagram of the design or process should contain details of the parts and how each piece will move or operate.

  Ask learners to make a list of materials and tools needed to create the prototype. This should include quantities and sizes.

- **Create**

  This part of the EDP has 3 components that repeat as needed. Learners test their prototype to see if it functions as expected. They may need to refine and improve the design.


CREATE
Elementary Engineering Design Packet
Build
Follow your plan and build the model.
- How did your drawing help you build your model?
- How would your drawings and notes help others?


CREATE
Elementary Engineering Design Packet
Test
Test your model. Describe the test you used.
Record your results.

  a. **Build**

  Provide materials, tools, and safety equipment for learners to follow their plans and build prototypes.

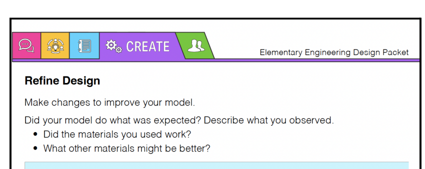
  Tools & Safety

  Stress proper use and storage of all tools and equipment.

  b. **Test**

  Guide learners to test their prototypes.

  - Carefully decide where to set up testing stations.
  - Have a plan for managing testing stations.
  - Provide learners with clear instructions for using testing stations.
  - Reinforce safety concerns.
  - Discuss how to record results.
  - Circulate during testing and ask guiding questions to check for content knowledge.
  - Guide learners to the checklist for self-assessment.


CREATE
Elementary Engineering Design Packet
Refine Design
Make changes to improve your model.
Did your model do what was expected? Describe what you observed.
- Did the materials you used work?
- What other materials might be better?

c. **Refine**

During this stage, learners critically assess how well their design meets the challenge, fulfilling the criteria while taking into consideration constraints.

Questions to guide learners through this stage:

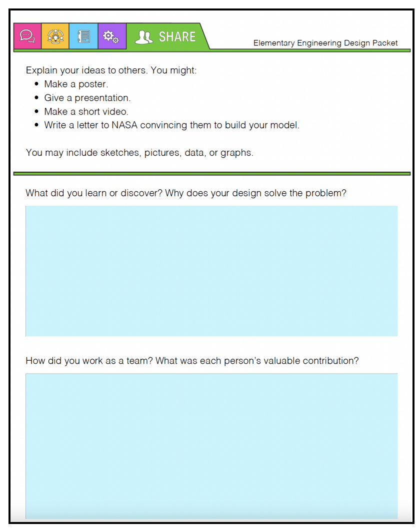
- How well did your model or prototype work?
- Which feature of your design worked well? Why was it successful?
- Which feature of your design underperformed or did not work? What was the cause?
- What modifications might improve your design?

If time permits, refine your design by creating a second model or prototype.

- How could you test which model or prototype is better? Decide on a test and try it out.
- How did the modification of your model or prototype compare to your original model?
- What improvement to the accuracy of your model or prototype did that modification result in?

- **Share**

Prompt learners to reflect on their experiences throughout the engineering design process. Encourage them to use their notes and recorded test data.



Questions to guide learners through this stage:

- What was the design challenge?
- What materials did you use?
- How well did you solve the challenge?
- Identify how you supported your team during this challenge.
- What did you discover or learn?
- How did you apply your (science/math/social studies/language arts/arts/etc.) knowledge and skills to solve the problem? Computer science is the study of how to manipulate, manage, transform and encode information. How did you use computer science in this design challenge?

Provide a variety of methods for learners to communicate their EDP experiences with others, such as creating:

- articles;
- videos;
- interactive posters;
- podcasts;
- infographics; and

- slideshow presentations.

After learners share their solutions, **extend** the experience with these questions:

- Compare your designs with others. How are the designs different?
- Is there some part of another design you would like to add to your design? What impressed you most about this design?
- How could you test which model or prototype is best? Decide on a test and try it out.
- How did the modification of your model or prototype compare to the original?
- What improvement to the accuracy of your model or prototype did that modification result in?

Engineering Design Process

My work shows evidence of all parts of the engineering design process.

Characteristics/Elements/Descriptors/Indicators	✓ Accomplished
I stated the problem and challenge in my own words. I identified the solution needed.	
I brainstormed more than one possible solution.	
I developed a diagram of the solution that explains the parts and their purpose. The plan contains a list of materials and tools needed.	
I used the plan to create the model or prototype. I tested my solution and recorded the results. I identified the weaknesses in the design of my model or prototype.	
I made changes to improve the design.	
I presented my model to others and explained how it solves the problem. I shared what I discovered and learned.	

