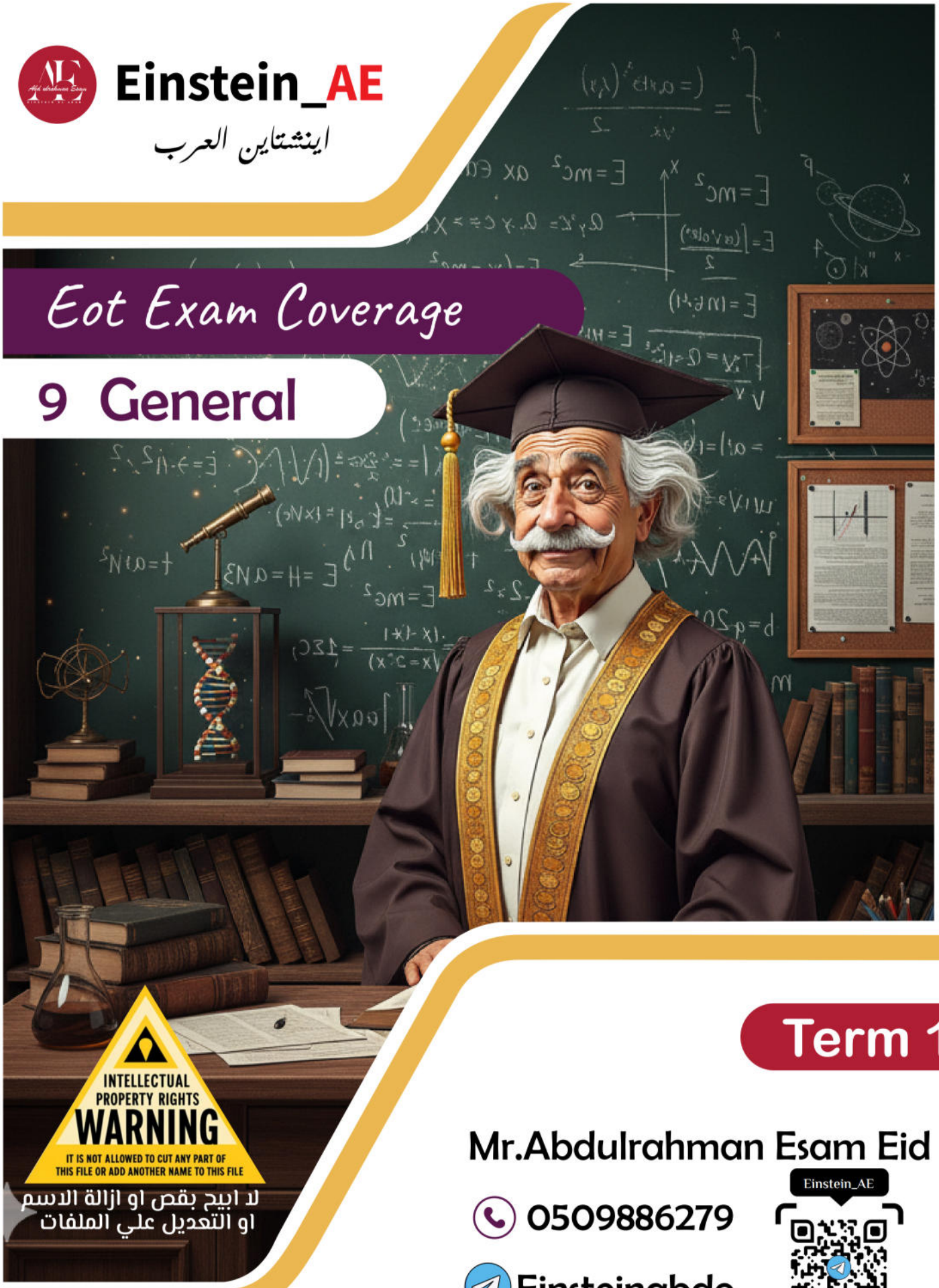
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9 General



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Term 1

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Scientific Theories and Laws

Scientific Theory

- A scientific theory is an explanation based on knowledge gained from many observations and investigations.
- It is **not a guess**. If scientists repeat an investigation and the results always support the hypothesis, the hypothesis can be called a **theory**.
- As new information becomes available, theories can be modified.

Scientific Law

- A scientific law is a statement about what happens in nature and that seems to be true all the time.
- **Laws** describe specific relationships under given conditions.
- They do **not** explain why or how something happens.
- **Gravity** is an example of a scientific law.
- The law of gravity states that any one mass will attract another mass.
- A theory can be used to explain a law, but **theories do not become laws**.

Example

- Many theories have been proposed to explain how the law of gravity works.
- Even so, there are few accepted theories in science and even fewer laws.

Evolution of Ideas About Why Objects Fall

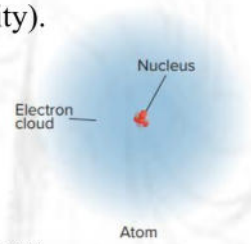
1. **Greek Philosophers** *(Early Idea)*
   - ✓ Proposed that objects fall because they seek their natural places.
   - ✓ The more massive the object, the faster it falls.
   - ✓ **Type:** Neither a scientific theory nor a law (it was a philosophical idea).

2. **Galileo's Revision** *(Scientific Theory)*
   - ✓ Showed that the speed at which an object falls depends on the amount of time it has fallen, **not on the object's mass**.
   - ✓ **Type:** Scientific Theory (based on observation and experimentation).

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3. **Newton's Revision** *(Scientific Law + Theory)*
   - ✓ Proposed that objects fall because the object and Earth are attracted by a **force** (gravity).
   - ✓ Stated that there is a force of attraction between any two objects with mass.
   - ✓ **Type:**
     - **Law:** Law of Universal Gravitation (describes the relationship mathematically).
     - **Theory:** Newton's explanation of why objects fall (mechanistic reasoning).
4. **Einstein's Revision** *(Scientific Theory)*
   - ✓ Suggested that the force of attraction between two objects is due to **mass causing space around it to curve** (General Relativity).
   - ✓ **Type:** Scientific Theory (explains the underlying cause of gravity).

1. Which figure represents a nucleus surrounded by an electron cloud?



A) Thomson's Model B) Rutherford's Model

C) Electron Cloud Model D) Dalton's Model

2. _____ An explanation of events based on knowledge gained from many observations and investigations.
   A) Scientific method B) Scientific theory C) Scientific law D) Hypothesis
3. _____ A statement about what happens in nature and seems to be true all the time.
   A) Scientific method B) Scientific theory C) Scientific law D) Hypothesis
4. Which atomic model stated that the atom consists of a nucleus with electrons orbiting around it in defined orbits?

A) Thomson's Model B) Rutherford's Model

C) Electron Cloud Model D) Dalton's Model

5. Which atomic model stated that the atom consists of electrons embedded in a ball of positive charge?
   A) Thomson's Model B) Rutherford's Model

   C) Electron Cloud Model D) Dalton's Model
6. A computer simulation for a nuclear reactor is an example of:
   A) Model B) Hypothesis C) Scientific law D) Scientific theory

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Mathematics in Physics

- **Physicists often use the language of mathematics.**
- In physics, **equations are important tools** for modeling observations and making predictions.
- Equations represent relationships between measurements.

International System of Units (SI)

- **Measurement requires a number and a unit.**
- **Units such as foot, gallon, and pound are part of the English system of measurement.**
- **Most nations use the metric system, which is based on multiples of ten.**
- **The International System of Units (SI) is a version of the metric system.**

SI Units and Derived Units

- **The SI (Système International 'Units or SI) system of measurement uses seven base quantities.**

Base quantities were originally defined in terms of direct measurements.

Derived Units

- **Other units, called derived units, are created by combining the base units in various ways.**

Examples of Derived Units:

- **Velocity: m/s**
- **Density: kg/m^3**
- **Force: $N = kg\ m/s^2$**

All other SI units are derived from these seven base units.

Quantity Measured	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Intensity of light	candela	cd

7. What is the SI unit for measuring mass?
   A) Meter B) Kilogram C) Ampere D) Kelvin
8. What is the SI base unit for temperature?
   A) Celsius B) Fahrenheit C) Kelvin D) Joule
9. Which of the following is a derived unit?
   A) Second B) Candela C) Newton D) Mole
10. A worker in a steel factory needs to write down the temperature of the steel rods using the SI unit. Which one of the following units should he use?
    A) Kelvin B) Fahrenheit C) Celsius D) Rankine

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A student wants to measure the luminous intensity of a lightbulb.
What is the correct unit for her measurement?

B) **A)** Ampere **B)** Candela **C)** Volt **D)** Kelvin

Which of the following is expressed using a derived unit?

A) Door length **B)** Room temperature **C)** Room area **D)** Lamp luminous intensity

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Significant Figures



- **Suppose you measure a pen and find that the end of the pen is just past 138 mm.**
- **You estimate that the pen is one-tenth of a millimetre past the last tick mark on the ruler and record the pen as being 138.1 mm long.**
- **This measurement has four valid digits:**
  - ✓ **The first three digits are certain, and the last one is uncertain.**

Definition

- **Significant figures are the valid digits in a measurement.**
- **The last digit given for any measurement is the uncertain digit.**
- **All nonzero digits in a measurement are significant.**

Are all zeros significant?

- **Example:**
  - ✓ **In the measurement 0.0860 m, the first two zeros only locate the decimal point and are not significant.**
  - ✓ **The last zero, however, is the estimated digit and is significant.**
- **The measurement 172,000 could have 3, 4, 5, or 6 significant figures.**
- **This ambiguity is one reason to use scientific notation.**
- **Example: 1.7200×10^5 m has five significant figures.**

Arithmetic with Significant Figures

- **When doing arithmetic operations, the result cannot be more precise than the least-precise measurement.**
- **Addition/Subtraction Rule: Round the result to the least-precise value involved.**

Example: 6.38 m + 22.4 m + 6.3 m = 35.08 m → 35.1 m

- **Multiplication/Division Rule: Round to the correct number of significant figures.**

Example:

$$\frac{409.2\ \text{km}}{35.9\ \text{km/h}} = 11.4\ \text{h}$$

because the least-precise measurement has three significant figures.

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Significant Figures Rules

- **All nonzero digits in a measurement are significant, but not all zeros are significant.**

Examples of Numbers and Their Significant Figures

Number	123	400	50001	0.0056	3.000	0.01230	9.0053	4×10^2	1.2×10^{-4}
Sig. Figures	3	1	5	2	4	4	5	1	2

Arithmetic with Significant Figures

Addition and Subtraction

- **Perform the operation, then round off the result to match the least-precise value.**

Examples:

- $3.86\ \text{m} + 2.4\ \text{m} = 6.26\ \text{m} \approx \text{round} \rightarrow 6.3\ \text{m}$
- $2.813\ \text{m} + 2.14\ \text{m} = 4.953\ \text{m} \approx \text{round} \rightarrow 4.95\ \text{m}$

Multiplication and Division

- **Perform the calculation, then round to the same number of significant digits as the least-precise measurement.**

Examples:

- $\frac{409.2\ \text{kg}}{11.4\ \text{L}} = 35.8947368 \approx \text{round} \rightarrow 35.9\ \text{kg/L}$
- $\frac{42.2\ \text{kg}}{5.5\ \text{L}} = 7.672727 \approx \text{round} \rightarrow 7.7\ \text{kg/L}$
- $666\ \text{m} \times 3.2\ \text{m} = 2131.2\ \text{m}^2 \approx \text{round} \rightarrow 2100\ \text{m}^2$

When a car travels 434 km in 4.5 h, what is the car's average speed?

Step 1: Analyze and Sketch the Problem

- **Known:**
  - ✓ **Distance = 434 km**
  - ✓ **Time = 4.5 h**
- **Unknown:**
  - ✓ **Speed = ?**

Relationship:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Step 2: Solve for the Unknown

$$\text{speed} = \frac{434\ \text{km}}{4.5\ \text{h}} = 96.4\ \text{km/h}$$

Significant Figures Practice

Solve using the correct number of significant figures:

a) $10.8\ \text{g} - 8.264\ \text{g} = 2.536\ \text{g} \approx 2.5\ \text{g}$

b) $4.75\ \text{m} - 0.4168\ \text{m} = 4.3332\ \text{m} \approx 4.33\ \text{m}$

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c) $139\ \text{cm} \times 2.3\ \text{cm} = 319.7\ \text{cm}^2 \approx 320\ \text{cm}^2$

d) $\frac{13.78\ \text{g}}{11.3\ \text{mL}} = 1.219469\ \text{g/mL} \approx 1.22\ \text{g/mL}$

Add:

$$1.6\ \text{km} + 1.62\ \text{m} + 1200\ \text{cm}$$

Step 1: Convert All Units to Meters

- $1.6\ \text{km} = 1.6 \times 1000 = 1600\ \text{m}$
- $1200\ \text{cm} = \frac{1200}{100} = 12.00\ \text{m}$

Step 2: Add the Values

$$1600\ \text{m} + 1.62\ \text{m} + 12.00\ \text{m} = 1613.62\ \text{m}$$

Step 3: Apply Significant Figures

- **The least precise measurement is 1.6 km (2 significant figures).**
- **So, the final answer should have 2 significant figures: 1600 m**

18. **What is the correct scientific notation for the number 300000?**
A) 3×10^2 **B)** 3×10^5 **C)** 0.3×10^6 **D)** 30×10^6

19. **What is the area of a rectangular calculator with dimensions of 4.5 cm by 3.25 cm, considering the correct number of significant figures?**

A) 14.6 cm² **B)** 15 cm² **C)** 14.625 cm² **D)** 14.63 cm²

20. **What is the number of significant figures in the number 0.0004020?**
A) 4 B) 8 C) 2 D) 7

21. **How many significant figures are there in the following measurements?**

450000	0.00067	98000000	0.000035	6200	0.00451	123000000

How many significant figures are there in the following measurements?

