

## LESSON 05

## The Kaleidoscope Robot

## Motor Control, Patterns &amp; Art-Science Connection

## □ LESSON OVERVIEW

<b>Subject Area</b>	STEM, Robotics, Computer Science
<b>Grade Level</b>	Grades 6–8
<b>Duration</b>	3 Class Periods × 45 Minutes = 135 Minutes Total
<b>Framework</b>	5E Instructional Model (Engage → Explore → Explain → Elaborate → Evaluate)
<b>Key Themes</b>	Motor Control • Rotational Motion • Pattern Creation • Art-Science Integration
<b>Materials</b>	NEZHA Inventor's Kit V2 • Markers • Large paper/poster board • MakeCode IDE • Optional: Projector

## □ LEARNING OBJECTIVES

- 01 Explain how motors work and how they are controlled, including the role of electrical energy in producing rotational motion.
- 02 Design and build a basic robot using the NEZHA Inventor's Kit V2 that creates visible patterns through its movement.
- 03 Write a MakeCode program to control the speed, direction, and duration of the robot's motors with precision.
- 04 Create a robot that produces kaleidoscopic patterns through coordinated movement sequences.
- 05 Identify and explain interdisciplinary connections between engineering principles and artistic expression.

## □ KEY VOCABULARY

Term	Definition
<b>Motor</b>	Device that converts electrical energy into rotational mechanical motion.
<b>Rotation</b>	Circular movement around a central axis or pivot point.

<b>Pattern</b>	A repeated or regular arrangement of shapes, colors, or movements.
<b>Symmetry</b>	A balanced arrangement where one side mirrors or repeats the other.
<b>Algorithm</b>	Step-by-step instructions a computer follows to complete a defined task.
<b>Iteration</b>	Repeating the design-test-improve cycle to optimize an outcome.
<b>Frequency</b>	How often a repeated motion or event occurs per unit of time.
<b>Amplitude</b>	The magnitude or extent of a motion or oscillation from its center point.

## 5E MODEL — LESSON PLAN

### ENGAGE

Step	Activity	Key Focus
1	Show a kaleidoscope or videos/images of kaleidoscopic patterns in nature and art.	Spark curiosity about patterns and symmetry in the world.
2	Ask guiding questions: 'What shapes do you see?' 'How are these patterns made?' 'What creates symmetry?'	Encourage observation, inquiry, and analytical thinking.
3	Introduce the challenge: 'Design a robot that draws kaleidoscope patterns using motor-controlled markers!'	Set an engaging and achievable creative engineering goal.

### EXPLORE

Step	Activity	Key Focus
1	Provide kits and let students experiment freely with motor connections and MakeCode commands.	Familiarize with components, wiring, and basic programming.
2	Guide students to attach markers to robots and test movements on poster board paper.	Explore the connection between motor motion and pattern creation.
3	Encourage collaboration in groups of 3–4; share observations about pattern outcomes.	Promote teamwork, idea-sharing, and collective problem-solving.

### EXPLAIN

Step	Activity	Key Focus
1	Discuss how motors work: electrical current flows through coils, creating magnetic fields that cause rotation.	Build foundational understanding of motor mechanics.
2	Explain programming concepts: speed (0–100%),	Strengthen coding vocabulary and

	direction (CW/CCW), duration (milliseconds).	skills.
3	Connect art and science: 'How do mathematical ratios and motor timing create artistic patterns?'	Highlight the interdisciplinary STEAM connections.

**ELABORATE**

Step	Activity	Key Focus
1	Challenge students to design and program a robot that creates a specific, reproducible kaleidoscope pattern.	Encourage design thinking, precision, and creativity.
2	Guide testing and iteration: adjust speed, direction, and timing to refine patterns.	Build problem-solving skills through structured iteration.
3	Suggest creative extensions: add color-switching markers, program multi-phase routines, create layered patterns.	Expand critical thinking and creative expression.

**EVALUATE**

Step	Activity	Key Focus
1	Host a 'Robot Gallery' where students display their patterns and explain the motor programming behind them.	Assess creativity, design execution, and communication.
2	Facilitate group presentations: explain the design rationale and the programming logic used.	Evaluate technical understanding and communication skills.
3	Reflect on challenges, successes, and art-science connections in engineering notebooks.	Encourage self-assessment and metacognitive thinking.

**PERIOD-BY-PERIOD TEACHER & STUDENT SCRIPTS**

**PERIOD 1 — ENGAGE (40 min)**

Time	Teacher Actions	Student Actions	Key Questions
0–8 min	Show kaleidoscope images/video. Ask: 'What patterns do you see? What could make a robot draw like this?'	Jot 2 observations about patterns in notebook.	What makes a pattern? What creates symmetry?
8–20 min	Introduce kit components. Demonstrate motor connection and a basic MakeCode 'spin' command.	Experiment freely — connect motor, run a test spin, observe.	What happens when you change the speed? The direction?