Collaboration/Teamwork

I shared responsibilities for completing the work. I showed appreciation for the contributions of each team member.

Characteristics/Elements/Descriptors/Indicators	✓ Accomplished
I voluntarily engaged in all steps of the project.	
I completed the tasks required by my team role.	
I offered ideas and encouragement to my team.	
I listened to the ideas and feedback of team members.	
I offered solutions and compromises to solve conflicts that came up.	

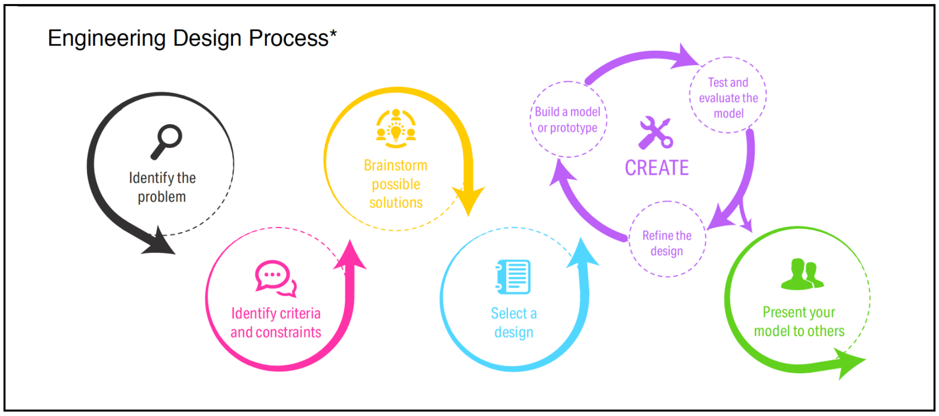
Content Knowledge and Skills

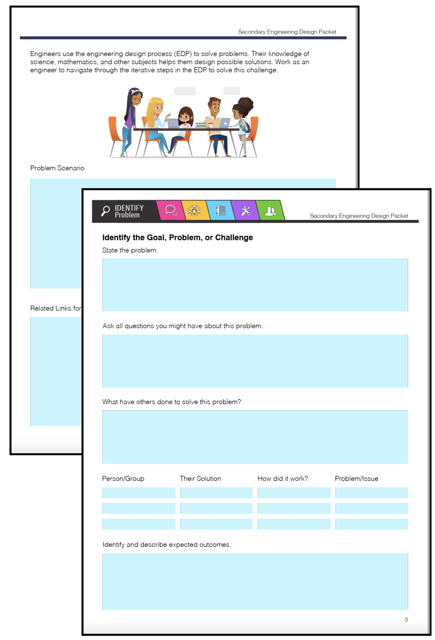
I can thoughtfully discuss and apply specific content knowledge and skills to complete the design challenge.

Characteristics/Elements/Descriptors/Indicators	✓ Accomplished
I explained...	
I identified...	
I used...	
I...	

Engineering Design Packet
(Rubric Grades 3-5)

Characteristics/ Elements/ Descriptors/Indicators	Advanced (above target)	Proficient (at target)	Emerging (below target)
Engineering Design Process ● stated the problem and identified the solution needed ● brainstormed more than one possible solution ● developed a diagram of the solution that explains the parts and their purpose ● created a plan that contains a list of materials and tools ● used the plan to create the model or prototype ● tested the model or prototype and recorded the results ● identified the weaknesses in the design ● made changes to improve the design ● presented the model or prototype to others and explained how it solves the problem ● shared what was discovered and learned	Work and documentation show evidence of an understanding of all parts of the engineering design process.	Work and documentation show evidence of an understanding of many of the parts of the engineering design process.	Work and documentation show little evidence of an understanding of the engineering design process.
Collaboration/ Teamwork ● voluntarily engaged in all steps of the project ● completed the tasks required by the team role ● offered ideas and encouragement to the team ● listened to the ideas and feedback of team members ● offered solutions and compromises to solve conflicts that arose	Shared responsibilities for completing the work. Showed an appreciation for the contributions of each team member.	Shared some of the responsibilities for completing the work. Mostly showed an appreciation for the contributions of each team member.	Shared few of the responsibilities for the design plan and/or showed little respect or appreciation for the contributions of other team members.
Content Knowledge and Skills *(Add specific learning targets or performance indicators based on the problem scenario and concepts reinforced within this challenge).*	Thoughtfully explained, discussed and applied specific content knowledge related to the design challenge. Accurately used content skills to complete the design challenge.	Mostly able to explain, discuss and apply specific content knowledge related to the design challenge. Mostly able to use content skills to complete the design challenge.	Unable to explain, discuss and apply specific content knowledge related to the design challenge. Unable to use content skills to complete the design challenge.




