LockwoodSTEM

Introduction to Engineering Design

Unit 4

Aerospace Mechanisms, Materials & Electromechanical Systems

Design, build, test, analyze, and revise a working aerospace-inspired system using material evidence, mechanism behavior, electrical integration, and data.

Student learning deck • LockwoodSTEM aerospace-aligned IED curriculum

Unit 4 Learning Arc

You will combine technical subsystems into one working prototype.

1

Select Materials

Compare material properties and test samples before committing to a design choice.

2

Control Motion

Explore mechanisms, motion types, force, friction, and system behavior.

3

Integrate Power

Use simple circuits and motors safely when the prototype needs electromechanical motion.

4

Test + Revise

Collect data, graph results, draw conclusions, and improve the prototype.

The final demonstration should prove the system works and explain the evidence behind each major decision.

Unit 4 Deliverables Map

Each lesson creates part of the final technical demonstration package.

Materials Evidence

- property comparison
- test data
- statistics/error notes
- material recommendation
- tradeoff statement

Mechanism Evidence

- motion classification
- mechanism exploration
- friction analysis
- motion graph
- decision matrix

System Evidence

- architecture diagram
- CAD layout
- prototype build photos
- circuit/motor diagram
- integration notes

Testing Evidence

- test protocol
- data table
- graph/conclusion
- revision evidence
- technical demo reflection

How Unit 4 Works

YOUR CORE CHALLENGE

Create an aerospace-inspired mechanism or electromechanical system prototype that moves, performs a function, and can be tested with data.

WHAT "WORKING" MEANS

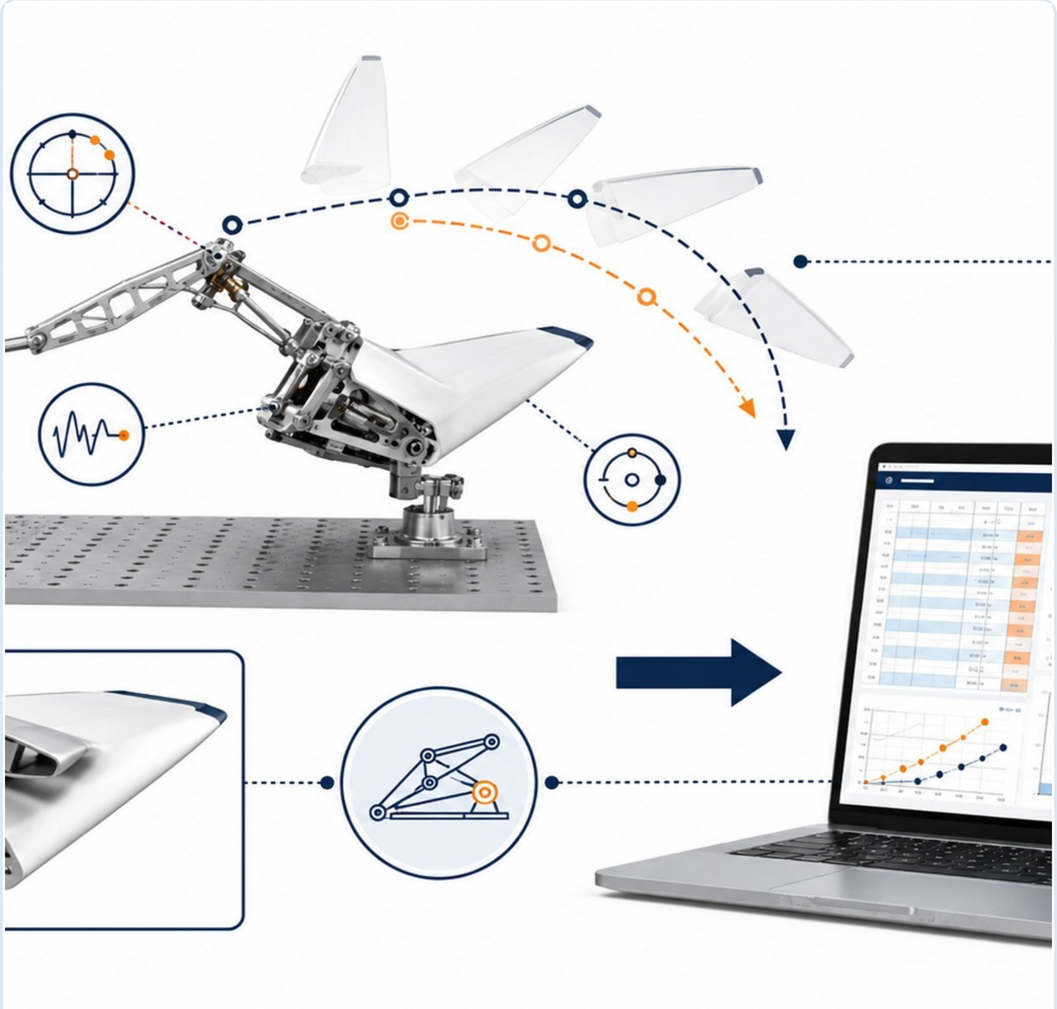
Working means the system is safe, reliable enough to demonstrate, and supported by material, mechanism, circuit, and testing evidence.

WHAT GOOD EVIDENCE LOOKS LIKE

Material test data, motion observations, circuit diagrams, test protocols, graphs, revision notes, and photos that show how the design improved.

ENGINEERING HABIT

Build only after you know what the system must do and how you will test success.



Unit 4 is about building a functional system and proving performance with evidence.

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Lesson 4.1

Unit 4 Challenge Launch: Aerospace Mechanisms, Materials & Electromechanical Systems

How can materials, mechanisms, circuits, and data work together in an aerospace system?

Unit 4 Challenge Launch: Aerospace Mechanisms, Materials & Electromechanical Systems

How can materials, mechanisms, circuits, and data work together in an aerospace system?

LESSON GOAL

Understand the Unit 4 aerospace system challenge and how materials, mechanisms, circuits, and data combine into one working prototype.

STUDENT OBJECTIVE

I can explain the challenge, identify system requirements, and describe the evidence my team will need to collect.

END PRODUCT

Challenge brief annotated with early criteria, constraints, subsystem ideas, and questions.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today’s technical decisions.

BIG IDEAS

• Unit 4 connects several engineering topics into one functional system.
• A system is made of interacting subsystems: structure, mechanism, power/control, and testing.
• Aerospace designs must balance mass, strength, motion, reliability, safety, and evidence.
• The final demonstration must show how the prototype works and how data supports design decisions.

Material choices are stronger when supported by testing, measurement, and data.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Read and annotate the Unit 4 challenge brief.
2. Identify required functions and system constraints.
3. List possible aerospace applications such as deployment, positioning, release, or motion control.
4. Sketch early subsystem ideas and questions.
5. Begin a team evidence plan for materials, mechanism, circuit, and data.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today’s evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Annotated challenge brief
☐ Initial criteria and constraints list
☐ Subsystem brainstorm sketch
☐ Early evidence plan
☐ Notebook reflection on the most important technical risk

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Challenge brief annotated with early criteria, constraints, subsystem ideas, and questions.

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Lesson 4.2

Aerospace Materials and Material Properties

How do material properties influence aerospace design decisions?

Aerospace Mechanisms, Materials & Electromechanical Systems

Aerospace Materials and Material Properties

How do material properties influence aerospace design decisions?

Technical systems require evidence from materials, motion, circuits, testing, and revision.

LESSON GOAL

Compare material properties that influence aerospace design choices.

STUDENT OBJECTIVE

I can connect material properties to design tradeoffs such as weight, stiffness, flexibility, durability, and manufacturability.

END PRODUCT

Material property comparison table and preliminary material recommendation.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- Materials are selected based on properties, not appearance.
- Useful properties include density, stiffness, strength, flexibility, toughness, conductivity, cost, and manufacturability
- Aerospace systems often prioritize strength-to-weight ratio and reliability.
- Different parts of the same prototype may require different materials.

Material choices are stronger when supported by testing, measurement, and data.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Compare classroom-approved materials using property categories.
2. Match materials to possible prototype parts or functions.
3. Identify at least two tradeoffs for each possible material.
4. Choose a preliminary material recommendation for one subsystem.
5. Record why the material choice fits the challenge requirements.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today’s evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Material comparison table
☐ At least three material-property observations
☐ Preliminary material recommendation
☐ Tradeoff statement
☐ Notebook reflection on material selection risk

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Material property comparison table and preliminary material recommendation.

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Lesson 4.3

Material Testing Lab

How can engineers test materials before choosing them for a prototype?

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Material Testing Lab

How can engineers test materials before choosing them for a prototype?

LESSON GOAL

Conduct a simple material test and use the results to support a design decision.

STUDENT OBJECTIVE

I can collect material test data and explain how the data affects a prototype decision.

END PRODUCT

Material test data table with a recommendation supported by evidence.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- Material testing helps engineers avoid guessing.
- A fair test controls variables so results are comparable.
- Deflection, failure, mass, and repeatability can help describe material performance.
- Test evidence is strongest when procedure, data, and conclusion are documented clearly.

Material choices are stronger when supported by testing, measurement, and data.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Set up a fair material test using approved classroom materials.
2. Measure the same variable for each material or sample.
3. Record raw data in a table.
4. Compare material performance using the test results.
5. Write a short evidence-based recommendation.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

- ☐ Material test setup sketch or photo
- ☐ Raw data table
- ☐ Controlled variables noted
- ☐ Material performance comparison
- ☐ Recommendation supported by data

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Material test data table with a recommendation supported by evidence.

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Lesson 4.4

Statistics and Measurement Error

How can statistics help engineers trust and interpret test results?

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Statistics and Measurement Error

How can statistics help engineers trust and interpret test results?

LESSON GOAL

Use basic statistics to interpret material or prototype test data.

STUDENT OBJECTIVE

I can calculate and interpret mean, range, variation, and measurement uncertainty in an engineering test.

END PRODUCT

Statistics summary for a test dataset with a reliability statement.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- One measurement rarely tells the whole story.
- Repeated trials help reveal variation and possible error.
- Mean describes a typical value; range shows spread.
- Measurement tools, human reading, setup differences, and sample variation can create error.
- Engineers use statistics to decide how much confidence to place in data.

Material choices are stronger when supported by testing, measurement, and data.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Review a small set of test data.
2. Calculate mean and range for repeated trials.
3. Identify possible sources of measurement error.
4. Decide whether the results are consistent enough to use.
5. Write a conclusion that mentions data reliability.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Completed statistics calculations
☐ Error source list
☐ Reliability statement
☐ Revised data conclusion
☐ Notebook reflection on how uncertainty affects decisions

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Statistics summary for a test dataset with a reliability statement.

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Lesson 4.5

Mechanisms and Types of Motion

How do mechanisms change or control motion in aerospace systems?

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Mechanisms and Types of Motion

How do mechanisms change or control motion in aerospace systems?

LESSON GOAL

Identify common mechanisms and describe how they change motion.

STUDENT OBJECTIVE

I can describe rotary, linear, reciprocating, and oscillating motion and connect them to mechanism examples.

END PRODUCT

Mechanism motion notes with aerospace application examples.

