### Unit 5

**Linear Relations: Constant Rate of Change, Initial Condition, Direct and Partial Variation**

#### Lesson Outline

**BIG PICTURE**

Students will:
- connect physical movement to resulting distance/time graphs;
- describe linearly related data graphically, in words and algebraically;
- describe linearly related data using initial condition and constant rate of change.

<table>
<thead>
<tr>
<th>Day</th>
<th>Lesson Title</th>
<th>Math Learning Goals</th>
<th>Expectations</th>
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<tr>
<td>1</td>
<td>Match Me!</td>
<td>• Use Calculator Based Ranger (CBR™) and graphing calculators to analyse motion graphs in terms of starting position, direction of motion, and rate of change (speed).</td>
<td>LR4.02, LR4.05, CGE 5a, 7i</td>
</tr>
<tr>
<td>2</td>
<td>Story Graphs</td>
<td>• Write stories related to piecewise graphs; demonstrate the connection between the position, direction, speed, and shape of the graph. • Investigate a variety of graphs in contexts with respect to rate of change, e.g., filling containers, raising a flag, temperature.</td>
<td>LR4.02, LR4.05, CGE 2d</td>
</tr>
<tr>
<td>3</td>
<td>Ramps, Roofs, and Roads</td>
<td><em>Presentation file: Rate of Change</em> • Examine rate of change in a variety of contexts. • Calculate rate of change using ( \frac{\text{rise}}{\text{run}} ) and connect to the unit rate of change. • Convert fractions ( \leftrightarrow ) decimals ( \leftrightarrow ) percents.</td>
<td>NA1.06, LR3.01, CGE 2c, 3c, 5a</td>
</tr>
<tr>
<td>4</td>
<td>Models of Movement</td>
<td>• Use rate of change to calculate speed in distance-time graphs. • Write stories with speed calculations.</td>
<td>NA1.06, LR3.01, LR4.02, CGE 3c, 5g</td>
</tr>
<tr>
<td>5</td>
<td>The Bicycle Trip</td>
<td>• Assess students’ ability to connect representations of linear relations and solve problems using a quiz. • Write a story to make literacy connections.</td>
<td>LR4.02, LR4.05, CGE 5a, 5e</td>
</tr>
<tr>
<td>6</td>
<td>Tables of Values, Equations, Graphs</td>
<td>• Make tables of values, equations, and graphs from descriptions of situations. • Compare the properties of direct and partial variation in applications and identify the initial value.</td>
<td>LR3.03, LR3.04, CGE 5b</td>
</tr>
<tr>
<td>7</td>
<td>Walk the Line</td>
<td>• Use the graphing calculator and CBR™ to collect linear motion data in order to determine the equation using the starting distance and walking rate. • Use technology to verify the equation. • Model linear relations with equations using the initial value and rate of change.</td>
<td>LR3.03, LR3.04, LR3.05, CGE 5a, 7i</td>
</tr>
<tr>
<td>8</td>
<td>Modelling Linear Relations with Equations</td>
<td>• Write equations representing linear relations from descriptions, tables of values, and graphs. • Review concepts of continuous and discrete data.</td>
<td>LR3.03, LR3.04, LR3.05, LR4.03, CGE 5a, 5b</td>
</tr>
<tr>
<td>9</td>
<td>Graphing Linear Relations in Context</td>
<td>• Given an equation in context, graph the relationship. • Graph linear relations using initial value and rate of change. • Identify initial value and rate of change from equations representing linear relations.</td>
<td>LR2.01, LR3.03, LR3.04, LR3.05, LR4.03, CGE 3c, 5a, 5e</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Instructional Jazz**

**Assessment**
**Unit 5: Day 1: Match Me!**

**Math Learning Goals**
- Use Calculator Based Ranger (CBR™) and graphing calculators to analyse motion graphs in terms of starting position, direction of motion, and rate of change (speed).

**Materials**
- viewscreen
- graphing calculators
- BLM 5.1.1, 5.1.2

**Assessment Opportunities**
- Minds On ... Whole Class
  - **Demonstration**
    Using the CBR™ (motion detector), graphing calculator, and viewscreen, with a student volunteer demonstrate connections between the shape and position of the graph and the direction, speed (including stopped), and starting position of their walk. Before each walk, students predict what they think the graph will look like and draw the actual graph after the walk (BLM 5.1.1).

- Action! Pairs → Peer Coaching
  - Students investigate the connection between the shape and position of the graph and the direction, speed, and starting position by using the “DIST MATCH” application of the Ranger program (BLM 5.1.2). One student reads the graph and gives walking instructions to a partner who cannot see the graph. They reverse roles.
  - Students match as many graphs as possible in the allotted time.

- Consolidate Debrief
  - Whole Class → Summarizing
    Discuss the key understandings involving the starting position relative to the CBR™, direction of walk, speed of the walk.
  - Whole Class → Exploration
    - **Learning Skill (Teamwork/Initiative)/Observation/Rating Scale:** Assess students’ ability to work collaboratively and to take initiative.
    - Check that students understand the difference between the path walked and shape of the graph by asking students to predict which alphabet letters can be walked, e.g., a student could make the letter “w” but the letter “b” is not possible. Ask students to explain why.
    - Discuss which letters of the alphabet can be “walked” using the CBR™.
    - Students use a CBR™ to verify/disprove predictions about the shape of distance time graphs.

- Home Activity or Further Classroom Consolidation
  - **Concept Practice**
    Draw a graph to match the following descriptions:
    - Stand 4 metres from the CBR™ and walk at a constant rate towards the CBR™ for 5 seconds. Stand still for 3 seconds then run back to the starting position.
    - Begin 0.5 metres from the CBR™, run away for 3 seconds at a constant rate, then gradually slow down until you come to a complete stop.
5.1.1: Walk This Way

1. Student walks away from CBR™ (slowly).

2. Student walks towards CBR™ (slowly).

3. Student walks very quickly towards CBR™.
5.1.1: Walk This Way (continued)

4. Student increases speed while walking towards the CBR™.

5. Student decreases speed while walking away from the CBR™.

6. Student walks away from ranger, at 2 metres stops for 5 seconds, then returns at the same pace.
5.1.2: CBR™: DIST MATCH Setup Instructions

You will need:
- 1 CBR™ with linking cable
- 1 graphing calculator

Insert one end of linking cable FIRMLY into CBR™ and the other end FIRMLY into graphing calculator.

Setting up the DIST MATCH Application

Press the APPS key
Select 2: CBL/CBR
Press ENTER
Select 3: RANGER
Press ENTER

You are at the MAIN MENU
Select 3: APPLICATIONS
Select 1: METERS
Select 1: DIST MATCH
Follow the directions on the screen.

If you are not happy with your graph,
Press ENTER
Select 1: SAME MATCH to try again

If you would like to try a different graph to match,
Press ENTER
Select 2: NEW MATCH

Select 5: Quit to quit
Part One: Walk the Line

Draw your graph.

Copy the scale markings on the distance and time axes from your calculator. Mark your start and finish position on the graph using the coordinates Time and Distance. Connect the start and finish position with a line made with your ruler.

