LESSON 06

The Dancing Robot

Motor & Gear Mechanics, Center of Gravity & Choreography

LESSON OVERVIEW

Subject Area	STEM, Robotics, Computer Science
Grade Level	Grades 6–8
Duration	3 Class Periods × 45 Minutes = 135 Minutes Total
Framework	5E Instructional Model (Engage → Explore → Explain → Elaborate → Evaluate)
Key Themes	Motor & Gear Mechanics • Gear Ratio • Center of Gravity • Choreography • MakeCode
Materials	NEZHA Inventor's Kit V2 • micro:bit board • MakeCode • Motors • Gears • Connectors • Computers

LEARNING OBJECTIVES

01	Design, build, and program a dancing robot that demonstrates at least 3 distinct coordinated movement sequences.
02	Explain the basic principles of how motors convert electrical energy to motion and how gears transfer and modify that motion.
03	Describe how the position of the center of gravity affects a robot's balance and stability during movement.
04	Apply iterative problem-solving skills to refine the robot's design, gear configuration, and programming.
05	Work collaboratively in groups to design, build, test, and present a functional dancing robot.

KEY VOCABULARY

Term	Definition
Gear	Toothed wheel that meshes with another gear to transmit and modify rotational force.
Gear Ratio	Ratio of teeth on driven gear to driver gear; determines speed vs. torque trade-off.

Torque	Rotational force produced by a motor or gear system; determines lifting/pushing power.
Stability	Ability of a structure to maintain its position without tipping or falling.
Center of Gravity	The single point where all of an object's weight effectively acts downward.
Motor	Converts electrical energy into rotational motion to drive the robot.
Rhythm	Regular, repeating pattern of movement or timing in a choreographed sequence.
Choreography	Planned sequence of movements, timing, and directions for a performance.

⚡ 5E MODEL — LESSON PLAN

☐ ENGAGE

Step	Activity	Key Focus
1	Show short videos of expressive dances (ballet, hip-hop) and discuss rhythm, expression, and timing.	Spark interest in movement, rhythm, and physical expression.
2	Show videos of dancing robots (Boston Dynamics Spot, Honda ASIMO) and discuss how they move.	Inspire creativity and connect robotics to real-world applications.
3	Introduce the challenge: 'Design and build a robot that performs a synchronized 3-move dance routine!'	Set a clear, engaging, and achievable engineering goal.

☐ EXPLORE

Step	Activity	Key Focus
1	Provide kits and encourage hands-on exploration of gears, motors, and structural components.	Familiarize with materials, gear meshing, and component functions.
2	Pose questions: 'How do gears affect motion speed and force?' 'How can you keep your structure stable?'	Guide student inquiry and direct observation of gear behavior.
3	Have students brainstorm and sketch dance move designs in small groups (3 moves minimum).	Promote creativity, collaboration, and design communication.

☐ EXPLAIN

Step	Activity	Key Focus
1	Discuss how motors work (electrical current → magnetic field → rotation) and how gears transfer that motion.	Build understanding of core motor and gear concepts.

2	Introduce terms: gear ratio (speed vs. torque), center of gravity (stability), stability (tipping point).	Expand technical vocabulary with concrete examples.
3	Demonstrate motor wiring and a basic MakeCode dance sequence: move A → pause → move B → pause → move C.	Provide foundational knowledge needed for robot building.

□ ELABORATE

Step	Activity	Key Focus
1	Guide students in building robots based on their approved sketches; coach gear alignment and CG placement.	Apply engineering and iterative design skills to the build.
2	Teach students to program micro:bit for both basic moves and a coordinated 3-move dance routine.	Integrate coding, timing, and sequencing into the robotics project.
3	Encourage iterative testing: test → observe → adjust gear ratio or CG → re-test minimum twice.	Foster systematic problem-solving and design resilience.

□ EVALUATE

Step	Activity	Key Focus
1	Host a 'Robot Dance-Off' where groups perform their programmed dance routines for the class.	Celebrate creativity, teamwork, and engineering achievement.
2	Facilitate group presentations: explain gear ratio choice, CG placement, and programming logic.	Evaluate technical understanding and communication skills.
3	Reflect in engineering notebooks: what design change had the biggest impact on stability?	Encourage self-assessment, critical thinking, and metacognition.