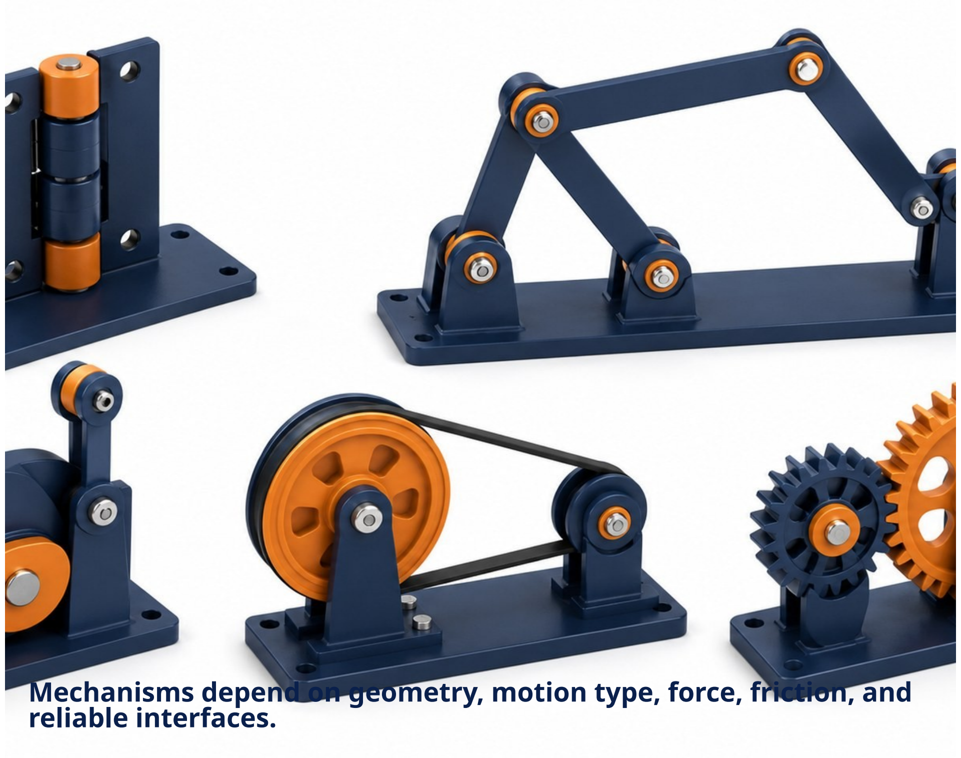
Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- Mechanisms transfer, change, or control motion.
- Common motion types include rotary, linear, reciprocating, and oscillating motion.
- Inputs and outputs may have different motion types, directions, speeds, or forces.
- Aerospace examples include doors, antennas, clamps, landing gear, deployable panels, and release systems.



Mechanisms depend on geometry, motion type, force, friction, and reliable interfaces.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Observe mechanism examples or diagrams.
2. Label input motion and output motion.
3. Classify motion type for each mechanism.
4. Identify where the mechanism could be used in an aerospace prototype.
5. Sketch one mechanism concept for the Unit 4 challenge.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Motion type notes
☐ Input-output labels
☐ Mechanism sketch
☐ Aerospace application example
☐ Notebook reflection on mechanism choice

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Mechanism motion notes with aerospace application examples.

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Lesson 4.6

Mechanism Exploration: Linkages, Hinges, Cams, Gears, and Pulleys

How can physical mechanism exploration reveal design possibilities and limitations?

Mechanism Exploration: Linkages, Hinges, Cams, Gears, and Pulleys

How can physical mechanism exploration reveal design possibilities and limitations?

LESSON GOAL

Explore mechanism examples to understand how geometry and constraints affect motion.

STUDENT OBJECTIVE

I can test or observe several mechanisms and identify advantages, limitations, and possible uses.

END PRODUCT

Mechanism exploration table with selected concept direction.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today’s technical decisions.

BIG IDEAS

- Mechanisms work because of geometry, constraints, and contact between parts.
- Linkages can guide motion through connected bars and pivots.
- Hinges allow rotation around an axis.
- Cams can convert rotary motion into repeated motion.
- Gears and pulleys can change speed, torque, direction, or force path.

Mechanisms depend on geometry, motion type, force, friction, and reliable interfaces.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Explore linkages, hinges, cams, gears, or pulleys.
2. Record what motion each mechanism creates.
3. Identify one strength and one limitation for each mechanism.
4. Connect at least one mechanism to your Unit 4 prototype idea.
5. Choose one mechanism type to investigate further.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today’s evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Mechanism exploration table
☐ Input/output motion notes
☐ Strength and limitation notes
☐ Prototype connection statement
☐ Selected mechanism direction

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Mechanism exploration table with selected concept direction.

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Lesson 4.7

Friction, Force, and Mechanism Performance

How does friction affect whether a mechanism works reliably?

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Friction, Force, and Mechanism Performance

How does friction affect whether a mechanism works reliably?

LESSON GOAL

Analyze how friction and force affect mechanism reliability.

STUDENT OBJECTIVE

I can identify places where friction helps or hurts a mechanism and suggest design improvements.

END PRODUCT

Friction and force analysis for a mechanism concept.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

• Friction can prevent motion, waste energy, create wear, or help parts grip.
• Mechanisms need enough force or torque to overcome friction and move the load.
• Contact surfaces, alignment, material choice, and lubrication can change friction.
• A reliable prototype must move consistently under expected conditions.

Mechanisms depend on geometry, motion type, force, friction, and reliable interfaces.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Identify contact points in a mechanism concept.
2. Predict where friction may help or hurt motion.
3. Test or simulate how force affects movement.
4. Propose ways to reduce unwanted friction or increase useful grip.
5. Update the design notes based on friction analysis.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today’s evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Mechanism contact-point sketch
☐ Friction helps/hurts notes
☐ Force or torque observation
☐ Improvement recommendation
☐ Notebook reflection on reliability risk

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Friction and force analysis for a mechanism concept.

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Lesson 4.8

Motion Graphs and System Behavior

How can graphs help engineers understand system behavior over time?

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Motion Graphs and System Behavior

How can graphs help engineers understand system behavior over time?

LESSON GOAL

Use motion graphs to describe how a mechanism or system behaves.

STUDENT OBJECTIVE

I can interpret simple position, time, speed, or angle data and connect the graph to prototype behavior.

END PRODUCT

Motion graph with written interpretation and design implication.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

Motion Graphs and System Behavior

What you need to understand

These ideas guide today’s technical decisions.

BIG IDEAS

- Graphs reveal patterns that are hard to see from a single observation.
- Motion data may include distance, angle, time, speed, or repeat count.
- A graph can show delays, inconsistent movement, overshoot, or improvement after revision.
- Engineers use graphs to compare system performance before and after a design change.

Mechanisms depend on geometry, motion type, force, friction, and reliable interfaces.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Collect or review motion data from a simple system.
2. Create a graph that matches the measured variable.
3. Identify the trend or pattern in the data.
4. Connect the graph to a real behavior of the prototype.
5. Write one design implication from the graph.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Motion data table
☐ Motion graph
☐ Trend statement
☐ System behavior explanation
☐ Design implication based on data

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Motion graph with written interpretation and design implication.

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Lesson 4.9

Electrical Safety and Simple Circuits

How can simple circuits safely support an engineering prototype?

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Electrical Safety and Simple Circuits

How can simple circuits safely support an engineering prototype?

LESSON GOAL

Understand basic electrical safety and simple circuit components.

STUDENT OBJECTIVE

I can build or diagram a simple safe circuit using a power source, load, switch, and conductors.

END PRODUCT

Simple circuit diagram with safety notes and component labels.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today’s technical decisions.

BIG IDEAS

- Circuits require a complete path for current to flow.
- Basic components include power source, wires, switch, load, and sometimes resistors or connectors.
- A short circuit can create heat and damage components.
- Prototype circuits should be low-voltage, organized, and easy to inspect.
- Safety includes correct connections, secure wires, and removing power when changing the circuit.

Electromechanical systems must be safe, organized, powered, mounted, and tested.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Identify circuit components and their symbols.
2. Build or diagram a simple LED, motor, or switch circuit.
3. Trace current path through the circuit.
4. Check for possible short circuits or loose connections.
5. Record safe setup and shutdown expectations.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Labeled circuit diagram
☐ Component list
☐ Current path marked
☐ Safety checklist notes
☐ Notebook reflection on circuit risk

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Simple circuit diagram with safety notes and component labels.

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Lesson 4.10

Motors and Electromechanical Motion

How can electrical energy create useful mechanical motion?

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Motors and Electromechanical Motion

How can electrical energy create useful mechanical motion?

LESSON GOAL

Connect motors to mechanical outputs in a prototype system.

STUDENT OBJECTIVE

I can explain how a motor produces motion and how that motion can be controlled or transferred.

END PRODUCT

Motor-to-mechanism concept sketch with input/output explanation.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- Electromechanical systems convert electrical energy into mechanical motion.
- Motors create rotary motion that can drive wheels, gears, cams, linkages, spools, or arms.
- Motor speed and torque must match the load and function.
- Mounting, alignment, wiring, and power supply affect reliability.
- Not every mechanism needs a motor; choose based on requirements.

Electromechanical systems must be safe, organized, powered, mounted, and tested.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Observe or test a motor and simple load.
2. Identify input energy and output motion.
3. Sketch how motor motion could drive a mechanism.
4. Consider speed, torque, mounting, and safety concerns.
5. Choose whether your prototype needs manual or powered motion.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Motor test notes or observation
☐ Input/output explanation
☐ Motor-to-mechanism sketch
☐ Power and mounting considerations
☐ Manual vs powered decision

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Motor-to-mechanism concept sketch with input/output explanation.

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Lesson 4.11

Concept Generation and Decision Matrix

How can engineers choose a mechanism concept using evidence and criteria?

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Concept Generation and Decision Matrix

How can engineers choose a mechanism concept using evidence and criteria?

LESSON GOAL

Generate multiple system concepts and select one using a decision matrix.

STUDENT OBJECTIVE

I can compare mechanism concepts using criteria, constraints, and early evidence.

END PRODUCT

Decision matrix with selected mechanism or system concept.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- A decision matrix helps teams make choices based on agreed criteria.
- Concepts should be compared before the team commits to one build direction.
- Criteria may include reliability, safety, mass, buildability, material use, motion quality, and data collection
- Scores should be justified with evidence or reasoning.
- A good selected concept can still be revised later.

Mechanisms depend on geometry, motion type, force, friction, and reliable interfaces.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Generate at least three mechanism or system concepts.
2. Choose criteria that match the challenge requirements.
3. Score each concept using the decision matrix.
4. Discuss score differences and assumptions.
5. Select the best concept direction and explain why.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Three concept sketches or descriptions
☐ Decision matrix
☐ Criteria list
☐ Selected concept justification
☐ Team notes on tradeoffs

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Decision matrix with selected mechanism or system concept.

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Lesson 4.12

System Architecture and Subsystem Planning

How do subsystems work together in an aerospace prototype?

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System Architecture and Subsystem Planning

How do subsystems work together in an aerospace prototype?

LESSON GOAL

Plan the architecture of the prototype as a system of interacting subsystems.

STUDENT OBJECTIVE

I can identify subsystem roles, interfaces, inputs, outputs, and dependencies.

END PRODUCT

System architecture diagram with subsystem responsibilities.

