

## U-Control

**Grade level:** 6-10

**Summary of lesson:**

Students will create a mechanical door opener in U Control. They will learn about simple machines and how engineers integrate them into mechanical systems in new, inventive ways. Students will think about existing mechanical and automatic door opener designs and consider the users and needs these designs meet. Students will consider new users and new designs to fit their needs. Students will cut and assemble a door out of foam insulation board. They will then learn about motors and motor control in Meetings 4 and 5. They will understand what a circuit is, and how to create a circuit using a breadboard to control a motor's motion. Finally, they will construct their mechanical door opener by attaching the motor, the breadboard, and the control arms to the door to make the door opener. They will consider improvements on the design as part of the prototyping process.

**Time/Duration:**

Each unit is designed to be 90 minutes. Teachers break down the lesson based on schedule minutes and available time. Example: 7<sup>th</sup>-8<sup>th</sup> grade science teaches 1 unit a week, and he meets 3 days a week, once for 55 minutes and twice for 90 minutes. It depends on deep educators who want to take it.

**Learning Principles by Subject Area:**

- Mechanical Systems
- Motor Science
- Electricity and Circuits
- Prototyping

## Subject areas/Standards:

### U Control

### Next Generation Science Standards - Middle School

| Meeting                                       | Core Ideas       | Science Standards       | Cross-Cutting Concepts                                                                                                                                                                                                                  | Practices                                                                                                                                                                                                                                                           |
|-----------------------------------------------|------------------|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Meeting 1:<br>Invention Introduction          | ETS1.A<br>ETS1.B | MS.ETS1-1<br>MS.ETS1-2  | <ul style="list-style-type: none"> <li>Structure &amp; Function</li> <li>Systems &amp; Cycles</li> <li>Cause &amp; Effect</li> </ul>                                                                                                    | <ul style="list-style-type: none"> <li>Asking Questions &amp; Defining Problems</li> <li>Constructing Explanations &amp; Designing Solutions</li> <li>Engaging in Argument from Evidence</li> <li>Obtaining, Evaluating, &amp; Communicating Information</li> </ul> |
| Meeting 2:<br>Introduction to Simple Machines | ETS1.A           | MS.ETS1-1               | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> <li>Cause &amp; Effect</li> </ul> | <ul style="list-style-type: none"> <li>Asking Questions &amp; Defining Problems</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                             |
| Meeting 3:<br>Build a Door                    | ETS1.B<br>ETS1.C | MS.ETS1-2*<br>MS.ETS1-4 | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> </ul>                             | <ul style="list-style-type: none"> <li>Developing and Using Models</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                                          |
| Meeting 4:<br>Motors 101                      | PS3.B            | MS.PS3-5*               | <ul style="list-style-type: none"> <li>Energy &amp; Matter</li> <li>Scale, Proportion, &amp; Quantity</li> </ul>                                                                                                                        | <ul style="list-style-type: none"> <li>Constructing Explanations &amp; Designing Solutions</li> <li>Using mathematics and computational thinking</li> </ul>                                                                                                         |
| Meeting 5:<br>Controlling a Motor             | ETS1.B<br>ETS1.C | MS.ETS1-4               | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Systems &amp; System Models</li> <li>Cause &amp; Effect</li> </ul>                                   | <ul style="list-style-type: none"> <li>Developing and Using Models</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                                          |
| Meeting 6:<br>Final Build                     | ETS1.B<br>ETS1.C | MS.ETS1-3<br>MS.ETS1-4  | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> </ul>                             | <ul style="list-style-type: none"> <li>Developing and Using Models</li> <li>Constructing Explanations &amp; Designing Solutions</li> <li>Analyzing and Interpreting Data</li> </ul>                                                                                 |
| Meeting 7:<br>Invention Extension             | ETS1.A<br>ETS1.B | MS.ETS1-1<br>MS.ETS1-2  | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> </ul>                             | <ul style="list-style-type: none"> <li>Asking Questions &amp; Defining Problems</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                             |

\* Loosely aligned

Standards alignment conducted by graduate students at Boston College's Lynch School of Education

