I. Lesson Overview

Strand	Measurement and Geometry
Sub-Strand	Rotation
Specific Learning Outcome	Determine the properties of rotation in different situations. 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? What properties remain unchanged when a shape is rotated?
Learning Resources	CBC Grade 10 Mathematics Textbooks, graph paper, ruler, protractor, pencil, coloured pencils

II. Learning Objectives

Category	Objective
Know	Define rotation as a transformation that turns a shape about a fixed point (the centre of rotation) through a given angle (the angle of rotation). State the two key properties of rotation: (1) the distance from any point to the centre equals the distance from its image to the centre, and (2) the angle of rotation is the same for all points. Recall that anticlockwise rotation is positive and clockwise rotation is negative. Understand that a rotation is completely defined by its centre and angle of rotation.
Do	Draw a triangle and its image on graph paper after rotation. Measure and verify that OA = OA′, OB = OB′, and OC = OC′ for a given centre O. Measure and verify that $\angle AOA' = \angle BOB' = \angle COC'$. Rotate a triangle through 90° clockwise about the origin on the coordinate plane. Find the centre and angle of rotation using the perpendicular bisector method.
Apply	Apply rotation rules to find image coordinates on the Cartesian plane. Determine the centre and angle of rotation given an object and its image. Use the perpendicular bisector

	construction to locate the centre of rotation. Recognise and describe rotations in real-life contexts such as clock hands, wheels, windmills, and Ferris wheels.

III. Materials & Resources

- CBC Grade 10 Mathematics Textbooks
- Graph paper (large sheets for group work)
- Rulers and set squares
- Protractors (one per pair)
- Pencils and coloured pencils
- Compasses (for constructing perpendicular bisectors)
- Printed handouts with pre-drawn triangles for the anchor activity

IV. Lesson Procedure

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

Anchor Activity: "Discovering the Properties of Rotation"

Materials: Graph paper, a ruler, a protractor and a pencil.

Instructions (Work in pairs):

- (a) On graph paper, draw triangle ABC and its image, triangle A′B′C′ as shown in the figure in the textbook (Section 2.3.1).
- (b) Pick a point on the graph to act as the centre of rotation. Mark this point O.
- (c) Using a ruler, draw a straight line from point A to O and also from point A′ to O. Measure the distance OA and OA′ and record your results. What do you notice?
- (d) Similarly, draw a straight line from point B to O and also from point B′ to O. Measure the distance OB and OB′ and record your results. What do you notice?
- (e) Finally, draw a straight line from point C to O and also from point C′ to O. Measure the distance OC and OC′ and record your results. What do you notice?
- (f) Now using a protractor, measure ∠AOA′ , ∠BOB′ and ∠COC′ and record your results. What do you notice?

Recording Table:

Point	Distance to O	Image Distance to O	Angle at O
A	OA = ___	OA′ = ___	∠AOA′ = ___
B	OB = ___	OB′ = ___	∠BOB′ = ___
C	OC = ___	OC′ = ___	∠COC′ = ___

Teacher's Role During Discovery:

- Circulate among pairs, ensuring students draw accurate lines from vertices to the centre O.
- Ask probing questions: "What do you notice about the distances OA and OA′?" "Are the angles at O the same for all three pairs of points?"
- For struggling pairs: "Use your ruler carefully. Measure from the vertex to O, then from the image vertex to O. Write both measurements down. Are they the same?"
- For early finishers: "What would happen if you chose a DIFFERENT point as the centre? Would the properties still hold?"
- Guide students to articulate: "The distances are equal" and "The angles are all the same."
- Identify 2–3 pairs with clear results to share with the class.

Expected Student Discoveries:

Observation	Mathematical Significance
OA = OA′, OB = OB′, OC = OC′	The distance from any point to the centre of rotation equals the distance from its image to the centre.
∠AOA′ = ∠BOB′ = ∠COC′	The angle of rotation is the same for ALL points in the shape.
The triangle and its image have the same shape and size.	Rotation preserves side lengths, angles, and area — the image is congruent to the original.
The centre O does not move.	The centre of rotation is a fixed (invariant) point.

Phase 2: Structured Instruction (10 minutes)

Key Takeaways:

The distance from a point to the centre of rotation is the same as the distance from the image of that point to the centre of rotation:

AO = A′O, BO = B′O, CO = C′O

The angle of rotation is the same for all points in the shape:

∠AOA′ = ∠BOB′ = ∠COC′ = 90°

In this case, Point O is the centre of rotation and 90° is the angle of rotation.

Properties of Rotation Summary Table:

Property	Description
Equal distances from centre	The distance from any point to the centre of rotation equals the distance from its image to the centre. OA = OA′ for every point A.
Equal angle of rotation	The angle formed at the centre between any point and its image is the same for all points. ∠AOA′ = ∠BOB′ = ∠COC′ .
Preserves side lengths	All corresponding sides of the original and image are equal. AB = A′B′.
Preserves angles	All corresponding angles of the original and image are equal. ∠A = ∠A′ .
Preserves area	The area of the image equals the area of the original shape.
Centre is invariant	The centre of rotation does not move. If a point lies at the centre, it maps to itself.

Important Notes:

- A rotation in the anticlockwise direction is taken to be positive, i.e., a rotation of 45° anticlockwise is +45°.
- A rotation in the clockwise direction is taken to be negative, i.e., a rotation of 45° clockwise is −45°.
- In general, for a rotation to be completely defined, the centre and angle of rotation must be stated.

Rotation Rules on the Coordinate Plane (about the origin):

Rotation	Rule: (x, y) →
90° anticlockwise (+90°)	(−y, x)
90° clockwise (−90°)	(y, −x)
180° (±180°)	(−x, −y)
270° anticlockwise (+270°)	(y, −x) [same as 90° clockwise]

Finding the Centre and Angle of Rotation (Perpendicular Bisector Method):

- Step 1: Join a point to its image (e.g., join A to A′).
- Step 2: Construct the perpendicular bisector of AA′.
- Step 3: Join another point to its image (e.g., join B to B′).
- Step 4: Construct the perpendicular bisector of BB′.
- Step 5: The point where the two perpendicular bisectors intersect is the centre of rotation O.
- Step 6: Join a point and its image to O (e.g., join A and A′ to O). Measure ∠AOA′ — this is the angle of rotation.
- Step 7: Determine the direction: if the rotation from A to A′ is anticlockwise, the angle is positive; if clockwise, the angle is negative.

Phase 3: Practice and Application (10 minutes)

Problem 1 (Worked Example from Textbook): Rotating Triangle PQR

The coordinates of the vertices of triangle PQR are P(−8, −6), Q(−2, −6) and R(−5, −3). The triangle is rotated through 90° in a clockwise direction about the origin to produce triangle P′Q′R′. Find the coordinates of P′Q′R′.

Solution:

For a 90° clockwise rotation about the origin, the rule is: $(x, y) \to (y, -x)$.

$P(-8, -6) \to P'(-6, 8)$

$Q(-2, -6) \to Q'(-6, 2)$

$R(-5, -3) \to R'(-3, 5)$

Verification: Check that OP = OP′:

$OP = \sqrt{(-8)^2 + (-6)^2} = \sqrt{64 + 36} = \sqrt{100} = 10$

$OP' = \sqrt{(-6)^2 + (8)^2} = \sqrt{36 + 64} = \sqrt{100} = 10$

OP = OP′ = 10 ✔ (Distance property confirmed)

Problem 2: Finding Centre and Angle of Rotation

Triangle X′Y′Z′ is the image of triangle XYZ after rotation. Using the perpendicular bisector method, the centre of rotation is found at (−1, 1) and the angle of rotation is −160° (clockwise).

Solution Steps:

Step 1: Join Z to Z′ and construct the perpendicular bisector of ZZ′.

Step 2: Join Y to Y′ and construct the perpendicular bisector of YY′.

Step 3: Mark the intersection point O of the two perpendicular bisectors. This is the centre of rotation.

Step 4: Join Z and Z′ to O. Measure $\angle ZOZ'$ using a protractor.

Centre of rotation = (−1, 1). Angle of rotation = −160° (clockwise).

Problem 3: Applying Rotation Rules

A square has vertices at A(1, 1), B(4, 1), C(4, 4), and D(1, 4). Find the coordinates of the image after a 90° anticlockwise rotation about the origin.

Solution:

For a 90° anticlockwise rotation about the origin: (x, y) → (−y, x).

A(1, 1) → A′(−1, 1)

B(4, 1) → B′(−1, 4)

C(4, 4) → C′(−4, 4)

D(1, 4) → D′(−4, 1)

Verification: AB = A′B′ = 3, BC = B′C′ = 3, CD = C′D′ = 3, DA = D′A′ = 3. All sides preserved — congruent.

Problem 4: 180° Rotation

Triangle LMN has vertices L(2, 3), M(5, 1), and N(6, 5). Rotate the triangle 180° about the origin. Find the image coordinates and verify the distance property.

Solution:

For a 180° rotation about the origin: $(x, y) \longrightarrow (-x, -y)$.

$L(2, 3) \longrightarrow L'(-2, -3)$

$M(5, 1) \longrightarrow M'(-5, -1)$

$N(6, 5) \longrightarrow N'(-6, -5)$

Verification: $OL = \sqrt{(4+9)} = \sqrt{13}$, $OL' = \sqrt{(4+9)} = \sqrt{13}$. $OL = OL'$ ✔

Phase 4: Assessment — Exit Ticket (5 minutes)

Assessment Questions:

1. State the two key properties of rotation.

2. A triangle has vertices at A(3, 2), B(6, 2), and C(5, 5). Rotate the triangle 90° clockwise about the origin. Find the coordinates of A′, B′, and C′.

3. Rectangle A′B′C′D′ is the image of rectangle ABCD under a rotation, centre O. Describe how you would find the centre and angle of rotation by construction.

4. A rotation of +135° means the shape has been rotated ___° in the ___ direction.

5. Give two real-life examples of rotation and identify the centre of rotation in each case.

Answer Key:

1. (i) The distance from any point to the centre of rotation equals the distance from its image to the centre (OA = OA′). (ii) The angle of rotation is the same for all points in the shape (∠AOA′ = ∠BOB′ = ∠COC′).

2. Using the rule (x, y) ⟶ (y, −x): A′(2, −3), B′(2, −6), C′(5, −5).

3. Join A to A′ and construct the perpendicular bisector. Join B to B′ and construct the perpendicular bisector. The intersection of the two perpendicular bisectors is the centre O. Join A and A′ to O and measure ∠AOA′ to find the angle of rotation.

4. 135° in the anticlockwise direction (positive = anticlockwise).

5. Examples: (i) Clock hands — centre of rotation is the central pivot of the clock. (ii) A Ferris wheel — centre of rotation is the central axle. (iii) A windmill — centre of rotation is the hub where the blades meet. (iv) A spinning top — centre of rotation is the tip of the top.

V. Differentiation Strategies

Learner Level	Strategy
Struggling Learners	Provide pre-drawn figures with the centre of rotation already marked. Use the recording table to structure measurements step by step. Focus on the 90° clockwise rotation rule only: (x, y) ⟶ (y, −x). Allow students to use tracing paper to physically rotate shapes. Pair with a stronger student during the discovery phase. Provide a reference card with all four rotation rules.
On-Level Learners	Complete all four practice problems using the rotation rules. Verify the distance property using the distance formula. Find the centre and angle of rotation using the perpendicular bisector method. Identify real-life examples and explain the centre and angle of rotation.
Advanced Learners	Investigate: What happens when you rotate a shape 360°? What about 720°? Explore

	composition of rotations: rotate 90° then 90° again — is this the same as rotating 180°? Find the centre and angle of rotation for non-origin centres. Prove that rotation preserves congruence using the distance formula. Investigate the relationship between rotation and reflection: is a 180° rotation equivalent to two reflections?

VI. Extension Activity

Activity: "Rotation in Real Life and Beyond"

1. A rectangle ABCD has vertices A(1, 1), B(5, 1), C(5, 3), D(1, 3). By construction, find the centre and angle of rotation that maps ABCD to A′B′C′D′ where A′(−1, 1), B′(−1, 5), C′(−3, 5), D′(−3, 1).

2. Investigate: The minute hand of a clock rotates 360° in 60 minutes. Through what angle does it rotate in: (a) 15 minutes? (b) 25 minutes? (c) 1 minute? Is this rotation positive or negative?

3. A windmill has 4 identical blades. If one blade points North, through what angles of rotation would you need to rotate the windmill so that each blade takes the position of the next blade? What is the order of rotational symmetry?

4. Composition of rotations: Triangle ABC has vertices A(1, 0), B(3, 0), C(2, 2). First rotate 90° anticlockwise about the origin, then rotate the image 90° anticlockwise again. Compare the final image with a single 180° rotation of the original. What do you notice?

Extension Answer Key:

1. Centre of rotation = (0, 0) (the origin). Angle of rotation = +90° (anticlockwise). Verification: (1,1) → (−1,1) using (−y, x) = (−1, 1) ✔.

2. (a) 15 min = 90°. (b) 25 min = 150°. (c) 1 min = 6°. The rotation is negative (clockwise) as clock hands move clockwise.

3. Rotate 90°, 180°, 270°, and 360° (back to start). The order of rotational symmetry is 4.

4. After two 90° anticlockwise rotations: A(1,0) ⟶ (0,1) ⟶ (−1,0). After one 180° rotation: A(1,0) ⟶ (−1,0). The results are the same. Two 90° rotations = one 180° rotation.

VII. Assessment Methods

Type	Method
Formative	Observation during pair work: Are students measuring distances and angles accurately? Do they notice the equal distances and equal angles? Questioning: "What are the two key properties?" "Is this rotation clockwise or anticlockwise?" "What sign do we use?" Recording table: Check that students complete the table with correct measurements.
Summative	Exit ticket with 5 questions: (1) State properties, (2) Apply 90° clockwise rotation rule, (3) Describe perpendicular bisector construction method, (4) Interpret positive/negative angle notation, (5) Identify real-life rotation examples. Complete answer key provided for marking.

VIII. Teacher Reflection

1. Did the hands-on measuring activity effectively help students discover the two key properties of rotation?

2. Were students able to accurately measure distances and angles using rulers and protractors?

3. Did students understand the difference between positive (anticlockwise) and negative (clockwise) rotation?

4. Were students able to apply the rotation rules on the coordinate plane?

5. Did students grasp the perpendicular bisector method for finding the centre and angle of rotation?

6. Were students able to connect rotation to real-life examples?

7. What common errors arose (e.g., confusing clockwise/anticlockwise, incorrect sign convention)?

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