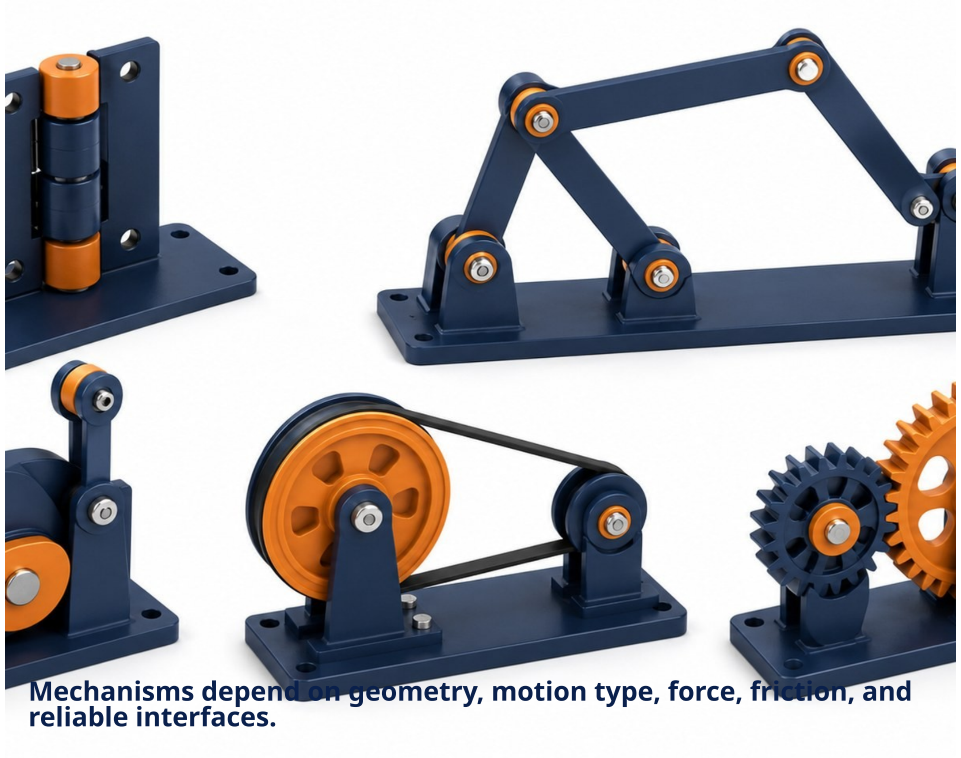
Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

• A system is easier to build when it is broken into subsystems.
• Subsystems may include structure, mechanism, power/control, materials, user interaction, and testing.
• Interfaces are where subsystems connect physically, electrically, or functionally.
• Many prototype failures happen at subsystem interfaces.
• A clear architecture diagram helps the team coordinate work.



Mechanisms depend on geometry, motion type, force, friction, and reliable interfaces.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. List the major subsystems in your selected concept.
2. Define the job of each subsystem.
3. Identify physical or electrical interfaces.
4. Mark dependencies and risks between subsystems.
5. Assign next steps for CAD, materials, circuit, and testing planning.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ System architecture diagram
☐ Subsystem responsibility list
☐ Interface notes
☐ Risk/dependency list
☐ Team next-step assignments

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

System architecture diagram with subsystem responsibilities.

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Lesson 4.13

CAD Planning and Assembly Layout

How can CAD planning prepare a mechanism for physical construction?

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CAD Planning and Assembly Layout

How can CAD planning prepare a mechanism for physical construction?

LESSON GOAL

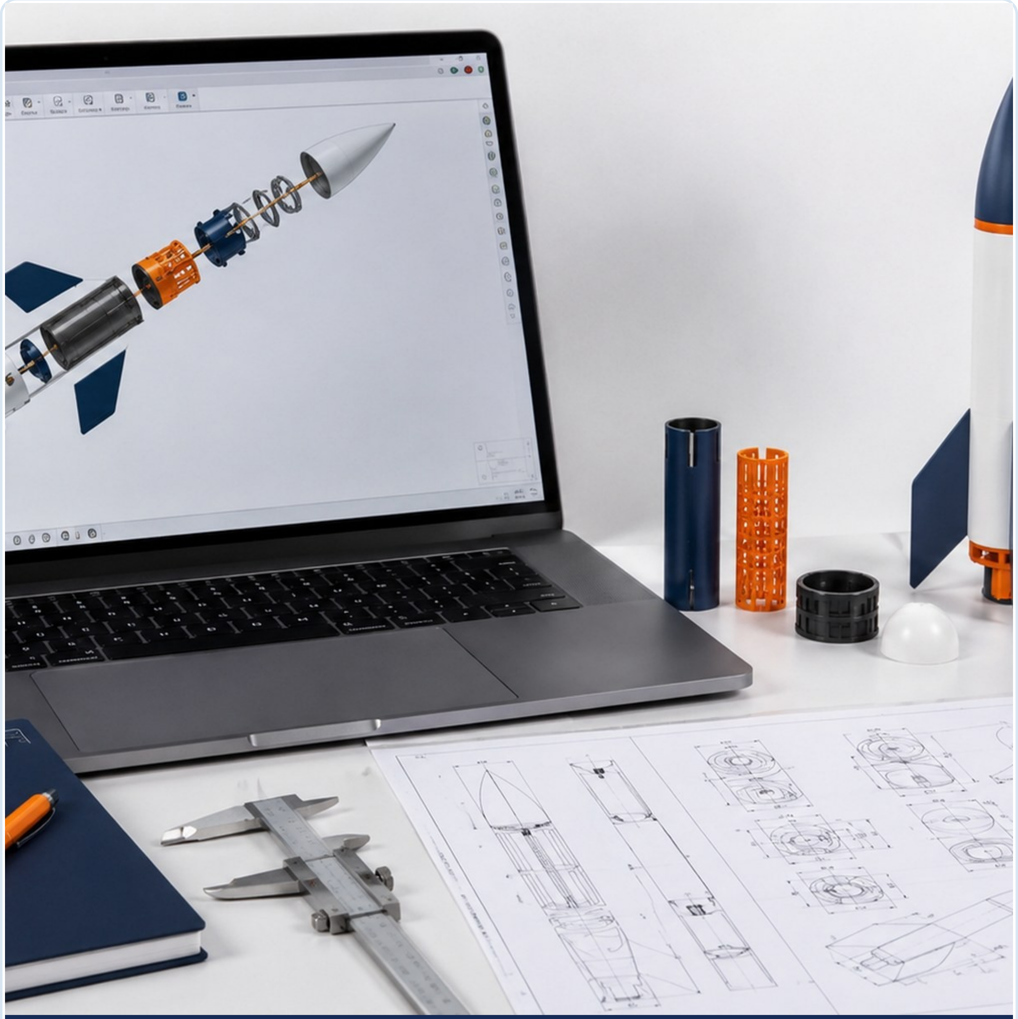
Plan the CAD layout for a mechanism or electromechanical prototype.

STUDENT OBJECTIVE

I can use sketches, dimensions, and layout constraints to prepare CAD work.

END PRODUCT

CAD planning sketch with key dimensions, components, and fit concerns.



Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

• CAD planning begins before modeling detailed parts.
• Layouts should show key dimensions, motion path, pivot locations, clearances, and mounting points.
• A planned assembly reduces wasted printing, cutting, or rebuilding time.
• CAD should reflect real materials, fasteners, and available fabrication methods.
• Mechanism CAD must consider moving parts and required space.

Materials, mechanisms, circuits, and data work together to create reliable aerospace systems.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Create a layout sketch for the selected system.
2. Mark key dimensions, pivots, paths, and clearances.
3. Identify parts that will be printed, cut, built, or purchased.
4. Check the layout against material and fabrication limits.
5. Prepare a CAD task list for the next workday.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ CAD planning sketch
☐ Key dimensions and clearances
☐ Fabrication method notes
☐ Parts/task list
☐ Fit or motion risk notes

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

CAD planning sketch with key dimensions, components, and fit concerns.

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Lesson 4.14

CAD Modeling Workday: Components, Motion, and Fit

How do engineers model and check parts before building?

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CAD Modeling Workday: Components, Motion, and Fit

How do engineers model and check parts before building?

LESSON GOAL

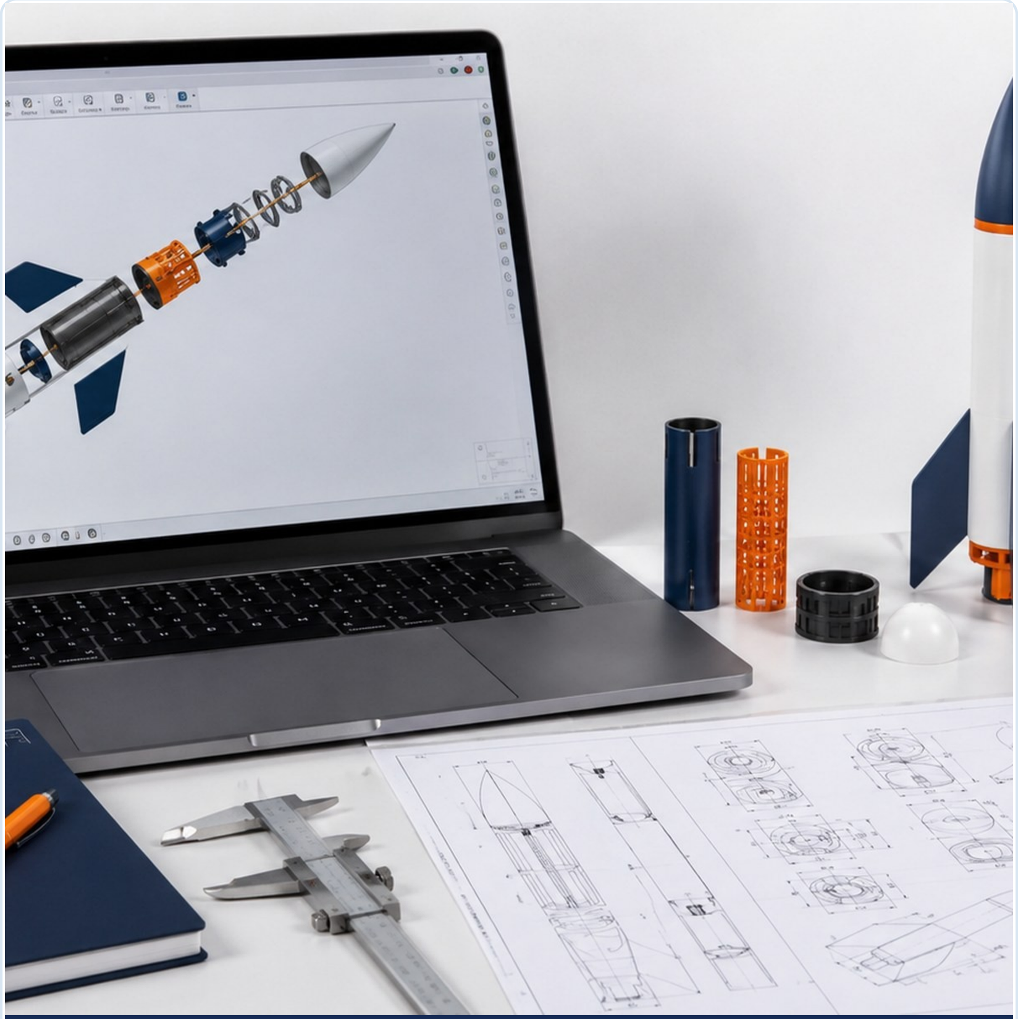
Model the components needed for the Unit 4 mechanism or system prototype.

