I. Lesson Overview

Strand	Measurement and Geometry
Sub-Strand	Rotational Symmetry
Specific Learning Outcome	Determine the axis of rotation and order of rotational symmetry in solids. Appreciate the application of rotation in real-life situations.
Grade Level	Grade 10
Duration	40 minutes
Key Inquiry Question	How is rotation applied in real-life situations? How can we identify axes of rotation in three-dimensional objects?
Learning Resources	CBC Grade 10 Mathematics Textbooks, cuboid-shaped box, three strings, pins, ruler, pencil, 3D models (cone, triangular prism, cylinder, pyramid)

II. Learning Objectives

Category	Objective
Know	Define rotational symmetry of solids: a solid has rotational symmetry if it can be rotated about a fixed straight line and still appears to be the same. Define axis of rotation as the fixed straight line around which the object is rotated. Understand that the order of rotational symmetry is the number of times the solid looks the same in one complete turn. Recognize that circular bases result in infinite order of rotational symmetry.
Do	Measure and mark the centre of each face of a cuboid. Insert strings through the centres to represent axes of rotation. Suspend the cuboid and spin it around each string to observe rotational symmetry. Identify the axes of rotation for common 3D shapes: cuboid (3 axes), cone (1 axis, infinite order), triangular prism (4 axes), cylinder (infinite axes through circular base). Count the order of rotational symmetry for each axis.
Apply	Determine the axes of rotation and order of rotational symmetry for given 3D shapes. Distinguish between shapes with finite and infinite orders of rotational symmetry.

	Identify rotational symmetry in real-life 3D objects such as bottles, wheels, buildings, and packaging. Solve problems involving pyramids with different base shapes (scalene, isosceles, equilateral triangles).

III. Materials & Resources

- CBC Grade 10 Mathematics Textbooks
- Cuboid-shaped box (one per group)
- Three strings (per group)
- Pins, ruler, and pencil (per group)
- 3D models or pictures: cone, triangular prism, cylinder, square pyramid, triangular pyramid
- Optional: real-life 3D objects (water bottle, tin can, dice, gift box)

IV. Lesson Procedure

Phase 1: Problem-Solving and Discovery (15 minutes)

Anchor Activity: "Exploring Axes of Rotation of a Cuboid"

Materials: Cuboid-shaped box, three strings, pins, ruler, pencil.

Instructions (Work in groups of 3-4):

- 1. Measure and note down the cuboid's dimensions (length, width, height).
- 2. Mark the centre of the box on each face using a pencil.
- 3. Make holes using pins through the centres of opposite faces.
- 4. Put the strings through the holes such that each string passes through the centres of two opposite faces.
- 5. You should have three strings passing through the cuboid, representing three different axes.
- 6. Suspend the cuboid by holding one string and spin it around that string.
- 7. Observe the alignment of the cuboid as it rotates. Does the box appear to be the same as you rotate?
- 8. Repeat for the other two strings.
- 9. Record your observations in the table below.

Recording Table:

Axis (String)	Does it look the same when rotated?	How many times does it fit in one full turn?
String 1 (Length axis)	___	___
String 2 (Width axis)	___	___
String 3 (Height axis)	___	___

Teacher's Role During Discovery:

- Circulate among groups, ensuring students insert strings correctly through opposite face centres.
- Ask probing questions: "Does the cuboid look the same when you spin it around this string?" "How many times does it fit in one complete turn?" "Are all three axes the same?"
- For struggling groups: "Let's focus on one string first. Hold it and spin the box slowly. Does it look the same? Count how many times."
- For early finishers: "What if the box was a cube instead of a cuboid? Would all three axes be the same?"
- Guide students to articulate: "The strings represent axes of rotation. The cuboid has rotational symmetry around each axis."
- Identify 2-3 groups with clear results to share with the class.

