Chapter 1 - Guided Notes Answer Key

Three Most Important Concepts

1. Scalars have only a magnitude (like distance and speed), while vectors have both a magnitude and a direction (like displacement and velocity).
2. The slope of a position-time graph represents an object's velocity: a steep line means fast movement, a flat line means no movement, and a downward slope means motion in the negative direction.
3. Average speed equals distance divided by time, while average velocity equals displacement divided by time and always includes a direction.

Fill in the Blank

1. distance
2. displacement
3. slope
4. acceleration
5. vector

Matching

1. Scalar → B
2. Vector → D
3. Distance → C
4. Displacement → E
5. Slope of a Position-Time Graph → A

True or False

1. **F.** Distance and speed are scalars, not vectors, since they carry no direction.
2. **T.** An object can travel real distance and still end with zero displacement if it returns to its starting point.
3. **F.** An accelerating cart's position-time graph curves, since its velocity keeps increasing rather than staying constant.
4. **T.** A steeper tilt on a velocity-time graph represents a faster rate of change in velocity, which is a greater acceleration.
5. **T.** At 30 meters per second (67 miles per hour), the car covers 30 meters (98 feet) in the first second alone.

Fill in the Table

Quantity/Concept	Scalar or Vector?
Distance	Scalar
Speed	Scalar
Displacement	Vector
Velocity	Vector
Slope of a Position-Time Graph	Vector (it represents velocity)

Application Questions

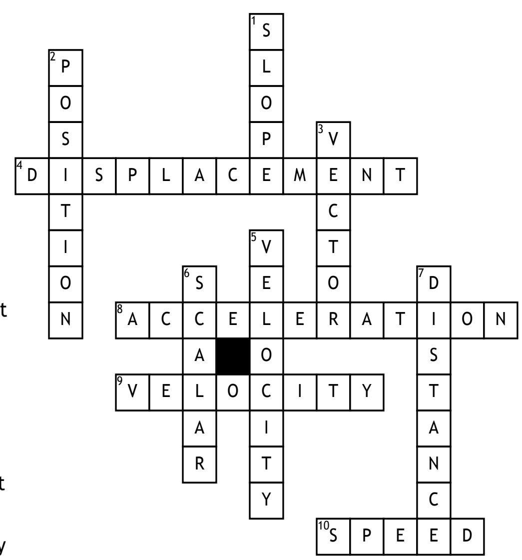
1. Average speed uses total distance (300 kilometers / 186 miles) divided by total time (3 hours), giving 100 kilometers per hour (62 miles per hour). Average velocity uses total displacement, which is 0 kilometers, since the car ends up back at its starting point, so average velocity is 0. Speed reflects the total ground covered, while velocity reflects the car's net change in position.
2. A straight, rising line means the vehicle moved at a constant speed. A line that curves and gets steeper over time means the vehicle was speeding up (accelerating), while a line that curves and flattens out means the vehicle was slowing down. All of this can be identified just from the shape of the line, with no calculation required.

Describing Motion

Y	U	K	A	N	Y	E	U	F	A	P	R	W	L	U	U	O	Z	W	P	E	J	O	E
D	D	K	V	S	I	B	U	Z	V	V	Z	U	V	G	O	G	N	G	D	Z	E	Q	R
I	T	T	E	U	M	W	Z	T	V	J	C	X	V	A	R	A	Z	F	A	E	P	Y	R
S	D	U	R	R	M	I	K	W	Q	L	J	L	F	D	P	U	Y	Q	C	G	E	W	Z
P	H	C	A	N	V	V	J	G	T	E	N	T	U	A	P	E	P	V	C	K	U	V	U
L	M	W	G	N	Z	E	R	S	K	G	O	R	Q	X	I	C	W	O	E	H	C	N	N
A	M	J	E	T	X	L	W	A	O	I	R	W	O	X	M	F	W	N	L	R	Y	Q	B
C	P	F	V	S	J	O	Y	B	E	C	G	L	G	Z	Y	V	G	I	E	X	S	G	R
E	C	U	E	T	O	C	A	V	E	R	A	G	E	S	P	E	E	D	R	A	N	E	N
M	J	A	L	K	N	I	G	T	M	T	C	O	B	S	K	P	J	N	A	W	F	G	C
E	O	W	O	L	V	T	W	R	L	I	H	D	V	L	X	P	K	I	T	E	R	S	V
N	A	R	C	S	W	Y	F	W	D	U	D	H	V	D	U	C	S	B	I	C	M	W	C
T	T	M	I	Q	X	T	C	Q	O	S	A	M	R	E	K	B	A	X	O	Y	T	A	C
R	N	J	T	Q	V	I	F	U	S	E	P	E	L	H	C	C	E	K	N	S	P	E	V
F	M	Z	Y	T	X	M	S	O	F	J	O	V	P	A	T	T	M	O	X	R	C	W	J
H	S	N	V	L	E	E	X	D	D	T	U	T	V	Z	U	B	O	L	R	N	E	I	I
V	L	I	Z	T	T	G	K	F	T	U	C	B	N	N	H	R	X	R	S	R	U	R	U
B	D	Z	U	M	L	R	K	Y	W	H	P	C	J	P	S	E	M	J	O	M	P	R	I
S	L	Z	Z	K	U	A	W	A	T	D	R	Z	P	P	U	C	E	Z	Y	U	J	X	Y
L	E	O	K	Y	Y	P	U	Z	F	L	Q	I	G	U	U	W	A	O	G	N	M	G	Q
C	O	Y	H	T	P	H	S	L	O	P	E	J	B	Y	E	S	P	L	Z	C	K	X	D
U	U	Q	M	U	T	I	Y	S	Q	V	W	Z	R	D	P	A	C	Z	A	S	V	F	C
Q	C	N	Z	D	I	S	T	A	N	C	E	L	B	O	U	D	D	Q	K	R	H	V	P
K	B	E	P	I	Q	P	O	S	I	T	I	O	N	T	I	M	E	G	R	A	P	H	W