32545600 m	0.0025 kg	0.4704008 s	1200 J	1.29×10^5 mol	1200.00 kg	26.860 K

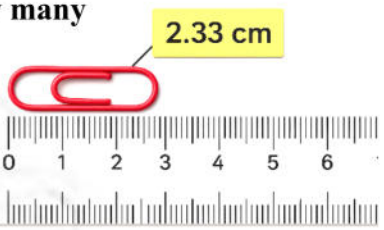
How many significant figures are there in the following measurements?

5703 m	20 kg	160 m/s	170.0 N

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A student measured the length of a paperclip using a ruler and expressed the result as (2.33 cm). What is the smallest division shown on the ruler used, and how many significant figures are there in the measurement written by the student?



A) The smallest division is 0.1 cm, and the number of significant figures is 2
B) The smallest division is 1.0 cm, and the number of significant figures is 3
C) The smallest division is 1.0 cm, and the number of significant figures is 2
D) The smallest division is 0.1 cm, and the number of significant figures is 3

Perform the following arithmetic operations and round the answers to the suitable number of decimal places

- 3.5 m + 2.67 m + 4.891 m = _____
- 7.85 kg - 2.4 kg = _____
- 12.34 cm + 3.1 cm = _____
- 5.123 L - 1.2 L = _____
- 4.6 m + 1.35 m + 2.3 m = _____
- 9.872 g ÷ 3.55 g = _____
- 6.75 m ÷ 1.2 m = _____

Perform the following arithmetic operations and round the answers to the suitable number of significant figures

- 3.45 m × 2.1 m = _____
- 15.678 g ÷ 2.3 g = _____
- 4.5 cm × 3.45 cm = _____
- 18.2 kg ÷ 4.1 kg = _____
- 6.3 m × 2.0 m = _____
- 22.56 L ÷ 3.4 L = _____
- 9.5 m × 1.75 m = _____

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Comparing Results

- Scientists share their results with others.
- Before new data are fully accepted, other scientists **examine the experiment**, look for possible sources of error, and try to reproduce the results.
- Results are often reported with an **uncertainty**.
- A new measurement that falls within the margin of uncertainty is considered **in agreement with the old measurement**.

Example

Archaeologists use **radiocarbon dating** to determine the age of cave paintings, such as those from the Niaux cave in France and the Chauvet cave, also in France.

- Each **radiocarbon date** is reported with an uncertainty.
- Three radiocarbon ages from a panel in the Chauvet cave are:
  - **30,940 ± 610 years**
  - **30,790 ± 600 years**
  - **30,230 ± 530 years**

Although none of the measurements match exactly, the uncertainties in all three **overlap**, so the measurements **agree with each other**.

- **Measurement** is a comparison between an unknown quantity and a standard.
- Measurements are usually reported as:

Example: (12.3 ± 0.05) cm

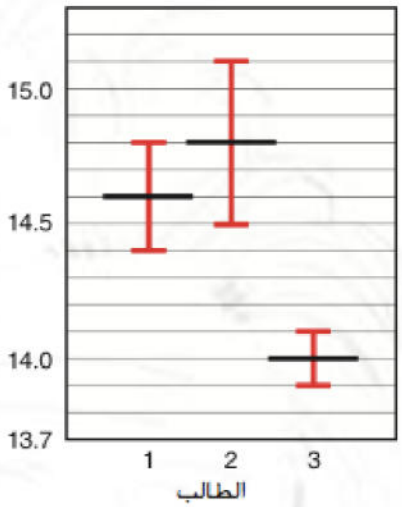
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Example Experiment

Three students measured the same object:

- **Student 1:**
  - ✓ Measurements: (14.4 cm, 14.8 cm)
  - ✓ Average: 14.6 cm
  - ✓ Result: 14.6 ± 0.2 cm
- **Student 2:**
  - ✓ Result: 14.8 ± 0.3 cm
- **Student 3:**
  - ✓ Result: 14.0 ± 0.1 cm



Analysis

- Student 1 and Student 2 are **less precise** because they have larger uncertainties (0.2 cm and 0.3 cm).
- Student 3 is the **most precise** because the uncertainty is smallest (0.1 cm).

Precision and Accuracy

- **Precision**: The degree of exactness of a measurement.
- **Accuracy**: Describes how well the results of a measurement agree with the real value.

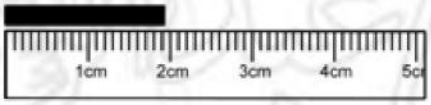
Sources of Error in Measurement

1. **Instrumental Errors**
   - ✓ Zero error, faulty scales, or malfunctioning instruments.
2. **Human Errors**
   - ✓ Parallax error, incorrect reading, reporting mistakes, or improper measuring technique.

Key Concept

- The device with the **finest division** on its scale produces the most precise measurement.
- **Precision of a measurement** = one-half (0.5) of the smallest division of the instrument.

Example:



(1.8 ± 0.05) cmor(18 ± 0.5) mm

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Report the measurement with its uncertainty margin

A) (2.1 ± 0.05) m B) (3 ± 0.05) m C) (2.1 ± 0.1) m D) (3 ± 0.1) m



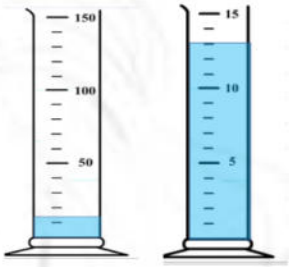
Report the measurement with its uncertainty margin

A) (3.6 ± 2.0) A B) (3.6 ± 0.2) A C) (3.6 ± 0.1) A D) (36 ± 0.1) A



Report the measurement with its uncertainty margin

A) (10 ± 2.0) mL B) (12 ± 5) mL C) (12 ± 10) mL D) (12 ± 0.1) mL



Report the measurement with its uncertainty margin

A) (10 ± 2.0) mL B) (12 ± 5) mL C) (13 ± 0.5) mL D) (12 ± 0.1) mL

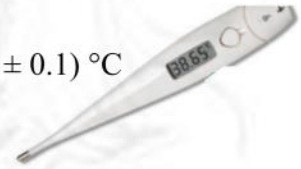
Report the measurement with its uncertainty margin

A) (62.0 ± 0.05) g B) (62.0 ± 1) g C) (620 ± 0.5) g D) (62.0 ± 1) g



Report the measurement with its uncertainty margin

A) (38.65 ± 0.05) °C B) (38.65 ± 0.005) °C C) (38.65 ± 0.01) °C D) (38.65 ± 0.1) °C



The voltage measurement of V is

A) (3 ± 0.5) V B) (0.3 ± 0.05) V C) (3.2 ± 0.1) V D) (3 ± 1) V



The voltage measurement of V is

A) (3 ± 0.5) V B) (0.3 ± 0.05) V C) (3.2 ± 0.1) V D) (3 ± 1) V

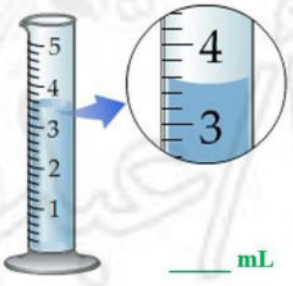


Report the following measurement with its uncertainty margin

A) (33 ± 0.1) A B) (30.3 ± 0.1) A C) (30.3 ± 0.05) A D) (33 ± 0.5) A

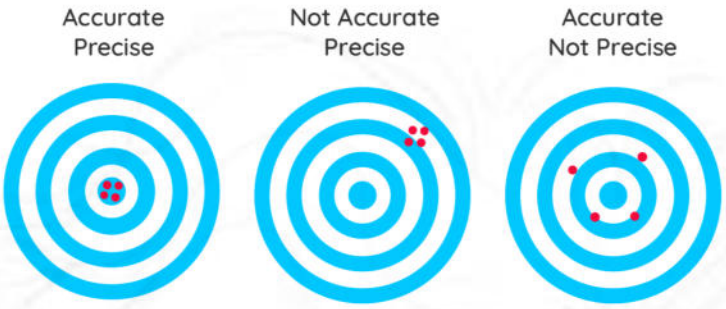
Report the following measurement with its uncertainty margin

A) (33 ± 0.1) mL B) (3.6 ± 0.1) mL C) (3.3 ± 0.1) mL D) (3.6 ± 0.2) mL



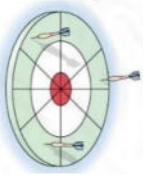
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- Arrows clustered at the center → Accurate and precise.
- Arrows clustered together but away from the center → Precise but not accurate.
- Arrows scattered and away from the center → Neither accurate nor precise.

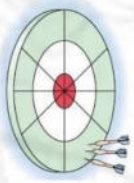
The three arrows represent three measurements for an experiment. Depending on the picture, which of the following statements is correct regarding precision and accuracy?



A) Accurate, precise B) Accurate, imprecise

C) Inaccurate, precise D) Inaccurate, imprecise

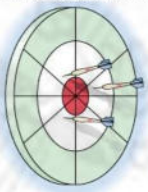
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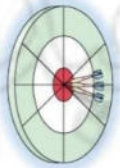
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A) Accurate, precise B) Accurate, imprecise

C) Inaccurate, precise D) Inaccurate, imprecise

The three arrows represent three measurements for an experiment. Depending on the picture, which of the following statements is correct regarding precision and accuracy?



A) Accurate, precise B) Accurate, imprecise

C) Inaccurate, precise D) Inaccurate, imprecise

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Student Data Analysis

Student	Measurements (°C)	Average (°C)	Result
A	99.5, 95.0, 85.5	93.3	Neither precise nor accurate
B	99.6, 100.1, 100.4	100.0	Accurate only
C	101.0, 101.1, 101.0	101.0	Precise only
D	100.1, 100.0, 100.2	100.1	Precise and accurate

1. If a person measures the same object several times and gets nearly the same result each time, this is called:
   Answer: Precision

2. How close a measurement is to the true value is called:
   Answer: Accuracy

49. Which group got a properly accurate and precise measurement of the mass of the paper clip (known mass = 1.04 g)?

Trial	Group 1	Group 2	Group 3	Group 4
Trial 1	1.03 g	1.13 g	1.04 g	0.99 g
Trial 2	1.05 g	1.10 g	1.41 g	1.00 g
Trial 3	1.02 g	1.11 g	1.52 g	1.19 g

A) Group 1 B) Group 2 C) Group 3 D) Group 4

Ahmed, Rashed and Saeed measure the length of a box and each of them reached the measurements:

Name	Measurement 1	Measurement 2	Measurement 3
Ahmed	18.46	18.47	18.48
Rashed	18.50	18.51	18.52
Saeed	18.40	18.53	18.44

(Actual length of the box = 18.47)

Answer the following:

1. Whose measurements are imprecise and inaccurate?

A) Ahmed B) Rashed C) Saeed

2. Whose measurements are precise and inaccurate?

A) Ahmed B) Rashed C) Saeed

3. Whose measurements are precise and accurate?

A) Ahmed B) Rashed C) Saeed

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According to the table for measuring the height of a whiteboard from the ground by four students (three attempts each). The real value of the height = 80.1 cm.

Student	1st Attempt	2nd Attempt	3rd Attempt
Mohammad	81.9 cm	82.1 cm	82.0 cm
Salem	79.6 cm	81.1 cm	83.1 cm
Abdullah	84.1 cm	82.8 cm	81.3 cm
Hamdan	80.3 cm	79.8 cm	79.9 cm

Which student has the most precise measurements?
A) Mohammad B) Salem C) Abdullah D) Hamdan

Which student has the most accurate measurements?
A) Mohammad B) Salem C) Abdullah D) Hamdan

According to the table below, four students measured the length of a book (real length = 30.3 cm) in three attempts each.