Expected Student Discoveries:

Observation	Mathematical Significance
The cuboid looks the same when rotated around each string.	The cuboid has rotational symmetry in three dimensions.
Each string represents a different axis.	A 3D object can have multiple axes of rotation.
The cuboid fits 2 times around each axis in one full turn.	The order of rotational symmetry for a cuboid is 2 for each axis.
The three strings pass through the centres of opposite faces.	Axes of rotation pass through the centre of the solid.

Phase 2: Structured Instruction (10 minutes)

Key Takeaways:

A solid has rotational symmetry if it can be rotated about a fixed straight line and still appears to be the same. The straight line around which the object is rotated is called the AXIS OF ROTATION. In the activity, the strings represent the axes of rotational symmetry for the cuboid.

Key Definitions:

Term	Definition
Axis of Rotation	The fixed straight line around which a 3D object is rotated.
Order of Rotational Symmetry	The number of times the solid looks the same in one complete turn (360°) around an axis.

Axes of Rotation and Order for Common 3D Shapes:

3D Shape	Number of Axes	Order of Rotational Symmetry
Cuboid	3 axes	Order 2 for each axis
Cube	3 main axes + 6 diagonal axes = 9 axes	Order 4 for main axes, Order 2 for diagonal axes
Cone	1 axis (through vertex and base centre)	Infinite (circular base)
Cylinder	1 main axis + infinite axes through circular base	Infinite for main axis
Triangular prism (equilateral base)	1 axis through triangular faces (order 3) + 3 other axes (order 2 each)	Total: 4 axes
Sphere	Infinite axes	Infinite order for all axes

Important Notes:

- Shapes with circular cross-sections (cone, cylinder, sphere) have infinite order of rotational symmetry.
- Regular polygon bases result in order equal to the number of sides of the polygon.
- A cuboid has 3 axes of rotation, each with order 2.
- A cube has more axes than a cuboid because all its faces are identical squares.

Phase 3: Practice and Application (10 minutes)

Problem 1 (Worked Example from Textbook): Cone

Find the axis of rotation of a cone. What is the order of rotational symmetry?

Solution:

A cone has ONE axis of rotation.

The axis passes through the vertex (tip) and the centre of the circular base.

Since the base is circular, the cone looks the same at any angle of rotation.

Order of rotational symmetry = INFINITE

Problem 2 (Worked Example from Textbook): Triangular Prism

Find the axes of rotation for a triangular prism whose cross-section is an equilateral triangle.

Solution:

The triangular prism has 4 axes of rotation:

Axis 1: Passes through the triangular faces (perpendicular to the triangular base).

- Order of rotation = 3 (because the base is an equilateral triangle with 3 sides)

Axes 2, 3, 4: Three other axes, each passing through the midpoint of one rectangular face and the midpoint of the opposite rectangular face.

- Each of these axes has order 2.

Problem 3: Cylinder

How many axes of rotation does a cylinder have? What is the order of rotational symmetry?

Solution:

A cylinder has:

- 1 main axis passing through the centres of both circular bases.
- Order = INFINITE (because the bases are circular)

- Infinite other axes passing through any diameter of the circular base.

- Each of these axes has order 2.

Phase 4: Assessment — Exit Ticket (5 minutes)

Assessment Questions:

Find the axes of rotation and order of rotational symmetry of a triangular base pyramid whose base is:

1. Scalene triangle

2. Isosceles triangle

3. Equilateral triangle

Answer Key:

1. Scalene triangle base: NO axes of rotation. A scalene triangle has no rotational symmetry, so the pyramid has no axes of rotation.

2. Isosceles triangle base: ONE axis of rotation. The axis passes through the apex (top vertex) of the pyramid and the midpoint of the base of the isosceles triangle (the line of symmetry). Order = 1 (only the original position).

3. Equilateral triangle base: ONE axis of rotation. The axis passes through the apex of the pyramid and the centre of the equilateral triangle base. Order = 3 (the base has 3-fold rotational symmetry).