## U Control

### Next Generation Science Standards - High School

| Meeting                                       | Core Ideas                 | Science Standards      | Cross-Cutting Concepts                                                                                                                                                                                                                  | Practices                                                                                                                                                                                                                                                           |
|-----------------------------------------------|----------------------------|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Meeting 1:<br>Invention Introduction          | ETS1.A<br>ETS1.B           | HS.ETS1-3              | <ul style="list-style-type: none"> <li>Structure &amp; Function</li> <li>Systems &amp; Cycles</li> <li>Cause &amp; Effect</li> </ul>                                                                                                    | <ul style="list-style-type: none"> <li>Asking Questions &amp; Defining Problems</li> <li>Constructing Explanations &amp; Designing Solutions</li> <li>Engaging in Argument from Evidence</li> <li>Obtaining, Evaluating, &amp; Communicating Information</li> </ul> |
| Meeting 2:<br>Introduction to Simple Machines | ETS1.B                     | HS.ETS1-1<br>HS.ETS1-2 | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> <li>Cause &amp; Effect</li> </ul> | <ul style="list-style-type: none"> <li>Asking Questions &amp; Defining Problems</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                             |
| Meeting 3:<br>Build a Door                    | ETS1.B<br>ETS1.C           | HS.ETS1-2<br>HS.ETS1-3 | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> </ul>                             | <ul style="list-style-type: none"> <li>Developing and Using Models</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                                          |
| Meeting 4:<br>Motors 101                      | PS3.A*                     | HS-PS3-3*              | <ul style="list-style-type: none"> <li>Energy &amp; Matter</li> <li>Scale, Proportion, &amp; Quantity</li> </ul>                                                                                                                        | <ul style="list-style-type: none"> <li>Constructing Explanations &amp; Designing Solutions</li> <li>Using mathematics and computational thinking</li> </ul>                                                                                                         |
| Meeting 5:<br>Controlling a Motor             | ETS1.B<br>ETS1.C<br>PS3.A* | HS.ETS1-2<br>HS-PS3-3* | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Systems &amp; System Models</li> <li>Cause &amp; Effect</li> </ul>                                   | <ul style="list-style-type: none"> <li>Developing and Using Models</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                                          |
| Meeting 6:<br>Final Build                     | ETS1.B<br>ETS1.C           | HS.ETS1-3              | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> </ul>                             | <ul style="list-style-type: none"> <li>Developing and Using Models</li> <li>Constructing Explanations &amp; Designing Solutions</li> <li>Analyzing and Interpreting Data</li> </ul>                                                                                 |
| Meeting 7:<br>Invention Extension             | ETS1.A<br>ETS1.B           | HS.ETS1-1<br>HS.ETS1-2 | <ul style="list-style-type: none"> <li>Influence of Science, Engineering, and Technology on Society and the Natural World</li> <li>Structure &amp; Function</li> <li>Systems &amp; System Models</li> </ul>                             | <ul style="list-style-type: none"> <li>Asking Questions &amp; Defining Problems</li> <li>Constructing Explanations &amp; Designing Solutions</li> </ul>                                                                                                             |

\* Loosely aligned

Standards alignment conducted by graduate students at Boston College's Lynch School of Education

## Breakdown of lessons:

### 1. Invention Introduction

Students do warm-up activities and discuss invention. Students play “Four Corners” to help the educator assign diverse teams.

### 2. Introduction to Simple Machines

<https://lemelson.mit.edu/resources/curricula>

For more information, contact [info-lemelson@mit.edu](mailto:info-lemelson@mit.edu)

Students learn about the three main types of mechanized door openers and how they work to fill users' needs. Students complete problem/ solution charts to develop an understanding of the design process in invention.

### 3. Build a Door

Students demonstrate an understanding of screws as simple machines and what foam insulation board is. Students learn how to use a utility knife to safely cut foam insulation board.

### 4. Motors 101

Students demonstrate an understanding of the basic types of motors. They can identify the basic parts of a DC motor and explain how they operate. Students know how to read and interpret a motor specification sheet.

### 5. Controlling a Motor

Students demonstrate an understanding of the devices used to control the motion of a motor, including H bridge motor drivers, switches, and breadboards. Students successfully breadboard a servo motor to a switch to control the motor's motion.

### 6. Final Build

Students use their knowledge of materials, building, and mechanical systems to brainstorm ideas for a prototype.

### 7. Invention Extension

Students conceptualize a purposeful invention that uses their new minds-on and hands-on skills from U Control.

### Materials:

**Download** the list of materials and tools used in this guide.