Secondary Engineering Design Packet

Engineers use the engineering design process (EDP) to solve problems. Their knowledge of science, mathematics, and other subjects helps them design possible solutions. Work as an engineer to navigate through the iterative steps in the EDP to solve this challenge.

Problem Scenario

Related Links for

IDENTIFY Problem

Secondary Engineering Design Packet

Identify the Goal, Problem, or Challenge

State the problem.

Ask all questions you might have about this problem.

What have others done to solve this problem?

Person/Group	Their Solution	How did it work?	Problem/Issue

Identify and describe expected outcomes.

3

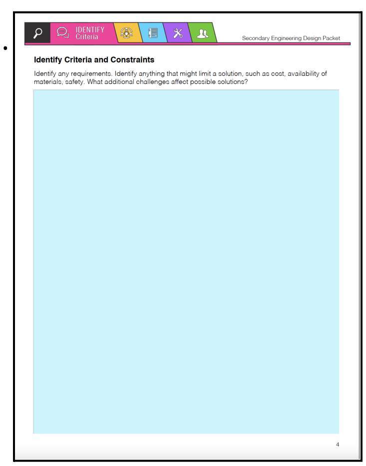
- **Identify the goal, problem, or challenge** design process facilitate discussions and provide opportunities for learners to:
  - ask questions about the design challenge;
  - learn how their products will be tested; and
  - review the rubric.

  Use these questions as a pre-assessment:
  - What do you already know about the topic?
  - What do you need to learn to successfully complete this challenge?

  Use related resources to fill any gaps or correct any misconceptions learners may have.

- **Identify criteria and constraints**

  As learners dissect the problem scenario, they identify the criteria and constraints influencing their design. ***Criteria*** refers to the desired function or elements needed for the design to be considered successful. ***Constraints*** are the limitations placed on a design.


IDENTIFY Criteria

Secondary Engineering Design Packet

Identify Criteria and Constraints

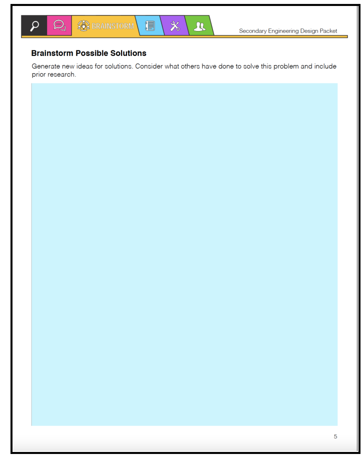
Identify any requirements. Identify anything that might limit a solution, such as cost, availability of materials, safety. What additional challenges affect possible solutions?

4

  Questions to guide learners through this stage:
  - What elements must be included in your design?
  - How will you address or work around the constraints?
  - What materials are available for your design?
  - What are safety issues that must be considered?

- **Brainstorm possible solutions**

In this stage of the design process learners use their creativity and knowledge to think of solutions. Encourage learners to apply what they've learned during their research. Provide learners time to work independently before collaborating with their team.


BRAINSTORM
Secondary Engineering Design Packet

Brainstorm Possible Solutions

Generate new ideas for solutions. Consider what others have done to solve this problem and include prior research.

5

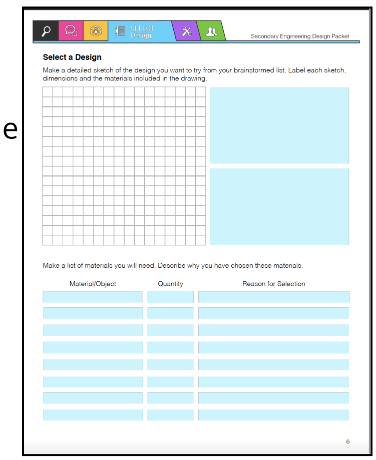
Questions to guide learners through this stage:

- How will your design show that you know ___________?
- Explain how your design will solve the problem.
- Have you thought about how to _______________?
- What have others done to solve this problem?

