Travel graphs: distance-time graphs

Lesson plan and teacher's notes · Form 2 Mathematics · 1 period of 40 minutes

School	(write school name)	**Teacher**	(write name)
Date	(date)	**Class**	Form 2
Subject	Mathematics	**Enrolment**	Boys ___ Girls ___ Total ___
Time	40 minutes	**Topic**	Travel graphs: distance-time graphs

Learners describe journeys using distance, time and speed, read a distance-time graph to say who is moving fastest, calculate speed, distance, time and average speed, and compare a predicted result with a measured one using absolute and percentage error. The lesson uses three learners walking to a sports ground and a timed route on the school field.

Specific outcomes

By the end of the lesson, learners should be able to:

1. Describe a journey using distance, time and speed
2. Read a distance-time graph and say who is moving fastest and why
3. Calculate speed, distance, time and average speed with compatible units
4. Find absolute error and percentage error between a predicted and a measured result

Prior knowledge

- Multiplying and dividing decimals
- Reading values from a table and plotting points on axes
- Units of metres, seconds and minutes

Teaching and learning materials

- chalk and board
- a measuring tape or a rope marked at known lengths
- a stopwatch or a phone timer
- graph paper or squared exercise books

References

Ministry of Education (CDC) Form 2 Mathematics syllabus and module; 25Schools learners' note: Travel graphs: distance-time graphs.

Lesson development

Stage and time	Teacher activities	Learner activities
Introduction 5 min	Ask which learner walks to school fastest and how anyone could know. Write distance, time and speed on the board.	Suggest ways to measure and say what they would record.
Development: reading the graph 10 min	Draw distance on the vertical axis and time on the horizontal axis. Plot Mwansa, Chipo and Tembo every 2 minutes. Show that a steeper line means more distance in the same time.	Plot the three lines and say which is steepest and why.
Development: calculating 12 min	Teach speed = distance ÷ time, distance = speed × time and time = distance ÷ speed. Work 30 m in 24 s and the average speed idea.	Solve four short calculations, checking units.
Development: predicting and error 10 min	Set Challenge A, predict the distance at 1.5 m/s for 20 s. Measure the real result and find the absolute and percentage error.	Predict, measure on the field, then calculate both errors.
Conclusion 3 min	Ask why a measurement should be repeated. Set the homework.	Answer and copy the homework.

Teacher's content notes

Read these before the lesson. They are what you need to know, not what to copy onto the board.

Distance, time and speed

Distance is how far an object has travelled, time is how long the journey takes, and speed is how fast the object is moving. Speed = distance ÷ time, distance = speed × time and time = distance ÷ speed. Keep units compatible: metres with seconds give metres per second.

Reading a distance-time graph

Put distance on the vertical axis and time on the horizontal axis. A steeper line means more distance in the same time, so the object is faster. A flat line means the object is stationary.

Average speed

Average speed is the total distance travelled divided by the total time taken. Human movement is not perfectly constant, so use an average, for example 30 m in 24 s gives 1.25 m/s.

Predicting and testing

Use the formulas to predict a result, then measure it. Repeat the measurement before drawing a conclusion, because timing with a stopwatch has some error.

Absolute and percentage error

Absolute error is |measured result − predicted result|. Percentage error is (absolute error ÷ predicted result) × 100%. For a prediction of 30 m and a measured 28.5 m the absolute error is 1.5 m and the percentage error is 5%.