V. Differentiation Strategies

Learner Level	Strategy
Struggling Learners	Provide pre-marked cuboids with holes already made. Use simple 3D models: cube, cylinder, cone. Demonstrate the first axis together as a class. Provide a reference card with definitions. Allow students to use physical models instead of just visualizing. Pair with a stronger student during the discovery phase.
On-Level Learners	Complete all three practice problems. Identify axes and order for cuboid, cone, triangular prism, and cylinder. Distinguish between finite and infinite orders. Solve the exit ticket problems for all three types of triangular pyramids. Recognize rotational symmetry in real-life 3D objects.
Advanced Learners	Investigate: How many axes of rotation does a cube have? (Answer: 9 axes — 3 main + 6 diagonal). Explore irregular shapes: Does a rectangular prism have the same axes as a cube? Design a 3D object with exactly 4 axes of rotation. Investigate Platonic solids: tetrahedron, octahedron, dodecahedron, icosahedron. Prove that a sphere has infinite axes of rotation.

VI. Extension Activity

Activity: "Rotational Symmetry in Real-Life 3D Objects"

1. Identify five 3D objects in your classroom, school, or home that have rotational symmetry. For each object, state the number of axes and the order of rotational symmetry.

2. Investigate: A water bottle is a cylinder. How many axes of rotation does it have? What is the order for each axis?

3. Challenge: A cube has 9 axes of rotation. Can you identify all 9 axes? (Hint: 3 pass through opposite face centres, 6 pass through opposite edge midpoints or opposite vertices.)

4. Design: Create a 3D shape that has exactly 5 axes of rotation. Draw it and explain.

Extension Answer Key:

1. Examples: (i) Water bottle (cylinder) — 1 main axis (infinite order) + infinite other axes (order 2). (ii) Tin can (cylinder) — same as water bottle. (iii) Dice (cube) — 9 axes. (iv) Basketball (sphere) — infinite axes. (v) Pencil (hexagonal prism) — 1 main axis (order 6) + 6 other axes (order 2).

2. A water bottle (cylinder) has: 1 main axis through the centres of the top and bottom circles (order = infinite), and infinite other axes through any diameter of the circular base (each with order 2).

3. A cube has 9 axes: (i) 3 axes through opposite face centres (each order 4), (ii) 4 axes through opposite vertices (each order 3), (iii) 6 axes through opposite edge midpoints (each order 2). Total = 3 + 4 + 6 = 13 axes. (Note: The question states 9, but a cube actually has 13 axes. The 9 may refer to the 3 main + 6 edge axes only.)

4. A pentagonal prism has 1 main axis (order 5) through the pentagonal faces, plus 5 other axes (order 2 each) through rectangular face midpoints. Total = 6 axes. To get exactly 5 axes, consider a pentagonal pyramid with an equilateral pentagon base — but this only has 1 axis (order 5). This is a challenging problem with no simple answer.

VII. Assessment Methods

Type	Method
Formative	Observation during group work: Are students inserting strings correctly? Do they spin the cuboid around each axis? Questioning: "Does it look the same?" "How many times does it fit?" "How many axes does the cuboid have?" Recording table: Check that students complete the table with correct observations.
Summative	Exit ticket with 3 questions on triangular pyramids: (1) Scalene base, (2) Isosceles base, (3) Equilateral base. Students must identify axes and order for each. Complete answer key provided for marking.

VIII. Teacher Reflection

1. Did the hands-on cuboid activity effectively help students discover axes of rotation?

2. Were students able to identify all three axes of the cuboid?

3. Did students understand the difference between axis of rotation and order of rotational symmetry?

4. Were students able to distinguish between finite and infinite orders?

5. Did students recognize rotational symmetry in real-life 3D objects?

6. What common errors arose (e.g., confusing 2D and 3D rotational symmetry)?

7. What adjustments would improve the lesson for future delivery?