Student	1st Attempt	2nd Attempt	3rd Attempt
Sheikha	**33.9 cm**	**31.1 cm**	**29.0 cm**
Awatef	**30.2 cm**	**30.1 cm**	**30.4 cm**
Aysha	**32.5 cm**	**32.4 cm**	**32.5 cm**
Laila	**32.3 cm**	**29.8 cm**	**34.1 cm**

Which student has the most accurate measurements?
A) Sheikha B) Awatef C) Aysha D) Laila

Which student has the most precise measurements?
A) Sheikha B) Awatef C) Aysha D) Laila

Khalid (65.0 kg) stepped on a digital scale four times in a row and recorded the readings shown in the table below. Which statement best describes his results?

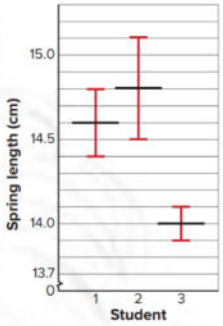
Trial 1	Trial 2	Trial 3	Trial 4
65.1 kg	**65.0 kg**	**64.9 kg**	**65.0 kg**

A) The readings are only precise
B) The readings are only accurate
C) The readings are both accurate and precise
D) The readings are inaccurate and imprecise

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Three students conducted a Min iLab to answer the question:
How does increasing mass affect the length of a spring?
Each student made two attempts (red line) and recorded the average measurement (black line) as shown in the figure. The springs used had a specified length of **14.8 cm**.



Which of the following statements is incorrect?

A) 3rd student measurement is the most precise
B) The tool used by 3rd student has the finest division on its scale
C) 3rd student measurement is the most accurate
D) 3rd student results are not consistent with 1st and 2nd students results

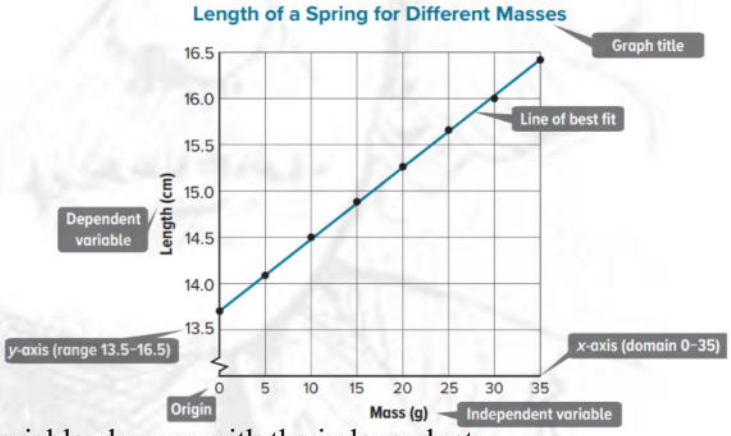
Identifying Variables

- **Independent Variable:** The factor that is changed or manipulated during the experiment.
- **Dependent Variable:** The factor that depends on the independent variable.

Example: Linear Relationship

Length of a Spring for Different Masses

Mass Attached (g)	Length of Spring (cm)
0	13.7
5	14.1
10	14.5
15	14.9
20	15.3
25	15.7
30	16.1
35	16.4



- **A line graph** shows how the dependent variable changes with the independent variable.
- The **line of best fit** is drawn as close as possible to all data points and is a better model for predictions than any single point.
- A well-designed graph helps visualize patterns that are not obvious in a list of numbers.
- Example: The graph shows that the **length of the spring increases as the mass suspended from the spring increases**.

Steps for Drawing a Scientific Graph

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1. **Identify the independent and dependent variables** in your data.
   - In this example:
     - Independent variable = **Mass (g)**
     - Dependent variable = **Length (cm)**
2. **Plot the variables**:
   - Independent variable → **Horizontal axis (x-axis)**
   - Dependent variable → **Vertical axis (y-axis)**
3. **Determine the range** of the independent variable to be plotted.
   - Here, the range is **0–35 g**.

Relationships Between Two Variables

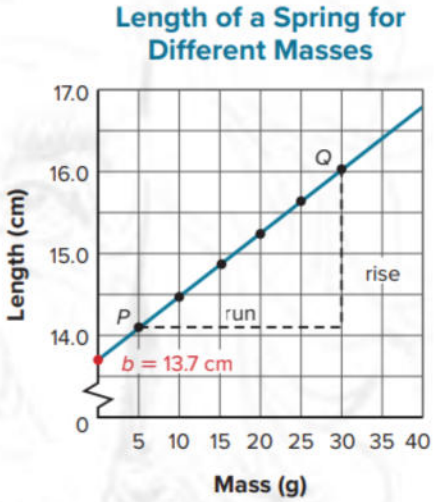
Equation and Slope

- Linear equation:

$$y = mx + b$$

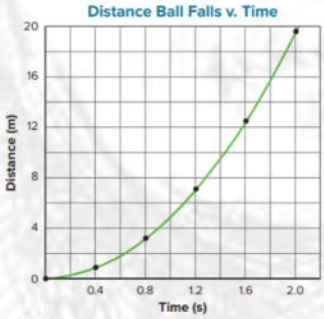
- Slope formula:

$$m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$



2. Quadratic Relationship

$y = ax^2 + bx + c$



3. Inverse Relationship

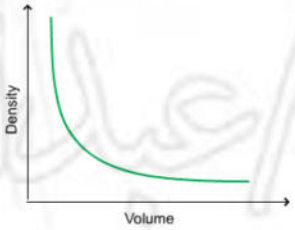
$$y = \frac{a}{x}$$



If the relationship between the two variables (R, S) is inverse, which of the following is true for these two variables?

A) R / S = constant B) RS = constant C) S / R = constant D) R = S

Which type of relationship is shown by the following graph?

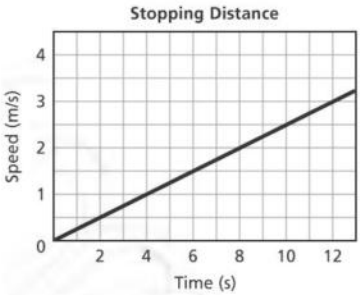


A) Linear B) Inverse C) Parabolic D) Quadratic

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What is the slope of the graph?



A) 0.220 m/s² B) 4.0 m/s² C) 5.2 m/s² D) 4.0 m/s

Which describes an independent variable?

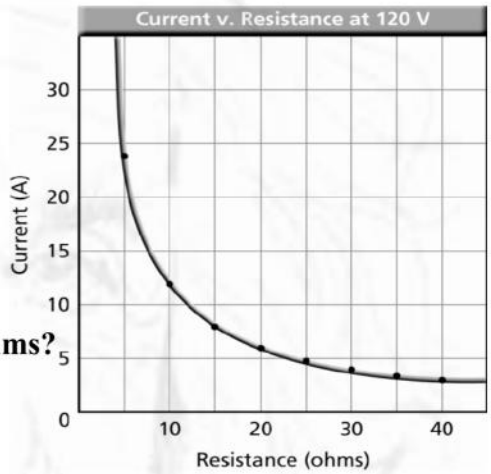
A) The factor that is changed or manipulated during an experiment

B) The factor that depends on what is changed or manipulated during an experiment

C) The line of best fit D) The result of an experiment

A - Refer to the graph to answer the following questions:

[Graph: Current vs Resistance at 120 V]



1. What sort of relationship is shown in this graph?

.....

2. Is the slope of this graph positive or negative?

.....

3. What are the units of the slope?

.....

4. What is the approximate current when the resistance is 25 ohms?

.....

5. Write an equation for this graph.

.....

According to the given equation below, what relationship exists between the variables F and v?

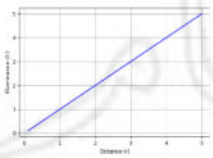
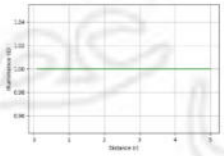
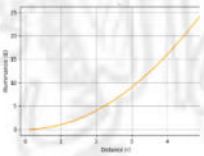
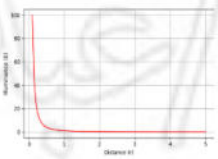
$$F = \frac{mv^2}{R}$$

A) Quadratic relationship
B) Linear relationship
C) Inverse relationship
D) Can't be determined without solving the equation

Relationship between F and m

What type of relationship exists between F and m?
A) Quadratic relationship
B) Linear relationship
C) Inverse relationship
D) Can't be determined without solving the equation

Which of the following graphs correctly shows the relationship between the variables F and v?

ⓐ  ⓑ  ⓒ  ⓓ 

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Which formula is equivalent to the kinetic energy equation?

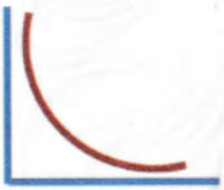
$$E = \frac{1}{2}mv^2$$

A) $m = \frac{2E}{v^2}$ **B)** $m = \frac{1}{2}Ev^2$ **C)** $m = \frac{v^2}{2E}$ **D)** $m = 2Ev^2$

According to the law, $\frac{X}{Y}$ = constant. If a graph is plotted with X against Y, the graph would be a(n):

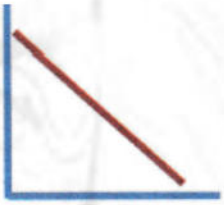
A) Straight line B) Curved line C) Wavy line D) Circle

According to Boyle's law, PV = constant. If a graph is plotted with the pressure P against the volume V, the graph would look

a. 

b. 

c. 

d. 

Mohammad wants to measure the rate at which ice cubes with different volumes melt in constant room temperature.

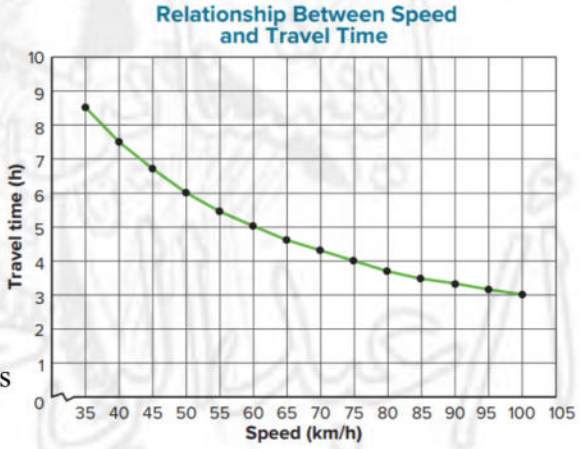
Based on the given information, determine the dependent and independent variables:

A) The volume is the dependent variable while the time is the independent variable.
B) The volume is the independent variable while the time is the dependent variable.
C) The room temperature is the dependent variable while the time is the independent variable.
D) The volume is the dependent variable while the room temperature is the independent variable.

Use the relationship shown in **Figure** to predict the travel time when the speed is **110 km/h**.

Given:

- Distance: $d = 300$ km
- Speed: $s = 110$ km/h
- Time: t =?



Solution:

$$t = \frac{d}{s} = \frac{300}{110} \approx 2.7 \text{ hours}$$

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Scalar vs Vector Quantities

Type	Definition	Examples
Scalar	Has **magnitude only**	Distance, Speed, Mass, Time, Temperature
Vector	Has **magnitude and direction**	Displacement, Velocity, Acceleration, Force

Examples

- **Distance (Scalar):** 50 m
- **Speed (Scalar):** 20 m/s

Scalar example: distance , mass , time , temperature , speed, work , energy, pressure

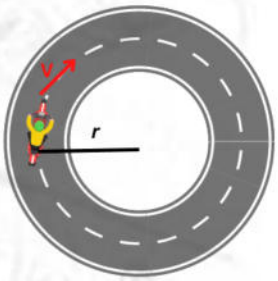
- **Displacement (Vector):** 50 m east
- **Velocity (Vector):** 20 m/s north

Vector example: position, displacement, velocity Acceleration, force

Distance vs Displacement

- **Distance**: The total length of the path traveled (scalar quantity).
- **Displacement**: The shortest straight-line distance from the starting point to the ending point (vector quantity).

Case 1: Circular Path



- If an object moves **around a full circle** and returns to the starting point:
  - ✓ **Distance** = Circumference = $2\pi r$
  - ✓ **Displacement** = 0 (because start and end points are the same).

Case 2: Semicircular Path

- If an object moves along a semicircle from one end to the other:
  - ✓ **Distance** = Half the circumference = πr
  - ✓ **Displacement** = Diameter = $2r$

Case 3: Rectangular Path

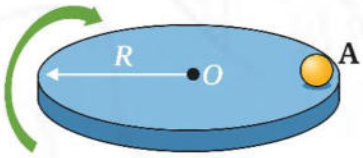
- If an object moves along the perimeter of a rectangle and returns to the starting point:
  - ✓ **Distance** = Perimeter = $2(L + W)$
  - ✓ **Displacement** = 0 (same reason).

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A particle moves along a circle of radius R. It starts from A and moves in a counterclockwise direction, as shown in the figure below. Answer the following:

- **Given:**
  Radius $R = 1.0$ m
  Circumference $C = 2\pi R$



$R = 1.0\ m$
$C = 2\pi R$
circumference (C)

a) Calculate the distance travelled by the particle in one complete revolution.

b) What is the displacement travelled by the particle in one complete revolution? Explain why.

