Machines in Motion
(1 week)

Authors

Nikita Patil

Penny Pate

SUBJECT/GRADE LEVEL

Subject Area: Electronics/Physics

Grade Level:High school

Materials

- Plan for a class of 30 students:
- Breadboards
- Jumper wires
- Resistors
- LEDs
- Power supplies or USB battery packs
- Rulers, stopwatches
- Inclined ramps (books, boards)
- Force sensors or spring scales (optional)
- Laptops with Arduino IDE installed (if previewing later weeks)

STANDARDS

Next Generation Science Standards

1. HS-PS2-6 – Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

2. HS-PS2-1 – Analyze data to support the claim that Newton's Second Law of Motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

3. HS-PS3-5 – Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

4. HS-ETS1-2 – Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems.

Mathematics Standards | Common Core State Standards

1. CCSS.MATH.CONTENT.HSA.REI.B.3 – Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

2. CCSS.MATH.CONTENT.HSS.ID.C.7 – Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of data.

3. CCSS.MATH.CONTENT.HSN.Q.A.1–3 – Use units as a way to understand problems and guide the solution of multi-step problems; choose and interpret units consistently in formulas.

English Language Arts Standards | Common Core State

1. CCSS.ELA-LITERACY.RST.11-12.3 – Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

2. CCSS.ELA-LITERACY.SL.11-12.1.A – Come to discussions prepared, having read and researched material under study; draw on preparation by referring to evidence.

3. CCSS.ELA-LITERACY.WHST.11-12.2 – Write informative texts, including scientific procedures and explanations of phenomena.

LESSON OBJECTIVE(S)

Students will be able to:

- Analyze and apply Newton's Laws of Motion to physical experiments.
- Construct basic electronic circuits using breadboards, resistors, and LEDs.
- Collect and interpret motion data from ramp-based physics experiments.
- Relate the concepts of friction and acceleration to real-world applications in robotics.

CAREER CONNECTION(S)

Mentor Background: Hayden Hanna,Research Engineer, ERDC, Vicksburg, MS

Hayden Hanna is a research engineer with the USACE Engineer Research and Development Center (ERDC) focused on the development of High performance composites and advanced manufacturing.His research interests are Wire Arc additive Manufacturing ,Laser Directed Energy Deposition ,Composite Fabrication,CNC Milling,Machining ,Manufacturing

STEM Careers:

AI Engineer

Materials Engineering

Polymer Engineering

Mechanical Engineering

Data Engineer

ENGAGEMENT

Brief Description: Robotics: Where Physics Meets Power

This lesson explores how electricity energizes robotic systems and how physics principles, like Newton's Laws and kinematics, govern their movement. Students will observe robotic behavior and learn about basic circuit structures. The lesson kicks off with a compelling video of robot motion, prompting students to identify underlying physics. This is followed by an introduction to basic circuit components and a live demonstration of a simple LED circuit. Students will brainstorm how robots navigate and what measurements describe their motion, then practice labeling circuit parts and tracing current on diagrams. Formative assessments include group discussions, written reflections on the motion video, and exit slips on current flow. Adaptations include using visuals and props for robot movement and providing pre-labeled diagrams and Jamboard for digital circuit learners.

Time Frame: 1 class period (45 minutes)

Procedures:

Teacher Actions: Start with a compelling video clip showing robot motion RoboCup - Short video and ask students what physics principles they observe. Then introduce basic circuit components and show a demo of a simple LED circuit on a breadboard.

Student Actions: Students brainstorm how robots follow paths and what measurements are needed to describe motion. Then, label parts of a sample circuit and trace current direction in paper diagrams.

Formative Assessment: Group discussion responses, short written reflection on motion video, exit slip identifying current flow in circuits.

Adaptations: Use visuals and physical props to model robot movement. For circuits, provide pre-labeled diagrams and Jamboard for digital learners.

EXPLORATION

Brief Description: Students measure real robot motion using timers and tape measures to understand velocity and acceleration. They also build circuits and apply Ohm's Law.