Questions to ask during the lesson

Question	Expected answer
A learner walks 45 m along the school path in 30 s while her friend waits at the end. (a) Find her average speed. (b) Write the formula used. (c) Give the unit.	(a) 45 ÷ 30 = 1.5 m/s. (b) Speed = distance ÷ time. (c) Metres per second.
A cyclist rides on a dry road at a steady speed of 4 m/s for 15 seconds. (a) Find the distance. (b) Write the formula. (c) Say what happens to the distance if the time doubles.	(a) 4 × 15 = 60 m. (b) Distance = speed × time. (c) It doubles, to 120 m.
A boy needs to walk 60 m to the water point at 1.5 m/s and wonders how long it will take. (a) Find the time. (b) Write the formula. (c) Say what he should record for each trial.	(a) 60 ÷ 1.5 = 40 s. (b) Time = distance ÷ speed. (c) The distance and the time so average speed can be calculated.
Tendai, Grace and Banda leave the school gate together, and after 4 minutes Tendai has covered 200 m, Grace 320 m and Banda 240 m. (a) Say who is fastest. (b) Find each learner's distance every minute. (c) Say whose line is steepest and why.	(a) Grace. (b) Tendai 50 m, Grace 80 m, Banda 60 m. (c) Grace's line, because a steeper line means more distance in the same time.

Worked examples for the board

Example 1: who is faster

Mwansa covers 100 m every 2 minutes and Tembo covers 80 m every 2 minutes. In 10 minutes, which is 5 intervals, Mwansa covers 5 × 100 = 500 m and Tembo covers 5 × 80 = 400 m. Mwansa covers more distance in the same time, so Mwansa is faster.

Example 2: average speed

A learner walks 30 m in 24 s. v = d ÷ t = 30 ÷ 24 = 1.25 m/s.

Example 3: percentage error

A group predicts 30 m but measures 28.5 m. Absolute error = |28.5 − 30| = 1.5 m. Percentage error = (1.5 ÷ 30) × 100% = 5%.

Board plan

Write the title and the three formulas. Left: the table of distances for Mwansa, Chipo and Tembo. Centre: the distance-time graph with three lines. Right: absolute error and percentage error with one worked example.

Learner	Every 2 minutes	After 10 minutes
Mwansa	100 m	500 m
Chipo	150 m	750 m
Tembo	80 m	400 m

Distances covered by three learners

Mistakes to expect

Learners often think	Put it right
A steeper line means the object travelled for longer.	A steeper line means more distance in the same time, so the object is moving faster.
Percentage error is the absolute error as a percentage of the measured result.	Percentage error divides the absolute error by the predicted result, then multiplies by 100.
A flat line means the object is going slowly.	A flat line means no distance is covered as time passes, so the object is stationary.

Differentiation

Learners who struggle

Give learners the three formulas on a card and a table with columns for distance, time and speed. Use whole numbers for the first two calculations and ask them to include units.

Learners who finish early

Ask learners who finish early to draw a graph of a journey with a rest in the middle and describe each part of the line.

Hearing or visual impairment

For learners with hearing impairment, write each formula and each step on the board. For learners with visual impairment, let them walk the route and feel the length, read the timings aloud and describe the shape of the graph in words.

No projector, no printing

Mark a route on the school field with sticks or a measured rope. A phone timer or a watch replaces the stopwatch, and graphs can be drawn on the board and in exercise books.

If time is short

Teach reading the graph and the three formulas. Leave absolute and percentage error for the next lesson.

Evaluation

Question or task	A correct answer shows

Three learners leave school at the same time and walk to a sports ground. Mwansa covers 100 m every 2 minutes, Chipo covers 150 m every 2 minutes and Tembo covers 80 m every 2 minutes. (a) Find the distance each covers in 10 minutes. (b) Say who is fastest. (c) Say which line on the graph is steepest.	(a) Mwansa 500 m, Chipo 750 m, Tembo 400 m. (b) Chipo. (c) Chipo's line, because a steeper line means more distance in the same time.
A learner at the school field walks a measured route of 30 m and the group times her at 24 s, and then she walks again briskly. (a) Find her average speed for the first walk. (b) Write the formula used. (c) Say why the group should repeat the measurement.	(a) 30 ÷ 24 = 1.25 m/s. (b) Speed = distance ÷ time. (c) Human movement is not constant and timing has error, so repeating shows whether results agree.
A group predicts that a learner walking at 1.5 m/s for 20 s will cover 30 m, but their measured distance is 28.5 m. (a) Find the absolute error. (b) Find the percentage error. (c) Say what the percentage error shows.	(a) $\|28.5 - 30\| = 1.5$ m. (b) (1.5 ÷ 30) × 100% = 5%. (c) The measured result differs from the prediction by 5% of the predicted distance.