Have learners share ideas with their team members. Remind learners to be respectful of all members by allowing each member the time to share their design without interruption or negative comments.

- **Select a design**

  Before teams begin this step, discuss the information to include in the detailed sketch of the design. Grid paper is provided in the packet. Encourage learners to draw different views of the design and label each part. Ask students to include scale, if possible. Teams should list each material and tool needed along with the quantity and purpose.


SELECT Design
Secondary Engineering Design Packet

Select a Design

Make a detailed sketch of the design you want to try from your brainstormed list. Label each sketch, dimensions and the materials included in the drawing.

Make a list of materials you will need. Describe why you have chosen these materials.

Material/Object	Quantity	Reason for Selection

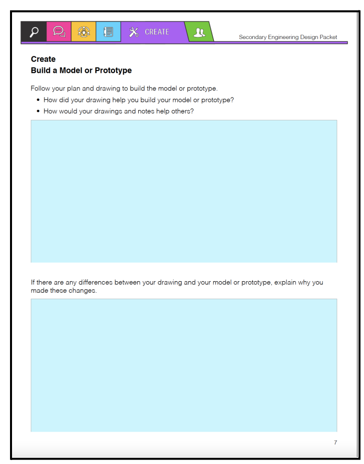
6

  Questions to guide learners through this stage:

  - How can you show the direction of movement of the different parts?
  - How can you show how the parts will be joined together?

- **Create**

  This part of the EDP has 3 components that repeat as needed. Learners test their prototype to see how it functions. They may need to refine and improve the design.


CREATE
Secondary Engineering Design Packet

Create
Build a Model or Prototype

Follow your plan and drawing to build the model or prototype.
- How did your drawing help you build your model or prototype?
- How would your drawings and notes help others?

If there are any differences between your drawing and your model or prototype, explain why you made these changes.

7

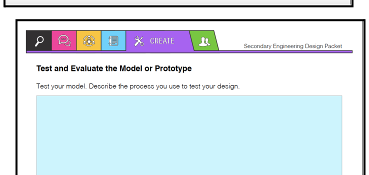
  ☐ **Build a model or prototype**

  Guide learners to create a plan to build the model or prototype. Identify materials, tools, and safety equipment available for use.

  Tools & Safety

  Stress proper use and storage of all tools.

  ☐ **Test and evaluate the model or prototype**


CREATE
Secondary Engineering Design Packet

Test and Evaluate the Model or Prototype

Test your model. Describe the process you use to test your design.

Guide learners to test their prototypes.

- Include clear instructions for managing testing stations.
- Reinforce safety concerns.
- Discuss how to record results.
- Circulate during testing and ask guiding questions to check for content knowledge.
- Guide learners to the checklist for self-assessment.

Evaluating the design

During this stage learners are to critically assess how well their design met the challenge and fulfilled the criteria and constraints. This is when learners think about redesigning and improving their design.

Questions to guide learners through this stage:

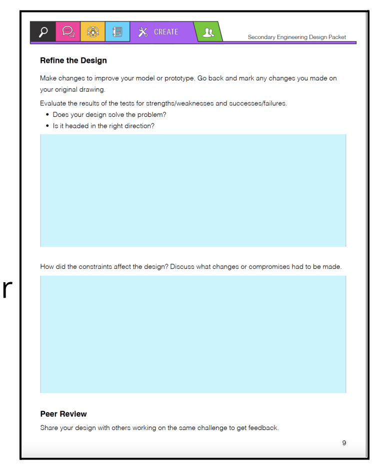
- How well did your model or prototype work?
- Which feature of your design worked well? Why was it successful?
- Which feature of your design underperformed or did not work? What was the cause?
- Identify a feature of another team's design that you could incorporate into your design. What impressed you the most about this feature?

☐ **Refine the design**

During this stage learners critically assess how well their design meets the challenge and fulfills the criteria and constraints. Learners consider ways to redesign and improve their design.

Questions to guide learners through this stage:

- How well did your model or prototype work?
- Which feature of your design worked well? Why was it successful?
- Which feature of your design underperformed or did not work? What was the cause?
- What modifications might improve your design?