Calculate the rate of change of the graph (speed of your walk).

Draw a large right-angled triangle under the graph and label it with the height as the rise and the base as the run. Show the lengths of each.

Calculate the rate of change of your walk using the formula: \[ \text{rate of change} = \frac{\text{rise}}{\text{run}} \]

Complete the following:

a) The rate of change of my walk is ________________.

b) The speed of my walk is ________________ m/s away from the CBR™.
5.1.2: CBR™: DIST MATCH Setup Instructions (continued)

Describe your walk.

Use your starting position and rate of change to write a walking description statement:

I started ____ metres from the CBR™ and walked away from it at a speed of ____ metres per second.

After 10 seconds, I was ____ ____ from the motion detector.

At this rate, estimate how far you would have walked after 30 seconds.

Construct an equation to model your walk.

Read this walking statement:

A student started 0.52 metres from the CBR™ and walked away at a speed of 0.19 metres/second.

The equation \( D = 0.52 + 0.19t \) models the student’s distance, \( D \), from the CBR™ after \( t \) seconds.

To graph it on the graphing calculator use: \( Y = 0.52 + 0.19x \).

Write a walking statement and equation for your walk:

_____________ started ____ from the CBR™ and walked away at a speed of ____ metres/sec.

The equation __________________________ models my position from the CBR™.

The graphing calculator equation is ____________________.
Verify your equation of your walk using the graphing calculator.

Turn off the STATPLOT

Type your equation into the Y = editor

Graph your equation (Press: GRAPH)

Turn on the STATPLOT. Press GRAPH again.

Change the numbers in your Y = equation until you get the best possible match for the graph you walked.

The best equation that matches your walk is: ___________________.
Use the equation to solve problems.
The equation $D = 0.52 + 0.19t$ models the student’s position from the CBR™. We can calculate the student’s distance from the CBR™ after 30 seconds:

\[
D = 0.52 + 0.19t \\
D = 0.52 + (0.19)(30) \\
D = 0.52 + 5.7 \\
D = 6.22
\]

The student will be 6.22 metres from the CBR™ after 30 seconds.

Calculate your position from the CBR™ after 30 seconds:

a) The equation ____________________ models your position from the CBR™ (from previous page).

b) Calculate your distance from the CBR™ after 30 seconds.

Check your answer with your graph.

First, turn off the STATPLOT

Next, press: GRAPH

Then press: TRACE

Arrow right until you reach 30 seconds.

Record the distance the CBR™ displays for 30 seconds _________.

How does this compare with your answer using the equation?

________________________________________________________________

How does this answer compare with your estimate at the beginning of the activity?

________________________________________________________________
Part Two: Walk Another Line

Draw your graph.

Copy the scale markings on the distance and time axes from your calculator. Mark your start and finish position on the graph using the coordinates Time and Distance. Connect the start and finish position with a line made with your ruler.

________________________’s Walk

Calculate the rate of change of the graph (speed of your walk).

Hint: The rise will be a negative number!

Draw a large right-angled triangle under the graph and label it with the rise and run values. Calculate the rate of change using the formula: \( \text{rate of change} = \frac{\text{rise}}{\text{run}} \).

Complete the following:
The rate of change of my walk is ________________.

The speed of my walk is ________________ m/s away from the CBR™.
Describe your walk.

Use your initial position and rate of change to write a walking description statement:

I started _____ metres from the CBR™ and walked towards it at a speed of _____ metres per second. After 10 seconds, I was _____ from the motion detector.

At this rate, how far would you have walked after 30 seconds?

Construct an equation to model your walk.

Read this walking statement:

A student started 4 metres from the CBR™ and walked towards it at a speed of 0.32 metres/second.

The equation $D = 4 - 0.32t$ models the student’s position from the CBR™.

To graph it on the graphing calculator use: $Y = 4 - 0.32X$.

Write a walking statement and equation for your walk:

_______________ started ____ metres from the CBR™ and walked towards it at a speed of _____ metres per second.

The equation ___________________________ models my position from the CBR™. To graph it on the graphing calculator use: ________________________.

Verify your equation with your walk using the graphing calculator.

Remember that you can change the numbers in your $Y =$ equation until you get the best possible match for the graph you walked.

The best equation that matches your walk is: ________________.
TIPS4RM: Grade 9 Applied – Unit 5: Linear Relations

Unit 5: Day 2: Story Graphs

Math Learning Goals
- Write stories related to piecewise graphs; demonstrate the connection between the position, direction, speed, and shape of the graph.
- Investigate a variety of graphs in contexts with respect to rate of change, e.g., filling containers, raising a flag, temperature.

Materials
- overhead projector
- BLM 5.2.1, 5.2.2, 5.2.3, 5.2.4

Assessment Opportunities

Minds On ...

Whole Class → Discussion
Explain the activity on BLM 5.2.1. Answer any questions. Use BLM 5.2.2 to discuss what their stories must include.
Stress the difference between constant rate of change and variable rate of change.

Action!

Pairs → Note Making/Presentation
Using one of the graphs from BLM 5.2.3, students work in pairs to write a story and orally present it to the class.
Encourage students to think beyond the distance-time graphs done on the CBR™ and think about raising a flag, filling containers, etc. Show some examples.
Note: Most students will find it easier to think of time as the independent variable rather than some other measure.
Curriculum Expectation/Observation/Checklist: Use BLM 5.2.2 as a tool to assess communication.

Consolidate Debrief

Whole Class → Discussion
Review the graphs with students and clarify any information that students may have misinterpreted (BLM 5.2.3).
Curriculum Expectation/Observation/Checklist: Assess student ability to use proper conventions for graphing.

Home Activity or Further Classroom Consolidation

Concept Practice Application
Complete worksheet 5.2.4, Interpreting Graphs.

Word Wall
increasing rapidly
increasing slowly
decreasing rapidly
decreasing slowly
contant rate of change
varying rate of change

See Think Literacy, Mathematics, pages 62–68 for more information on reading graphs.

NCTM has many activities that relate to rates of change and graphs at www.nctm.org.
5.2.1: Graphical Stories

Below the following graphs are three stories about walking from your locker to your class.

**Two** of the stories correspond to the graphs. Match the graphs and the stories. Write stories for the other two graphs. Draw a graph that matches the third story.

1. I started to walk to class, but I realized I had forgotten my notebook, so I went back to my locker and then I went quickly at a constant rate to class.

