I. Lesson Overview

Strand	Measurement and Geometry
Sub-Strand	Rotation and Congruence
Specific Learning Outcome	Deduce congruence from rotation. 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 does rotation preserve shape and size?
Learning Resources	CBC Grade 10 Mathematics Textbooks, graph paper, rulers, protractors, tracing paper, scissors

II. Learning Objectives

Category	Objective
Know	Define congruence: two figures are congruent if they are identical in size and shape. Understand that rotation is a transformation that repositions an object but preserves its shape and size. Recognize that rotation produces congruent figures. Understand direct congruence: when a figure and its rotated image have the same orientation.
Do	Copy triangle ABC and point D on graph paper. Draw dotted lines from each vertex to the centre of rotation D. Use a protractor to measure the angle of rotation (e.g., −90° or −45°). Use a ruler to mark image points at equal distances from D. Connect the image points to form the rotated triangle. Verify that corresponding sides have equal lengths. Verify that corresponding angles remain equal.
Apply	Rotate triangles and other shapes about a given centre using ruler and protractor. Deduce that rotated figures are congruent to the original. Identify axes of rotational symmetry and order for 3D shapes (cylinder, rectangular pyramid, sphere, cube). Recognize rotation and congruence in real-life

	contexts (wheels, gears, clock hands, rotating doors).

III. Materials & Resources

- CBC Grade 10 Mathematics Textbooks
- Graph paper (one sheet per student)
- Rulers and protractors (one per student)
- Tracing paper (optional, for verification)
- Scissors (optional)
- Pre-drawn triangles on handouts
- Real-life objects showing rotation: wheels, gears, clock, rotating door pictures

IV. Lesson Procedure

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

Anchor Activity: "Rotating Triangle ABC"

Instructions (Work in groups of 3-4):

- 1. Copy triangle ABC and point D on your graph paper. (Triangle ABC should be a right triangle with vertices at approximate coordinates: A(2,6), B(2,2), C(6,2). Point D should be at approximately (4,4) — below and to the right of the triangle.)
- 2. Using a ruler and protractor, you will rotate the triangle −90° (90° clockwise) about point D.
- 3. Draw a dotted line to connect vertex A to point D.
- 4. Place a protractor at the line AD with the centre of the protractor at D.
- 5. Measure 90° clockwise from line AD. (Since the rotation is −90°, measure clockwise.)
- 6. Using a ruler, draw DA-prime such that AD = DA-prime. (Mark point A-prime at the same distance from D as A, but 90° clockwise.)
- 7. Repeat steps 3-6 for vertices B and C to find B-prime and C-prime.
- 8. Connect A-prime, B-prime, and C-prime to form triangle A-primeB-primeC-prime.
- 9. Measure the side lengths of both triangles: AB vs A-primeB-prime, BC vs B-primeC-prime, AC vs A-primeC-prime.
- 10. Measure the angles of both triangles: ∠A vs ∠A-prime, ∠B vs ∠B-prime, ∠C vs ∠C-prime.
- 11. Record your findings in the table below.

Recording Table:

Measurement	Triangle ABC	Triangle A-primeB-primeC-prime
Side AB vs A-primeB-prime	___	___
Side BC vs B-primeC-prime	___	___
Side AC vs A-primeC-prime	___	___
Angles (∠A, ∠B, ∠C) vs (∠A-prime, ∠B-prime, ∠C-prime)	___	___

Teacher's Role During Discovery:

- Circulate among groups, ensuring students draw dotted lines from each vertex to point D.
- Ask probing questions: "Are the side lengths the same?" "Are the angles the same?" "What does this tell you about the two triangles?"
- For struggling groups: "Let us focus on vertex A first. Draw a line from A to D. Now use your protractor at D to measure 90° clockwise. Mark A-prime at the same distance from D."
- For early finishers: "What if you rotated the triangle 180° instead? Would it still be congruent?"
- Guide students to articulate: "The triangles have the same side lengths and angles. They are congruent."
- Identify 2-3 groups with clear results to share with the class.

Expected Student Discoveries:

Observation	Mathematical Significance
All corresponding side lengths are equal: AB = A-primeB-prime, BC = B-primeC-prime, AC = A-primeC-prime.	Rotation preserves side lengths.
All corresponding angles are equal: ∠A = ∠A-prime, ∠B = ∠B-prime, ∠C = ∠C-prime.	Rotation preserves angles.
The two triangles have the same shape and size.	The triangles are congruent.
The image triangle is in a different position but has the same properties.	Rotation is a transformation that produces congruent figures.

Phase 2: Structured Instruction (10 minutes)

Key Takeaways:

CONGRUENCE refers to a relationship between two figures or objects whereby they are identical in size and shape.

ROTATION is a type of transformation that repositions an object but preserves the shape and size of the object. Thus, rotation produces congruent figures.

ΔABC and ΔA-primeB-primeC-prime are similar in size and shape. Therefore, they are said to be DIRECTLY CONGRUENT.

Properties Preserved Under Rotation:

Property	Description
Side Lengths	All corresponding sides have equal lengths: AB = A-primeB-prime, BC = B-primeC-prime, AC = A-primeC-prime.
Angles	All corresponding angles remain equal: ∠A = ∠A-prime, ∠B = ∠B-prime, ∠C = ∠C-prime.
Shape	The shape of the figure is preserved (e.g., triangle remains a triangle).
Size (Area)	The area of the figure remains the same.

Important Notes:

- Rotation is a rigid transformation (also called isometry) — it preserves distances and angles.
- Direct congruence means the figure and its image have the same orientation after rotation.
- Negative angles indicate clockwise rotation; positive angles indicate anticlockwise rotation.
- The centre of rotation is the fixed point around which the figure rotates.

Phase 3: Practice and Application (10 minutes)

Problem 1 (Worked Example from Textbook): Triangle Rotation −45°

Triangle ABC is mapped onto A-primeB-primeC-prime after a rotation of −45° and centre of rotation D.

Solution:

Observations:

• ΔABC and ΔA-primeB-primeC-prime have the same shape and size.

• The length of the corresponding sides of ΔABC and ΔA-primeB-primeC-prime are the same.

• Every corresponding internal angle for the triangles remains the same.

Therefore, ΔABC and ΔA-primeB-primeC-prime are said to be directly congruent.

Problem 2: Verifying Congruence After Rotation

A square ABCD is rotated 90° anticlockwise about its centre O to form A-primeB-primeC-primeD-prime. Prove that the two squares are congruent.

Solution:

Step 1: Identify corresponding vertices: A ↔ A-prime, B ↔ B-prime, C ↔ C-prime, D ↔ D-prime.

Step 2: Since rotation preserves distances, all corresponding sides are equal:

AB = A-primeB-prime, BC = B-primeC-prime, CD = C-primeD-prime, DA = D-primeA-prime.

Step 3: Since rotation preserves angles, all corresponding angles are equal:

∠A = ∠A-prime = 90°, ∠B = ∠B-prime = 90°, ∠C = ∠C-prime = 90°, ∠D = ∠D-prime = 90°.

Step 4: Since all corresponding sides and angles are equal, the two squares are congruent.

Problem 3: Real-Life Application

A clock hand rotates from 12 to 3 (90° clockwise). Is the hand congruent to its original position?

Solution:

Yes, the clock hand is congruent to its original position because rotation preserves the length and shape of the hand. Only the position (orientation) has changed.

Phase 4: Assessment — Exit Ticket (5 minutes)

Assessment Questions:

1. Identify the axes of rotational symmetry and their respective order in the following:

a) Cylinder

b) Rectangular pyramid

c) Sphere

d) Cube

2. True or False: Rotation changes the size of a figure. Explain your answer.

3. Triangle PQR is rotated 180° about point M to form P-primeQ-primeR-prime. Are the two triangles congruent? Why or why not?

Answer Key:

1. a) Cylinder: 1 main axis (through centres of circular bases) with infinite order + infinite other axes (through diameters) with order 2.

b) Rectangular pyramid: 0 axes (if base is not a square). If base is a square: 1 axis (through apex and centre of base) with order 4.

c) Sphere: Infinite axes, all with infinite order.

d) Cube: 9 axes (3 main axes with order 4, 4 diagonal axes with order 3, 6 edge axes with order 2). Note: Some sources count 13 axes.

2. False. Rotation does NOT change the size of a figure. Rotation is a rigid transformation that preserves distances, angles, shape, and size. Only the position (orientation) changes.

3. Yes, the two triangles are congruent. Rotation preserves side lengths and angles, so PQ = P-primeQ-prime, QR = Q-primeR-prime, PR = P-primeR-prime, and all corresponding angles are equal. Therefore, ΔPQR ≅ ΔP-primeQ-primeR-prime.

V. Differentiation Strategies

Learner Level	Strategy
Struggling Learners	Provide pre-drawn triangles and points on handouts. Use tracing paper to physically rotate the triangle and verify congruence. Demonstrate the first vertex rotation together as a class. Provide a reference card with rotation steps. Allow students to use protractor templates. Pair with a stronger student during the discovery phase.
On-Level Learners	Complete all three practice problems. Rotate triangles using ruler and protractor. Verify congruence by measuring sides and angles. Identify axes and order for cylinder, rectangular pyramid, sphere, cube. Recognize rotation and congruence in real-life contexts (clock, wheels, gears).
Advanced Learners	Investigate: What happens if you rotate a figure 360°? (Returns to original position.) Explore composition of rotations: rotate 90° then 90° again = 180° total. Prove algebraically that rotation preserves distance using coordinate geometry. Design a logo with rotational symmetry of order 6. Investigate rotation matrices in coordinate geometry.

VI. Extension Activity

Activity: "Rotation and Congruence in Real-Life"

1. Identify five real-life objects or mechanisms that involve rotation. For each, explain whether the rotated object is congruent to its original position. Examples: clock hands, wheels, rotating doors, gears, fan blades.

2. Investigate: A Ferris wheel rotates passengers around a central axis. Are the passenger cabins congruent at different positions? Explain.

3. Challenge: Prove that rotating a figure 360° returns it to its original position. (Hint: 360° = 4 × 90°.)

4. Design: Create a symmetric logo or pattern that has rotational symmetry of order 8. Verify that rotating it 45° produces a congruent image.

Extension Answer Key:

1. Examples: (i) Clock hands — congruent at all positions (same length). (ii) Wheels — congruent at all rotations (same shape and size). (iii) Rotating door — congruent at all angles. (iv) Gears — teeth are congruent at all positions. (v) Fan blades — each blade is congruent to its rotated positions.

2. Yes, the passenger cabins are congruent at all positions because rotation preserves shape and size. Only the position (height and horizontal location) changes, but the cabin itself remains the same.

3. Rotating 360° means completing one full turn. Since rotation preserves all properties (side lengths, angles, shape, size), and 360° brings the figure back to its starting orientation, the figure returns to its original position. Algebraically: $360° = 4 \times 90°$, so four 90° rotations return the figure to the original.

4. A logo with order 8 rotational symmetry fits onto itself 8 times in 360°, so each rotation is $360° \div 8 = 45°$. Examples: 8-pointed star, octagon with symmetric design. Verify by tracing and rotating 45° — the image should match the original.

VII. Assessment Methods

Type	Method
Formative	Observation during group work: Are students drawing dotted lines from vertices to centre D? Are they using the protractor correctly? Do they measure equal distances? Questioning: "Are the side lengths equal?" "Are the angles equal?" "What does this tell you?" Recording table: Check that students

	complete the table with correct measurements.
Summative	Exit ticket with 3 questions: (1) Identify axes and order for cylinder, rectangular pyramid, sphere, cube. (2) True/False on rotation changing size. (3) Congruence after 180° rotation. Complete answer key provided for marking.

VIII. Teacher Reflection

1. Did the hands-on rotation activity effectively help students discover congruence?

2. Were students able to use the ruler and protractor accurately?

3. Did students understand that rotation preserves side lengths and angles?

4. Were students able to deduce that rotated figures are congruent?

5. Did students recognize rotation and congruence in real-life contexts?

6. What common errors arose (e.g., incorrect angle measurement, unequal distances)?

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