STUDENT OBJECTIVE

I can create or revise CAD parts while checking fit, motion, and fabrication constraints.

END PRODUCT

Updated CAD files with screenshots showing component design and fit checks.



Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today’s technical decisions.

BIG IDEAS

- CAD models should support a real build, not just look complete on screen.
- Each component should have a clear function in the system.
- Motion and fit checks help reveal interference before fabrication.
- Simple models with correct dimensions are better than detailed models that cannot be built.
- Screenshots create evidence of design intent and revision.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Model or revise key components in CAD.
2. Check dimensions, clearances, and part relationships.
3. Use assembly positioning or simple motion checks where possible.
4. Prepare parts for fabrication or prototyping.
5. Capture screenshots showing important design decisions.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Updated CAD file
☐ Component screenshots
☐ Fit or motion check evidence
☐ Fabrication-ready part notes
☐ Design decision explanation

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Updated CAD files with screenshots showing component design and fit checks.

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Lesson 4.15

Prototype Build Day 1: Structure and Mechanism

How do engineers build the structure and core mechanism of a prototype?

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Prototype Build Day 1: Structure and Mechanism

How do engineers build the structure and core mechanism of a prototype?

LESSON GOAL

Begin building the physical structure and core mechanism of the prototype.

STUDENT OBJECTIVE

I can safely build and assemble the mechanical portion of the system while documenting progress.

END PRODUCT

Partially built prototype with structure/mechanism evidence and build notes.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

• Build days should follow the plan but still allow evidence-based adjustments.
• Structure provides support, alignment, and stability for the mechanism.
• Mechanism quality depends on pivots, clearances, friction, and secure mounting.
• Teams should test motion early instead of waiting for the full system.
• Documentation during the build prevents lost decisions.

Mechanisms depend on geometry, motion type, force, friction, and reliable interfaces.

Prototype Build Day 1: Structure and Mechanism

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Gather approved materials and fabricated parts.
2. Build the main structure or base.
3. Assemble the core mechanical components.
4. Check alignment, motion, and clearance during assembly.
5. Photograph progress and record build issues.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Build progress photos
☐ Structure/mechanism assembly notes
☐ Alignment or clearance observations
☐ Build issue list
☐ Next build priorities

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Partially built prototype with structure/mechanism evidence and build notes.

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Lesson 4.16

Prototype Build Day 2: Electrical or Electromechanical Integration

How can electrical or electromechanical features be integrated safely into a prototype?

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Prototype Build Day 2: Electrical or Electromechanical Integration

How can electrical or electromechanical features be integrated safely into a prototype?

LESSON GOAL

Integrate the electrical, motor, or control elements needed for the prototype.

STUDENT OBJECTIVE

I can connect and test low-voltage electrical or electromechanical components safely.

END PRODUCT

Integrated prototype subsystem with circuit/motor evidence and safety notes.

Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- Electrical integration should be organized, low-voltage, and easy to inspect.
- Wires, switches, motors, batteries, and LEDs must be secured and protected.
- Electrical components must not interfere with moving mechanisms.
- Testing should begin with small, controlled checks.
- A functional circuit is only useful if it is safe and reliable.

Electromechanical systems must be safe, organized, powered, mounted, and tested.

Prototype Build Day 2

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Review circuit or motor plan before powering anything.
2. Connect components using safe low-voltage practices.
3. Secure wires and check for interference with moving parts.
4. Test one electrical function at a time.
5. Record results, issues, and revisions.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Circuit/motor integration photo
☐ Updated circuit diagram
☐ Safety check notes
☐ Subsystem test result
☐ Revision or troubleshooting notes

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Integrated prototype subsystem with circuit/motor evidence and safety notes.

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Lesson 4.17

Testing Protocol Development

How do engineers design fair tests to evaluate whether a prototype works?

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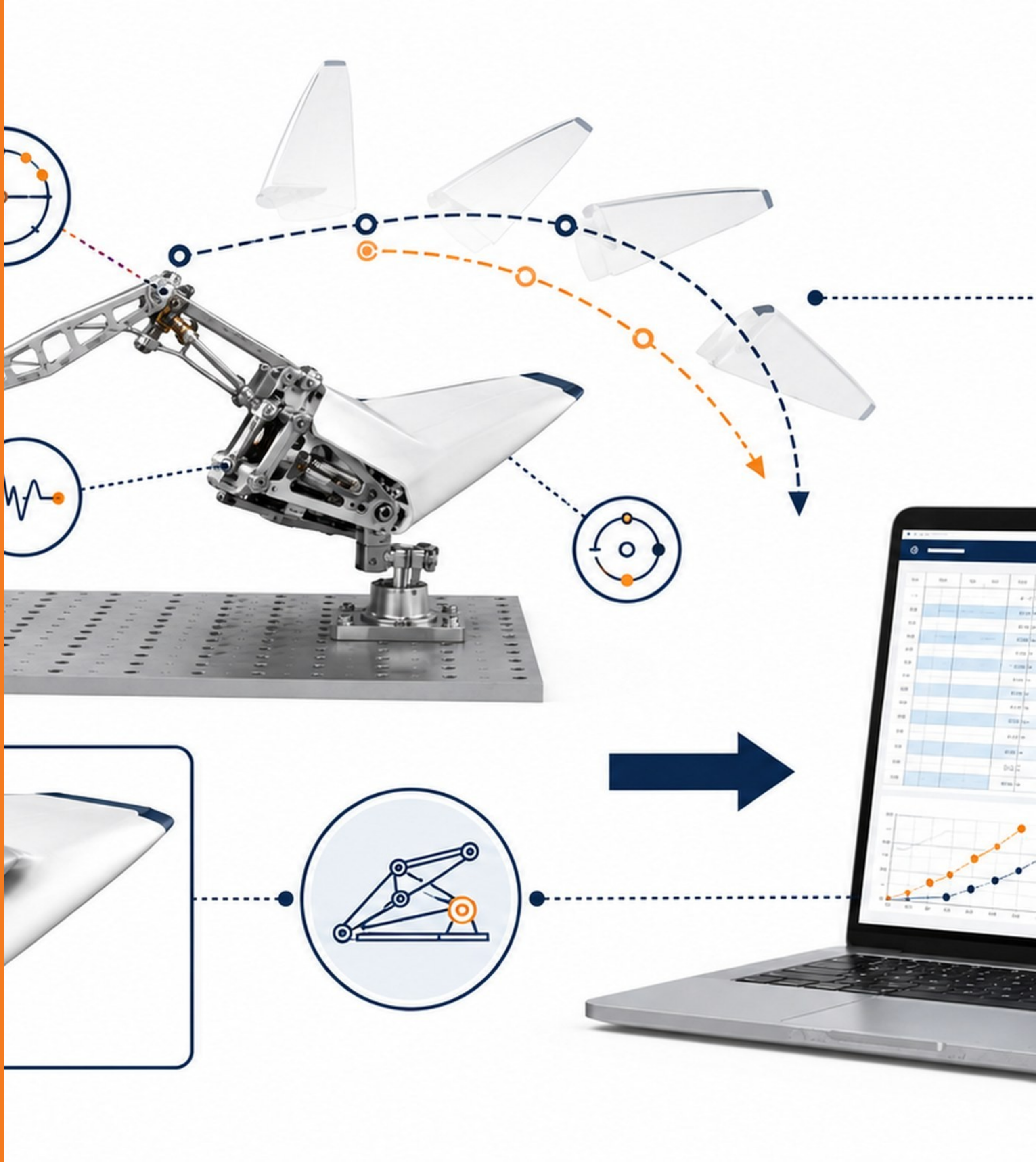


Testing Protocol Development

How do engineers design fair tests to evaluate whether a prototype works?

LESSON GOAL

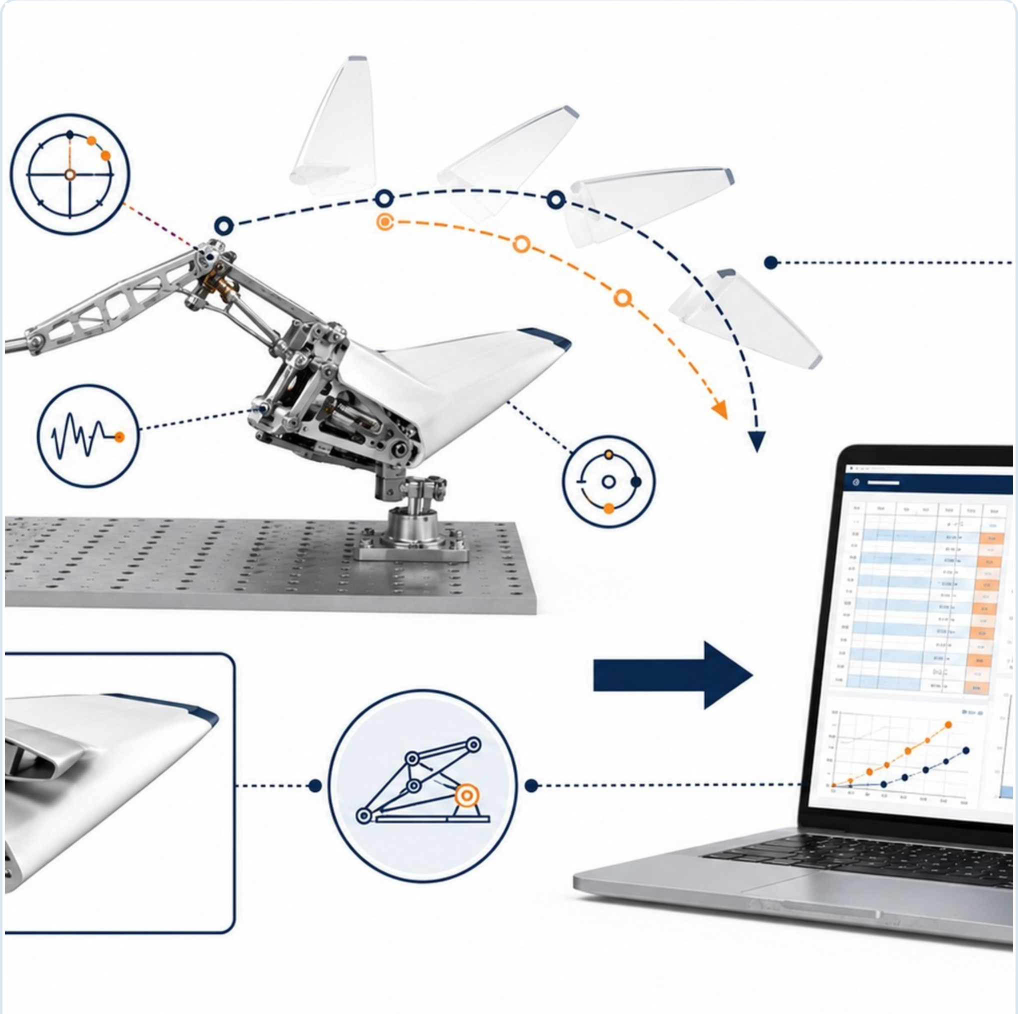
Create a fair testing protocol for the Unit 4 prototype.