20–35 min	Guide marker attachment. Students tape a marker to the robot arm and run it on poster board.	Produce first pattern; sketch the output and label the motor settings used.	How does changing speed change the pattern shape?
35–40 min	Groups share their first patterns. Identify which settings produced the most interesting results.	Record the motor settings that created their favorite pattern in the notebook.	What would you change to get a different pattern?

**PERIOD 2 — EXPLORE (45 min)**

Time	Teacher Actions	Student Actions	Key Questions
0–15 min	Introduce multi-speed sequences in MakeCode. Demo: fast spin → slow spin → direction change.	Build a 3-phase program: fast 2s → slow 3s → reverse 2s. Run and observe pattern.	How does combining speeds create more complex patterns?
15–30 min	Facilitate group design challenge: create a specific pattern (spiral, star, wave) on purpose.	Work as team to plan, code, and test their targeted pattern. Iterate at least twice.	How close is your actual pattern to your planned design?
30–38 min	Gallery walk: post patterns and settings on wall. Rotate and leave sticky-note feedback.	View others' patterns; write one strength and one suggestion per team.	Which team's approach was most creative? Why?
38–45 min	Debrief gallery walk. Introduce tomorrow's final Robot Gallery challenge.	Write goal for final pattern in notebook: what pattern, what settings.	What one change will make your final pattern most impressive?

**PERIOD 3 — EXPLAIN → ELABORATE → EVALUATE (45 min)**

Time	Teacher Actions	Student Actions	Key Questions
0–15 min	Mini-lecture: motor speed → rotation rate → mark frequency → pattern density. Draw diagram.	Label diagram connecting motor setting to observed pattern characteristic.	How is motor frequency similar to musical tempo?
15–30 min	Final build and program: 15 min to finalize the design for the Robot Gallery.	Complete final programming; run 2 reproducibility tests — same code, same pattern?	How do you know your code reliably produces the same pattern?
30–42 min	Robot Gallery: each group demonstrates their robot live and explains their MakeCode program.	Present: show the pattern, read out the key settings, explain 1 science concept behind it.	What science concept (rotation, frequency, symmetry) explains your pattern?
42–45 min	Exit ticket: diagram of a motor + label 3 programming parameters that affect the pattern.	Complete individually and submit before leaving.	Can you predict what pattern a new set of settings would make?

□ DIFFERENTIATION & SCAFFOLDING

SUPPORT — Struggling Students	EXTENSION — Advanced Students
<ul style="list-style-type: none"> <li>• Provide pre-built robot frames so students focus only on attaching markers and programming.</li> <li>• Offer a simplified MakeCode template with speed and duration pre-filled.</li> <li>• Allow partner read-aloud for written notebook prompts.</li> <li>• Use visual matching cards: pattern image → motor setting card.</li> </ul>	<ul style="list-style-type: none"> <li>• Challenge students to program a robot that creates the same pattern at two different scales.</li> <li>• Have advanced students write a formal analysis connecting motor frequency to pattern geometry.</li> <li>• Encourage integration of a second motor to create 2D compound patterns.</li> <li>• Research the math of spirograph curves and replicate one with the robot.</li> </ul>

□ ASSESSMENT BREAKDOWN

Assessment Component	Weight	Description
Exit Ticket	20%	Motor diagram with 3 labeled programming parameters (individual)
Pattern Portfolio	25%	Final pattern displayed with annotated settings and 3-sentence science explanation
Robot Gallery	20%	Live demonstration with clear verbal explanation of motor control logic
Team Collaboration	20%	Peer assessment rubric: contribution, communication, idea-sharing
Engineering Notebook	15%	Sketches, settings logs, observations, and reflection entry

□ TEACHER NOTES

- Adapt lesson complexity based on student abilities and available time.
- Encourage collaboration and peer support throughout the design process.
- Emphasize the value of iterative design: every 'failure' is data for the next attempt.
- Celebrate creativity, originality, and engineering effort regardless of final outcome.
- Provide regular formative check-ins using the engineering notebook as a formative tool.

□ REAL-WORLD CONNECTIONS

The engineering principles explored in this lesson appear throughout real-world industries:

- **Robotics Engineering:** Professional robots use the same motor control and sensor concepts in manufacturing, medicine, and exploration.
- **Biomimicry Design:** Engineers worldwide study animals to design better robots, vehicles, and structures.
- **STEAM Integration:** The connection between art, science, math, and engineering is a cornerstone of 21st-century innovation.
- **Career Connections:** Robotics engineers, software developers, mechanical engineers, and product designers all apply these skills daily.