CREATE

Secondary Engineering Design Packet

Refine the Design

Make changes to improve your model or prototype. Go back and mark any changes you made on your original drawing.

Evaluate the results of the tests for strengths/weaknesses and successes/failures.

- Does your design solve the problem?
- Is it headed in the right direction?

How did the constraints affect the design? Discuss what changes or compromises had to be made.

Peer Review

Share your design with others working on the same challenge to get feedback.

9

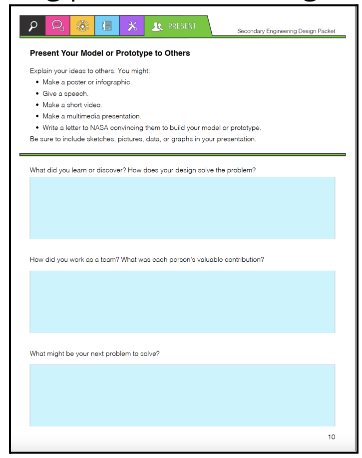
If time permits, refine your design by creating a second model or prototype.

- How could you test which model or prototype is better? Decide on a test and try it out.
- How did the modification of your model or prototype compare to your original model or prototype?
- What improvement to the accuracy of your model or prototype did that modification result in?

  - Identify a feature of another team's design that you could incorporate into your design. What impressed you the most about this feature?

- **Present your model or prototype to others**

  Prompt learners to reflect on the steps used in the engineering process. Encourage them to use their notes and recorded test data.



PRESENT

Secondary Engineering Design Packet

Present Your Model or Prototype to Others

Explain your ideas to others. You might:

- Make a poster or infographic.
- Give a speech.
- Make a short video.
- Make a multimedia presentation.
- Write a letter to NASA convincing them to build your model or prototype.

Be sure to include sketches, pictures, data, or graphs in your presentation.

What did you learn or discover? How does your design solve the problem?

How did you work as a team? What was each person's valuable contribution?

What might be your next problem to solve?

10

  Questions to guide learners through this stage:

  - What was the design challenge?
  - What materials did you use?
  - How well did you solve the challenge?
  - Identify how you supported your team during this challenge.
  - What did you discover or learn?
  - How did you apply your science knowledge about __________in this challenge?
  - How did you apply your (science/math/social studies/language arts/arts/etc.) knowledge and skills to solve the problem? Computer science is the study of how to manipulate, manage, transform and encode information. How did you use computer science in this design challenge?

  Provide a variety of methods for learners to communicate their EDP experiences with others, such as creating:

  - articles;
  - videos;
  - interactive posters;
  - podcasts;
  - infographics; and
  - slideshow presentations.

After learners share their solutions, **extend** the experience with these questions:

- Compare your designs with others. How are the designs different?
- Is there some part of another design you would like to add to your design? What impressed you most about this design?
- How might you merge each group's ideas to create one "best" design?

Secondary Engineering Design Packet
Learner Checklist -- Grades 6 - 12

Engineering Design Process

My work shows evidence of all parts of the engineering design process.

Characteristics/Elements/Descriptors/Indicators	✓ Accomplished
I identified and explained the problem in detail including all criteria and constraints.	
I researched how others have solved the problem.	
I listed possible solutions and selected one.	
I developed a plan for construction that includes a diagram of the solution that explains the parts and their purpose, and a list of needed materials and tools.	
I followed the plan to create the model or prototype and noted any issues, the cause of the issue, and how to resolve the issue.	
I tested my solution and recorded the results accurately in organized data tables. I identified the strengths and weaknesses in the design of my model or prototype.	
I made and documented modifications to improve the design based on test results.	
I presented my model or prototype to others and explained how I used the design process to solve the problem. I shared what I discovered and learned.	

Collaboration/ Teamwork

I shared responsibilities for completing the work. I showed appreciation for the contributions of each team member.

Characteristics/Elements/Descriptors/Indicators	✓ Accomplished
I voluntarily engaged in all steps of the project and completed the tasks required by my team role.	
I listened to the ideas and feedback of team members.	
I offered solutions and compromises to solve conflicts that came up.	

Content Knowledge and Skills

I thoughtfully discussed and applied specific content knowledge related to the design challenge.

Characteristics/Elements/Descriptors/Indicators	✓ Accomplished
I explained...	
I discovered...	
I identified...	
I learned...	