STUDENT OBJECTIVE

I can define variables, procedures, success criteria, and data collection methods for a prototype test.

END PRODUCT

Testing protocol ready for prototype data collection.



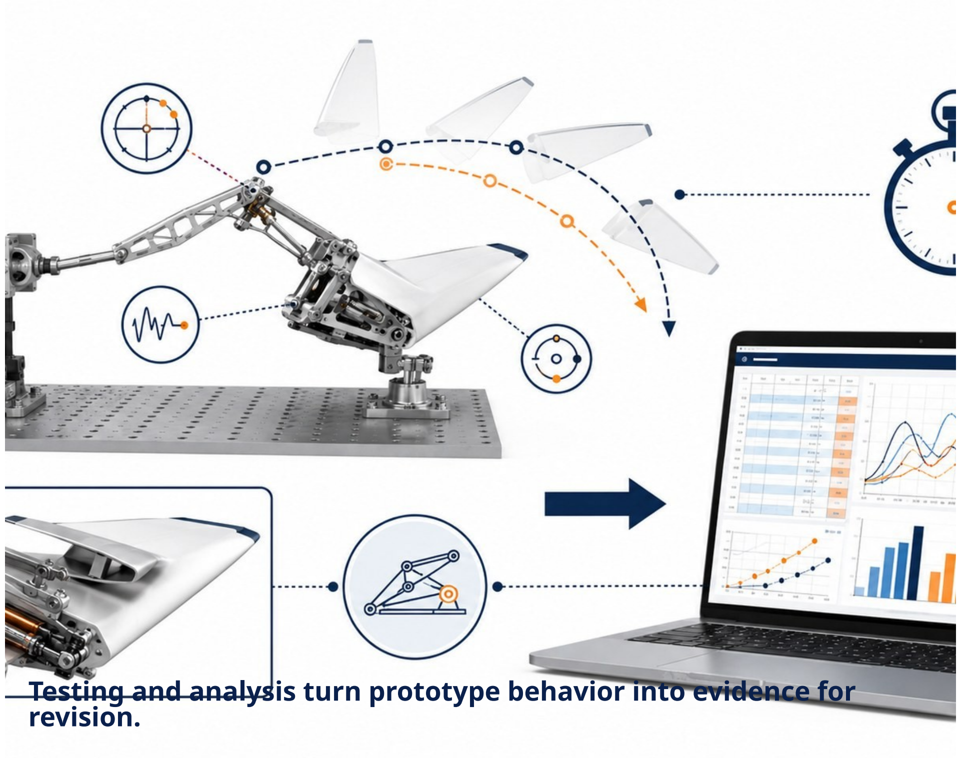
Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- A testing protocol turns a prototype trial into usable engineering evidence.
- Fair tests identify what changes, what stays the same, and what is measured.
- Success criteria should connect to the original challenge requirements.
- Data collection methods should be realistic and repeatable.
- A protocol makes results easier to compare after revision.



Testing and analysis turn prototype behavior into evidence for revision.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Define the function being tested.
2. Identify independent, dependent, and controlled variables.
3. Write step-by-step test procedure.
4. Decide how many trials to run and what data to record.
5. Create a data table before testing begins.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Testable question or purpose
☐ Variable list
☐ Step-by-step procedure
☐ Success criteria
☐ Prepared data table

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Testing protocol ready for prototype data collection.

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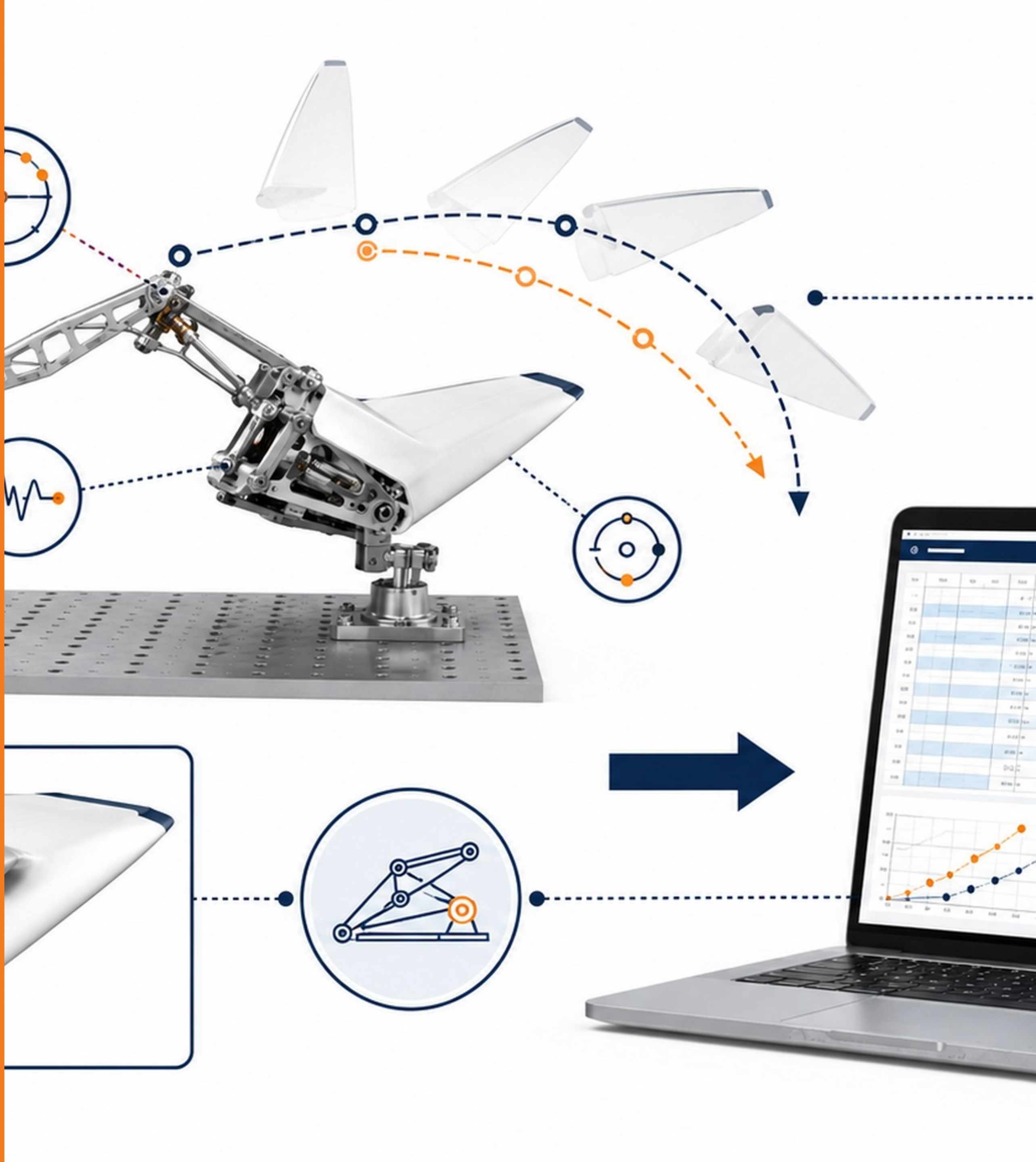
Lesson 4.18

Prototype Testing and Data Collection

How can engineers collect useful data from a prototype test?

Aerospace Mechanisms, Materials & Electromechanical Systems



Prototype Testing and Data Collection

How can engineers collect useful data from a prototype test?

LESSON GOAL

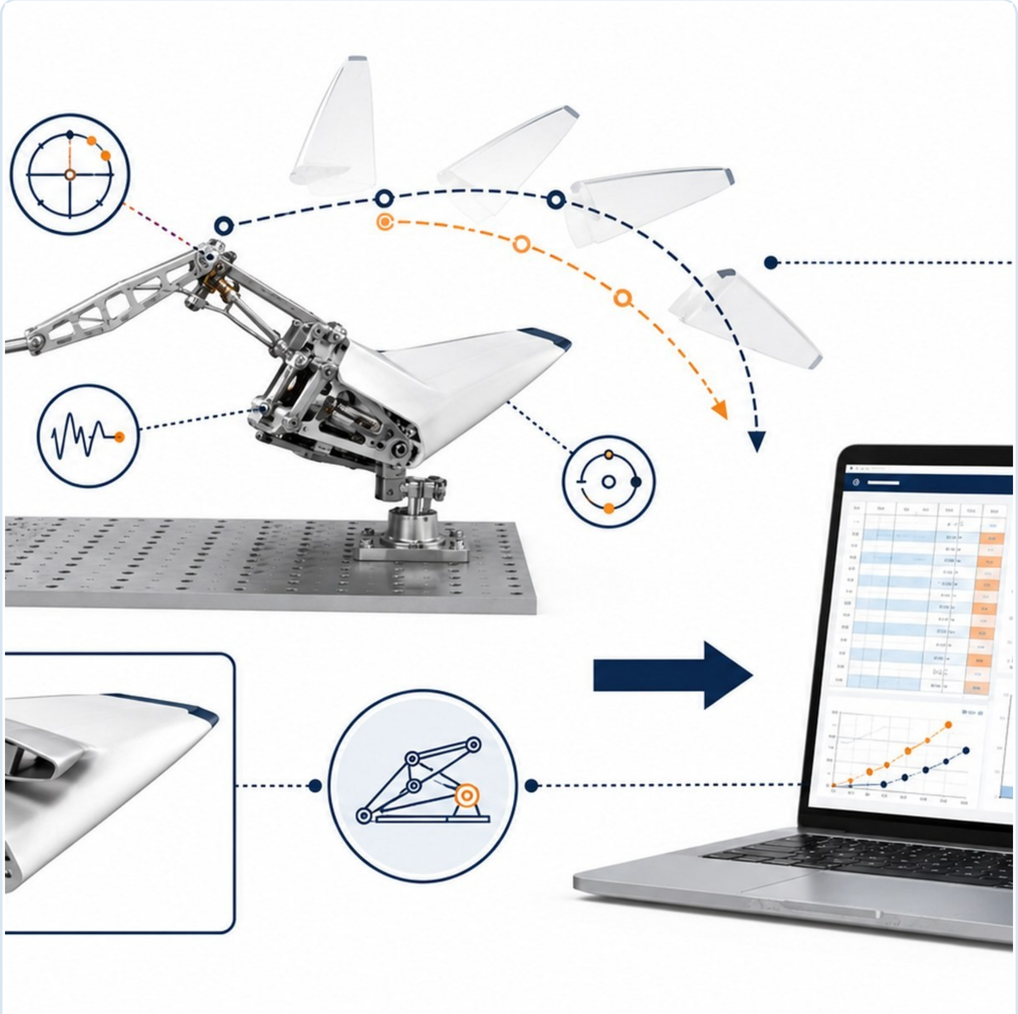
Run the testing protocol and collect reliable prototype data.

STUDENT OBJECTIVE

I can collect, organize, and document prototype test data using a planned procedure.

END PRODUCT

Completed prototype data table with test photos and observations.



Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today’s technical decisions.

BIG IDEAS

• Testing should follow the protocol as closely as possible.
• Repeated trials help distinguish pattern from accident.
• Observations are important, but data is stronger when measured.
• Unexpected behavior should be documented instead of ignored.
• Photos and notes help explain the context of the data.

