FUTURE U.

Topic Series: Flight Path

Objectives

Students will be able to:

- **Consider** the key elements of manufacturing
- **Simulate** the manufacturing process to create a 3D plane prototype intended to fly with minimal drag

Episode 2

Fabrication and Manufacturing—How are we going to make this?

Materials

- Students' airplane designs from Activity 1
- Modeling clay or play dough, two handfuls per groups of four
- 747-8 Freighter video, to project
- Manufacturing Checklist handout, one per student
- Prototype Manufacturing handout, one per student
- Airplane fabrication materials, a combination of several of the following materials for each group of four:*
    - Hot glue and a hot glue gun and/or another strong adhesive
    - Scissors
    - Cardboard or cereal boxes
    - Balsa wood (with one utility knife for the instructor)
    - Paperclips
    - Straws
    - Aluminium foil
    - Paper towels, napkins, or tissues
    - Rubber bands
    - Paint stirrers and/or popsicle sticks
    - Masking tape or duct tape
    - Foam sheets
    - Paper towel and/or toilet paper tubes
    - Clay and/or play dough (leftover from the beginning of the activity)
    - Any other classroom or home materials that may be used to construct a model plane

Note: These fabrication materials are suggestions, and it is not necessary to assemble all of them. Think about what students could use to make plane prototypes that can glide through the air, and then make the supply list work for your classroom. Students can be creative when building their prototypes!

Timing

45–60 minutes

National Standards

Next Generation Science Standards
Engineering Design

- 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.

ITEEA Standards for Technological Literacy
Standard 9: Engineering Design
To comprehend engineering design, students should learn that:

- F. Design involves a set of steps, which can be performed in different sequences and repeated as needed.
- H. Modeling, testing, evaluating, and modifying are used to transform ideas into practical prototypes.

Engage

- Instruct students to find their group members from Activity #1 and take out their two completed airplane designs.
- Distribute two handfuls of clay or play dough to each group. Challenge students to spend about 5 minutes making 3D models of their two designs.
- Then bring the class back together and discuss and/or introduce the idea of a prototype. Explain that a prototype is a model or preliminary version of a design. They come in all shapes and sizes. The models they just created are an example of a basic prototype.
- Discuss:
    - What may be the advantages of having a tangible 3D model over a 2D sketch or a digital 3D model?
    - Could this 3D prototype help you work toward solving the problem: How can we minimize airplane drag? Why or why not?
    - If you were to design another prototype, how could you construct it so it better helps you work toward solving this problem?

Investigate & View

- Write the word “manufacturing” on the board, and explain that prototype development is a key part of the manufacturing process. Encourage students to turn to a partner and share what comes to mind when they see this word.
- Then distribute one Manufacturing Checklist handout to each student, and read the directions provided.
- Reiterate that there is more to manufacturing than most people realize. The video will describe what is involved, including the questions that should be asked throughout the process. Instruct students to jot these questions on their Manufacturing Checklist handout as they are introduced during the Manufacturing video.

- Then play the video. It might be helpful to pause at a couple points to give students a chance to make notes.
- When the video is complete, instruct students to turn to their peers and share the questions they recorded. Students should add any questions they didn't have a chance to write down.