□ PERIOD-BY-PERIOD TEACHER & STUDENT SCRIPTS

PERIOD 1 — ENGAGE (40 min)

Time	Teacher Actions	Student Actions	Key Questions
0–8 min	Show dance videos then dancing robot clips. Ask: 'What is the robot doing to stay balanced?'	List 2 observations about how the dancing robot maintains balance.	How does a robot know when it's about to tip over?
8–20 min	Introduce gear meshing demo: turn one gear slowly, observe the other. Change gear sizes.	Sketch two meshed gears and label driver, driven, direction of rotation.	What happens when you use a small gear to drive a large gear?
20–35 min	Groups brainstorm and	Produce a labeled design	Where should the heaviest

	sketch their 3-move dance routine with labeled gear positions and CG.	sketch: gear positions, motor location, CG mark.	part be to keep the robot balanced?
35–40 min	Groups share one design feature. Class votes on the most creative stability solution.	Record predicted gear ratio and stability score (1–5) for their design.	How will you test whether your CG position is correct?

PERIOD 2 — EXPLORE (45 min)

Time	Teacher Actions	Student Actions	Key Questions
0–15 min	Coach build: check gear alignment, motor mount security, and CG position.	Assemble robot frame, mount gears and motor, verify smooth rotation.	Does your robot tip when you place it on one side? Where is the CG?
15–30 min	Guide MakeCode: program Move A (2s) → pause (1s) → Move B (2s) → pause (1s) → Move C (2s).	Enter 3-move sequence, download, run test. Adjust timing if moves overlap.	Which move looks most like a real dance move? How would you improve it?
30–38 min	Stability test: push robot gently from 4 sides. Rate stability 1–5 for each direction.	Record stability scores; identify weakest direction and hypothesize the fix.	If it tips to the left, what change would move the CG to the right?
38–45 min	Prompt CG adjustment: move one heavy component 1 cm. Re-test stability.	Make one targeted CG change, re-test, record new stability score.	Did the stability score improve? Why or why not?

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

Time	Teacher Actions	Student Actions	Key Questions
0–15 min	Mini-lecture: gear ratio formula, torque vs. speed trade-off, CG formula intuition.	Solve 2 gear ratio problems using their own robot's gear sizes.	If you need more torque, do you use a larger or smaller driven gear?
15–30 min	Robot Dance-Off preparation: 5 min to finalize routine, then perform for class.	Rehearse full 3-move routine twice; make any last-minute adjustments.	Is every move in your routine intentional and reproducible?
30–42 min	Each group performs dance routine; class scores creativity and smoothness (rubric).	Perform routine live; answer 2 class questions about gear choice or CG.	What was the hardest engineering challenge in creating a dancing robot?
42–45 min	Exit ticket: gear ratio calculation + explain how CG affects stability.	Complete individually and submit before leaving.	Can you redesign your robot so it dances faster without losing stability?

DIFFERENTIATION & SCAFFOLDING

SUPPORT — Struggling Students	EXTENSION — Advanced Students
• Provide a pre-built robot chassis so students focus on gear attachment and programming. • Offer a simplified MakeCode dance template with 3 pre-named moves to customize. • Pair struggling students with a peer coach during the build phase. • Use visual gear ratio reference cards showing speed vs. torque outcomes.	• Challenge students to program a dance routine synchronized to a musical beat pattern. • Have advanced students calculate the exact gear ratio needed for a target RPM. • Incorporate sensors: program the robot to start dancing when it detects sound. • Research famous dancing robots and write a one-page engineering analysis.

ASSESSMENT BREAKDOWN

Assessment Component	Weight	Description
Exit Ticket	**20%**	Gear ratio calculation + CG stability explanation (individual)
Dance Performance	**25%**	3-move routine executed successfully with consistent timing
Stability Analysis	**20%**	Before/after stability scores with justified CG adjustment
Team Presentation	**20%**	Clear explanation of gear choice, CG placement, and programming logic
Engineering Notebook	**15%**	Sketches, gear labels, stability data, 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.