Time Frame: 2 class periods (45 minutes each)

- Day 1: Motion capture activity and kinematics calculations
- Day 2: Breadboarding and Ohm's Law simulations

Procedures:

Background Information:
Electricity powers robotic systems, but physical laws such as Newton's Laws and kinematics dictate how robots move. Engagement will include both observing robotic behavior and reviewing basic circuit structure.

Teacher Actions: Start with a compelling video clip showing robot motion Robot slippery ground and ask students what physics principles they observe. Then introduce basic circuit components and show a demo of a simple LED circuit on a breadboard.

Student Actions: Students brainstorm how robots follow paths and what measurements are needed to describe motion. Then, label parts of a sample circuit and trace current direction in paper diagrams.

Formative Assessment: Group discussion responses, short written reflection on motion video, exit slip identifying current flow in circuits.

Adaptations: Use visuals and physical props to model robot movement. For circuits, provide pre-labeled diagrams and Jamboard for digital learners.

EXPLANATION

Brief Description: Students interpret their experimental data on both motion and electricity. They construct scientific explanations using CER and calculate key physical quantities.

Time Frame: 1 class period (45 minutes)

Procedures:

Teacher Actions: Guide students through creating CERs for their motion and circuit data. Lead a review of kinematic formulas (e.g., v = u + at) and Ohm's Law relationships, comparing theoretical and observed values.

Student Actions: Students complete CER explanations of why an LED circuit behaved a certain way and describe how their robot's velocity changed over time. They also annotate diagrams and participate in peer feedback.

Formative Assessment: CER submissions, data analysis worksheets, peer review.

Hyperlinks:

- CER Graphic Organizer
- Series/Parallel Circuit Video
- Physics Notes on Kinematics

Adaptations: Provide sentence starters for CERs. Use differentiated question sets for varying skill levels.

ELABORATE

Brief Description: Students apply both physics and electronics knowledge to build a prototype circuit and calculate the motion of a robotic system under certain conditions.

Time Frame: 1–2 class periods

- Day 1: Circuit design challenge and force/motion calculations
- Day 2: Build and test project

Procedures:

Teacher Actions: Assign each group a design challenge: build a circuit that powers an LED system on a mock robot or calculate and verify how fast a robot must accelerate to reach a target within 5 seconds. Support with sample calculations and circuit templates.

Student Actions: Design circuits using Ohm's Law, test them using breadboards, and explain current paths. Concurrently, solve motion problems using kinematic equations and explain how robot forces (friction, torque) are managed.

Formative Assessment: Project rubric, oral presentations, walkthroughs with the teacher.

Hyperlinks:

- Voltage Divider Calculator

Adaptations: Support IEP students with circuit guides and formula sheets. Challenge advanced students to factor in energy or torque.

EVALUATION

Brief Description: Students demonstrate understanding through a quiz, performance assessment, and a reflective report.

Time Frame: 1 class period (45 minutes)

Procedures:

Teacher Actions: Distribute and grade short quiz on circuits and motion. Assess final circuit builds and collect CER-based reflection reports.

Student Actions: Complete the quiz, build or refine circuits, and submit a final CER that connects both electrical and motion concepts.

Formative Assessment: Quiz, rubric-assessed circuit, and CER reflection on integrated learning.

Hyperlinks:

- CER Graphic Organizer
- Tinkercad for Virtual Builds

Adaptations: Allow video explanations in place of written reflections. Offer simplified quizzes with visuals or scaffolded questions.

REFERENCES

- PhET Ohm's Law Simulation: https://phet.colorado.edu/en/simulation/ohms-law
- Tinkercad Circuits: https://www.tinkercad.com/circuits
- BBC Bitesize – Electrical Circuits: https://www.bbc.co.uk/bitesize/topics/zq99q6f
- Arduino Project Hub: https://create.arduino.cc/projecthub
- NGSS Science Standards: https://www.nextgenscience.org
- Common Core Math Standards: http://www.corestandards.org/Math/
- Common Core ELA Standards: http://www.corestandards.org/ELA-Literacy/
- CER Template: CER Graphic Organizer