Testing and analysis turn prototype behavior into evidence for revision.

Prototype Testing and Data Collection

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Set up the prototype using the testing protocol.
2. Run the planned number of trials.
3. Measure and record data consistently.
4. Capture photos or short notes from the test setup.
5. Record failures, unexpected results, and possible causes.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Completed data table
☐ Test setup photo
☐ Trial observations
☐ Failure or issue notes
☐ Initial data pattern statement

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Completed prototype data table with test photos and observations.

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Lesson 4.19

Data Analysis, Graphing, and Design Conclusions

How can data help engineers decide whether a prototype was successful?

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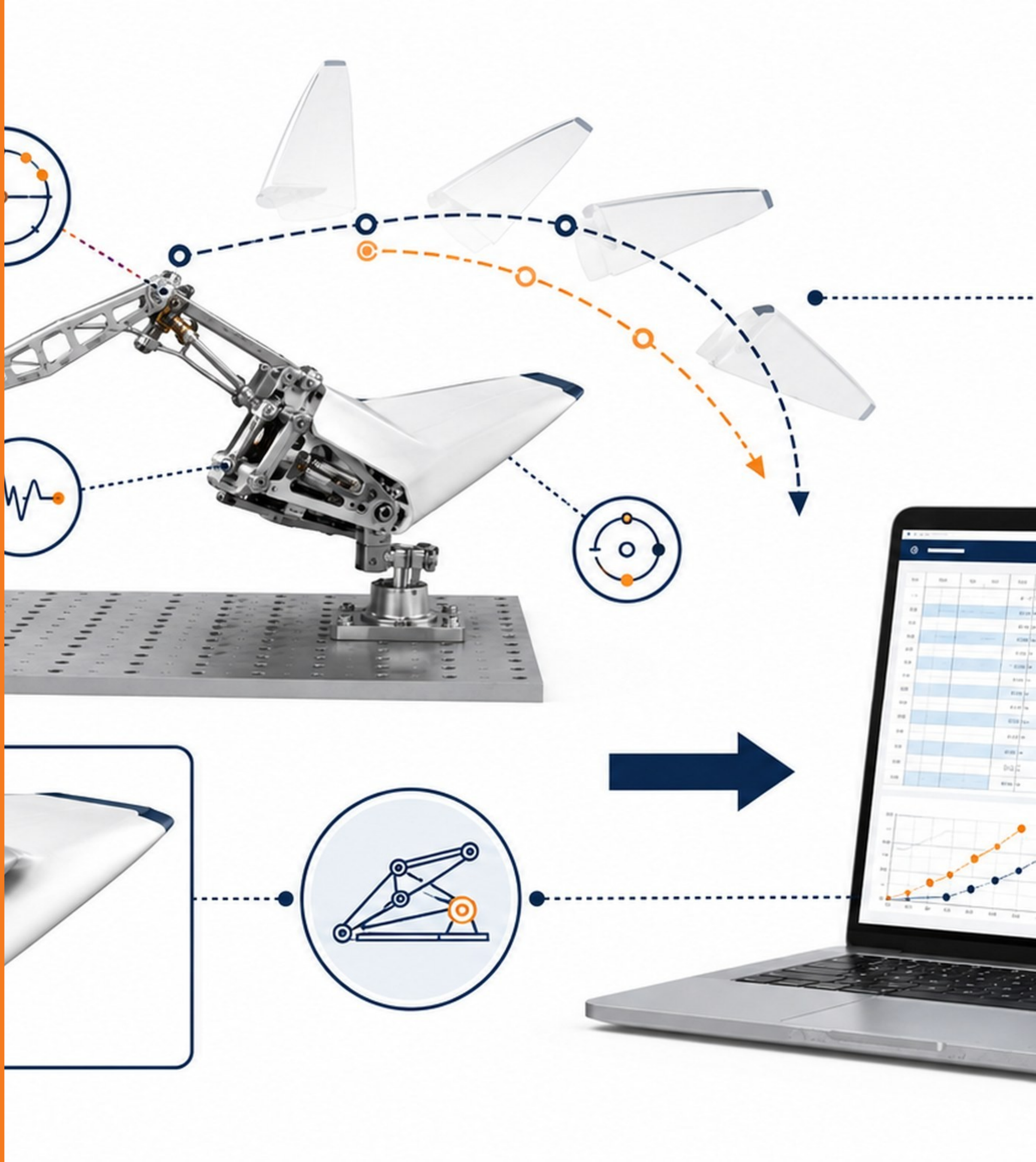


Data Analysis, Graphing, and Design Conclusions

How can data help engineers decide whether a prototype was successful?

LESSON GOAL

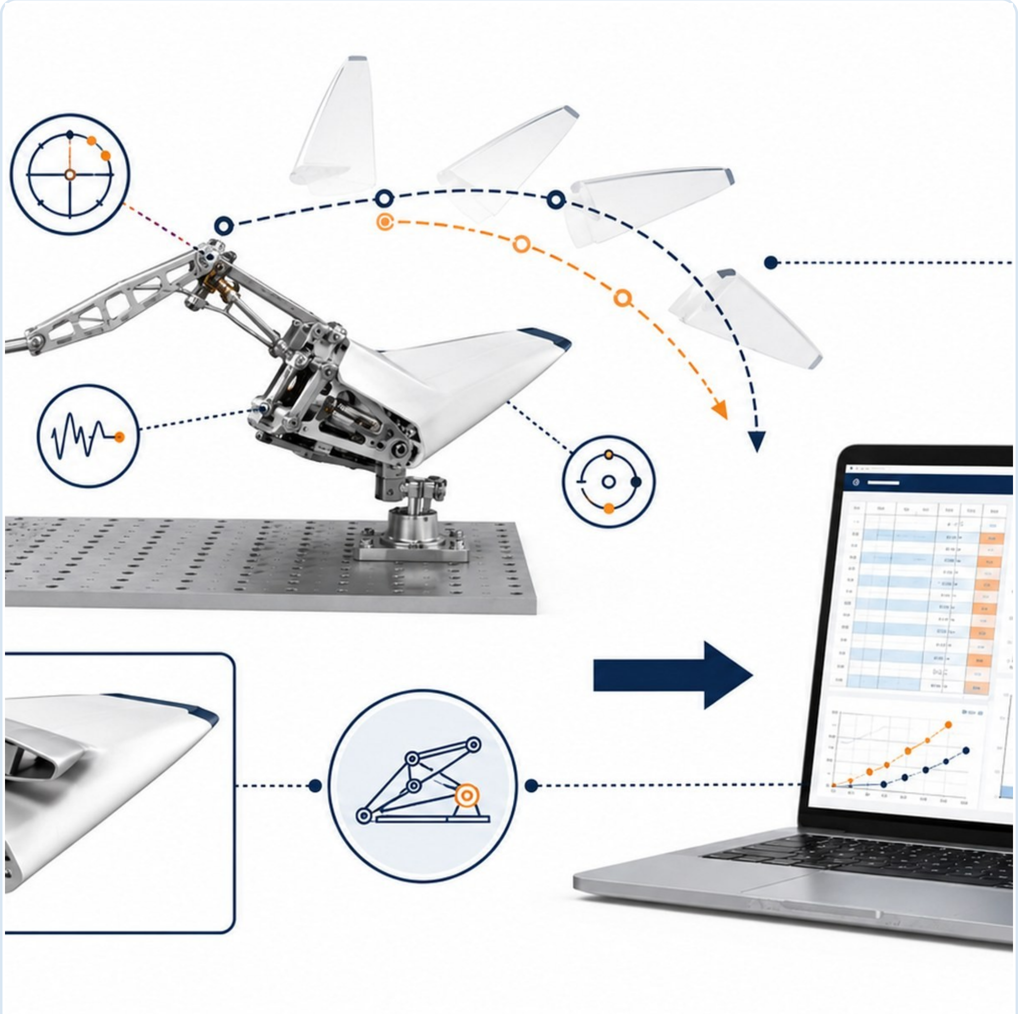
Analyze prototype test data and draw evidence-based design conclusions.

STUDENT OBJECTIVE

I can create a graph, identify patterns, and explain what the data means for the design.

END PRODUCT

Graph and written conclusion showing prototype performance.



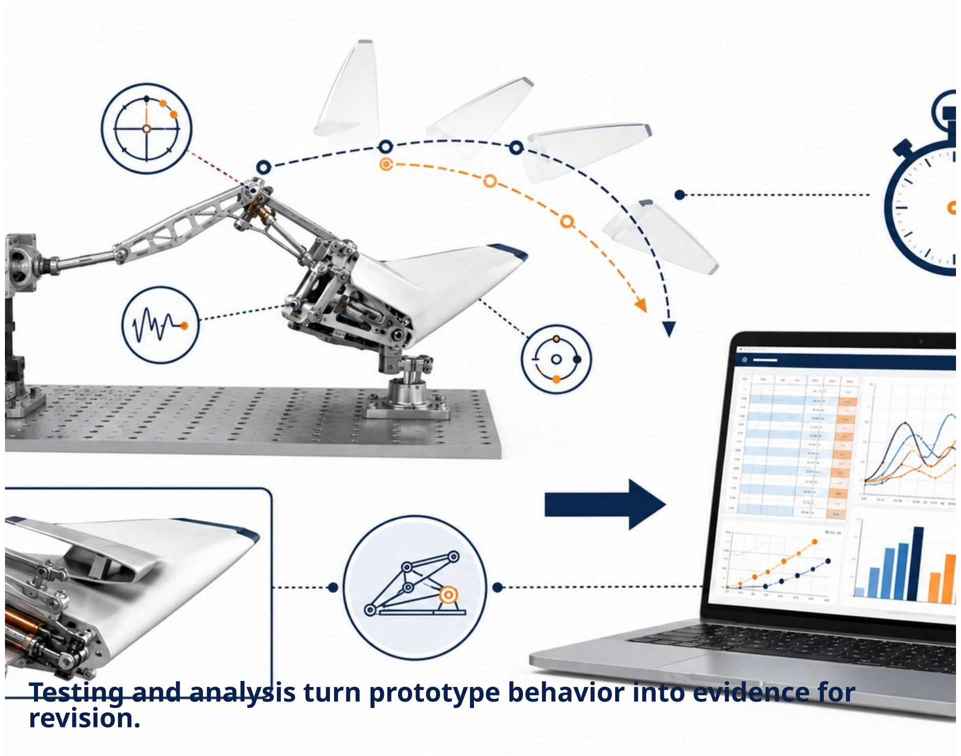
Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- Data analysis turns raw numbers into engineering meaning.
- Graphs help compare trials, materials, versions, or system performance.
- A conclusion should connect data back to success criteria.
- Engineers should honestly report limitations and uncertainty.
- Data can support keeping, revising, or replacing a design feature.



Testing and analysis turn prototype behavior into evidence for revision.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Review collected test data for completeness.
2. Calculate summary values if needed.
3. Create a clear graph that matches the question.
4. Identify trends, outliers, or performance limits.
5. Write a conclusion tied to criteria and constraints.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Clean data table
☐ Graph
☐ Summary calculations if needed
☐ Data conclusion
☐ Statement of limitations or uncertainty

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Graph and written conclusion showing prototype performance.

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Lesson 4.20

Iteration and Prototype Revision

How do engineers decide what to change after testing a prototype?