Velocity-Time Graph
Position-Time Graph
Average Velocity
Average Speed
Vector
Slope
Scalar
Distance
Displacement
Acceleration

Describing Motion



Across

4. The straight-line change in an object's position from start to finish, including direction.

8. The rate at which an object's velocity changes over time.

9. An object's total displacement divided by the total time, including the direction of that displacement. Average ____

10. The total distance an object travels divided by the total time it takes, without any direction included. Average ____

Down

1. How steeply a line on a graph rises or falls, used on a position-time graph to represent velocity.

2. A graph that shows an object's position on the vertical axis and time on the horizontal axis, with the slope of the line representing velocity. ____-Time Graph

3. A quantity that has both a magnitude and a direction.

5. A graph that shows an object's velocity on the vertical axis and time on the horizontal axis, with a tilted line representing acceleration. _____-Time Graph

6. A quantity that has only a magnitude, with no direction attached.

7. The total length of the path an object travels, regardless of direction.

Chapter 1 - Hypothetical & Case Study / Frontier Application Answer Key

Sample answers: accept other reasonable responses grounded in the article.

Hypothetical 1: Rideshare Route

a) The 12 kilometers (7 miles) is the distance; the 6 kilometers (4 miles) is the size of the displacement.
b) Average speed would be larger, since it uses the longer distance value; average velocity uses the shorter displacement.
c) The company could use straight-line displacement instead of driving distance to give a more realistic sense of how far away a driver is.

Hypothetical 2: Self-Driving Car Sensors

a) Velocity requires knowing how position changes over time, so a single reading cannot show a rate of change.
b) A flat reading suggests the other car is not moving, or is moving at the same speed and direction as the self-driving car.
c) Position alone would not reveal that the car ahead is speeding up or slowing down, causing a late reaction.

Case Study: Usain Bolt’s 100-Meter (328-Foot) World Record

Researchers tracked Bolt’s position at fixed time intervals to build a position-time graph, demonstrating the article’s concepts of position-time graphs and the importance of a shared reference point.

A. Researchers measured Bolt’s position at fixed time intervals. A shared frame of reference mattered because every camera measured position relative to the same fixed starting line, so the segments of his run could be fairly compared.
B. A steepening slope revealed the acceleration phase, since his position changed at a faster rate over time, while the nearly straight top-speed section showed his position changing at a nearly constant rate, meaning almost constant velocity.
C. A student would look for which sprinter’s position-time graph reached the steepest section, since the steepest slope represents the highest velocity at that point in the race.

Frontier Application: Self-Driving Vehicle Perception

The article’s concept of describing motion with position, velocity, and a consistent reference point operates directly inside a self-driving car’s sensor system.

A. The car repeatedly measures the position of the car ahead over short time intervals, then uses the change in that position over time to calculate its velocity, similar to reading slope off a position-time graph.
B. If motion were measured against different reference points from one moment to the next, position and velocity readings would not line up consistently, making it impossible to reliably tell whether another vehicle is getting closer or farther away.
C. Without tracking acceleration, the car could react correctly to a vehicle’s current velocity but be caught off guard if that vehicle suddenly sped up or slowed down, since acceleration is what reveals how velocity itself is changing.

Chapter 1 - Reflection Questions & Data Analysis Answer Keys

Sample answers: reflection questions are open-ended; accept any response that shows thoughtful engagement with article concepts.

Reflection #1: Societal Impact
Sample Answer: My neighborhood has a lower speed limit near the elementary school, and this lesson helped me understand why. Reaction time alone means a car covers real distance before braking even starts, so I imagine icy roads need even more caution for the same reason.

Reflection #2: Interdisciplinary Connections
Sample Answer: This reminds me of how two people can describe the same event differently depending on where they were standing. In physics, a shared reference point lets motion be compared fairly, and I think perspective works the same way in a debate or a story.