If the Emirati Hope Probe orbited Mars one full cycle, what is the probe's **distance traveled** and **displacement**?



a) **Distance is the circumference of the circular orbit while displacement is zero.**
b) Distance and displacement both are zero.
c) Distance is zero while displacement is the circumference of the circular orbit.
d) Distance and displacement both are equal to the circumference of the circular orbit.

A biker rides north for 50 m from his starting position, then turns and bikes back south 70 m. What is his net displacement?

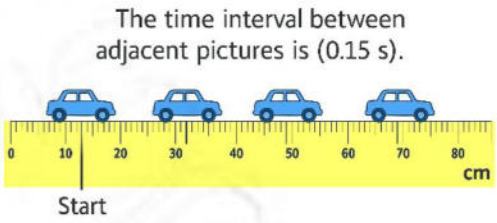
A) 20 m south B) 20 m north C) 120 m south D) 120 m north

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Depending on the movement of the toy car in the figure, what is the car's displacement after 0.30 s from the beginning of its motion?

(The time interval between adjacent pictures is 0.15 s)



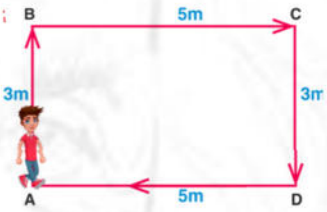
A) +70 cm B) +50 cm C) +80 cm D) +40 cm

A driver rides his bike a distance of 20 m towards the east from the origin, then travels another 15 m towards the east. What is the driver's total displacement?

A) 35 m east B) 5 m east C) 35 m west D) 5 m west

Adam started moving from point A, passed points B, C, and D as shown in the figure, and then returned to point A.

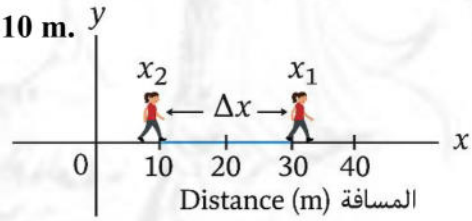
What are the displacement and distance respectively?



A) 0 m and 16 m B) 16 m and 16 m C) 0 m and 34 m D) 34 m and 34 m

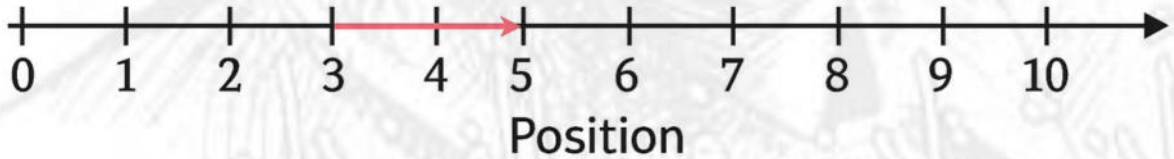
Sara starts at $x_1 = 30$ m and walks to the left to the point $x_2 = 10$ m.

What is Sara's displacement?



A) 20 m B) -10 m C) 40 m D) -20 m

In the graph, a toy car rolls from position +3 m to +5 m. Which of the following statements is true?



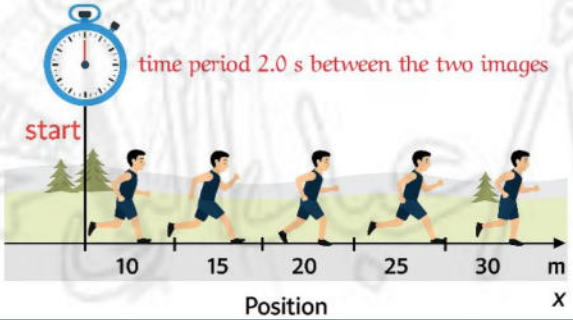
A) $x_f = +3$ m B) $\Delta x = +3$ m C) $v_{avg} = 3$ m/s D) $x_i = +3$ m

Depending on the figure,

what is the displacement for the runner after

(6.0 s) from the beginning of his movement?

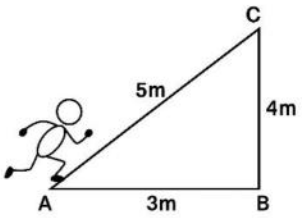
A) +25 m B) +15 m C) −25 cm D) −15 m



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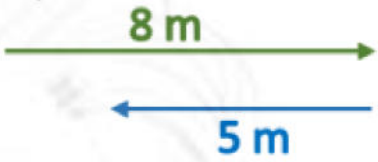
A boy moved from point A to B to C and finally back to A as shown below.



What is his displacement?

A) 0 m B) 3 m C) 5 m D) 12 m

In the figure there are two vectors. The first vector magnitude is (8 m) directed east, and the second vector magnitude is (5 m) directed west.



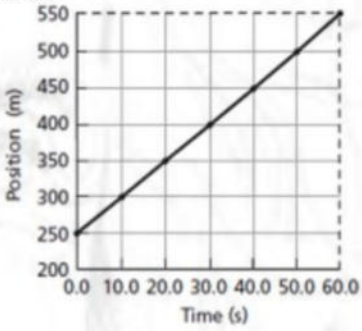
What is the sum of the two vectors?

A) 13 m East B) 3 m East C) 13 m West D) 3 m West

The (position–time) graph below shows a cyclist's location in a 60 s time interval.

What is the cyclist's displacement from the starting position after 40.0 s?

a) 200 m b) 400 m c) 450 m d) 250 m



Which statement about drawing vectors is true?

A) A vector is a quantity that has a magnitude but no direction.

B) All quantities in physics are vectors.

C) The vector's length should be directly proportional to its magnitude.

D) Determining the vector direction is not subject to any rules and is optional.

The graph represents a hockey puck gliding across a frozen pond.



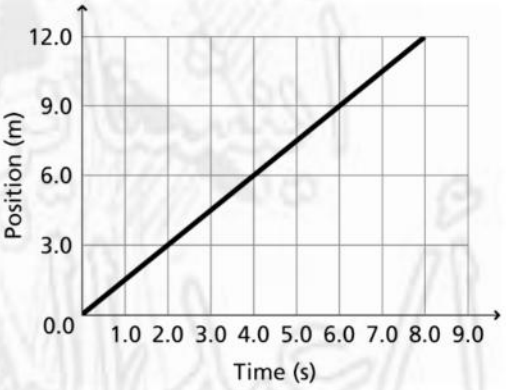
How far did the puck move between 0 s and 4 s?

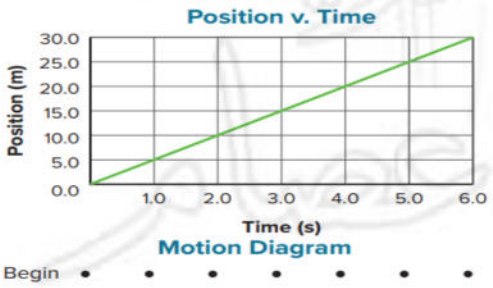
A) 20 m B) 40 m C) 60 m D) 80 m

Refer to the diagram below to answer questions below.

a. What is the position of the object at 6.0 s?

b. How much time has passed when the object is at 6.0 m?





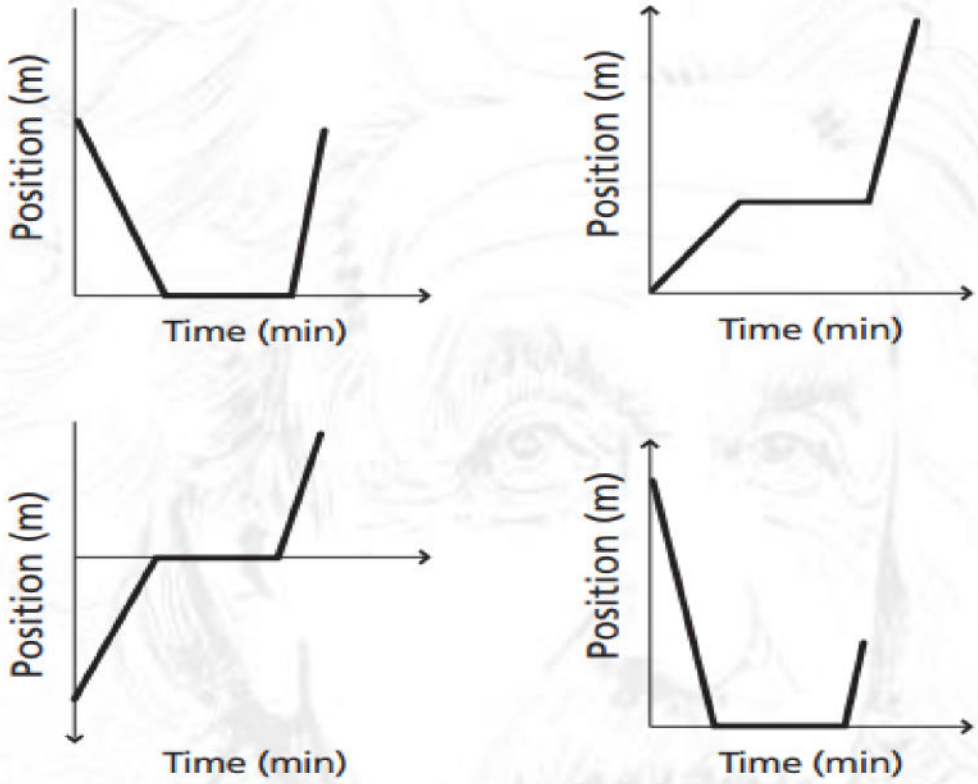
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A cat took 15 s to go down a fence whose height is (2.5 m) with a constant speed.

The cat stopped on the ground for 25 s, then suddenly jumped in 2 s up a box whose height is (1.25 m) with a constant speed. The diagrams represent position versus time curves.

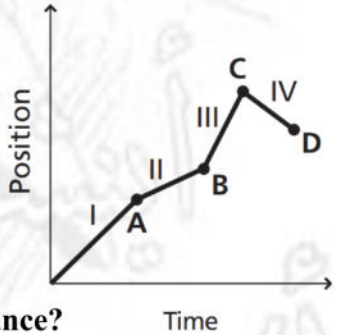
Which of the following diagrams represent the motion of the cat?



Use this graph for problems

The graph shows the motion of a person on a bicycle. When does the person have the greatest velocity?

A) section I B) section II C) point D D) section IV



When is the person on the bicycle farthest away from the starting point?

A) point A B) point B C) point C D) point D

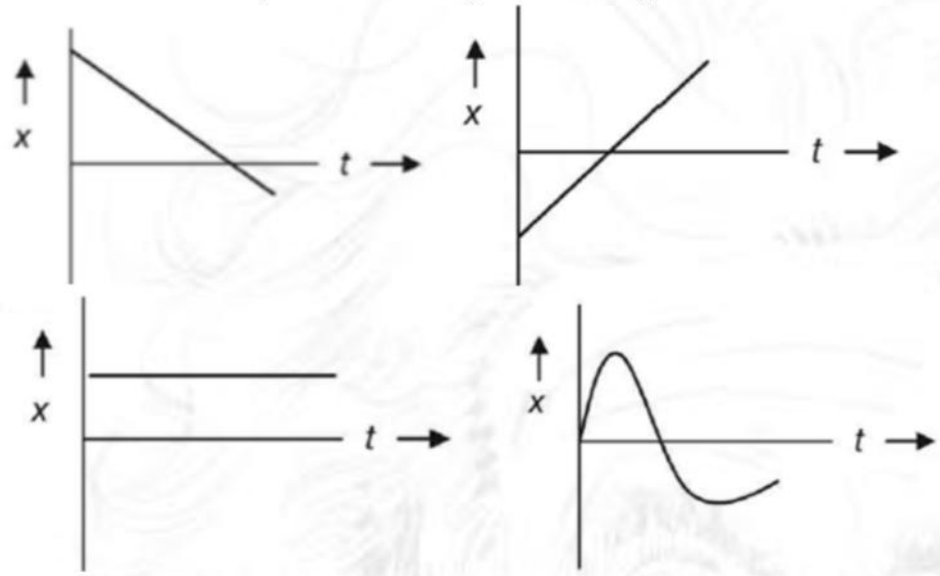
Over what interval does the person on the bicycle travel the greatest distance?

A) section I B) section II C) section III D) section IV

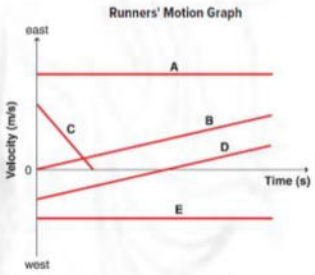
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The position-time graphs of four different objects are shown below. If the positive direction is forward, then which object is moving backward at a constant velocity?

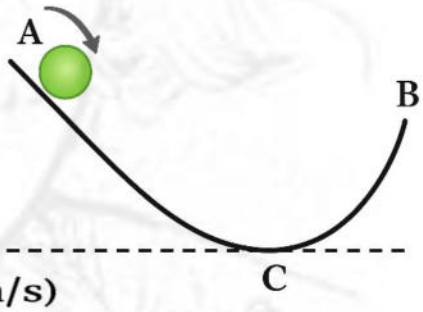


The velocity-time graph below represents the motion of 5 runners in a free marathon. Which one of the runners changed his running direction during the marathon?

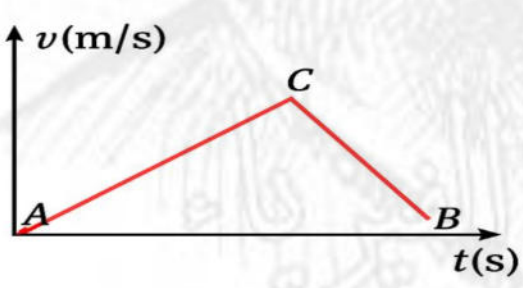


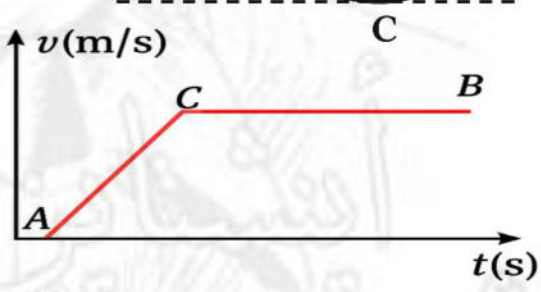
a) Runner D b) Runner B c) Runner C d) Runner E

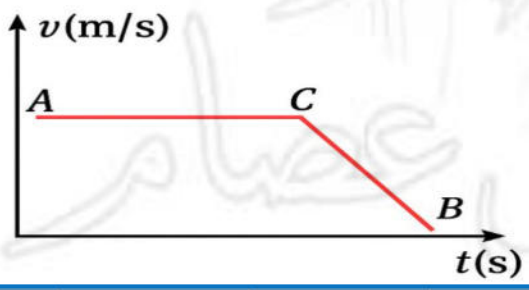
As shown in the figure, a ball starts its motion from rest at point A at the top of a smooth slope, until it reaches point C, then continues its motion upward until it reaches point B.

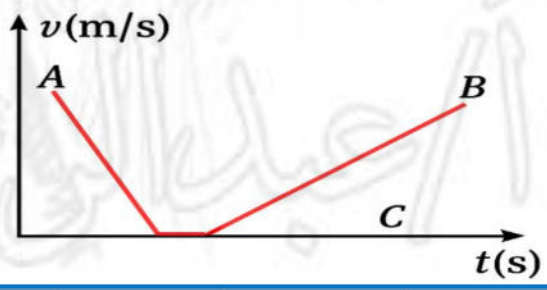


Which of the following figures represents the change in the speed of the ball (its acceleration) as it moves from A to B?







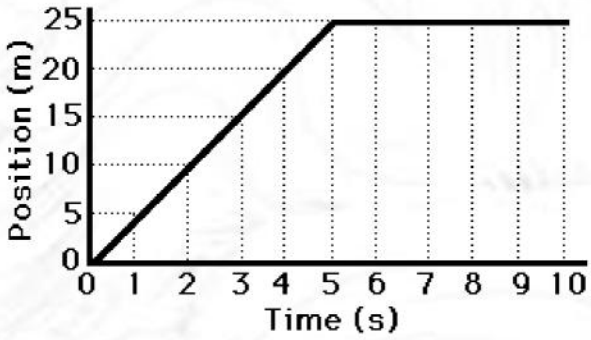


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A motion of a bus is represented in the graph below.

Which statement describes the motion of the bus?



a) The bus started to move from stationary with constant speed of 5 m/s for 5 seconds then it stopped.
b) The bus started to move from stationary with speed of 5 m/s then it speeded up to 25 m/s.
c) The bus started to move at t = 5 s.
d) The bus started to move from stationary with speed of 25 m/s then it stopped after 5 seconds.

Position

An object's position is equal to the average velocity multiplied by time plus the initial position:

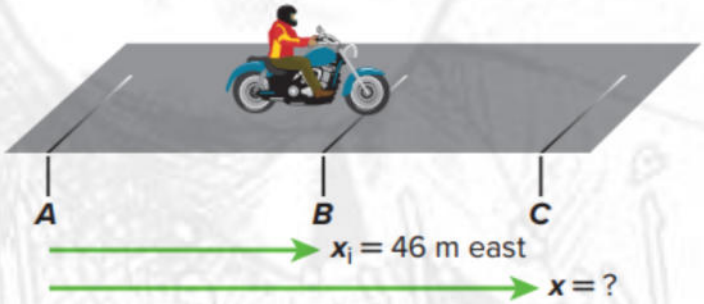
$$x = \bar{v}t + x_i$$

The figure shows a motorcyclist traveling east along a straight road. After passing point B, the cyclist continues to travel at an average velocity of **12 m/s east** and arrives at point C **3.0 s later**. What is the position of point C?

Analyze the Problem

Known:
$\bar{v} = 12$ m/s east
$x_i = 46$ m east
$t = 3.0$ s

Unknown: $x = ?$



Solve for the Unknown

$$x = \bar{v}t + x_i$$

$$x = (12 \text{ m/s})(3.0 \text{ s}) + 46 \text{ m}$$

$$x = 82 \text{ m east}$$

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The final position of a ball motion is given by the equation:

$$x_f = +0.70 + 3.0t + 2.0t^2$$

What are the initial position and initial velocity for the ball?

Option	Initial Velocity	Initial Position
A	+2.0 m/s	+0.70 m
B	+3.0 m/s	+0.70 m
C	+2.0 m/s	+3.0 m
D	+3.0 m/s	+3.0 m

An object's equation of motion is given by:

$$x_f = (12\text{ m}) + (5\text{ m/s})\,t$$

where x_f is the final position and t is the time. Which statement is true for the object?

A) Initial velocity could be 12 m/s
B) Moves with a constant velocity of 5 m/s
C) Moves with a constant velocity of 12 m/s
D) Accelerates at 5 m/s²

The equation of motion for a person riding a bicycle is:

$$x = 6.0\text{ m} + (5.0\text{ m/s})t$$

a) Where is the bike at $t = 2.0$ s?

$$x = 6.0\text{ m} + (5.0\text{ m/s})(2.0\text{ s}) = 16\text{ m}$$

b) At what time is the bike at the location $x = 26$ m?

$$26\text{ m} = 6.0\text{ m} + (5.0\text{ m/s})t$$

$$t = \frac{26\text{ m} - 6.0\text{ m}}{5.0\text{ m/s}} = 4.0\text{ s}$$

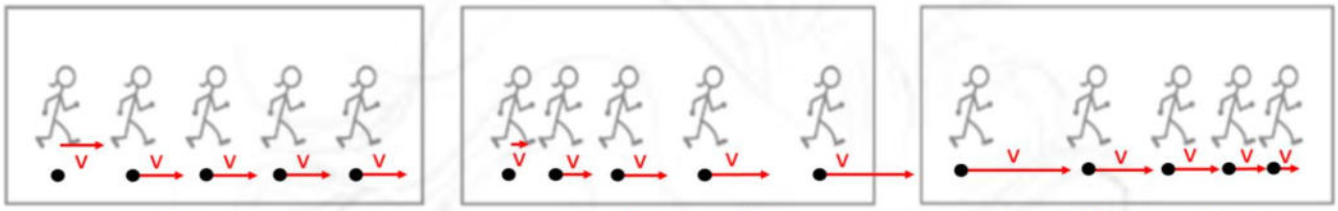
A dog runs down a straight path with an average velocity of 4.00 m/s for 2.00 min. What is its final position, taking its initial position to be zero?

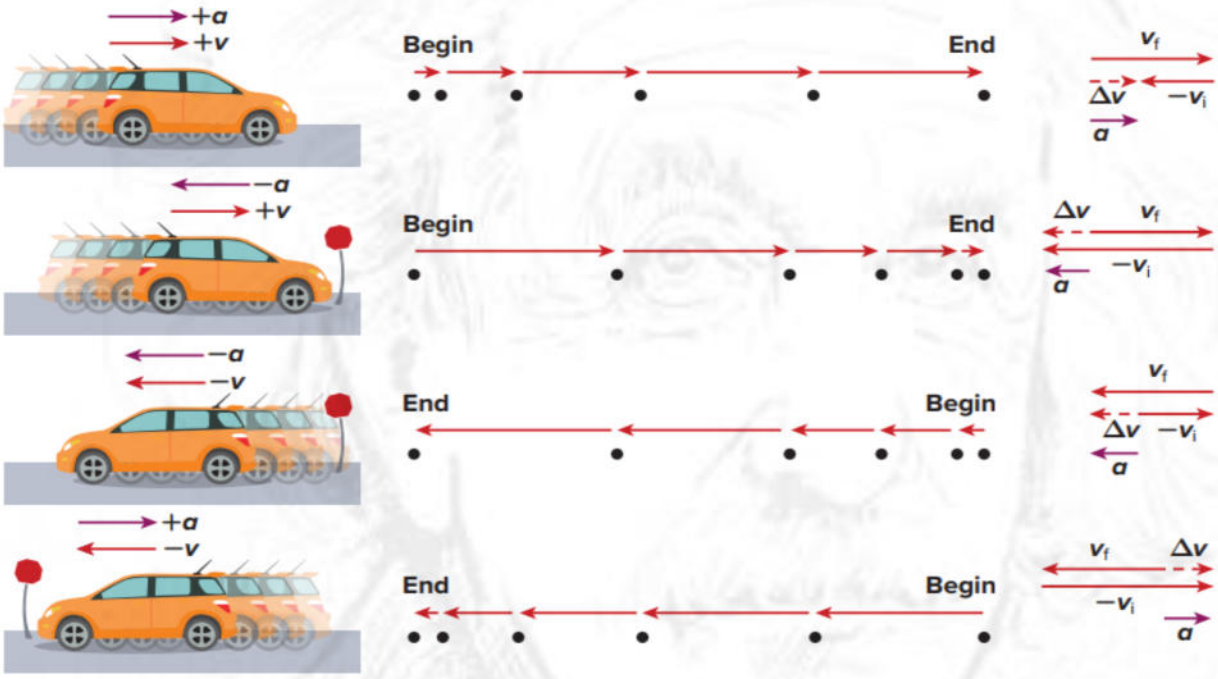
A) 480 m
B) 240 m
C) 120 m
D) 8 m

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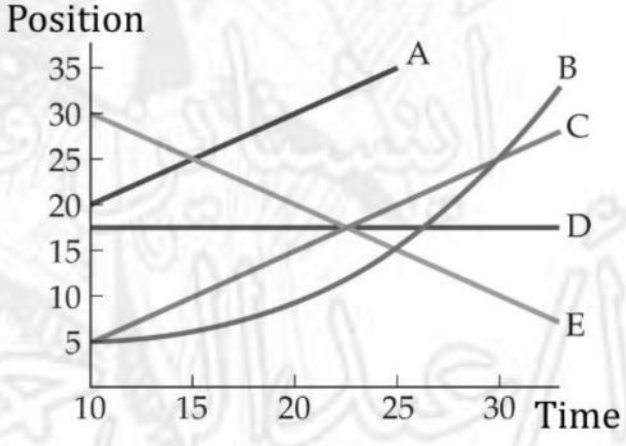
An object's motion can be uniform or nonuniform.
Nonuniform motion means that the object is experiencing a change in its velocity





The figure below represents the position-time graph for four different objects A, B, C and D.
Give a correct description of motion for each of the objects in the table below.

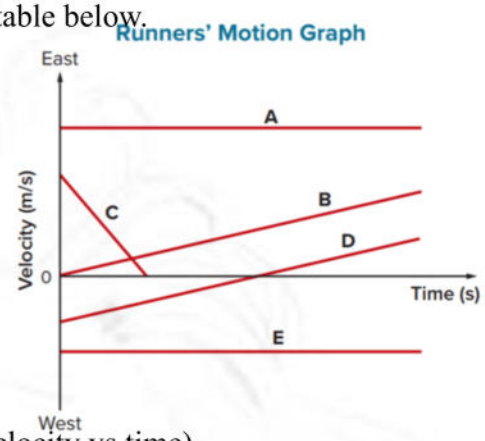
Object	Description
A	Positive, constant velocity
B	Positive increasing velocity/ Accelerating
C	Positive, constant velocity
D	At rest
E	Negative velocity



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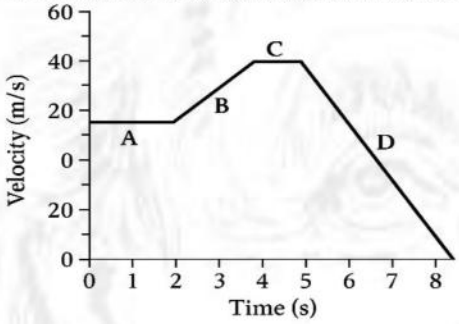
The figure below represents the velocity -time graph for four different objects A, B, C and D.
Give a correct description of motion for each of the objects in the table below.



A : moving at a constant velocity to the right.
B : accelerating (speeding up) to the right
C : decelerating (slowing down) to the right
D: decelerating to the left, stopping , then accelerating to the right.
E: moving at constant velocity to the left

The graph represents the motion of Mohammed toward the club (velocity vs time).

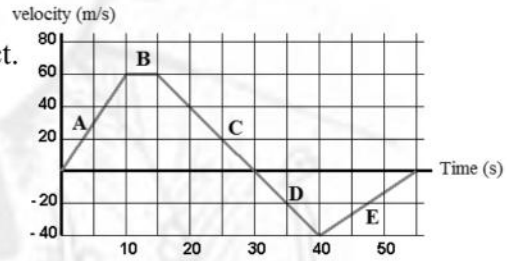
Answer the following:



During which time interval (A, B, C, D) does Mohammed have positive acceleration?
A) A B) B C) C D) D

During which time interval (A, B, C, D) does Mohammed have zero acceleration?
A) C B) B C) A D) D

The following velocity-time graph represents the motion of an object.

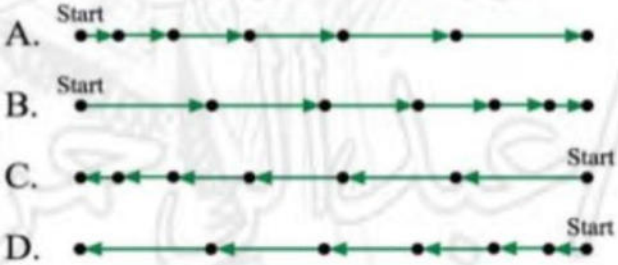


When is the acceleration zero?
A) A B C) C D) D

When is the acceleration negative?
A) A B) B C D) E

The motion diagrams below show the motion of four buses moving along the x-axis.

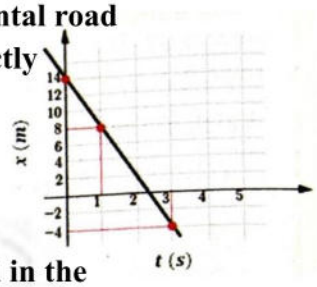
Which buses have positive acceleration?
a) A and C
b) B and D
c) A and D
d) B and C



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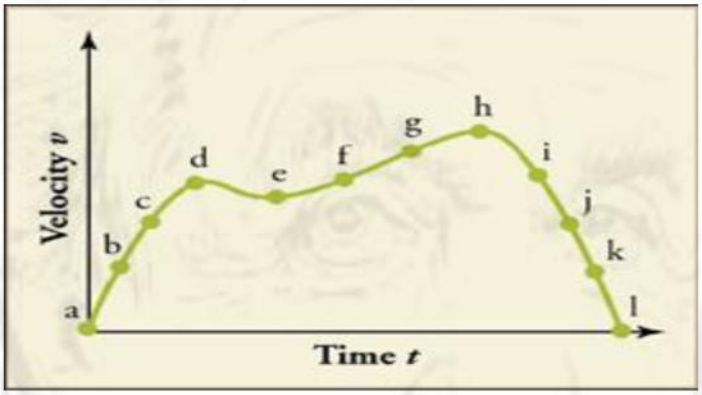
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The figure shows a position–time graph of a car moving on a straight horizontal road (x) at a constant speed during (3 s). Which of the following statements correctly expresses the motion of the car in the figure?



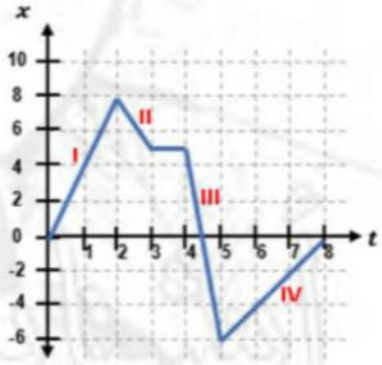
A. **It moves towards the positive x-axis (+x).**
B. **It moves towards the negative x-axis (–x).**
C. **In the time period (0 – 2.5 s) it moves towards the positive x-axis (+x), and in the period (2.5 – 3.0 s) it moves towards the negative x-axis (–x).**
D. **This cannot be deduced from the graph.**

In the velocity-time graph below, **during which periods is the object slowing down and speeding up?**



a) It is slowing down between **d–e** and then after **h**. It is speeding up between **a–d** and **e–h**
b) It is slowing down between **d–e** and it is speeding up between **a–d** and **e–h**
c) It is slowing down between **a–d** and **e–h**. It is speeding up between **d–e** and then after **i**
d) It is slowing down between **a–d** and **e–h**. It is speeding up between **d–e** and then after **i**

The figure below shows a simplified graph of a bicycle's motion.



When is the bicycle's speed greatest?
a) Section III
b) Section I
c) Section II
d) Section IV

Depending on the particle model in the figure for the motion of a vehicle, which of the following is true for the vehicle's motion?



A) The vehicle moved at constant velocity
B) The vehicle moved faster
C) The vehicle moved slower
D) The vehicle started to move faster and then slower

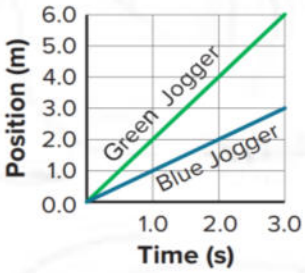
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In the Paris 2024 Olympics, among the many competitions, in the running race, the motion of the runners (competitors) was studied and represented graphically in the figure.

By analysing the two lines in the graph, each of which belongs to one of the runners,

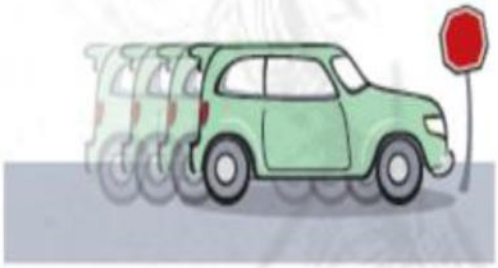




Which of the following expressions can be derived from the graph shown in the figure?

A) The blue runner covered a greater distance in 3 s
B) Both runners covered the same distance in 3 s
C) The blue runner covered the distance faster
D) The green runner covered the distance faster

The car in the figure travels from the Start point to the End point in a straight line with a variable speed. **Which of the following statements is true about the motion of the car?**

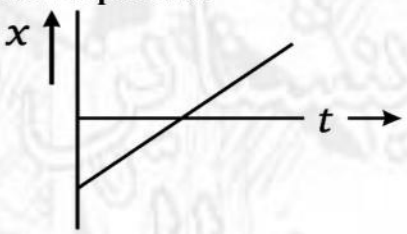




a) Speed decreases and acceleration is directed to the right
b) Velocity and acceleration remain constant in magnitude and both are directed to the right
c) Speed increases and acceleration is directed to the left
d) Speed decreases and acceleration is directed to the left

Which type of motion does the (position-time) graph below represent?

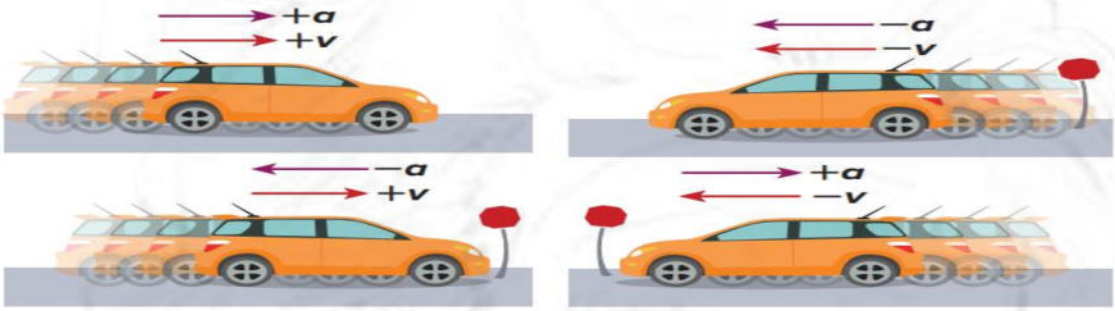
a) Motion with zero acceleration
b) Motion with a constant positive acceleration
c) Motion with a constant negative acceleration
d) Motion with zero velocity



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An object that is moving can accelerate by changing speed. To determine whether it is accelerating (speeding up) or decelerating (slowing down), we need to know the direction of both the velocity and acceleration vectors. **Study the diagrams attached below carefully.**

Which **motion diagram** represents the car moving **in the positive direction and slowing down (decelerating)?**



To better understand the motion of objects and to describe their motion, their motion diagrams are studied using consecutive images and the particle model.

The figure shows a runner jogging on a racetrack.



What does the diagram in the figure show?

A. The runner's speed decreases
B. The runner's speed increases
C. The runner's speed is constant
D. The runner moves in position without covering any distance

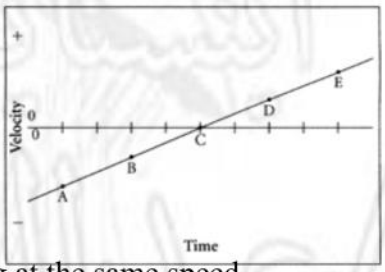
Which statement **correctly describes** the motion of the girl in the motion diagram below?



A. The girl is speeding up in the negative direction
B. The girl is speeding up in the positive direction
C. The girl is slowing down in the negative direction
D. The girl is slowing down in the positive direction

Which of the following is NOT an example of accelerated motion?

A. **An airplane taking off on a straight runway.**
B. **A cyclist moving in a straight line at a constant speed.**
C. **A ball being thrown straight up.**
D. **A boulder falling off a cliff in a straight path.**



What happened to the motion of the object at point C?

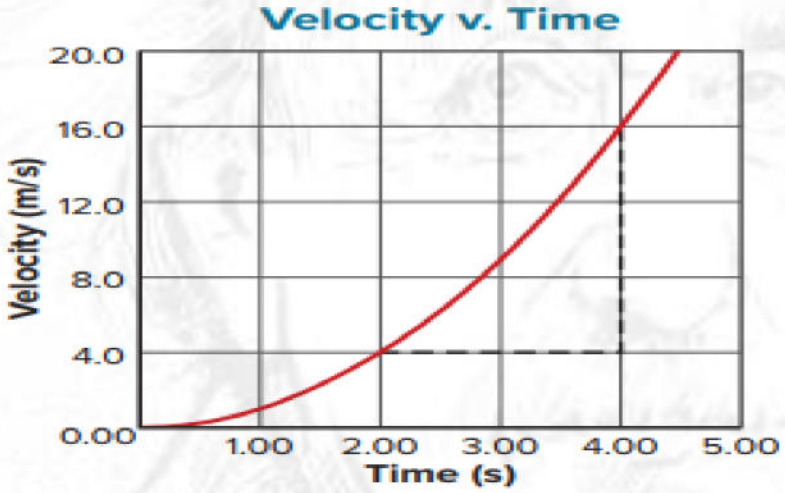
A) The object stopped to change the direction then continued moving at the same speed
B) Direction remains the same, but the object stopped
C) Direction is changed and the object accelerated
D) Both direction and velocity remain the same

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Average and Instantaneous Acceleration

- **The acceleration of most moving objects continually changes.**
- **The average acceleration of an object:**
  It is the change in velocity during some measurable time interval divided by that time interval.
- Average acceleration is measured in meters per second per second (m/s/s), or simply meters per second squared (**m/s^2**).
- **An average velocity** depends only on **the starting and ending displacement**.
- **An average acceleration** depends only on **the starting and ending velocity** during a time interval.

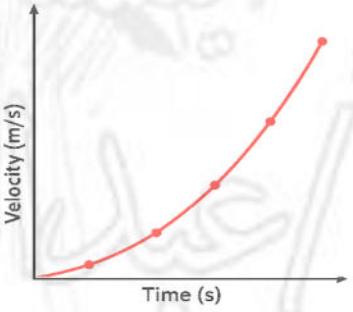


- **Notice**, however, that because the line is curved, the average acceleration in this graph varies depending on **the time interval that you choose**.

The figure shows a graph of an object moving in a straight line with a changing acceleration.

How can its instantaneous acceleration be calculated for this object at a certain time?

A) by calculating the slope of the tangent on a position-time graph
B) by calculating the area under the graph on a position-time graph
C) by calculating the area under the graph on a velocity-time graph
D) by calculating the slope of the tangent on a velocity-time graph



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Based on the velocity-time graph of a car moving in a straight line,

which of the following is correct?