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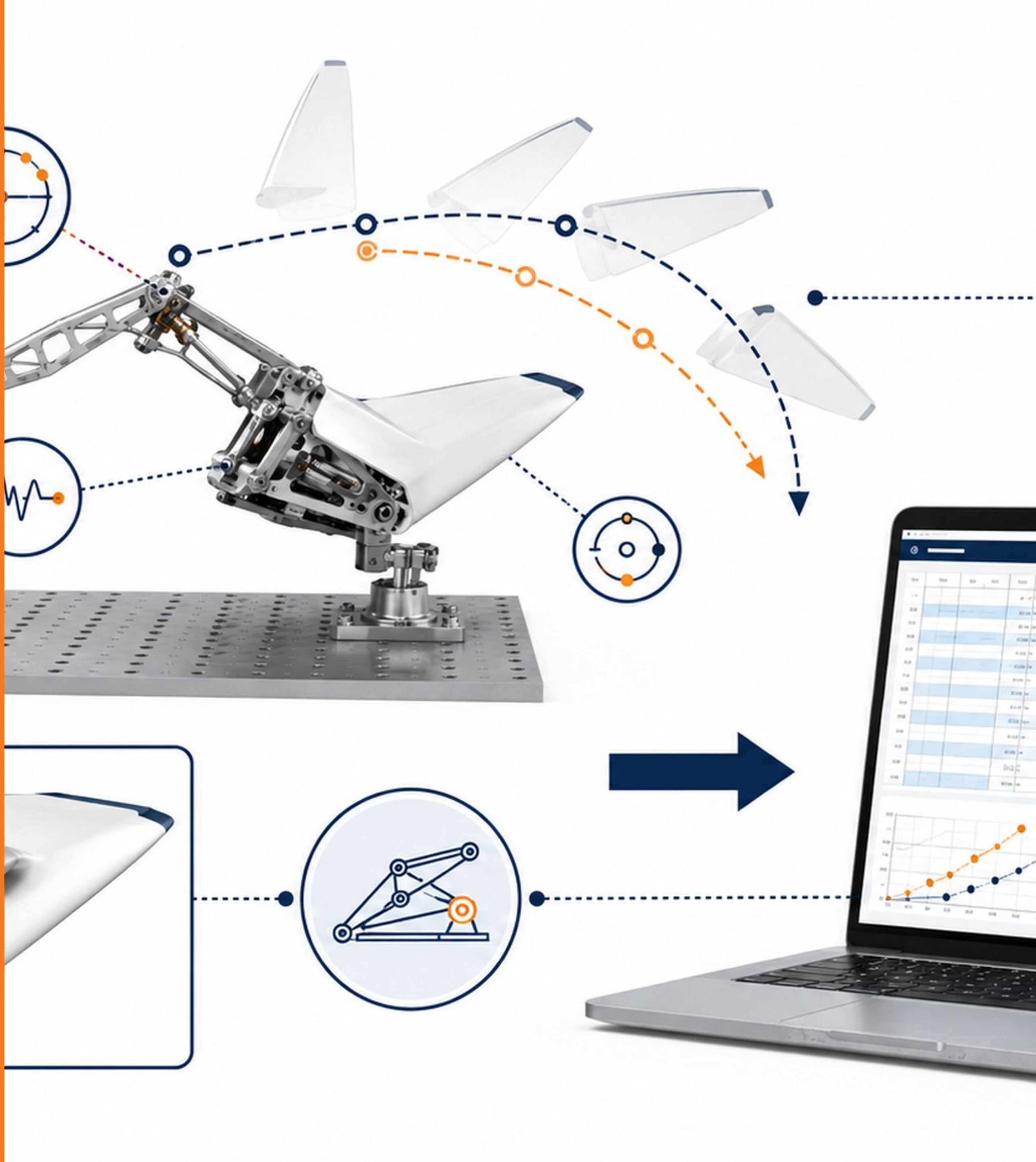


Iteration and Prototype Revision

How do engineers decide what to change after testing a prototype?

LESSON GOAL

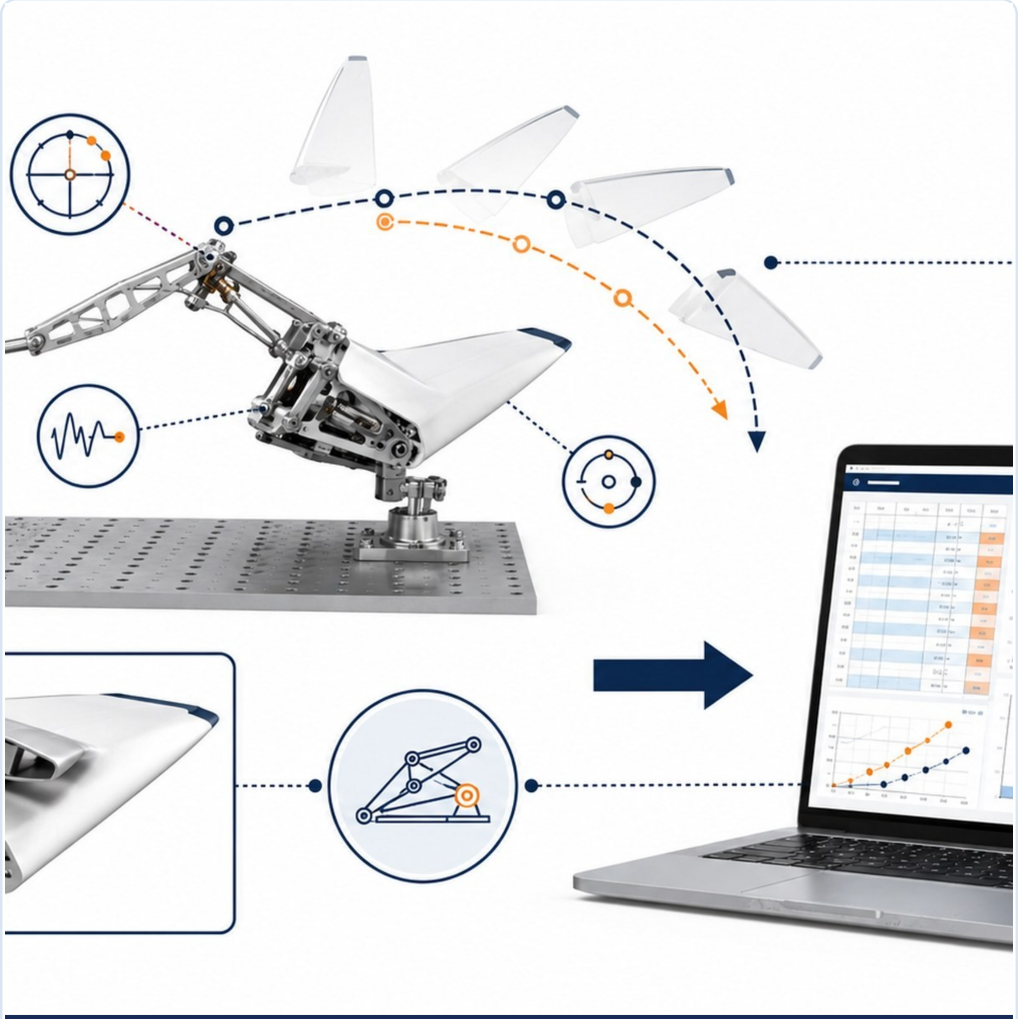
Use test data and observations to revise the prototype.

STUDENT OBJECTIVE

I can choose a revision based on evidence and explain how it should improve system performance.

END PRODUCT

Prototype revision plan and revised prototype evidence.



Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

• Iteration should be based on evidence from testing.
• A revision can change geometry, material, alignment, friction, circuit layout, or test procedure.
• Changing too many variables at once can make improvement harder to understand.
• A good revision targets the most important failure mode or performance gap.
• Before-and-after evidence shows engineering progress.

Testing and analysis turn prototype behavior into evidence for revision.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Review data, photos, and observations from testing.
2. Identify the highest-priority problem to fix.
3. Choose one or two focused revisions.
4. Update the prototype or CAD plan.
5. Document before/after evidence and expected improvement.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Problem diagnosis from data
☐ Revision plan
☐ Before/after sketch or photo
☐ Updated prototype evidence
☐ Expected improvement statement

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Prototype revision plan and revised prototype evidence.

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Lesson 4.21

Final Technical Documentation: Mechanism, Circuit, Data, and Revision

How do engineers document a functional system so others can understand, test, build, or improve it?

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Final Technical Documentation

Final Technical Documentation: Mechanism, Circuit, Data, and Revision

How do engineers document a functional system so others can understand, test, build, or improve it?

LESSON GOAL

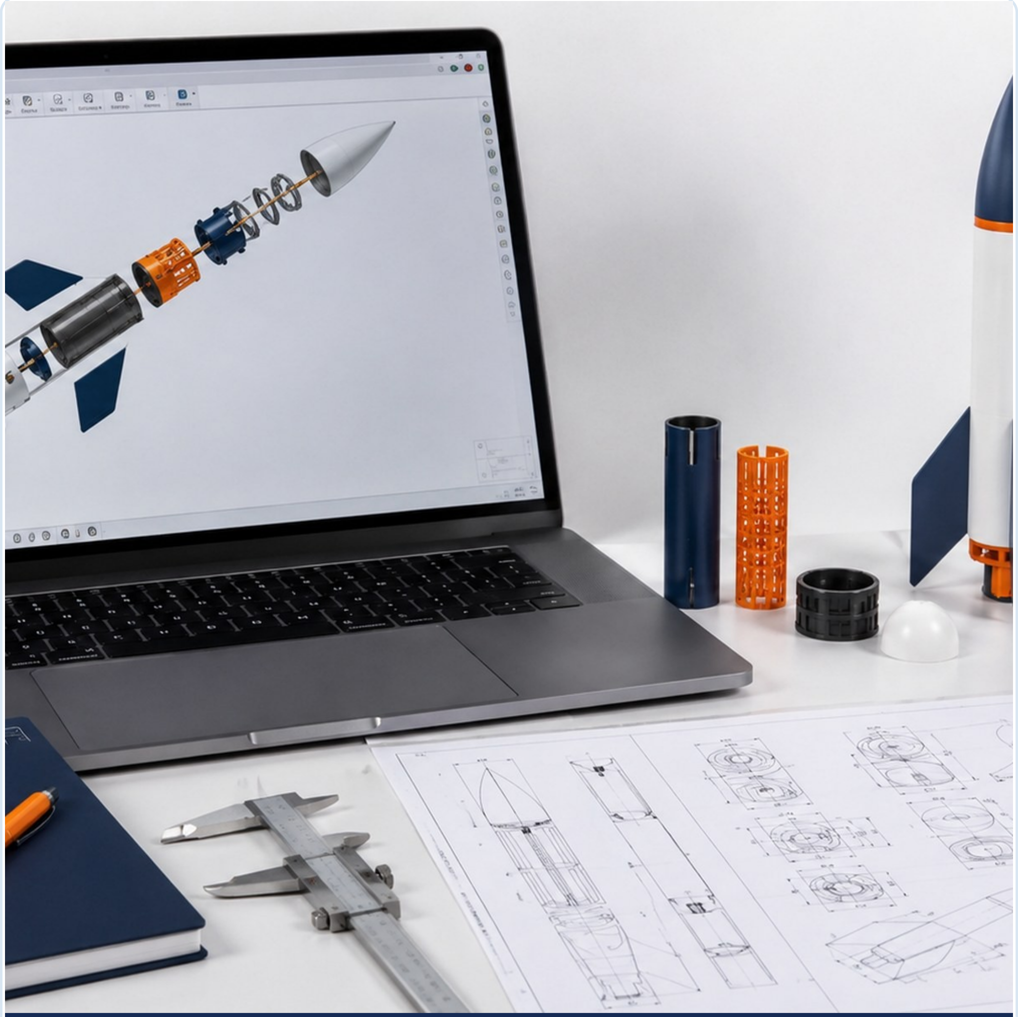
Prepare final documentation that explains the prototype system, evidence, and revisions.

STUDENT OBJECTIVE

I can organize mechanism, circuit, data, and revision evidence into a clear technical record.

END PRODUCT

Final Unit 4 technical documentation package.



Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today’s technical decisions.

BIG IDEAS

• Technical documentation should make a system understandable to someone who was not on the team.
• Important documentation includes mechanism description, circuit diagram, materials, test data, graph, and revision history
• A strong package connects requirements, design choices, evidence, and final performance.
• Limitations should be reported honestly.
• Clear documentation helps others rebuild, test, improve, or evaluate the prototype.

Testing and analysis turn prototype behavior into evidence for revision.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Organize mechanism and subsystem diagrams.
2. Include material choices and circuit or motor documentation.
3. Add final test data, graph, and conclusion.
4. Summarize revisions and why they were made.
5. Check that the documentation supports the final demonstration.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Mechanism/system diagram
☐ Circuit or motor documentation
☐ Final data and graph
☐ Revision summary
☐ Technical documentation package

BEFORE MOVING ON

Your work should be:

- connected to the original challenge requirements
- clear enough for another team to understand
- based on measured data or a documented observation
- saved in the correct file, notebook, or project folder
- useful for the final technical demonstration

Final Unit 4 technical documentation package.

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Lesson 4.22

Unit 4 Technical Demonstration and Reflection

How can engineers use a technical demonstration to communicate how a system works and how it improved?

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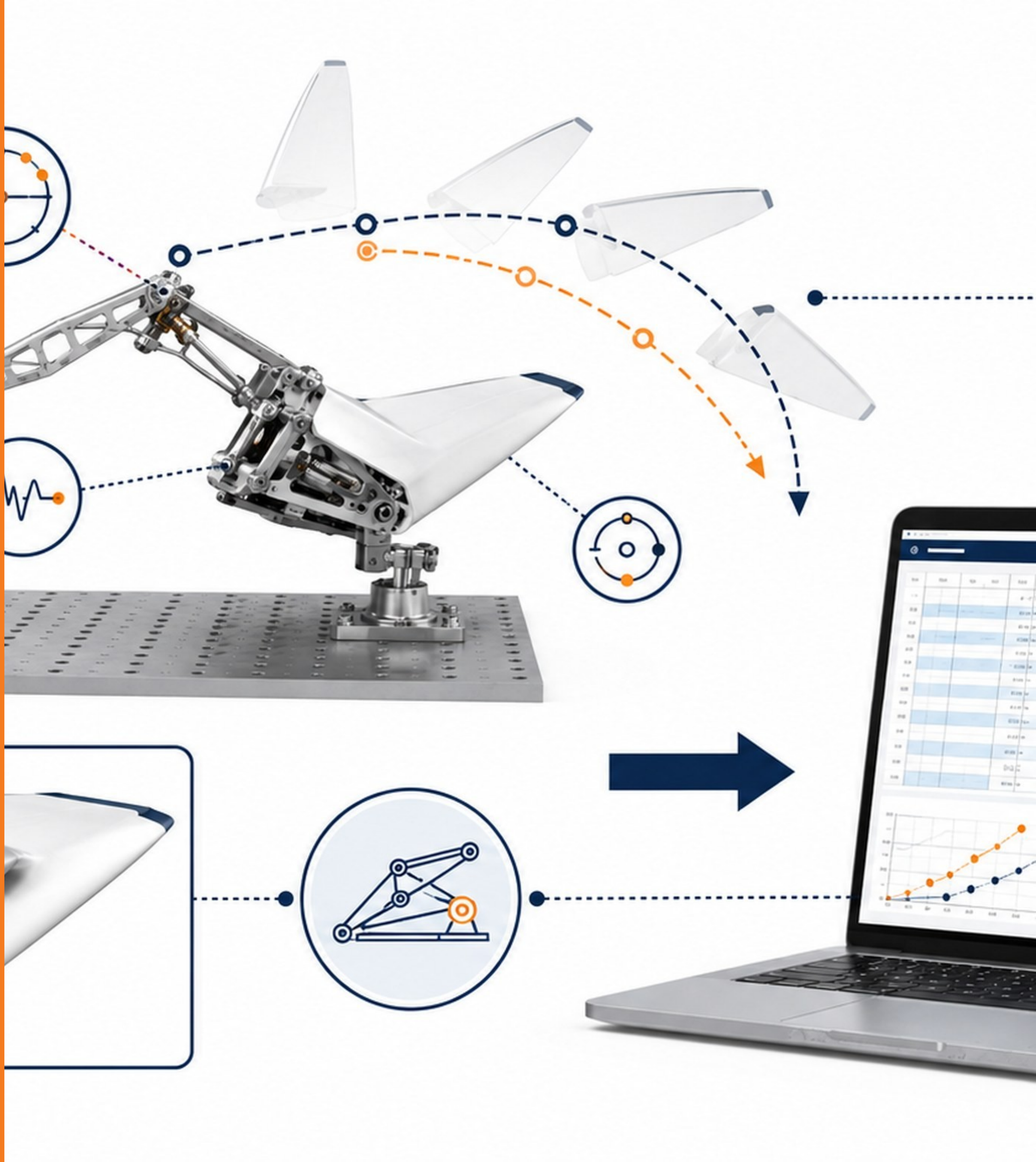


Unit 4 Technical Demonstration and Reflection

How can engineers use a technical demonstration to communicate how a system works and how it improved?

LESSON GOAL

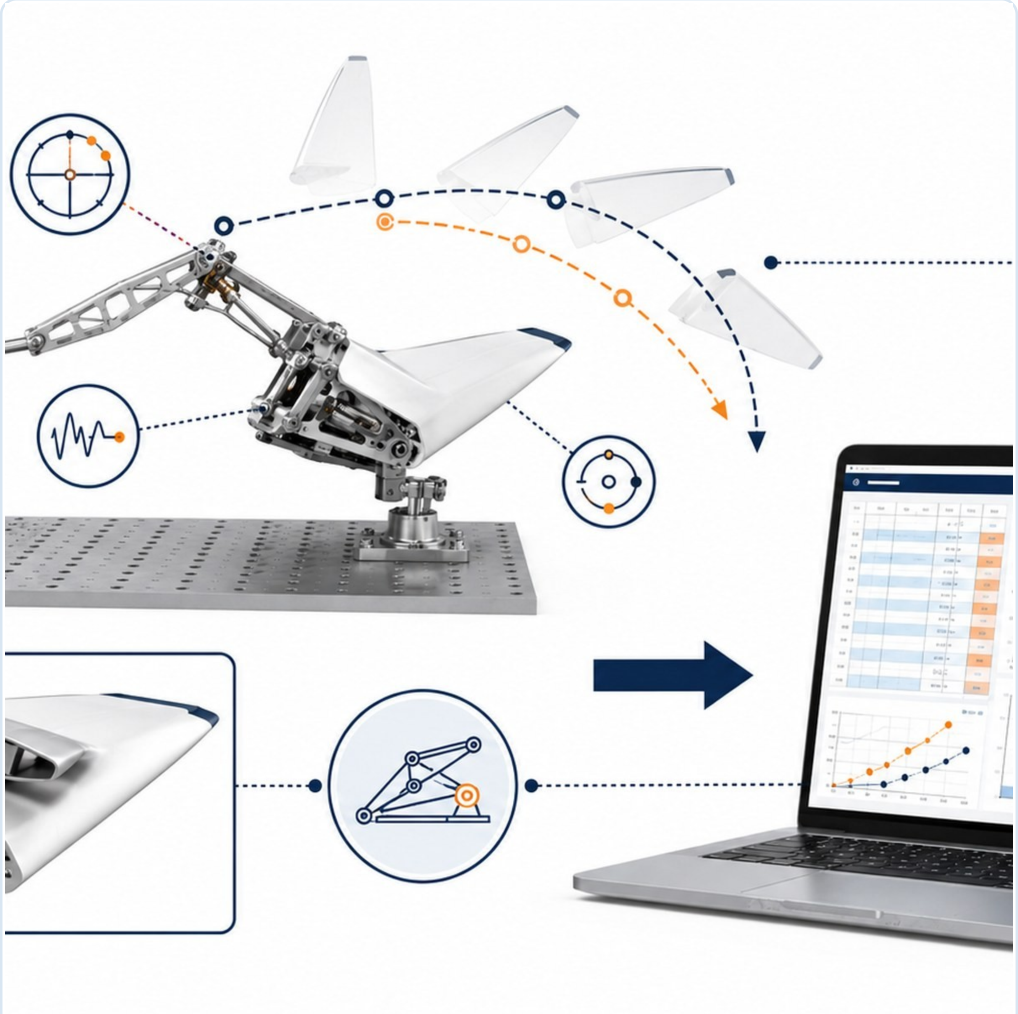
Demonstrate the prototype and explain how evidence shaped the final design.

STUDENT OBJECTIVE

I can present a functional system, describe its subsystems, and use data to explain performance and improvement.

END PRODUCT

Technical demonstration and final reflection for Unit 4.



Technical systems require evidence from materials, motion, circuits, testing, and revision.

What you need to understand

These ideas guide today's technical decisions.

BIG IDEAS

- A technical demonstration shows both function and engineering reasoning.
- The audience should understand what the system does, how it works, and what evidence supports it.
- Strong presentations include both success and limitations.
- Data and revision history make the design story credible.
- Reflection helps prepare for the human-centered capstone in Unit 5.

Testing and analysis turn prototype behavior into evidence for revision.

What you will do

Follow this workflow to create evidence for the final technical demonstration.

1. Prepare the prototype for demonstration.
2. Explain materials, mechanism, circuit/motor, and data evidence.
3. Demonstrate the system safely and clearly.
4. Describe one important revision and its impact.
5. Complete a reflection on technical growth and next steps.

Document the decision while the evidence is still fresh.

Evidence checklist

Check whether today's evidence is ready for the Unit 4 technical package.

REQUIRED EVIDENCE

☐ Technical demonstration
☐ Prototype/system explanation
☐ Data-supported performance statement
☐ Revision impact statement
☐ Final Unit 4 reflection

BEFORE MOVING ON

Your work should be:

• connected to the original challenge requirements
• clear enough for another team to understand
• based on measured data or a documented observation
• saved in the correct file, notebook, or project folder
• useful for the final technical demonstration

Technical demonstration and final reflection for Unit 4.

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Unit 4 Close

From Prototype System to Technical Evidence

A successful prototype is not just something that moves. It is a system whose materials, motion, power, data, and revisions can be explained with evidence.

FINAL MINDSET

The best design story connects what you built, how you tested it, what failed, and how evidence made it better.