The Tech
Museum of Innovation

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Ant-Man Saves the Day

The Tech Challenge 2016 Flight Lesson 1:
Developed by The Tech Academies of Innovation

I. Lesson Overview

Build Ant-Man a flying device to transport him safely to fight crime!

Lesson Description:

Students will start exploring flight by participating in a design challenge which will help them activate prior knowledge about flight and introduce them to engineering design concepts and vocabulary. They will then work on building oral and written communication skills by engaging in narrative writing which encompasses an explanation of their engineering design.

Grade Levels: 4-8

Education Outcomes:

Students will:

- build a flying device that meets stated criteria and constraints
- describe their engineering design using correct engineering vocabulary
- write a narrative using the engineering process, descriptive language (sensory, emotion, etc.), correct sequence and incorporate relevant engineering vocabulary to describe the engineering process

Education Standards

Met: (Note: bolded parts of the standards are fully met by this lesson)

NGSS Disciplinary Core Ideas (DCI)

3-5-ETS1.A: Defining and Delimiting Engineering Problems

- **Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria).** Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

3-5-ETS1.B: Developing Possible Solutions

- At whatever stage, **communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.**

Common Core Standards:

(4-8) CCSS.ELA-Writing.WS 4.3, 5.3, 6.3, 7.3, 8.3: Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences.

Addressed: (The following standards are practiced in this lesson but are not explicitly taught and assessed)

NGSS Disciplinary Core Ideas (DCI)

3-5-ETS1.B: Developing Possible Solutions

- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.

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6-8-ETS1.A: Defining and Delimiting Engineering Problems

- 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 of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

6-8-ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
- Models of all kinds are important for testing solutions.

NGSS Science and Engineering Practices (SEP):

3-5 SEP 1: Asking Questions and Defining Problems

- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

6-8 SEP 1: Asking Questions and Defining Problems

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

NGSS Crosscutting Concepts (CCC):

6-8-CCC 6. Structure and Function - The way an object is shaped or structured determines many of its properties and functions.

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Common Core Standards:

CCSS RL Craft and Structure
4. Interpret words and phrases
5. Analyze structure of texts
6. Assess how point of view or purpose shapes the content and style of a text

English Language Development Standards:

Part 1A.1: Exchanging information and ideas with others through oral collaborative conversations on a range of social and academic topics

Part 1B.5: Listening actively to spoken English in a range of social and academic contexts

Part 1C.10: Composing/writing literary and informational texts to present, describe, and explain ideas and information, using appropriate technology

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II. Advanced Prep & Set-Up for Lesson

Ant-Man Flying Device Set-Up

Materials (for approximately 30 students)
NOTE: The following materials are suggestions of the types of materials needed for this lesson. Feel free to modify the following list to easily accessible materials. In general, you will need:

- Materials for building and sculpting
- Materials for sketching and designing

SAMPLE Materials (you can substitute materials):

- Construction paper (one pack)
- Tissue paper (one pack)
- Markers (3-4 sets)
- Crayons (3-4 sets)
- Toothpicks (one box)
- Paper clips (2 boxes - more if you are not providing tape)
- Straws (2 boxes)
- Rubber bands (one box)
- Foil (one roll/box)
- Pipe cleaners (3 packages)
- Paper plates (20)
- Paper cups (20)
- Cardstock (one pack)
- Plastic bags (an assortment of different type of bags)
- Scissors (one box)
- String (three rolls)
- Soda caps (one pack)
- CDs (10-20)
- CD holder spindles, spacers (three)
- Coffee filters (5-10)
- 9 mm pony beads (to represent Ant-Man, one per device)
- Tape (optional)

Ant-Man Flying Device Set-Up

- Set up 1-2 tables to place materials

- Set up space for testing station:
  - You need a long, open space of at least 20 feet
  - Tape launch line to indicate starting point. Make sure it is labeled e.g. "LAUNCH Here" written on tape
  - At each foot, tape down a line of tape on the floor and label the distance from the launch line e.g. "1ft, 2ft, 3ft, etc."
  - Mark 6 feet from launching point with an "X", as this meets the criteria for this design project