Accept other reasonable answers that reference the data and connect to article concepts.

Data Table Reference

Independent variable: distance segment of the race. Dependent variable: average velocity for each 20-meter (66-foot) segment, based on Bolt's real 2009 World Championship split times.

Question 1: Basic Interpretation

Answer: 12.12 meters per second (27.1 miles per hour)
Source: Row 3 (40 to 60 m segment), Average Velocity column

Question 2: Pattern Identification

Answer: Bolt's average velocity nearly doubled from the first segment (6.94 m/s, 15.5 mph) to the middle segments, peaking around 12.27 m/s (27.4 mph) between 60 and 80 meters, then dipping slightly to 12.05 m/s (27.0 mph) in the final segment as he began to tire.

Question 3: Application

Answer: A single average speed would blend the slow start, the peak-speed middle, and the slight late-race dip into one flattened number, hiding exactly when Bolt was speeding up versus holding steady. A self-driving car's software needs the same kind of segment-by-segment data. Without it, the car could not tell whether a nearby vehicle is still accelerating partway through a merge, since one average speed reading would hide that change in motion.

Describing Motion: Teacher Lecture Notes

Opening Hook

• Ask: has anyone used a fitness app that tracks “distance run”? The number can be misleading if the run ends where it started.
• Speedometer example: a car can hold 97 km/h (60 mph) the whole trip and still end up close to where it started.

Scalars vs. Vectors

• Two families of physics quantities: **scalars** (magnitude only) and **vectors** (magnitude + direction).
• **Distance** = scalar, the total path length walked, driven, or run.
• **Displacement** = vector, the straight-line change in position, plus direction.
• Board demo: draw a winding path, then draw one straight arrow from start to end to represent displacement.
• Classic example: one full lap on a 400 m (1,312 ft) track. Distance = 400 m (1,312 ft). Displacement = 0.
• Extend to speed vs. velocity, the rate versions of the same idea:
  • Average speed: $v = d / t$ (distance over time).
  • Average velocity: same structure, but displacement over time, with direction included.
• Key point to stress: $v = d / t$ only ever gives speed. Swap in displacement and the result is velocity instead.
• Relatable example: a student bikes to school and back. Total distance pedaled might be several kilometers, but round-trip displacement is zero.

Reading Motion on Graphs

• **Position-time graphs**: position on the y-axis, time on the x-axis.
  • Slope = velocity.
  • Flat line = at rest.
  • Steep line = fast movement.
  • Downward slope = motion in the negative direction, often back toward the start.
• Simple classroom demo: a student walks away from the door, pauses, then walks back. The graph shows a rising line, a flat line, then a falling line.
• Cart-on-ramp demo, if available: a released cart accelerates down the ramp.
  • Its position-time graph curves. It is not a straight line, because velocity keeps increasing.
  • A steeper ramp produces a sharper curve, showing greater acceleration.
• **Velocity-time graphs**: velocity on the y-axis, time on the x-axis.
  • Flat line = constant velocity.
  • Tilted line = acceleration, the rate at which velocity changes.
  • A sudden jump, rather than a gradual tilt, signals a direction reversal at a constant speed, like a ball bouncing off a wall.

Why This Matters: Motion Data and Safety

- Traffic engineers need reliable average speed and reaction-time data to calculate safe stopping distances.
  - Example: at 30 m/s (67 mph), a car covers 30 m (98 ft) in the first second of reaction time alone.
  - At a two-second reaction time, distance covered before braking even begins can exceed 60 m (197 ft).
- Self-driving cars and GPS apps repeatedly measure position to calculate velocity and direction, all relative to a shared reference point.
- Case study tie-in: Usain Bolt's 100 m (328 ft) world record shows how interval position data reveals a sprinter's full story, including his acceleration phase and his top-speed phase, something a single finishing time hides.
- Frontier application tie-in: self-driving vehicle perception depends on tracking not just position, but velocity and acceleration, for every nearby vehicle.

Key Vocabulary to Reinforce

- Scalar, vector, distance, displacement, average speed, average velocity, slope, acceleration, position-time graph, velocity-time graph.

Common Misconceptions to Address

- Students may assume a steep line always means "fast" without checking which axis is graphed.
- Students often assume any moving object makes a straight position-time line. Correct this with the cart-on-ramp curve.
- Students may use "speed" and "velocity" interchangeably. Reinforce that velocity always requires a direction.

Discussion Questions

1. Why can two different vehicles cover the same distance but end up with very different displacements?

2. What is a real-world situation where knowing only the average speed of a trip would give a misleading picture?

3. In your own words, why does a curving position-time graph mean an object is accelerating?

4. Why might engineers designing self-driving cars care more about acceleration data than position data alone?

5. Can you think of a job or hobby where reading a graph quickly, without doing any math, would be a genuinely useful skill?