2. I was rushing to get to class when I realized I wasn’t really late, so I slowed down a bit.

3. I started walking at a steady, slow, constant rate to my class, and then, realizing I was late, I ran the rest of the way at a steady, faster rate.
5.2.2: Writing Stories Related to a Graph

Names:

As you create your story: Focus on the rate of change of each section of the graph and determine whether the rate of change is constant, varying from fast to slower or slow to faster or zero.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does your story include:</td>
<td></td>
</tr>
<tr>
<td>• the description of an action? (e.g., distance travelled by bicycle, change of height of water in a container, the change of height of a flag on a pole)</td>
<td>✓</td>
</tr>
<tr>
<td>• the starting position of the action?</td>
<td></td>
</tr>
<tr>
<td>• the ending position of the action?</td>
<td></td>
</tr>
<tr>
<td>• the total time taken for the action?</td>
<td></td>
</tr>
<tr>
<td>• the direction or change for each section of the action?</td>
<td></td>
</tr>
<tr>
<td>• the time(s) of any changes in direction or changes in the action?</td>
<td></td>
</tr>
<tr>
<td>• the amount of change and time taken for each section of the action?</td>
<td></td>
</tr>
<tr>
<td>• an interesting story that ties all sections of the graph together?</td>
<td></td>
</tr>
</tbody>
</table>

Scale your graph, and label each axis!
5.2.3: Oral Presentation Story Graphs
5.2.4: Interpretations of Graphs

Sunflower Seed Graphs
Ian and his friends were sitting on a deck and eating sunflower seeds. Each person had a bowl with the same amount of seeds. The graphs below all show the amount of sunflower seeds remaining in the person’s bowl over a period of time.

Write sentences that describe what may have happened for each person.

Multiple Choice
Indicate which graph matches the statement. Give reasons for your answer.

1. A bicycle valve’s distance from the ground as a boy rides at a constant speed.

2. A child swings on a swing, as a parent watches from the front of the swing.
Unit 5: Day 3: Ramps, Roofs, and Roads

Math Learning Goals
- Examine rate of change in a variety of contexts.
- Calculate rate of change using \( \frac{\text{rise}}{\text{run}} \) and connect to the unit rate of change.
- Convert fractions ↔ decimals ↔ percents.

Materials
- computer/data projector
- BLM 5.3.1

Assessment Opportunities
- Rate of Change.ppt
  - If a projection unit is not available, the pages in the electronic presentation can be made into transparencies.

Minds On ...
Whole Class → Demonstration
Review converting between fractions, decimals, and percents.
Show the Rate of Change electronic presentation, summarizing the main ideas. Students make notes.
With the students, complete the first example, Ramps, and the first two table rows on Roads (BLM 5.3.1).

Action!
Pairs → Problem Solving
Students complete each page of BLM 5.3.1 in pairs and share answers in groups of four.
Learning Skill (Work habits)/Observation/Anecdotal: Observe students’ work habits and make anecdotal comments.

Consolidate Debrief
Whole Class → Sharing
Select students to share their answers to BLM 5.3.1. Draw out the mathematics, and clear up any misconceptions.

Home Activity or Further Classroom Consolidation
- Complete rate of change practice questions.
- In your journal, give an example of where rate of change occurs in your home.

Concept Practice Journal

Word Wall
- pitch
- grade
- ramp incline
- rate of change = \( \frac{\text{rise}}{\text{run}} \)
5.3.1: Ramps, Roofs, and Roads

### Ramps

<table>
<thead>
<tr>
<th>Types of inclines and recommendations by rehabilitation specialists</th>
<th>Rise (Vertical Distance)</th>
<th>Run (Horizontal Distance)</th>
<th>Rate of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>The recommended incline for wheelchair uses is 1:12.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For exterior ramps in climates where ice and snow are common, the incline should be more gradual, at 1:20.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For unusually strong wheelchair users or for motorized chairs, the ramp can have an incline of 1:10.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The steepest ramp should not have an incline exceeding 1:8.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Building Ramps

Which of four ramps could be built for each of the clients below?

1.  

2.  

3.  

4.  

<table>
<thead>
<tr>
<th>Clients</th>
<th>Choice of Ramp and Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client A lives in a split-level town house. He owns a very powerful motorized chair. He wishes to build a ramp that leads from his sunken living room to his kitchen on the next level.</td>
<td></td>
</tr>
<tr>
<td>Client B requires a ramp that leads from her back deck to a patio. She is of average strength and operates a manual wheelchair.</td>
<td></td>
</tr>
<tr>
<td>Client C lives in Sudbury where ice and snow are a factor. She is healthy, but not particularly strong. Her house is a single level bungalow but the front door is above ground level.</td>
<td></td>
</tr>
<tr>
<td>Client D will not get approval because the design of his ramp is too dangerous.</td>
<td></td>
</tr>
</tbody>
</table>
5.3.1: Ramps, Roofs, and Roads (continued)

Roofs
Calculate the rate of change (pitch) of each roof. Answer the questions that follow the diagrams.

1. If all four roofs were placed on the same-sized foundation, which roof would be the most expensive to build?
   **Hint:** Steeper roofs require more building materials.

2. Why do you think apartment buildings have flat roofs? What is the rate of change of a flat roof?

3. In the winter snow builds up on the roof. Sometimes, if the snow builds up too high, the roof becomes damaged. Which roof would be the best for areas that have a large amount of snowfall? Why?
5.3.1: Ramps, Roofs, and Roads (continued)

Roads
The inclination of a road is called “percent grade.” Severe grades (greater than 6%) are difficult to drive on for extended amounts of time. The normal grade of a road is between 0% and 2%. Warning signs are posted in all areas where the grades are severe.

<table>
<thead>
<tr>
<th>Percent grade</th>
<th>Fraction</th>
<th>Rise</th>
<th>Run</th>
<th>Rate of change (decimal form)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td>0.035</td>
</tr>
<tr>
<td>D</td>
<td>4%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td>525</td>
<td>10000</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>(\frac{3}{50})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>H</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>J</td>
<td></td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>(\frac{2}{5})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>8.25%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which of the roads, A–L, would require a warning sign?

Some of the values in the table are fictional. There are no roads that have grades that are that severe. Which roads, A–L, could not exist? Explain your reasoning.

Describe a road with a 0% grade.
Rate of Change

Rate of Change of a Linear Relationship

The rate of change of a linear relationship is the steepness of the line.

Rates of change are seen everywhere.

The steepness of the roof of a house is referred to as the pitch of the roof by home builders.

Give one reason why some homes have roofs which have a greater pitch.

There is less snow buildup in the wintertime.

Engineers refer to the rate of change of a road as the grade.

A grade of 8% would mean for every rise of 8 units there is a run of 100 units.

Rate of change = \frac{8}{100} = 8\%

They often represent the rate of change as a percentage.

The steepness of wheelchair ramps is of great importance for safety.

Rate of change of wheelchair ramp = \frac{1}{12}

If the rise is 1.5 m, what is the run?

Answer: 18 m because \frac{1}{12} \times 18 = \frac{1.5}{2}

Determine the rate of change (pitch) of the roof.

rate of change = \frac{5}{3}

Determine the rate of change of each staircase.

rate of change = \frac{2}{3}

rate of change = \frac{3}{3} = 1

Determine the rate of change.

Which points will you use to determine rise and run?
rate of change = \frac{rise}{run}
rate of change = \frac{5}{4}
rate of change = \frac{20}{4} = 5 \text{$/hr}$

What does this rate of change represent?

The hourly wage.
Math Learning Goals
- Use rate of change to calculate speed on distance-time graphs.
- Write stories with speed calculations.

Materials
- BLM 5.4.1, 5.4.2, 5.4.3

Assessment Opportunities

Minds On ...
Whole Class → Demonstration
Demonstrate how to calculate rate of change on a distance-time graph using BLM 5.4.1
First complete the scale to reinforce that each unit is not worth 1, as in the previous lesson.
For example, the first calculation would be
\[
\text{rate of change } AB = \frac{800 \text{ m}}{5 \text{ min}} = 160 \text{ m/min or } 9.6 \text{ km/h}
\]
\[
\frac{800 \text{ m}}{5 \text{ m}} = \frac{160 \text{ m}}{1 \text{ m}}
\]
\[
\frac{160 \times 60}{1 \times 6} = \frac{9600 \text{ m}}{1 \text{ h}}
\]
\[
= 9.6 \text{ km/h}
\]
Reinforce that they must look at the scale, rather than count the squares.

Action!
Individual/Pairs → Problem Solving
Students complete BLM 5.4.2 individually, then they compare their answers with their partner.

Learning Skill (Works Independently)/Observation/Anecdotal: Observe students’ ability to work independently.

Consolidate Debrief
Whole Class → Connections
Review students’ answers. Make a connection between the rate of change of the graph and the speed and direction of motion.
Guiding questions:
- If the rate of change is negative, what does that tell us about the direction the person is moving?
- If the rate of change is zero, what does that tell us about the motion?
- What does the point (20, 600) represent?
- What does the graph look like if the rate of change is constant?
- Ask a student to read their story about Micha’s journey.

With students, sketch a graph.
Example: A flag is at half mast and is lowered at 85 cm/min. Together, describe the effect on the graph of:
- a) lowering the flag at 50 cm/min.
- b) starting the flag at the top of the flag pole and lowering at 85 cm/min.

Home Activity or Further Classroom Consolidation
Concept Practice
Complete worksheet 5.4.3, The Blue Car and the Red Car.
5.4.1: A Runner’s Run

Chris runs each day as part of his daily exercise. The graph shows his distance from home as he runs his route.

![Graph showing distance vs. time](image)

Calculate his rate of change (speed) for each segment of the graph.
5.4.2: Models of Movement

At 11 o’clock, Micha’s mother sends him to the corner store for milk and tells him to be back in 30 minutes. Examine the graph.

1. Why are some line segments on the graph steeper than others?

2. Calculate the rate of change (speed) of each of the line segments:
   - Rate of change AB =
   - Rate of change BC =
   - Rate of change CD =
   - Rate of change DE =
   - Rate of change EF =
   - Rate of change FG =
3. Over what interval(s) of time is Micha travelling the fastest?

the slowest?

Compare steepness, not direction.

4. How long did it take Micha to reach the store? How do you know?

5. How long did Micha stay at the store?

6. How long did it take Micha to get home from the store?

7. How can you use the graph to tell which direction Micha is travelling?

8. Did Micha make it home in 30 minutes? How do you know?

9. Using the information the graph provides, write a story that describes Micha’s trip to the store and back.
5.4.3: The Blue Car and the Red Car

Two friends are leaving a parking lot at the same time. They agree to meet later at the home of a friend who lives 400 km from the parking lot. One friend drives a blue car and the other a red car. The blue car is labelled B and the red car, R. Answer the questions below using the following graph.

1. At what time do the cars pass each other? How far are they from the parking lot?

2. Which car stopped and for how long? How far from the parking lot did the car stop?

3. Suggest reasons for the car stopping.

4. Which car got to the final destination first? Explain.

5. The posted speed limit was 80 km/h. If you were a police officer, could you stop either of the cars for speeding? Explain.
Unit 5: Day 5: The Bicycle Trip

Math Learning Goals
- Assess students’ ability to connect representations of linear relations and solve problems using a quiz.
- Write a story to make literacy connections.

Whole Class → Discussion
Take up the students’ work from the Home Activity, The Blue Car and the Red Car (BLM 5.4.3). Students mark their own work. Describe the assessment task (BLM 5.5.1 and 5.5.2) and answer any questions.

Individual → Assessment
Curriculum Expectations/Quiz/Marking Scheme: Assess students’ understanding of concepts.

Students complete the quiz independently (BLM 5.5.2). Circulate to give support.

Once students have handed in the quiz, they can start writing their bicycle trip story (BLM 5.5.1).

Pairs → Check for Understanding
Students will give feedback on how to improve their story by peer editing each other’s work. Provide criteria for editing this graphical story.

Suggested criteria:
- Does the story include references to position, direction, speed, and time?
- Does the story indicate when the rate of change is constant?
- Does the story make sense?
- Does the story include reasons to explain each segment of the graph?

In providing feedback, peers suggest one criterion that was well done and one criterion for improvement.

Home Activity or Further Classroom Consolidation
Revise your bicycle trip story and make a final copy.

Concept Practice

Materials
- BLM 5.5.1
- BLM 5.5.2 (quiz)

Assessment Opportunities

For some students you may want to accept oral answers to some questions.

Use a coloured pen to identify what you helped the student with.

Collect the stories to give feedback to students.
5.5.1: The Bicycle Trip

Mary and Carolyn set out for a bicycle trip. The distance-time graph shows their progress as they reach their destination.

Write a story that describes their trip. This could be a play-by-play sportscast.

Details you should include:
- times they were together/apart, stopped, or going faster/slower
- possible events explaining the different sections of the graphs
- references to time and distance, as well as your calculations of speeds in a narrative style
- comparisons and contrasts

Write a creative story as you use the information in the graph.
5.5.2: Quiz

Rate of Change and Story Graphs

Name: ____________________________

1. Devin went for a bicycle ride. The graph below shows his trip. 
   **Note:** Distance is the number of kilometres from home.

(4) a) Calculate his speed during the first hour (AB) and the second hour (BC). Show your work.

(2) b) How does the speed between A and B compare with the speed between B and C?

(2) c) Explain what segment CD tells you about Devin’s motion.

(2) d) Which section of the graph shows that Devin was changing speeds? Explain.

(2) e) What information can you determine from segment EF?
5.5.2: Quiz (continued)

(10) 2. Sketch the graph that is described in each story.
   a) Begin 5 metres from the sensor.
      Walk towards the sensor for 6 seconds at a steady rate of 1 metre in 2 seconds.
      Stop for 5 seconds.
      Run back to your starting position at a steady rate of 1 metre per second.
      Stop.

   b) Begin at the sensor.
      Walk very slowly at a steady rate away from the sensor for 3 seconds.
      Increase your speed and walk at this new speed for 3 seconds.
      Stop for 3 seconds.
      Walk very slowly at a steady rate towards the sensor for 3 seconds.
      Gradually increase your speed to a run and go back to the sensor.

(3) 3. If a wheelchair ramp has a rate of change (incline) greater than 0.1, then it is considered unsafe.

      Determine whether or not each of the following ramps is safe.
      Show your work and explain your reasoning.
TIPS4RM: Grade 9 Applied – Unit 5: Linear Relations

**Unit 5: Day 6: Tables of Values, Equations, Graphs**

**Math Learning Goals**
- Make tables of values, equations, and graphs from descriptions of situations.
- Compare the properties of direct and partial variation in applications and identify the initial value.

**Materials**
- BLM 5.6.1, 5.6.2
- overhead projector

**Assessment Opportunities**

**Minds On ...**

**Pairs → Brainstorm**
Brainstorm scenarios in which there is an initial condition and a rate. For example: Taxis charge a base amount, plus a cost per kilometre.

Brainstorm everyday situations where there is an initial condition and a rate.
Examples that students may suggest:
- ice cream cone plus extra scoops
- pizza (pizza plus toppings)
- rentals (item plus time or distance)
- repairs and service (base amount plus hourly rate)
- memberships (membership plus user fees)

Work through the questions with the students (BLM 5.6.1).

**Action!**

**Pairs → Applying Knowledge**
Students work in pairs to complete BLM 5.6.2.

Students should connect the verbal description, the calculations in the table, the graph, and the equation.

**Learning Skill/Observation/Checklist:** Assess student ability to choose an appropriate scale for their graph.

**Consolidate Debrief**

**Whole Class → Connecting**
Using BLM 5.6.1, connect each of the models to one another.
- **Description:** Highlight the base fee and the fee per hour.
- **Table of Values:** Show how the numbers increase and connect to rate.
- **Graph:** Identify the initial value and calculate the rate of change.
- **Equation:** Connect the numbers to the description. Reinforce the fact that the rate is the one with the variable.

**Home Activity or Further Classroom Consolidation**
Highlight the connections you made on worksheet 5.6.2 during the class discussion.
Jaraad wants to rent a canoe for a day trip. He gathers this information from two places and decides to make a table of values and graph each of these relationships.

- Big Pine Outfitters charges a base fee of $40 and $10 per hour of use.
- Hemlock Bluff Adventure Store does not charge a base fee, but charges $30 per hour to use the canoe.

**Jaraad’s Working Sheet**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Big Pine Cost ($)</th>
<th>Hemlock Bluff Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40 + 10(0) = 40</td>
<td>30(0) = 0</td>
</tr>
<tr>
<td>1</td>
<td>40 + 10(1) = 50</td>
<td>30(1) = 30</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>90</td>
</tr>
</tbody>
</table>

1. a) What is the cost of each canoe if Jaraad cancels his reservation?

b) Compare the rate of change of cost for Big Pine and for Hemlock Bluff to the cost per hour for each outfitter.
2. Which graph illustrates a proportional relation? How do you know? This is called a direct variation.

3. Which graph has an initial value other than zero? This is called a partial variation.

4. Which outfitter company should Jaraad choose if he estimates he will canoe for 0.5 h? 1.5 h? 2.5 h?

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Big Pine Cost ($)</th>
<th>Hemlock Bluff Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explain how you determined your answers.
5.6.1: Outfitters (continued)

5. Write an equation to model the cost for each outfitter.
   Let $C$ represent the cost in dollars and $h$ represent the time in hours.

   Big Pine
   $C =$

   Hemlock Bluff
   $C =$

6. If Big Pine Outfitters decided to change its base fee to $50 and charge $10 per hour, what effect would this have on the graph?
   a) Draw a sketch of the original cost and show the changes on the same sketch.

   b) Write an equation to model the new cost.

7. If Hemlock Bluff Adventure Store decided to change its hourly rate to $40, what effect would this have on the graph?
   a) Draw a sketch of the original cost and show the changes on the same sketch.

   b) Write an equation to model the new cost.
8. For Big Pine Outfitters, how are the pattern in the table of values, the description, the graph, and the equation related?

**Description**
Big Pine Outfitters charges a base fee of $40 to deliver the canoe to the launch site and $10 per hour of use.

**Table of Values**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
</tbody>
</table>

**Equation**

\[ C = 40 + 10h \]

9. For Hemlock Bluff, how are the pattern in the table of values, the description, the graph, and the equation related?

**Description**
Hemlock Bluff charges $30 per hour.

**Table of Values**

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>90</td>
</tr>
<tr>
<td>4</td>
<td>120</td>
</tr>
</tbody>
</table>

**Equation**

\[ C = 30h \]
1. A rental car costs $50 per day plus $0.20 for each kilometre it is driven.
   a) What is the dependent variable?
   b) Make a table of values for the rental fee up to 1000 km.
   c) Graph the relationship.

<table>
<thead>
<tr>
<th>Number of Kilometres</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td></td>
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<td>700</td>
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<td></td>
</tr>
<tr>
<td>900</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td></td>
</tr>
</tbody>
</table>

   d) Write an equation to model the relationship. $C$ is the cost and $n$ is the number of kilometres.

   ____ = _______________

   e) Does this relation represent a partial or direct variation? Explain.

   f) Determine the rental fee for 45 km. Show your work.
2. There is $500 in Holly’s bank account. She takes out $50 from her account each month but doesn't put any back in.

   a) Make a table of values for up to 6 months.
   b) Graph the relationship.

   

   c) Write an equation to model the relationship.

   \[ \underline{____} = \underline{________} \]

   d) Does this relation represent a partial or direct variation? Explain.

   e) How much will Holly have in her account after 8 months? Show your work.

   f) How many months will have passed when Holly has $50 in her account? Show your work.
3. Nisha is just learning how to snowboard. White Mountain charges $10/hour for lessons and $40 for the lift ticket and snowboard rental.
   a) Make a table of values for up to 6 hours.
   b) Graph the relationship.

<table>
<thead>
<tr>
<th>Hours</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
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<tr>
<td>1</td>
<td>50</td>
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<td>60</td>
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<tr>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \text{Cost} = 10x + 40 \]

\[ x = \text{number of hours} \]

\[ \text{Cost} \]

\[ \text{Total Cost} \]

\[ \text{Cost} \]

\[ \text{Lessons} \]

\[ \text{Hours} \]

\[ \text{ticket} \]

\[ \text{rental} \]

\[ \text{Lessons} + \text{ticket} + \text{rental} \]

\[ \text{Total Cost} \]

\[ \text{Cost} \]

\[ \text{Lessons} \]

\[ \text{Hours} \]

\[ \text{ticket} \]

\[ \text{rental} \]

\[ \text{Total Cost} \]

\[ \text{Cost} \]

\[ \text{Lessons} \]

\[ \text{Hours} \]

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\[ \text{Lessons} \]

\[ \text{Hours} \]

\[ \text{ticket} \]

\[ \text{rental} \]

\[ \text{Total Cost} \]
5.6.2: Descriptions, Tables of Values, Equations, Graphs (continued)

4. Ishmal sells high-definition televisions. He is paid a weekly salary of 20% commission of his total weekly sales.
   a) Complete the table of values.          b) Graph the relationship.

<table>
<thead>
<tr>
<th>Weekly Sales ($)</th>
<th>Total Pay ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>200</td>
</tr>
<tr>
<td>2000</td>
<td>400</td>
</tr>
<tr>
<td>3000</td>
<td>600</td>
</tr>
<tr>
<td>4000</td>
<td>800</td>
</tr>
<tr>
<td>5000</td>
<td>1000</td>
</tr>
</tbody>
</table>

   c) Write an equation to model the relationship.

   ___ = ________________

   d) Does this relation represent a partial or direct variation? Explain.

   e) Determine Ishmal’s pay if his sales for the week were $8000. Show your work.

   f) Ishmal made $975. How much were his weekly sales? Show your work.
Math Learning Goals
- Use the graphing calculator and CBR™ to collect linear motion data in order to determine the equation using the starting distance and walking rate.
- Use technology to verify the equation.
- Model linear relations with equations using the initial value and rate of change.

Whole Class ➔ Discussion
With the help of a student volunteer (the walker), demonstrate walking away from a CBR™ to create a linear graph of a 10-second walk. Using the viewscreen calculator, project the graph for student viewing. Trace the graph, axes, and scale onto the paper. Demonstrate the construction of a right-angled triangle showing the rise and run under the graph. Mark the start and finish position using the coordinates (time, distance) of the points. Join the first and last point with a straight line. Discuss how to:
  - calculate the rate of change using the \( \frac{\text{rise}}{\text{run}} \) formula.
  - use the graph to extrapolate the distance from the CBR™ after 20 seconds.

Pairs ➔ Investigation
Learning Skill (Teamwork)/Observation/Checklist and Curriculum Expectations/Observation/Mental Note: Observe students as they complete their investigations.

Pairs support each other with the operation of the CBR™ experiment, e.g., running the Ranger Program, making sure the walking alley is clear as they complete BLM 5.7.1. Students write the motion equations using \( x \) for time and \( y \) for distance. Explain that they must write the equation in the form: distance = initial value + (rate of change) \( x \), so that the graphing calculator can be used. Discuss the issues that arise when collecting motion data when the walker is moving towards the CBR™.

Whole Class ➔ Connecting
Discuss what changes the students made to their equations in order to make a better match between the equation and the graph. Determine an equation for the demo graph constructed at the start of the lesson. Students exchange their work with a peer to verify their walking description statements match with their equations. Verify their understanding of “starting position” and “walking rate” by locating the graph and equation among the class set of work that begins the closest/farthest from the CBR™. Represent the fastest/slowest walk. Summarize how to model linear motion with an equation.

Home Activity or Further Classroom Consolidation
Record the walking description statements of five of your classmates. Create the graph and equation for each.
Use the information to determine the distance each classmate would be from the CBR™ after 30 seconds if they walked at a constant rate.
5.7.1: Walk the Line: Setup Instructions

You will need:
- 1 CBR™
- 1 graphing calculator
- 1 ruler

Connect your calculator to the CBR™ with the Link cable and follow these instructions:

<table>
<thead>
<tr>
<th>Setting up the RANGER Program</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Press the <strong>APPS</strong> key</td>
<td></td>
</tr>
<tr>
<td>Select 2: <strong>CBL/CBR</strong></td>
<td></td>
</tr>
<tr>
<td>Press <strong>ENTER</strong></td>
<td></td>
</tr>
<tr>
<td>Select 3: <strong>RANGER</strong></td>
<td></td>
</tr>
<tr>
<td>Press <strong>ENTER</strong></td>
<td></td>
</tr>
</tbody>
</table>

You are at the **MAIN MENU**.
Select 1: **SETUP/SAMPLE**

Use the cursor → and ↓ keys and the **ENTER** key to set-up the **CBR**:

<table>
<thead>
<tr>
<th>MAIN MENU</th>
<th>START NOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>REAL TIME:</td>
<td>no</td>
</tr>
<tr>
<td>TIME(S):</td>
<td>10</td>
</tr>
<tr>
<td>DISPLAY:</td>
<td>DIST</td>
</tr>
<tr>
<td>BEGIN ON:</td>
<td>[ENTER]</td>
</tr>
<tr>
<td>SMOOTHING:</td>
<td>none</td>
</tr>
<tr>
<td>UNITS:</td>
<td>METERS</td>
</tr>
</tbody>
</table>

Cursor up to **START NOW**

Press **ENTER** to start collecting data

1. Walk away at a steady pace.
2. Press **ENTER** then 5: **REPEAT SAMPLE** if necessary.
3. Press **ENTER** then 7: **QUIT** when you are satisfied with the graph.
4. Press **GRAPH**. This is the graph you will analyse.
Part One: Draw your graph.
Stand about 0.5 metres from the CBR™. Walk slowly away from the CBR™ at a steady pace.
• Copy the scale markings on the distance and time axes from your calculator.
• Mark your start and finish position on the graph using the coordinates Time and Distance.
• Connect the start and finish position with a line made with your ruler.

Calculate the rate of change of the graph (speed of your walk).
• Draw a right-angled triangle under the graph and label it with the rise and run values.

• Calculate the rate of change of your walk using the formula \( \text{rate of change} = \frac{\text{rise}}{\text{run}} \).

• Complete the following:
  a) The rate of change of my walk is ________________.
  b) The speed of my walk is ________________ m/s away from the CBR™.
Describe your walk.
Use your starting position and rate of change to write a walking description statement:

I started ____ metres from the CBR™ and walked away from it at a
speed of ____ metres per second.

After 10 seconds, I was ____ ____ from the motion detector.

At this rate, how far would you have walked after 30 seconds?

Construct an equation to model your walk.
Read this walking statement:

A student started 0.52 metres from the CBR™ and walked away at a speed
of 0.19 metres/second.

The equation $D = 0.52 + 0.19t$ models the student’s position from the CBR™.
To graph it on the graphing calculator use: $Y = 0.52 + 0.19x$.

Write a walking statement and equation for your walk:

____________ started _____ from the CBR™ and walked away at a speed of _____
metres/sec.

The equation __________________________ models my distance from the CBR™. The
graphing calculator equation is ____________________.
Verify your equation with your walk using the graphing calculator.

Turn off the STATPLOT.

Type your equation into the Y= editor

Graph your equation (Press: GRAPH)

Turn on the STATPLOT. Press GRAPH again.

Change the numbers in your Y = equation until you get the best possible match for the graph you walked.

The best equation that matches your walk is: ___________________.

The best equation that matches your walk is: ___________________.

TIPS4RM: Grade 9 Applied – Unit 5: Linear Relations 44
5.7.1: Walk the Line: Setup Instructions (continued)

Use the equation to solve problems.

The equation $D = 0.52 + 0.19t$ models the student’s distance away from the CBR™, over time.

We can calculate the student’s distance from the CBR™ after 30 seconds:

$D = 0.52 + 0.19t$

$D = 0.52 + (0.19)(30)$

$D = 0.52 + 5.7$

$D = 6.22$

The student will be 6.22 metres from the CBR™ after 30 seconds.

Now, calculate your distance from the CBR™ after 30 seconds:
(Use the best equation that matches your walk.)

a) The equation ____________________ models your distance from the CBR™.

b) Calculate your distance from the CBR™ after 30 seconds:

Check your answer with your graph.

First, turn off the STATPLOT

Next, press: GRAPH

Then press: TRACE

Arrow right until you reach 30 seconds.

Record the distance the CBR™ displays for 30 seconds _______.

How does this compare with your answer using the equation?