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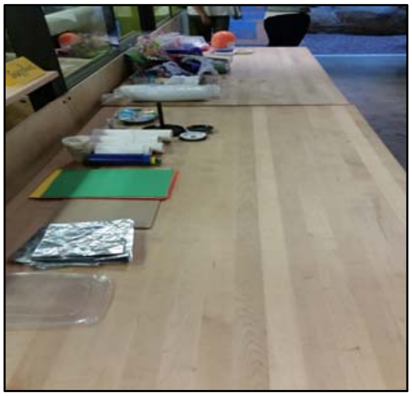
- Examples of setup tables and testing area are below:



Ant-Man Flying Device Narrative Set-Up

Materials

- For students writing individual essays:
  - Binder paper (one+ sheets per student)
  - Pencils (one per student)
  - Engineering Checklist and Journal (one per student)
  - Narrative Graphic Organizer (one per student)
- Crayons (recommend a box or 2 per table in case students want to draw)
- Construction paper (1 ream in case students want to draw)

Ant-Man Flying Device Narrative Set-Up

- Have students individually work on their narrative
- Students should write a rough draft and final draft

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III. Ant-Man Saves the Day Lesson Guide

Design Problem: Help Ant-Man fight crime. Ant-Man needs to create a flying device, object or machine to help him travel where he is needed.

A. Introduction (10 minutes)

1. Introduce relevant vocabulary so students can begin to internalize it for narrative.

   - As you introduce engineering vocabulary, connect it to how students might use it in their narrative.

   - After showing various engineering marvels (examples may include Burj Khalifa - tallest building in the world, Golden Gate Bridge, Apple iPhone, a fork): Who do you think built these marvels? (Allow students to share some ideas) A person who uses his/her knowledge of science to design and create things to solve a problem is called an **engineer**.

   - Engineers have **constraints** and **criteria** that they must meet.
     - A **constraint** is a limitation or restriction. Because there is limited money, materials, or time, engineers must find the most efficient/ practical way to achieve their goal. For example, an engineer might be told he/she only has a certain amount of space and money to build his/her design. That means the engineer needs to find a way to make his/her creation fit in the space and not use more money than he/she has to work with.

     - **Criteria** are standards that a system or device must meet. These are requirements that a design must meet in order to be successful.

   - Also review/introduce the following vocabulary:
     - **Design problem:** Identified constraints/ goals/ needs. What you are trying to solve.

     - **Engineering process:** Engineers rely on the "design process" to guide them. These are the steps used to come up with solutions:

     NOTE: These steps are non-linear or sequential; they often overlap and blur. The order is sometimes fluid and is adaptable to each individual design/project and process.

Facilitator Notes:
Engineering Vocabulary Strategies:
- Introduce key vocabulary using one or more of the following strategies:
  - Visual glossary: word wall with definitions and visuals
  - Discussion/ pair share
  - Concept circle: frame of reference, definitions, examples/ non-examples and visual *(see Appendix B)*
- Connect engineering vocabulary to students' prior knowledge and/or real world examples.
- Model academic language usage and encourage students to use words.
- One recommendation is to have students engage in mini design challenges prior to beginning this lesson for students to internalize the design process. When reviewing the vocabulary teachers should use the words: **constraints** and **criteria** in the mini-challenges as examples. Possible mini design challenges could be:
  1. Build the tallest tower in groups with 100 index cards and 6 inches of masking tape to hold up stuffed toy for 10 seconds.
  2. Build the tallest structure using 20 uncooked spaghetti sticks and 1 jumbo marshmallow per group (*See Appendix B section for other ideas on mini design challenges).*
- **A common misconception** is that all limitations are constraints. Some criteria may seem like limitations to design but fall under criteria if they are requirements of the design. For example, if a client wants a car that will fit in a 3 foot parking space, this would be a criteria of the design rather than a constraint. One way to think about this is that criteria are what we want the design solution to do. Constraints are real-life limitations that the design must accommodate for.
- Other strategies to engage students could be to use the suggested stories *What's Smaller Than a Pygmy Shrew?* and/or *Hey Little Ant* to introduce the idea of size perspective. (*See Appendix B)*

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B. Experiment Design (40-60 minutes)

1. Brainstorm things that fly. Suggested discussion questions:
   - What kind of things fly?
   - Create a list of things that fly
   - What shapes are these flying devices/animals?
   - What are some things that travel through the air?
   - How are the means of travel different/same?
   - What are some things that you know that fly?
   - Do all flying things fly the same way? How do things fly differently?

2. Introduce the design challenge.
   Design Problem:
   - Ant-Man needs a conveniently sized flying device to transport him to help fight crime without getting smashed. Build a flying device to transport Ant-Man safely!

   Criteria (Design Requirements/Desired Features):
   - Flying device must go at least 6 feet
   - Must be launched at the line
   - Ant-Man must be visible either through a window or outside of the flying device
   - You must safely transport Ant-Man
   - He cannot fall off the aircraft or be under the aircraft when it lands
   - Complete engineering checklist and journaling

   Constraints (Design Limitations):
   - You may only use the materials provided
   - You will have 10 minutes to complete this challenge (extra five minutes to redesign)

   Testing:
   - Flight Test: A single person will hand launch all devices two times from the same location to minimize launch variables.
     Flight Observation: During both tests, observe and document how each aircraft design behaves during flight.

3. While students are working on their designs, walk around and ask questions. Some suggested questions are:
   - What materials did you choose? /What do you plan to create with your materials?
   - In what ways are you using your materials? Why?
   - What are your next steps?
   - How do you plan to design your flying device?

Facilitator Notes:
Design Challenge Tips
- You might mix up the criteria and constraints and see if students can correctly categorize them to check for understanding.
- Encouraging Creativity:
  - Avoid providing examples and/or models that may encourage copying.
  - Choose to not use certain materials (e.g. tape, paper, glue) to promote problem-solving skills and creativity.
- Set clear norms/expectations (state orally and have written norms/expectations posted for student reference).
- Brainstorming:
  - Teacher may choose to engage students in a pair-share or group-share to generate ideas.
  - Students can do a "rally robin" in pairs to list as many things that fly as they can while taking turns and not repeating ideas.
  - Students can then share their ideas orally or on a post-it note.
- Students may need more than 10 minutes to build their device. Give time limits in increments, as needed. This creates a sense of urgency that can help students to not over-think their first design.
- We want youth to test early so they can improve their designs. For this reason, it's also important to have a testing area available during build time.

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4. Prior to testing, have students reflect on how their design meets the criteria and constraints given to them. Some questions to use during facilitation may include:
   - **Reflect** on and share the design decisions you made. Can you explain why you made those design decisions?
   - Why do you think your design will be successful when **tested**?
   - Which parts of the **criteria** or **constraints** did you find the hardest to meet? Which did you find the easiest?

5. Prior to testing as a whole class, go over launch/safety procedures. Some possible pre-test questions:
   - Why did you choose that particular shape or structure?
   - How do you think/**imagine** your device will fly, given it's shape or structure?
   - What do you think/**imagine** will happen?
   - What do we need to do to keep everyone safe during the testing?
   - What do we need to do to respect everyone's aircraft?

Facilitator Notes:
Testing Tips
- Bolded words are engineering design process vocabulary that should be emphasized by the teacher to promote an engineering mindset.
- Students should be encouraged/challenged to make iterations to their designs to improve results ("things can also be made better").
- Teacher should use probing questions to reinforce concepts and academic words learned.
- The teacher may choose to extend activity by challenging students to complete a second design with specific criteria.

6. Run tests and have students observe how different devices perform. Suggested discussion questions:
   - What things did you observe about your flying device?
   - **Reflecting** on your observations, why do you think your flying device flew like it did?
   - How do you think Ant-Man felt flying in your flying device?
   - Do you think Ant-Man felt safe? Why? Why not?
   - In what ways can you improve/**iterate** your flying device to help Ant-Man achieve his goal and feel safe?
   - What shape or structure of your aircraft do you think caused it to _______? Why do you think they made the aircraft do that?

7. Have students complete Engineering Checklist and Journal *("Engineering Checklist and Journal," Appendix C)*
   - As students are completing their journal, circulate and encourage students to use close observations and detailed writing.

8. Redesign - Additional Constraints (Optional):
   - Give each group different constraints such as varying distances, soft-landing, **accuracy** (hitting a given target), **precision** (hitting the same spot multiple times), speed etc. to get a variety of solutions.
   - If you choose to do a redesign, have students document and fill out the checklist and journal for Trial 2 *(page 2 of "Engineering Checklist and Journal," Appendix C)*.

Facilitator Notes:
Accuracy vs. Precision:
- **Accuracy** and **precision** are both important factors to consider when gathering data. Both terms reflect how close a measurement is to a value.
- **Accuracy** measures how close a measurement is to a known value or location. In the example of hitting a target, accuracy is how close your marks are to the center of the target, even if they are all on different sides of the target.
- **Precision** measures how reproducible measurements are. Precisely hitting a target means that all the marks are closely spaced, even if they are far from the center of the target.

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C. Narrative Writing (approximately 120-180 minutes)

1. Introduce the narrative writing project through discussion of Ant-Man's engineering and flying experience. Suggested questions include:
   - What was the problem that Ant-Man was trying to solve? What were the design criteria? What were his constraints?
   - What steps did Ant-Man take to design, build and improve his flying device?
   - Where did Ant-Man travel and why?
   - What was it like to be Ant-Man? What did it feel like? What did it look like?
   - Explain that students will be writing about how Ant-Man used the engineering process to design, build, use, and improve his flying device.

Facilitator Notes:
Narrative Writing Tips
- Lead discussion about what students observed during the testing phase. Again, reference and model using the engineering language and encourage students to use this vocabulary when discussing and writing.
- Teacher may want to remind students about dialogue usage in narrative writing and how it is a powerful way to enhance storytelling. "Why would dialogue, or communication between characters, make the story better?"

2. Review Engineering Vocabulary
   - Reconnect with students by reviewing vocabulary and holding a discussion
   - Have students play the ***Envelope Vocabulary Game:***
     - Have pre-written engineering concepts on cards for each team of 4. (engineer, design problem, criteria, constraint)
     - Students are required to verbalize sentences to describe their flying devices using the vocabulary on the cards.
     - Students get points for each vocabulary word they use in context correctly and self-score on sticky notes.
     - Students are allowed a maximum of 2 points per turn, no matter how many words they use in a sentence.
     - Students can share out their sentences as closure.

3. Have students brainstorm ideas for narrative
   - Have students engage in peer-to-peer discussions to generate ideas. Have each describe the engineering and flight experience from Ant-Man's perspective to the other. Encourage them to use lots of descriptive details and sequence words. (i.e. First, next, then, finally.)
   - Use Engineering Checklist and Journal completed during the design challenge to guide important components to include in narrative *("Engineering Checklist and Journal," Appendix C)*
   - Write ideas down in Narrative Graphic Organizer using the boxes to organize ideas and thoughts for their narrative before beginning to write the narrative *("Narrative Graphic Organizer," Appendix C)*

Facilitator Notes:
Narrative Writing Tips
- Flash Write or Quick Write is a writing activity where students have 5-10 minutes to write (continuously) all their thoughts and ideas down with no guidelines regarding formatting, spelling, etc. To help guide students with his strategy, teacher should give students an open-ended question to write about.
- Use Peer Revision Checklist to help guide student learning (*see Appendix C*). Guide conversations about feedback and critiques.
  - Students learn from critiques and revision
  - Start by discussing what was right
  - Critiques need to be specific
  - Remember to talk about progress
- Remind students to continually think with the perspective of scientist: Imagining, being curious, asking why, questioning, researching, and providing evidence. *(See Appendix B "Austin's Butterfly")*
- Celebrate students' work with a culminating event. Some suggested ideas are:
  - Whole class/small group share-out
  - Read stories to another class
  - Class story book (all students' stories bound in a class book)

4. Have students write a rough draft
    - Have students write a flash draft/quick write (see Facilitator Note for more information)
    - Students can share and revise their rough draft
    - Partner students and have them trade work and fill out the "Peer Revision Checklist" *(Appendix C).* Have students go through their Peer Revision Checklists with each other as a way to facilitate critiques and feedback.

5. Have students write a final draft
    - Have students edit and publish their final drafts
    - Students may also illustrate their narratives
    - Optional Extension: Students could also turn their narrative into a graphic novel.

Some examples of flying devices made by students:




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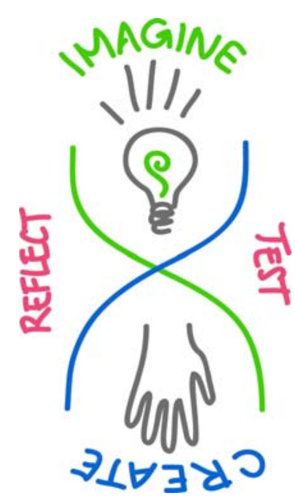
IV. Appendices

A. Vocabulary and Background Information

The following is the start of a suggested list of words to discuss as you read and discuss with students.

accuracy	How close a measurement is to a known value or location. In the example of hitting a target, accuracy is how close your marks are to the center of the target, even if they are all on different sides of the target.
constraint	The limitations of a design problem which typically include budget and schedule limitations but may also include other limitations such as maximum size restrictions.
criteria	The requirements or desired features of a design problem often describing the purpose and standards that a system or device must meet.
design problem	The identified challenge, goals, or needs that a design addresses. What you are trying to solve.
engineer	Someone who finds innovative (original) solutions to real-life problems (e.g. mechanical engineer, hardware engineer, software engineer, civil engineer, electrical engineer)
engineering process	A series of steps that engineers use to guide them as they solve problems. The process is non-linear but cyclical, meaning that engineers repeat the steps as many times as needed, making improvements along the way of imagining, creating, reflecting, testing and iterating. These are steps used to come up with solutions:



precision	Measures how reproducible measurements are. Precisely hitting a target means that all the marks are closely spaced, even if they are far from the center of the target.

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C. Lesson Handouts

Name: ______________________________

Date: __________ Class: ______________

Engineering Checklist and Journal

Trial 1:

Imagine you were Ant-Man...

- ❑ Did you only use the materials provided?
- ❑ Did your flying device travel at least 6 feet?
- ❑ Were you (Ant-Man) visible from outside the aircraft?
- ❑ Did you land safely?

Observation Journal: Describe what happened on your voyage? Use your scientific eyes. Be specific.

Name: ___________________________________

Date: ____________ Class: _________________

Trial 2:

Imagine you were Ant-Man...
What was your added constraint? ____

- ❏ Did you only use the materials provided?
- ❏ Did your flying device travel at least 6 feet?
- ❏ Were you (Ant-Man) visible from outside the aircraft?
- ❏ Did you land safely?

Observation Journal: Describe your voyage, what happened? Use your scientific eyes. Be specific.

Name: ______________________________

Date: __________ Class: ______________

Narrative Graphic Organizer

Setting:	Time:	Place:

Characters:

Problem:

What is the design problem?