A. **The car is moving at constant velocity.**
B. **The car's acceleration is negative.**
C. **The car's velocity is increasing uniformly.**
D. **The car's acceleration is positive.**

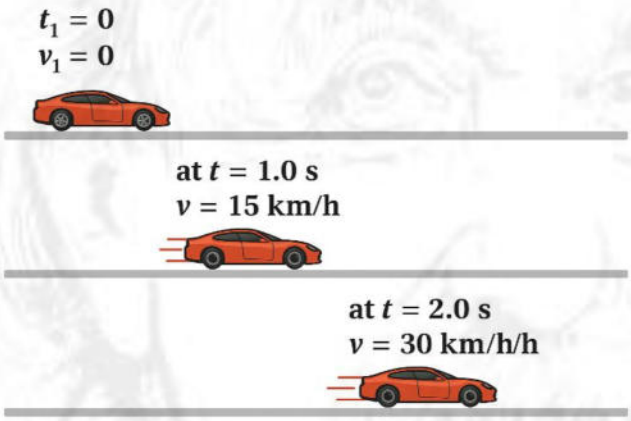
A cheetah can accelerate from 0 km/h to 120 km/h in 3 s.

What is the average acceleration of the cheetah?



A. 11.1 m/s B. 11.1 m/s² C. 11.1 km/s² D. 11.1 km/h²

Using the motion diagram of a racing car, what is the average acceleration of the car?



A. 15 km/h² B. 30 km/h² C. 0.5 km/h² D. 45 km/h²

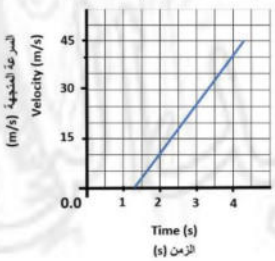
Ahmad was running toward the football field with the speed of (vi = 4.50 m/s). He felt he had time so he started to slow down, and he reached the speed of (vf = 0.95 m/s) after 10.0 s. What was the magnitude of his average acceleration during this (10.0 s) time interval?

Formula: $a = \frac{\Delta v}{\Delta t}$

A) 1.80 m/s² B) 0.712 m/s² C) 0.355 m/s² D) 35.5 m/s²

The figure represents the velocity versus time for a moving object. What is the average acceleration for the object during the time interval from (t = 2.0 s) till (t = 4.0 s)?

A) (0.0) m/s²
B) (+11) m/s²
C) (+5.0) m/s²
D) (+15) m/s²

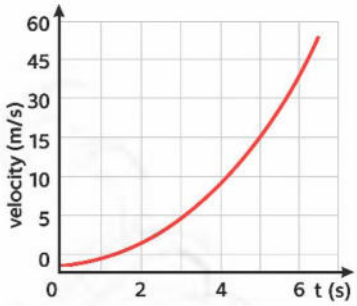


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Depending on the graph for an object's motion,

what is the acceleration of the object between (4.0 s) to (60 s)?



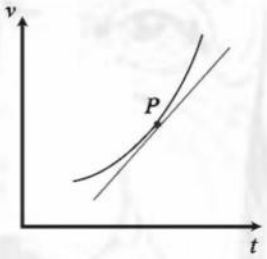
A) 0.0 m/s²
B) +15 m/s²
C) +17 m/s²
D) +5.0 m/s²

The speedometer of a moving car shows a direct reading of instantaneous speed. What type of speed is that?



A) Average speed
B) Instantaneous speed rate
C) Average velocity
D) Instantaneous velocity

Which value of acceleration could be found from the tangent at point P?



a) Instantaneous acceleration
b) Average acceleration
c) Centripetal acceleration
d) Free fall acceleration

How can the instantaneous acceleration of an object with varying acceleration be calculated?

A) By calculating the slope of the tangent on a velocity-time graph
B) By calculating the area under the graph on a velocity-time graph
C) By calculating the slope of the tangent on a position-time graph
D) By calculating the area under the graph on a position-time graph

The change in velocity during a measurable time interval, divided by the time interval, is the _____.

A) Instantaneous velocity B) Average velocity

C) Instantaneous acceleration D) Average acceleration

A race horse coming out of the gate accelerates from rest to a velocity of 15.0 m/s due west in 1.80 s. What is its average acceleration?

A) –8.33 m/s² B) 8.33 m/s² C) –27 m/s² D) 27 m/s²

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Equations of Motion for Constant Acceleration

1. **Final Velocity with Average Acceleration**

$$v_f = v_i + \bar{a}\Delta t$$

Used: When **distance** is not given or asked.

A bus traveling at 30.0 km/h east has a constant increase in speed of 3.5 m/s². What velocity does it reach 6.8 s later?

Given:

- $v_i = 30.0$ km/h east
- $a = 3.5$ m/s^2
- $t = 6.8$ s

Convert initial velocity to m/s:

$$30.0 \text{ km/h} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ h}}{3600 \text{ s}} = 8.33 \text{ m/s}$$

$$v_f = v_i + at$$

$$v_f = 8.33 \text{ m/s} + (3.5 \text{ m/s}^2)(6.8 \text{ s}) = 32.13 \text{ m/s}$$

Convert back to km/h:

$$32.13 \text{ m/s} \times \frac{3600 \text{ s}}{1000 \text{ m}} = 115.7 \text{ km/h east}$$

If a car accelerates from rest at a constant rate of 5.5 m/s² north, how long will it take for the car to reach a velocity of 28 m/s north?

Given:

- $v_i = 0$ m/s
- $v_f = 28$ m/s north
- $a = 5.5$ m/s^2

$$v_f = v_i + at$$

$$t = \frac{v_f - v_i}{a}$$

$$t = \frac{28 - 0}{5.5} = 5.09 \text{ s}$$

A car slows from 22 m/s to 3.0 m/s at a constant rate of 2.1 m/s².
How many seconds are required before the car is traveling at 3.0 m/s?
Given:

- $v_i = 22.0$ m/s
- $v_f = 3.0$ m/s
- $a = -2.1$ m/s^2 (negative because slowing down)

$$v_f = v_i + at$$

$$t = \frac{v_f - v_i}{a}$$

$$t = \frac{3.0 - 22.0}{-2.1} = 9.05 \text{ s}$$

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A car with an initial velocity of 22 m/s is accelerated uniformly at the rate of 1.6 m/s² for 6.8 s. What is its final velocity?

Given:

- $v_i = 22$ m/s
- $a = 1.6$ m/s^2
- $t = 6.8$ s

$$v_f = v_i + at$$
$$v_f = 22 + (1.6)(6.8) = 32.88 \text{ m/s}$$

A bus traveling at 30.0 km/h east has a constant increase in speed of 1.5 m/s². What velocity does it reach 6.8 s later?

Given:

- $v_i = 30.0$ km/h east
- $a = 1.5$ m/s^2
- $t = 6.8$ s

Convert v_i to m/s: $30.0 \times \frac{1000}{3600} = 8.33$ m/s

$$v_f = v_i + at$$
$$v_f = 8.33 + (1.5)(6.8) = 18.53 \text{ m/s}$$

Convert back to km/h:

$$18.53 \times \frac{3600}{1000} = 66.7 \text{ km/h east}$$

A golf ball rolls up a hill toward a miniature-golf hole. Assume the direction toward the hole is positive.

Given:

- **Initial velocity: $v_i = +2.0$ m/s**
- **Acceleration: $a = -0.50$ m/s^2 (negative because slowing down)**
- **Time for part (a): $t = 2.0$ s**
- **Time for part (b): $t = 6.0$ s**

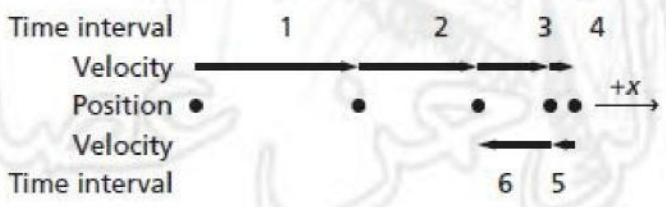
a. What is its velocity after 2.0 s?

$$v_f = v_i + at$$
$$v_f = +2.0 + (-0.50)(2.0) = +1.0 \text{ m/s (toward the hole)}$$

b. What is its velocity if the constant acceleration continues for 6.0 s?

$$v_f = v_i + at$$
$$v_f = +2.0 + (-0.50)(6.0) = -1.0 \text{ m/s opposite direction}$$

c. Describe the motion of the golf ball in words and with a motion diagram.



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If a car accelerates from rest at a constant rate of 5.5 m/s² north, how long will it take for the car to reach a velocity of 28 m/s north?

Given:

- $v_i = 0$ m/s
- $v_f = 28$ m/s north
- $a = 5.5$ m/s^2

$$v_f = v_i + at$$

$$t = \frac{v_f - v_i}{a}$$

$$t = \frac{28 - 0}{5.5} = 5.09 \text{ s}$$

A car slows from 22 m/s to 3.0 m/s at a constant rate of 2.1 m/s². How many seconds are required before the car is traveling at a forward velocity of 3.0 m/s?

Given:

- $v_i = 22.0$ m/s
- $v_f = 3.0$ m/s
- $a = -2.1$ m/s^2

$$v_f = v_i + at$$

$$t = \frac{v_f - v_i}{a}$$

$$t = \frac{3.0 - 22.0}{-2.1} == 9.05 \text{ s}$$

An airplane accelerated uniformly from rest at the rate of **5.0 m/s² south** for **14 s**.

What final velocity did it attain?

Given:

- $v_i = 0$ m/s(starts from rest)
- $a = 5.0$ m/s^2 south
- $t = 14$ s

$$v_f = v_i + at$$

$$v_f = 0 + (5.0)(14) = 70 \text{ m/s south}$$

A car starts from rest and goes down a hill with a constant acceleration of 5 m/s². After 5 s the car reaches the bottom of the hill. What is the car's final speed?

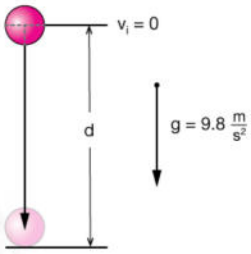
A) 25 m/s
B) 10 m/s
C) 50 m/s
D) 1 m/s



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Definition of Free Fall

Free fall is the motion of an object when **gravity is the only significant force acting on it**, with no appreciable effect from air resistance.

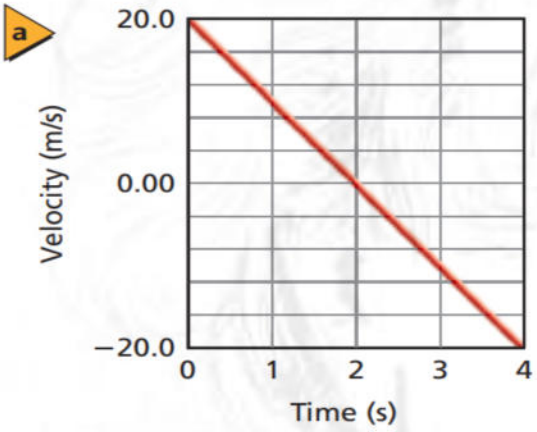


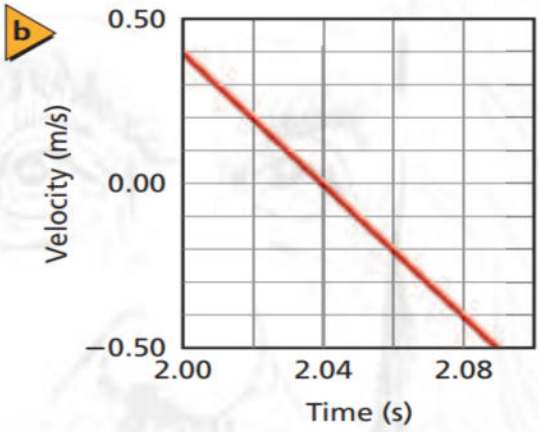
Free-Fall Acceleration

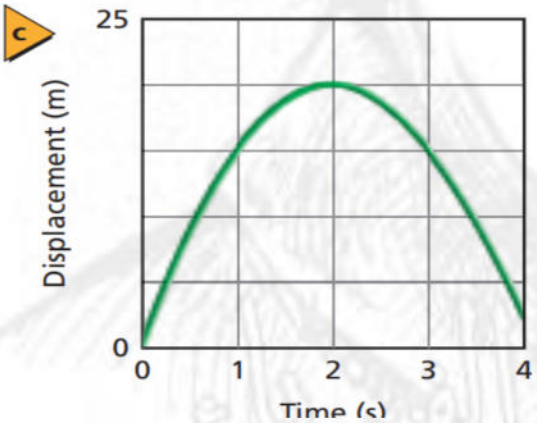
- The acceleration of an object due only to gravity is called **free-fall acceleration**.
- Near Earth's surface:

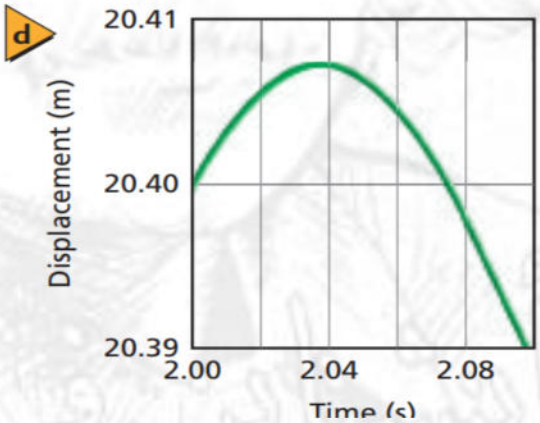
$$a = g = 9.8\ \text{m/s}^2 \text{ downward}$$

- This means the object's velocity changes by **9.8 m/s every second** during free fall.