Homework

A cyclist rides at 6 m/s for 25 seconds on a school road while a friend walks 90 m at 1.5 m/s. (a) Find the distance the cyclist covers. (b) Find the time the friend takes. (c) Say which of the two has the steeper line on a distance-time graph and why.

Extra practice with answers

Question	Answer
1. A learner plans to cover 40 m at an intended average speed of 1.25 m/s, and her group times her at 34 s. (a) Predict the time. (b) Find the absolute error. (c) Find the percentage error.	(a) 40 ÷ 1.25 = 32 s. (b) $\|34 - 32\| = 2$ s. (c) (2 ÷ 32) × 100% = 6.25%.
2. A learner predicts a time of 16 s for a 20 m route, but her group measures 18 s. (a) Find the absolute error. (b) Find the percentage error. (c) Say why the two differ.	(a) $\|18 - 16\| = 2$ s. (b) (2 ÷ 16) × 100% = 12.5%. (c) Human movement varies and timing has some error.
3. A girl walks 120 m in 60 s along a path, then 60 m in 60 s up a slope. (a) Find the total distance. (b) Find the total time. (c) Find the average speed.	(a) 180 m. (b) 120 s. (c) 180 ÷ 120 = 1.5 m/s.
4. A learner plots a graph of her walk and notices that part of the line is flat for 3 minutes while she waits for a friend. (a) Say what the flat line shows. (b) Say what her speed is during it. (c) Say what a steeper line after it would show.	(a) She has stopped and is stationary. (b) Zero. (c) She is moving faster.
5. A bus travels 120 km between two towns in 2 hours. (a) Find the average speed. (b) Say the unit. (c) Find the time at the same speed for 90 km.	(a) 120 ÷ 2 = 60 km/h. (b) Kilometres per hour. (c) 90 ÷ 60 = 1.5 hours.

6. A learner runs 8 m/s for 5 s in a race on the school field. (a) Find the distance. (b) Write the formula. (c) Say how the graph of this run looks.	(a) 8 × 5 = 40 m. (b) Distance = speed × time. (c) A straight line sloping upwards, because the speed is constant.

Answers to the learners' check-yourself questions

1. Which axis of a distance-time graph shows distance?
   The vertical axis. Time is on the horizontal axis.
2. A learner walks 45 m in 30 s. Find the average speed.
   v = 45 ÷ 30 = 1.5 m/s.
3. How far does a cyclist go at 4 m/s in 15 seconds?
   Distance = speed × time = 4 × 15 = 60 m.
4. How long does it take to walk 60 m at 1.5 m/s?
   Time = distance ÷ speed = 60 ÷ 1.5 = 40 s.
5. Why is it useful to repeat a measurement before drawing a conclusion?
   Human movement is not perfectly constant and timing has measurement error, so repeating shows whether the results agree.
6. You are a learner in a group testing a 20 m route at school. You predict a time of 16 s but your group measures 18 s. (a) Find the average speed from the measured time. (b) Find the absolute error. (c) Find the percentage error and say what it tells you.
   (a) v = 20 ÷ 18 = 1.11 m/s (to 2 decimal places). (b) Absolute error = |18 − 16| = 2 s. (c) Percentage error = (2 ÷ 16) × 100% = 12.5%. The measured time differs from the prediction by 12.5% of the predicted time.
7. Three learners, Tendai, Grace and Banda, leave the school gate at the same time. After 4 minutes Tendai has covered 200 m, Grace 320 m and Banda 240 m. (a) Who is moving fastest? (b) Find each learner's distance every minute. (c) On a distance-time graph, whose line would be the steepest and why?
   (a) Grace, who covered the most distance in the same time. (b) Tendai 200 ÷ 4 = 50 m, Grace 320 ÷ 4 = 80 m, Banda 240 ÷ 4 = 60 m. (c) Grace's line, because a steeper line means more distance in the same time.

Teacher's reflection

What went well:

What I will change next time:

Learners who need follow-up: