CBC Grade 10 Mathematics Lesson Plan

Linear Motion in Real-Life

Strand	Measurement and Geometry
Sub-Strand	Linear Motion
Specific Learning Outcome	Apply linear motion principles to solve real-life problems in transportation safety, sports, and engineering
Key Inquiry Questions	How do we apply linear motion principles in real-life situations?
Learning Resources	CBC Grade 10 textbooks, calculators, chart paper, markers
Lesson Duration	40 minutes

Lesson Structure Overview

Phase	Activity	Duration
Phase 1	Problem-Solving and Discovery (Anchor Activity)	15 minutes
Phase 2	Structured Instruction (Key Takeaways)	10 minutes
Phase 3	Practice and Application (Worked Examples)	15 minutes
Phase 4	Assessment (Exit Ticket)	5 minutes

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

Anchor Activity: School Bus Stop Safety Analysis
Work in Groups

The local government plans to introduce a new school bus stop along a straight road near your school. Before approval, the transport committee needs to determine whether the stopping distance is safe for learners crossing the road.

You are part of a team of student consultants tasked with analyzing the motion of a school bus using principles of linear motion.

Your team is given the following data:

- • The bus is travelling at 20 m/s along a straight road.
- • The driver notices learners crossing 50 meters ahead.
- • The driver's reaction time is 2 seconds.
- • After reacting, the bus decelerates uniformly at 4 m/s² until it stops.

What to do:

1. (a) Reaction distance is the distance the vehicle travels from the moment the driver perceives a hazard to the moment they apply the brakes.

   i. Calculate the distance travelled during the 2-second reaction time.

   ii. State whether the bus is accelerating, decelerating, or moving at constant velocity during this time.

2. (b) Braking distance is the distance it takes for the bus to come to a complete stop after the driver starts braking.

   i. Calculate the time taken for the bus to come to rest after braking begins.

   ii. Calculate the braking distance using the formula $v^2 = u^2 + 2as$.

3. (c) Total stopping distance is the sum of the reaction distance and the braking distance.

   i. Calculate the total stopping distance of the bus.

   ii. Compare this with the 50 m available before the crossing.

   iii. Conclude whether the bus will stop in time.

4. (d) Find:

   i. The total displacement of the bus from the moment the driver notices the learners to when the bus stops.

   ii. The average velocity during the entire stopping process.

5. (e) Based on your calculations, recommend one of the following:

- • Reduce the speed limit
- • Move the bus stop further away
- • Install a speed bump
- • Maintain the current arrangement

6. (f) Share your work with other learners

Teacher Guidance for Anchor Activity

This anchor activity engages students in a real-world transportation safety problem. Students apply linear motion concepts (velocity, acceleration, stopping distance) to determine whether a proposed bus stop location is safe.

Facilitation Strategy:

- • Organize students into groups of 3-4
- • Emphasize the real-world context: this is how engineers and planners make safety decisions
- • Guide students to break the problem into parts: reaction distance, braking distance, total stopping distance
- • Encourage discussion about safety margins and recommendations
- • Ask probing questions: "What happens if the bus is going faster?" "Why is reaction time important?"
- • Help students connect calculations to safety implications
- • Use student findings as bridge to formal concepts about motion in real-life

Phase 2: Structured Instruction (10 minutes)

Key Takeaways

After students have explored through the anchor activity, formalize their discoveries with these key concepts:

1. Linear Motion in Transportation Safety

Linear motion principles are fundamental in transportation safety. Understanding stopping distances helps engineers and planners design safer roads and establish appropriate speed limits in different zones.

The relationship between speed, reaction time, and braking distance directly impacts pedestrian safety and accident prevention.

Key components of stopping distance:

- • Reaction distance = speed × reaction time (vehicle travels at constant velocity)
- • Braking distance = distance to stop after brakes applied (vehicle decelerates)
- • Total stopping distance = reaction distance + braking distance

2. Engineering Applications

Engineers apply motion calculations when designing vehicles, elevators, and transport systems to ensure safety and efficiency.

Examples of engineering applications:

- • Vehicle braking systems designed for minimum stopping distance
- • Elevator acceleration profiles for passenger comfort
- • Railway signaling systems based on train stopping distances
- • Road design with appropriate sight distances and speed limits

3. Sports Performance Analysis

In sports, motion analysis improves performance by evaluating speed, acceleration, and timing.

Athletes and coaches use motion principles to:

- • Analyze sprint starts and acceleration phases
- • Optimize running technique for maximum speed
- • Calculate optimal takeoff velocities in jumping events
- • Design training programs targeting specific acceleration improvements

4. Industrial Applications
Industries use constant motion principles to control machines and production systems.

Manufacturing applications include:

- • Conveyor belt speed control for production efficiency
- • Robotic arm motion planning for precision assembly
- • Automated guided vehicle navigation in warehouses
- • Quality control systems monitoring product movement

5. Safety Implications
Higher speeds increase accident risk because:

- • Reaction distance increases proportionally with speed
- • Braking distance increases with the square of speed
- • Total stopping distance grows rapidly as speed increases
- • Impact forces in collisions increase dramatically at higher speeds

Scaffolding Strategies
Address common misconceptions revealed during the anchor activity:

- • Clarify that reaction distance occurs at constant velocity (no braking yet)
- • Emphasize that braking distance involves deceleration
- • Show why doubling speed more than doubles stopping distance
- • Use real-world examples to make concepts concrete
- • Connect to prior knowledge of velocity, acceleration, and equations of motion

Phase 3: Practice and Application (15 minutes)

Worked Examples

Example 1: Car Braking (Transportation Safety)
A car is travelling at a velocity of 20 m/s. The driver applies brakes and the car comes to rest in 5 seconds.

a) Calculate the acceleration of the car.

b) Calculate the stopping distance.

c) Explain why higher speeds increase accident risk.

Solution:

a) Given: u = 20 m/s, v = 0 m/s, t = 5 s

  Using: a = (v - u) / t

  a = (0 - 20) / 5 = -4 m/s^2

  The negative sign indicates deceleration.

b) Using: s = ut + ½at^2

  s = (20)(5) + ½(-4)(5)^2

  s = 100 - 50 = 50 m

c) When the initial speed increases, the stopping distance increases. A higher velocity means the vehicle covers more distance before it can come to rest, increasing the likelihood of a collision.

Example 2: Sprinter Performance (Sports)
A sprinter starts from rest and accelerates uniformly at 3 m/s^2 for 4 seconds.

a) Calculate the final velocity.

b) Calculate the distance covered during this time.

c) Explain how improving acceleration benefits performance.

Solution:

a) Given: u = 0, a = 3 m/s^2, t = 4 s

  Using: v = u + at

  v = 0 + 3 × 4 = 12 m/s

b) Using: s = ut + ½at^2

  s = 0 + ½(3)(4)^2 = ½(3)(16) = 24 m

c) Greater acceleration allows an athlete to reach a higher speed in a shorter time. This provides a competitive advantage, especially at the start of a race.

Example 3: Elevator Motion (Engineering)
An elevator accelerates uniformly from rest to 4 m/s in 2 seconds.

a) Calculate the acceleration.

b) Explain why gradual acceleration is important.

Solution:

a) Given: u = 0, v = 4 m/s, t = 2 s

  Using: a = (v - u) / t

  a = (4 - 0) / 2 = 2 m/s²

b) Gradual acceleration ensures passenger comfort and safety. Sudden acceleration would cause passengers to lose balance and could result in injury.

Individual Practice (Students work independently)
Provide students with similar problems to solve:

7. 1. A student walks 10 m in 8 s. Another runs the same distance in 3 s. Calculate both speeds and explain how a PE teacher could use this information.
8. 2. A car travels at 20 m/s with driver reaction time of 1 s. Calculate reaction distance and explain why lower speed limits are enforced in pedestrian areas.
9. 3. Two cars at 25 m/s: Car A stops in 5 s, Car B stops in 8 s. Calculate accelerations, determine which has shorter stopping distance, and explain which braking system is more effective.

Phase 4: Assessment - Exit Ticket (5 minutes)
Students complete individually to demonstrate understanding:

Question 1: A cyclist travelling at 5 m/s takes 2 s to react and brake to a stop. A child runs into the road 12 m ahead.

10. a) State the equation relating distance, speed and time.
11. b) Calculate the cyclist's reaction distance.
12. c) Determine and explain whether the cyclist will stop before reaching the child.

Question 2: A delivery truck travels at 15 m/s. The driver has a reaction time of 1.5 seconds and can brake with deceleration of 5 m/s².

13. a) Calculate the reaction distance.
14. b) Calculate the braking distance.
15. c) Calculate the total stopping distance.
16. d) Recommend a safe following distance for this truck and justify your answer.

Exit Ticket Answer Key
Question 1:

a) Distance = speed × time

b) Reaction distance = 5 × 2 = 10 m

c) Yes, the cyclist will stop before reaching the child. The reaction distance of 10 m is less than the 12 m available, leaving a safety margin of 2 m.

Question 2:

a) Reaction distance = 15 × 1.5 = 22.5 m

b) Using $v^2 = u^2 + 2as$: $0^2 = 15^2 + 2(-5)s$, s = 225/10 = 22.5 m

c) Total stopping distance = 22.5 + 22.5 = 45 m

d) Safe following distance should be at least 50-60 m (allowing for safety margin beyond stopping distance) to ensure the truck can stop safely if the vehicle ahead brakes suddenly.

Differentiation Strategies

For Struggling Learners:
- • Provide formula sheets with equations of motion
- • Break problems into smaller steps with guided questions
- • Use visual aids showing reaction and braking phases
- • Allow calculators for all calculations
- • Provide worked examples as reference
- • Focus on one application area (transportation) before introducing others

For Advanced Learners:
- • Introduce more complex scenarios with multiple phases of motion
- • Explore non-uniform acceleration problems
- • Investigate real-world data from crash tests or sports analytics
- • Design their own safety analysis for a local road
- • Research how different road conditions affect braking distance
- • Calculate energy dissipation during braking

Extension Activity

Real-World Safety Analysis Project
Objective: Apply linear motion principles to analyze safety in a real-world context.

Activity Description:

17. 1. Choose a real-world scenario (select one):

- • School zone speed limit analysis
- • Pedestrian crossing safety assessment
- • Sports performance optimization (100m sprint)
- • Elevator design for a building

18. 2. Collect relevant data (speeds, distances, times, accelerations).
19. 3. Apply linear motion equations to analyze the scenario.
20. 4. Calculate key values (stopping distances, velocities, accelerations).
21. 5. Make safety recommendations based on calculations.
22. 6. Present findings to the class with visual aids.

Community Engagement
Students can:

- • Survey local roads and identify potential safety improvements
- • Interview traffic police or road engineers about how they use motion principles
- • Create awareness posters about stopping distances for school zones
- • Present findings to school administration or local government

Post-Lesson Reflection for Teachers
- • Did students successfully apply motion equations to real-world problems?
- • Were students able to interpret their calculations in terms of safety?
- • What misconceptions emerged about stopping distances?
- • How engaged were students with the real-world context?
- • Did the anchor activity effectively introduce practical applications?
- • What adjustments are needed for future lessons on this topic?