Apply

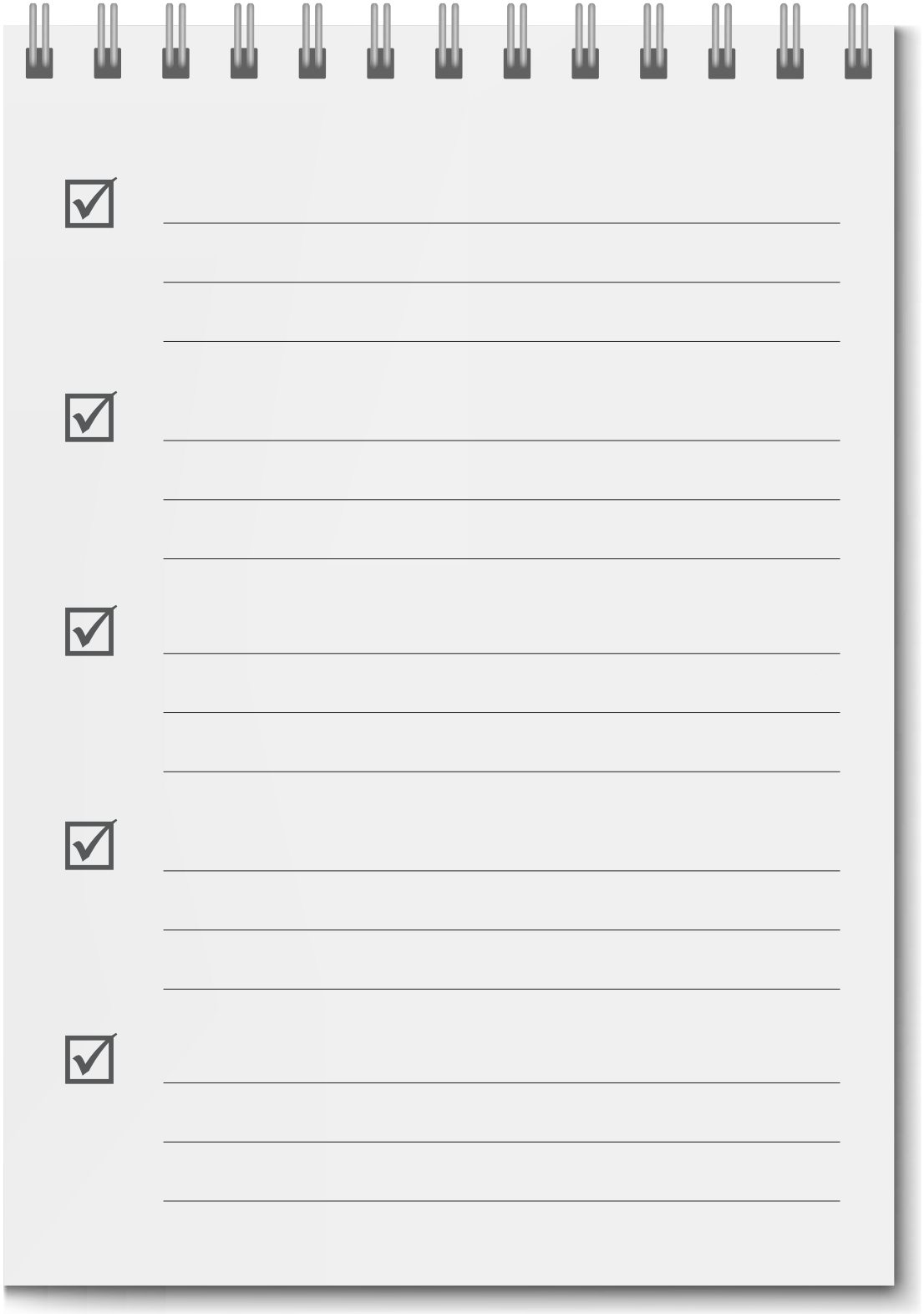
- Encourage students to refer to the notes they took during the video, and discuss as a class:
    - What questions should we be asking ourselves as we begin the manufacturing process?
    - What should our next step be?
- Then distribute one Prototype Manufacturing handout to each student. Review the directions, reiterate the three goals, and show students where they can find the fabrication materials.
- Acknowledge that it may not be possible to exactly recreate their designs with the available materials, but they should try to create prototypes that are as close as possible to what they envisioned. They will eventually be testing how each prototype flies, so they should choose their materials wisely.
- Finally, explain that you will give a signal every so often (flashing the lights, playing a phone alarm, etc.) that will indicate that each group needs to stop building and select a question from their Manufacturing Checklist to discuss. Once they have discussed an answer, you will then instruct them to continue working!
- Deduct five minutes from the end of the class session, and give students this much time to create their prototypes. Signal every 7–10 minutes that groups should pause and discuss one of their checklist's questions.* Try to pause for at least three questions throughout the building process.

  **Tip:* If a question isn't quite applicable to the students' prototype or manufacturing process, encourage groups to be creative and instead imagine how the question may be answered if they were working on their prototype at a Boeing facility.
- Then bring the class back together to discuss one final question: Based on what you experienced today, what are the most important parts of the manufacturing process? Share this 747-8 Freighter video for students to see real life example of an 747-8 Freighter being assembled.
- Conclude the session by previewing that students will soon put their prototypes to the test and analyze their flight performance!

Manufacturing Checklist

Directions: Manufacturing is about much more than just building. When teams collaborate to create and build new planes, there are many questions to keep in mind.

As you watch the Manufacturing video, jot some of the questions that must be considered during the manufacturing process:



Prototype Manufacturing

Directions: Follow the steps below to develop new 3D prototypes of your two airplane designs so that the flight of these prototypes can eventually be tested and analyzed.

Step 1: Familiarize yourself with Boeing's three goals for these prototypes:

- Goal #1: Prototypes must be constructed from materials that have been thoughtfully selected.
- Goal #2: Prototypes must able to fly/glide when thrown like a paper airplane.
- Goal #3: Prototypes must be designed in a way that is likely to minimize drag.

Step 2: Review the materials you have available and discuss which ones would be most effective for your designs. Then jot the materials you will use for each prototype below:

Plane 1:

Plane 2:

Step 3: With the three goals in mind, use these materials to construct your two prototypes. Each prototype should be no larger than 12 inches long. You may use the space below to jot notes, sketches, ideas, etc.