Indirect Measurement Lab: Measuring outside

MPM2D, Unit 6: Similar and Right Triangles, Lesson 4. 75 minutes. Teacher lesson plan.

Lesson at a glance

Real measurements are never perfect. Using two methods (shadows and a mirror) to measure the same tall object, then comparing the results, shows how similar triangles work in practice and how measurement error affects the answer.

What students do: Students go outside in small groups to measure a tall object (a flagpole, light standard or wall) with the shadow method and the mirror method, record their data, calculate the height both ways, compare the results with a percent difference, and explain sources of error. A rainy-day data set is provided.

Curriculum expectations

Code	Students will…
T1.3	solve problems involving similar triangles in realistic situations (e.g., shadows, reflections, scale models, surveying) (Sample problem: Use a metre stick to determine the height of a tree, by means of the similar triangles formed by the tree, the metre stick, and their shadows.).

From The Ontario Curriculum, Grades 9 and 10: Mathematics (2005, revised), MPM2D, and the MPM2D Addendum (2022). QR = Quadratic Relations of the Form $y = ax^2 + bx + c$, AG = Analytic Geometry, T = Trigonometry. Codes follow the order of the expectations in the curriculum document.

Learning goals and success criteria

Learning goals	Success criteria
• We are learning to use similar triangles to measure a real object. • We are learning to compare methods and explain error.	• I can collect accurate measurements. • I can calculate a height with similar triangles. • I can compare two methods. • I can explain sources of error.

Materials and preparation

- **Slides:** Indirect Measurement Lab deck.
- **Handouts:** Lab Sheet (page 1), Analysis (page 2).
- **Equipment:** Measuring tapes, small flat mirrors, chalk or markers; a sunny day (or the rainy-day data).

Lesson sequence

Time (min)	Part	Teacher	Students	Look for
0–10	**Hook**	Plan the lab.	Plan.	

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Time (min)	Part	Teacher	Students	Look for
10–20	**Safety and roles**	Methods review.	Note.	Safe.
20–50	**Measure**	Outside.	Collect data.	Careful readings.
50–70	**Analysis**	Page 2.	Calculate; compare.	Errors named.
70–75	**Exit**	Exit ticket.	Respond.	

Differentiation

- **Support:** Assign roles; a filled example row.
- **ELL:** Vocabulary: measure, record, percent difference, error, method.
- **Challenge:** Estimate the percent error if the eye-height measurement is off by 5 cm.

Assessment

Type	Tool	Purpose
Assessment for learning	Lab Sheet and Analysis	Solving similar-triangle problems in a real situation (T1.3)

Answers: pages 1 and 2

- **Page 1:** Data and results vary by group.
- **Page 2, 1. Shadow (rainy-day data):** h ÷ 12.6 = 1.70 ÷ 2.55: h = 8.40 m.
- **2. Mirror:** h ÷ 6.5 = 1.55 ÷ 1.25: h ≈ 8.06 m.
- **3. Compare:** 8.40 m and 8.06 m differ by 0.34 m; the mean is 8.23 m, so the percent difference is about 4.1%.
- **4. Errors:** For example, the mirror not being level, finding the exact end of a fuzzy shadow, eye height measured to the wrong point, the ground not being level.
- **5. Improve:** Repeat measurements and average; mark shadow ends with chalk; use a level.

Teacher notes

- Safety: stay in the assigned area, never look at the sun, and keep mirrors flat on the ground (no sunlight reflected into eyes).
- Mirror method: place the mirror flat; the observer moves until they see the top of the object in the centre of the mirror.
- Percent difference = |difference| ÷ mean × 100%.
- Challenge: with the rainy-day mirror data, h = eye height × 6.5 ÷ 1.25, so a 5 cm error in eye height changes h by 0.05 × 6.5 ÷ 1.25 ≈ 0.26 m, about 3%.

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Coming up

Lesson 5, The Primary Trigonometric Ratios.

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