What are the constraints?

What are the criteria?

Plot/Events:

1.

2.

3.

Resolution:

Name: ______________________

Date: __________ Class: ______________

Peer Revision Checklist

	Author: ______________________ Editor: ______________________	Got it!	Still Working on it!
Narrative Writing	1. Story has a character or multiple characters.		
	2. Story includes a setting or multiple settings.		
	3. Story has a beginning and includes details that set up the plot including describing the character(s) and setting.		
	4. Story has a middle that explains important events.		
	5. Story has an ending that includes a solution to the problem.		
	6. Story has a problem and solution.		
	7. Author uses dialogue and/or sensory details to enhance writing.		
	8. Author uses transitional words and phrases.		
	9. Author uses correct conventions (capital letters, punctuation, etc.)		
Engineering	10. Author clearly describes the design problem.		
	11. Author answered engineering questions		
	12. Author explains the criteria and constraints of the design problem.		
	13. Author describes the engineering process he/she followed.		
	14. Author uses engineering vocabulary in writing: design problem, criteria, constraint, and engineer.		

Name: ______________________________

Date: __________ Class: ______________

Rubric for Assessment of Narrative Writing

Score	4	3	2	1
Narrative Focus	The narrative is clearly focused and maintained throughout. Effectively establishes a setting, narrator and/or characters.	The narrative is focused and maintained throughout approximately 90% of the writing. Establishes a setting, narrator, and/or characters.	The narrative may be maintained but may provide little or no focus or may only be maintained for 75% of the writing. Inconsistently establishes a setting, narrator and or characters.	The narrative may be maintained but may provide little or no focus: May be very brief, May have a major drift, Focus is confusing or ambiguous
Organization	The narrative has an effective plot helping create unity and completeness: • Effective, consistent use of a variety of transitional strategies. • Logical sequence of events from beginning to end. • Effective opening and closure for audience and purpose.	The narrative has an evident plot, though there may be minor flaws and some ideas may be loosely connected: • Adequate use of a variety of transitional strategies. • Adequate sequence of events from beginning to end. • Adequate opening and closure for audience and purpose.	The narrative has an inconsistent plot, and flaws are evident: • Inconsistent use of basic transitional strategies with little variety • Uneven sequence of events from beginning to end. • Opening and closure, if present are weak. • Weak connection among ideas.	The narrative has little or no discernable plot: • Few or no transitional strategies are evident • Frequent extraneous ideas may intrude.
Elaboration	The narrative provides thorough and effective elaboration using details, dialogue and description	The narrative provides adequate elaboration using details, dialogue and description.	The narrative provides uneven cursory elaboration using partial and uneven details, dialogue and description.	The narrative provides minimal elaboration using little or no details, dialogue, and description.
Language & Vocabulary	The narrative clearly expresses experiences or events: • Effective use of sensory, concrete and figurative language clearly advance the purpose.	The narrative adequately expresses experiences or events.	The narrative unevenly expresses experiences or events.	The narrative is vague lacks clarity or is confusing.
Conventions	The narrative demonstrates a strong command of conventions: • Few, if any errors in usage and sentence formation. • Effective and consistent use of punctuation, capitalization and spelling	The narrative demonstrates an adequate command of conventions.	The narrative demonstrates a partial command of conventions.	The narrative demonstrates a lack of command of conventions.
Engineering Concepts	The narrative includes an accurate definition of the design problem, criteria, constraints and design process. All of the following engineering vocabulary is used accurately: • design problem • constraints • criteria • engineer	The narrative includes a description of the design process and design problem. Most of the criteria and constraints are accurate At least 2 out of 4 engineering terms are used accurately in written explanations	The narrative includes a limited description of the design process and design problem. Many criteria and constraints are missing or inaccurately categorized. Only 1 out of 4 key engineering terms are used accurately in written explanations	The narrative does not include a description of the design process or design problem and no identified key vocabulary are used accurately.