How does this answer compare with your estimate at the beginning of the activity?

Use your equation to calculate how long it will take to walk 1 km from the CBR™.
Part Two: Draw your graph.
Stand about 3 metres from the CBR™. Walk slowly towards the CBR™ at a steady pace.
- Copy the scale markings on the distance and time axes from your calculator.
- Mark your start and finish position on the graph using the coordinates Time and Distance.
- Connect the start and finish position with a line made with your ruler.

Calculate the rate of change of the graph (speed of your walk).
Draw a large right-angled triangle under the graph and label it with the rise and run values.

Calculate the rate of change using the formula: \( \text{rate of change} = \frac{\text{rise}}{\text{run}} \).

The rate of change of my walk is __________.

**Hint:** The rise will be a negative number! Why?

The speed of my walk is __________ m/s away from the CBR™.
Describe your walk.
Use your initial position and rate of change to write a walking description statement:

I started ______ metres from the CBR™ and walked towards it at speed
of _____ metres per second.

After 10 seconds, I was _____ from the motion detector.

At this rate, how far would you have walked after 30 seconds?

Construct an equation to model your walk.
Read this walking statement:

A student started 4 metres from the CBR™ and walked towards it at a speed
of 0.32 metres/second.

The equation \( D = 4 – 0.32t \) models the student’s position from the CBR™.

To graph it on the graphing calculator use: \( Y = 4 – 0.32x \).

Write a walking statement and equation for your walk:

__________started ____ metres from the CBR™ and walked towards it at a speed of
_____ metres per second.

The equation __________________________ models my distance from the CBR™. To graph
it on the graphing calculator use: ________________________.

Verify your equation with your walk using the graphing calculator.
Remember that you can change the numbers in your \( Y = \) equation until you get the best
possible match for the graph you walked.

The best equation that matches your walk is: _____________________
### Math Learning Goals
- Write equations representing linear relations from descriptions, tables of values, and graphs.
- Review concepts of continuous and discrete data.

### Materials
- BLM 5.8.1

#### Assessment Opportunities

<table>
<thead>
<tr>
<th>Minds On ...</th>
<th>Whole Class → Discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss some of the student responses to the Home Activity and point out the range of the CBR™ and how close to the CBR™ students should stand.</td>
<td></td>
</tr>
<tr>
<td>Using some of the examples generated in the brainstorming session (Day 6 and BLM 5.6.1), identify the initial values and the rates of change from the descriptions.</td>
<td></td>
</tr>
<tr>
<td>Briefly describe the activity (BLM 5.8.1) and answer any questions.</td>
<td></td>
</tr>
<tr>
<td>Complete the first page with the students.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Action!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pairs → Peer Coaching</td>
</tr>
<tr>
<td>Students work in pairs to complete BLM 5.8.1. A coaches B and B coaches A.</td>
</tr>
<tr>
<td>Students write the equation in the same manner that the line was described. (Dependent variable = initial value + rate of change × independent variable)</td>
</tr>
</tbody>
</table>

| Whole Class → Check for Understanding |
| Take up examples from the peer coaching activity. |
| Ask guiding questions: |
| - Notice that some graphs had dotted lines, while some had solid lines. Why? |
| - If you graphed the data found in the tables of values for which ones would you use a dotted line? |

<table>
<thead>
<tr>
<th>Consolidate Debrief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual → Presentation</td>
</tr>
<tr>
<td>Students create and answer their own questions (one description, one graph, and one table). Students present the graph of description and their equation to the class.</td>
</tr>
</tbody>
</table>

| Curriculum Expectations/Demonstration/Checklist: |
| Assess the students’ understanding as they present their graphs and equations. |

| Home Activity or Further Classroom Consolidation |
| Concept Practice Application |
| Journal: A pizza costs $9 plus $2 per topping. Discuss the effect on the graph of changing the initial cost to $10 and lowering the cost per topping to $1.50. |
5.8.1: Modelling Linear Relations with Equations

Food Frenzy

Partner A: ______________________ Partner B: _______________________

Write the equation for each relationship in the space provided. Show any calculations you made. Indicate if the relation is a partial or direct variation and whether the line modelling the relationship is solid or dashed.

<table>
<thead>
<tr>
<th>A coaches B</th>
<th>B coaches A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A family meal deal at Chicken Deluxe costs $26, plus $1.50 for every extra piece of chicken added to the bucket.</td>
<td>2. A Chinese food restaurant has a special price for groups. Dinner for two costs $24 plus $11 for each additional person.</td>
</tr>
</tbody>
</table>

3. 

4. 

5. | Number of Toppings | Cost of a Large Pizza ($) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>9.40</td>
</tr>
<tr>
<td>1</td>
<td>11.50</td>
</tr>
<tr>
<td>2</td>
<td>13.60</td>
</tr>
<tr>
<td>3</td>
<td>15.70</td>
</tr>
<tr>
<td>4</td>
<td>17.80</td>
</tr>
</tbody>
</table>

6. | Number of Scoops | Cost of Ice Cream with Sugar Cone ($) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.25</td>
</tr>
<tr>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>2</td>
<td>2.75</td>
</tr>
<tr>
<td>3</td>
<td>3.50</td>
</tr>
<tr>
<td>4</td>
<td>4.25</td>
</tr>
</tbody>
</table>
5.8.1: Modelling Linear Relations with Equations (continued)

Planning a Special Occasion

Partner A: ______________________ Partner B: _______________________

Write the equation for each relationship in the space provided. Show any calculations you made. Indicate if the relation is a partial or direct variation and describe why these variables are discrete.

<table>
<thead>
<tr>
<th>A coaches B</th>
<th>B coaches A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A banquet hall charges $100 for the hall and $20 per person for dinner.</td>
<td>2. The country club charges a $270 for their facilities plus $29 per guest.</td>
</tr>
</tbody>
</table>

3. **Cost of Holding a Wedding at a Hotel**

   ![Graph of cost vs. number of guests for weddings](image)

4. **Cost of Holding a Formal at a Banquet Hall**

   ![Graph of cost vs. number of guests for formal events](image)

5. **Number of Athletes | Cost of Attending a Hockey Tournament**

<table>
<thead>
<tr>
<th>Number of Athletes</th>
<th>Cost of Attending a Hockey Tournament</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>255</td>
</tr>
<tr>
<td>2</td>
<td>450</td>
</tr>
<tr>
<td>3</td>
<td>675</td>
</tr>
<tr>
<td>4</td>
<td>900</td>
</tr>
</tbody>
</table>

6. **Number of People | Cost of Holding an Athletic Banquet**

<table>
<thead>
<tr>
<th>Number of People</th>
<th>Cost of Holding an Athletic Banquet</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>20</td>
<td>275</td>
</tr>
<tr>
<td>40</td>
<td>475</td>
</tr>
<tr>
<td>60</td>
<td>675</td>
</tr>
<tr>
<td>80</td>
<td>875</td>
</tr>
</tbody>
</table>
5.8.1: Modelling Linear Relations with Equations (continued)

From Here to There

Partner A: ______________________ Partner B: _____________________

Write the equation for each relationship in the space provided. Show any calculations you made. Indicate if the relation is a partial or direct variation and whether the line modelling the relationship is solid or dashed.