Secondary Engineering Design Challenge Rubric

Grades 6-12

Characteristics/ Elements/ Descriptors/Indicators	Advance (above target)	Proficient (at target)	Emerging (below target)
Engineering Design Process ● stated the problem and identified the solution needed ● researched the problem and solutions of others ● brainstormed more than one possible solution ● developed a diagram of one solution that explains the parts and their purpose ● created a plan containing a list of materials and tools needed ● used the plan to create the model or prototype ● tested the model or prototype and recorded the results ● identified the weaknesses in the design ● made changes to improve the design ● presented the solution to others and explained how it solves the problem ● shared what was discovered and learned	Work and documentation show evidence of all parts of the engineering design process.	Work and documentation show evidence of many of the parts of the engineering design process.	Work and documentation do not show evidence of the engineering design process.
Collaboration/Teamwork ● voluntarily engaged in all steps of the project ● completed the tasks required by the team role ● offered ideas and encouragement to the team ● listened to the ideas and feedback of team members ● offered solutions and compromises to solve conflicts that came up	Shared responsibilities for completing the work. Showed an appreciation for the contributions of each team member.	Shared some of the responsibilities for completing the work. Mostly showed an appreciation for the contributions of each team member.	Shared few of the responsibilities for the design plan and/or showed little respect or appreciation for the contributions of other team members.
Content Knowledge and Skills (Add specific indicators based on the problem scenario and concepts reinforced within this challenge.)	Thoughtfully explained, discussed and applied specific content knowledge related to the design challenge. Accurately used content skills to complete the design challenge.	Mostly able to explain, discuss and apply specific content knowledge related to the design challenge. Mostly able to use content skills to complete the design challenge.	Unable to explain, discuss and apply specific content knowledge related to the design challenge. Unable to use content skills to complete the design challenge.

Standards Addressed:

Next Generation Science Standards

3-5.Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

MS.Engineering Design

Students who demonstrate understanding can:

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.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

HS.Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

ITEEA Standards for Technological and Engineering Literacy

STEL 1 Nature and Characteristics of Technology and Engineering

Grades 3-5

1H. Design solutions by safely using tools, materials, and skills.

Grades 6-8

1J. Develop innovative objects and systems that solve problems and extend capabilities based on individual or collective needs and wants.

Grades 6-8

1M. Apply creative problem-solving strategies to the improvement of existing devices or processes or the development of new approaches.

Grades 9-12

1Q. Conduct research to inform intentional inventions and innovations that address specific needs and wants.

1R. Develop a plan that incorporates knowledge from science, mathematics, and other disciplines to design or improve a technological product or system.

STEL 2 Core Concepts of Technology and Engineering

Grades 3-5

2L. Create a new product that improves someone's life.

Grades 6-8

2S. Defend decisions related to a design problem.

Grades 9-12

2T. Demonstrate the use of conceptual, graphical, virtual, mathematical, and physical modeling to identify conflicting considerations before the entire system is developed and to aid in design decision making.

2X. Cite examples of the criteria and constraints of a product or system and how they affect final design.

2Y. Implement quality control as a planned process to ensure that a product, service, or system meets established criteria.

2Z. Use management processes in planning, organizing, and controlling work.

STEL 7 Design in Technology and Engineering Education

Grades 3-5

7I. Apply the technology and engineering design process.

7J. Evaluate designs based on criteria, constraints and standards.

7M. Evaluate the strengths and weaknesses of existing design solutions, including their own solutions.

7N. Practice successful design skills.

7O. Apply tools, techniques, and materials in a safe manner as part of the design process.

Grades 6-8

7Q. Apply the technology and engineering design process.

7R. Refine design solutions to address criteria and constraints.

7S. Create solutions to problems by identifying and applying human factors in design.

7T. Assess design quality based upon established principles and elements of design.

7U. Evaluate the strengths and weaknesses of different design solutions.

7V. Improve essential skills necessary to successfully design.

Grades 9-12

7W. Determine the best approach by evaluating the purpose of the design.

7X. Document trade-offs in the technology and engineering design process to produce the optimal design.

7Y. Optimize a design by addressing desired qualities within criteria and constraints.

7Z. Apply principles of human-centered design.

7AA. Illustrate principles, elements and factors of design.

7BB. Implement the best possible solution to a design.

7CC. Apply a broad range of design skills to their design process.

7DD. Apply a broad range of making skills to their design process.