<table>
<thead>
<tr>
<th>A coaches B</th>
<th>B coaches A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rent a car for the weekend costs $50 plus $0.16/km.</td>
<td>2. A race car travels at a constant speed of 220km/h. Write an equation for the total distance travelled over time.</td>
</tr>
</tbody>
</table>

3. [Depreciated Value of a Mid-size Car graph]

4. [Height of a Balloon graph]

5. | Distance (km) | Cost of a Taxi Fare ($) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.50</td>
</tr>
<tr>
<td>10</td>
<td>6.50</td>
</tr>
<tr>
<td>20</td>
<td>9.50</td>
</tr>
<tr>
<td>30</td>
<td>12.50</td>
</tr>
<tr>
<td>40</td>
<td>15.50</td>
</tr>
</tbody>
</table>

6. | Distance (km) | Cost of Bus Charter ($) |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>170</td>
</tr>
<tr>
<td>100</td>
<td>210</td>
</tr>
<tr>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>300</td>
<td>290</td>
</tr>
<tr>
<td>400</td>
<td>330</td>
</tr>
</tbody>
</table>
Math Learning Goals
- Given an equation in context, graph the relationship.
- Graph linear relations using initial value and rate of change.
- Identify initial value and rate of change from equation representing linear relations.

Materials
- BLM 5.9.1, 5.9.2, 5.9.3

Assessment Opportunities

Minds On ...
Whole Class → Discussion
Using BLM 5.9.1, discuss with students how to:
- write the equation given the description
- graph the equation using the initial value as the starting point, then from this point use the rate of change \( \frac{\text{rise}}{\text{run}} \) to build two more points on the line.
- connect the points.

Action!
Pairs → Investigation
Curriculum Expectations/Demonstration/Mental Note: Observe students’ ability to identify the initial value and use the rate of change to locate two more points.
Students work in partners to complete BLM 5.9.2.
Whole Class → Discussion
Guide a class discussion about appropriate scales on the axes, referencing BLM 5.9.2.
Pairs → Creating Graphs
Students coach each other as they complete the task. (BLM 5.9.2)
Learning Skill (Initiative)/Observation/Rating Scale: Observe student initiative in taking responsibility for their learning and their partner’s learning.

Consolidate Debrief
Whole Class → Connections
Discuss the benefits of using this method of graphing.
Help students articulate strategies for determining scales for the horizontal and vertical axes that will facilitate graphing.

Home Activity or Further Classroom Consolidation
Application
Complete the worksheet 5.9.3, Relationships: Graphs and Equations.
5.9.1: Graphing Linear Relations

A tennis club charges $25 initial membership fee plus $5 per day. The equation of this relation is $C = 25 + 5d$, where $C$ is the cost and $d$ is the number of days.

Indicate where the rate of change is displayed on the graph.

If the initial membership fee is changed to $15 and daily cost to $10, graph the new relation on the same grid.

Indicate the procedure you followed to graph the line.
5.9.2: The Speedy Way to Graph

Partner A ___________________________ Partner B___________________________

Write the equation for the relationship and graph the relationship.

1. A golf club charges an annual membership fee of $1000 plus $100 for a green fee to play golf.

   Equation:

2. Repair-It charges $60 for a service call plus $25/h to repair the appliance.

   Equation:

3. Movie House charges $5 to rent each DVD.

   Equation:

4. A kite is 15 m above the ground when it descends at a steady rate of 1.5 m/s.

   Equation:
Write the equation for the relationship and graph the relationship.

1. The Recreation Centre charges a monthly membership fee of $20 plus $5 per class. Show the relationship for one month.

2. Repair Window charges a $20 service fee plus $10/h to fix the window pane.

3. Yum-Yum Ice Cream Shop charges $0.50 for the cone plus $1 per scoop of ice cream.

4. A submarine model starts 6.5 m above the bottom of the pool. It gradually descends at a rate of 0.25 m/s.
5.9.3: Relationships: Graphs and Equations

Write the equation for the relationship and graph the relationship.

1. A taxi cab company charges $3.50 plus $0.50/km.
   Equation: 

2. Shelly has $250 in her bank account. She spends $10/week on snacks.
   Equation: 

3. Dino’s Pizza charges $17 for a party-sized pizza plus $2 per topping.
   Equation: 

4. Katie sells programs at the Omi Arena. She is paid 50 cents for every program she sells.
   Equation: 

Unit 5 Test

Name: ___________________ Date: ____________________

(2) 1. The graph describes Rami’s walk with a motion detector. Tell the story that describes this graph. Use distance away from the wall and times in your story.

2. A story is described in each question. Sketch the graph that describes the story in the screen provided.

(2) a) Begin 5 metres from the wall. Walk towards the wall for 5 seconds. Stop for 5 seconds. Run back to your starting position. Stop.

(2) b) Begin at the wall. Walk very slowly away from the wall for 3 seconds. Increase your speed for 3 seconds. Stop for 3 seconds. Walk very slowly towards the wall for 3 seconds. Run back to the wall. Stop.

(2) 3. Jen tried her new snowboard at the One Plank Only Resort. The graph shows her first run. Tell the story that describes Jen’s first run.
(4) 4. If a wheelchair ramp has a rate of change greater than 0.1 in size, then it is considered unsafe. Determine whether or not each of the following ramps is safe. Show your work and explain your reasoning.

![Ramp Diagram](Image)

(2) 5. Calculate the rate of change of the staircase from A to B.

![Staircase Diagram](Image)
6. Arcadia charges players a $15 admission fee to their gaming centre. Arcadia also charges each player $5 per game.

(2) a) Write an equation to model the cost of playing games at Arcadia.

(2) b) What is the rate of change for this relation and how does it relate to the cost of playing games at Arcadia?

(2) c) What is the initial value for this relation and how does it relate to the cost of playing games at Arcadia?

(4) d) Graph the relation.

(1) e) How many games can Jeremy play if he has saved $60 for a day at Arcadia?

(1) f) How much will it cost Renay to spend a day at Arcadia if she plays 30 games?

(2) g) How would the graph from a) change if Arcadia decreases the admission fee to $10? Write an equation that represents the new cost of a day spent gaming at Arcadia.
(2) h) How would the graph from a) change if Arcadia charges an admission of $10 and increases the cost per game to $7? Write an equation that represents the new cost of a day spent gaming at Arcadia.

7. The local swimming pool is open 5 days a week for 8 weeks during the summer holidays. The admission prices are displayed at the entrance.

   Splash World Swim Park
   Price List
   Season's pass .......... $60 plus $2 per day
   Daily swim pass ....... $5

(2) a) How much will it cost one person to go to the pool every day the pool is open?
   i) with a season's pass?

   ii) with a daily pass?

(2) b) Write an equation that represents the cost of a season’s pass, and an equation that represents the cost of a daily pass.

(4) c) Graph both relations on the same grid.

(2) d) Which pass is better? Explain your reasoning.