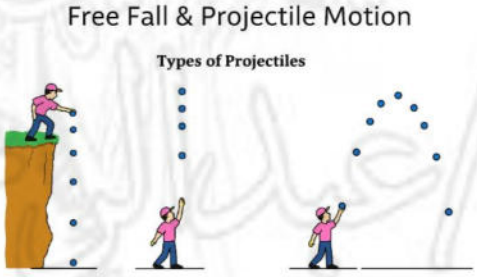


- If upward is positive, then:

$$g = -9.8\ \text{m/s}^2$$

- If downward is positive, then:

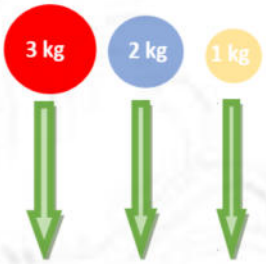
$$g = +9.8\ \text{m/s}^2$$



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Kareem drops three balls with different masses from the same height. Which ball has the greatest acceleration? (Ignore air resistance)

A) All the balls have the same acceleration
B) The blue ball
C) The red ball
D) The yellow ball



The Saudi football national player Saleh Al-Shehri kicked the ball vertically upwards in Qatar World Cup 2022. What is the direction of the ball's velocity and acceleration while going up in the air?











A football is thrown straight up with an initial speed of (vi). It is caught after it returns to the same location from which it was thrown above the ground after (4 s), as shown in Figure (1). Using Figure (2) and Figure (3), which choice in the table is correct?

	Initial Speed	Maximum Height
A)	–20.0 m/s	40.0 m
B)	0.0 m/s	0.0 m
C)	+20.0 m/s	20.0 m
D)	20.0 m/s	25.0 m



Figure (1)

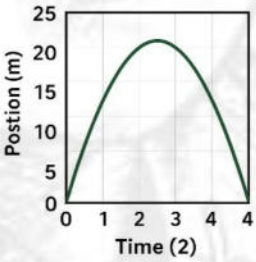


Figure (2)

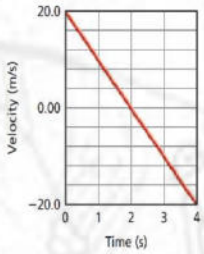
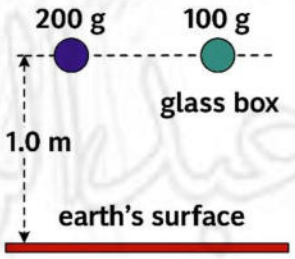


Figure (3)

There are two balls in a glass box with no air on the ground as shown in the figure. If the two balls start falling together, which of the following is correct for the two balls?

A) The ball (100 g) reaches the ground surface first
B) The ball (200 g) reaches the ground surface first
C) The two balls reach the ground surface together
D) Neither ball will reach the ground surface



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Part2/ FRQ

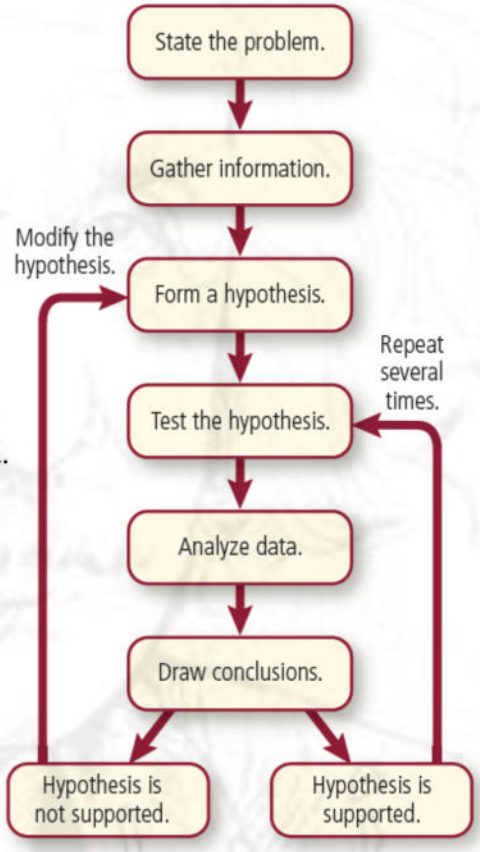
List the common steps of scientific methods used in investigations.
Classify common quantities into base and derived quantities with their SI units.
(Student Textbook: Pages 4, 9)

A Scientific Method

A scientific method is a set of steps that scientists follow to solve problems depending on investigation.

Note: Physicists often adjust, repeat, or even skip steps depending on the situation.

The pattern of investigation procedures:



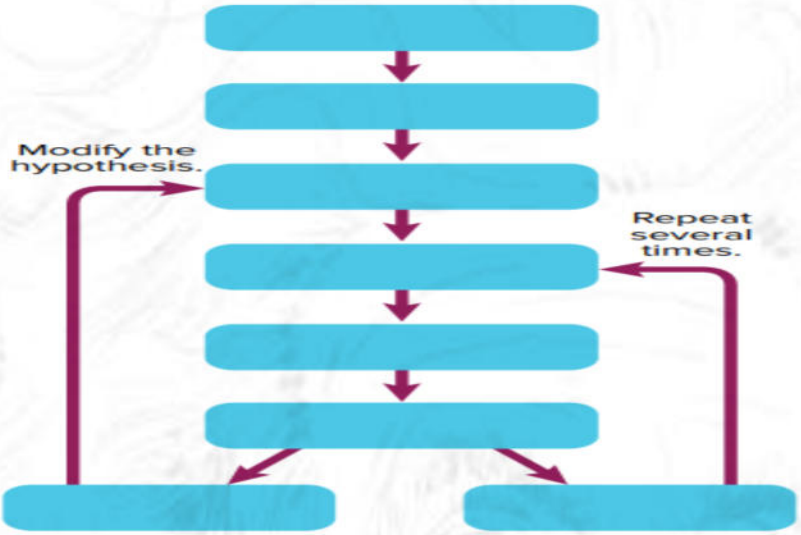
1. **State the Problem**
   - ✓ The question of *"why," "what," or "how."*
2. **Gather Information**
   - ✓ Researching relevant data.
3. **Form a Hypothesis**
   - ✓ A hypothesis is a possible explanation for a problem using what you know and have observed.
4. **Test the Hypothesis**
   - ✓ Hypotheses can be tested by:
     - **Observations**
     - **Models**
     - **Experiments (investigation)**
5. **Analyze Data**
   - ✓ Includes recording observations and organizing data into easy-to-read tables and graphs.
6. **Draw Conclusions**
   - ✓ Decide whether the hypothesis is supported or not.
   - ✓ If not supported, modify the hypothesis and repeat the process.

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Reorder the following sentences to get a diagram about : (scientific methods)

Draw conclusions- Form a hypothesis -State the problem -Test the hypothesis

Gather information -Analyze data -Hypothesis is not supported -Hypothesis is supported



Models

A model represents an idea, event, structure, or object that helps people understand it better.

Examples: Earth model, engine model, computer simulation.

Scientific Theories and Laws

Scientific Theory: An explanation of things or events based on knowledge gained from many observations and investigations.

Scientific Law: A statement about what happens in nature and seems to be true all the time.

A - Match the phrase (definition) in Column (A) with its appropriate term/concept in Column (B):

Column (A) – Phrase (Definition)	Match	Column (B) Term/Concept
A representation of an idea, event, structure, or object that helps people better understand it.		Scientific law
An explanation of things or events based on knowledge gained from many observations and investigations, which is subject to modification and refinement.		Model
A possible explanation for a problem using what you know and have observed; can be tested through experimentation and observation.		Hypothesis
A statement about what happens in nature and seems to be true all the time, but does not explain why or how it happens.		Scientific theory

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Match each term with its description

Term	Match	Description
Hypothesis		A testable explanation for a problem.
Peer review		Evaluation of research by scientists in the same field.
Bias		Personal expectations affecting results.
Percy Spencer		Scientist who discovered microwave cooking by accident.
Analyze data		Careful organization of observations into tables and graphs.

Base Quantities in SI System

These are the fundamental quantities from which other quantities are derived.

Derived Quantities

These are formed by combining base quantities.

Base Quantities			Derived Quantities	
Quantity	**SI Unit**	**Symbol**	**Quantity**	**SI Unit**
Time	second	s	**Volume**	cubic meter m^3
Mass	kilogram	kg	**Density**	kg/m^3
Temperature	kelvin	K	**Speed**	m/s
Length	meter	m	**Acceleration**	m/s^2
Electric Current	ampere	A	**Force**	newton (N)
Amount of Substance	mole	mol	**Energy**	joule (J)
Luminous Intensity	candela	cd	**Pressure**	pascal (Pa)

The speed of a body is the distance travelled per unit time.

a. What is the SI unit of speed?

b. Is the unit of speed a basic unit or a derived unit?

Classify the following physical quantities in the table into base quantities and derived quantities.

Physical Quantity	Classification
5 kg	.....
3.5 m	.....
20 m/s	.....
9.8 m/s^2	.....
300 K	.....
2 mol	.....
50 N	.....
1.2 kg/m^3	.....

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Read the text below and extract from it the names of the physical quantities whose values are given, placing them in the following table:

Salma went on a school trip from Sharjah to Khor Fakkan, covering 110 km in 70 min, as shown on the GPS map, to visit its beautiful landmarks, including a waterfall and a Roman amphitheatre. On the way, she bought two bottles of water, two litters of juice, and 500 g of nuts. Upon her safe return, she went back to tell her sister about how much she enjoyed the trip and the beauty of Khor Fakkan.



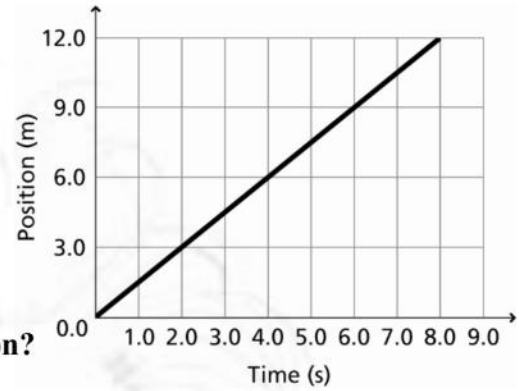
Table to complete:

Amount of physical quantity	Physical quantity
1	
2	
3	
4	

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Refer to the diagram below to answer questions (a to e):



a. What is the position of the object at 6.0 s?

Answer: 9.0 m

b. How much time has passed when the object is at 6.0 m?

Answer: 4.0 s

c. How far does the object travel for every second it is in motion?

Answer: 1.5 m/s

d. If the object continues at this speed, when will the object reach 18.0 m?

$$v_{av} = \frac{\Delta x}{\Delta t}$$

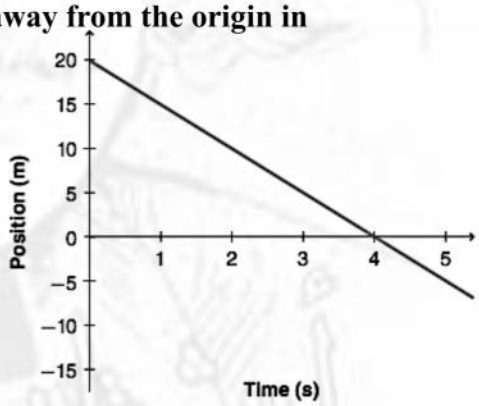
$$\Delta t = \frac{\Delta x}{v_{av}} = \frac{18.0\ \text{m}}{1.5\ \text{m/s}} = 12\ \text{s}$$

e. Where will the object be after 300 s?

$$\Delta x = v_{av} \times \Delta t = (1.5\ \text{m/s})(300\ \text{s}) = 400\ \text{m}$$

The graph below shows how the position of an object is changing with time.

a. From the graph, identify if the object is moving towards or away from the origin in the first 4 s.



Answer: The object is moving towards the origin.

b. What is the object's average velocity at 4 s?

$$v_{av} = \text{slope of the graph} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$v_{av} = \frac{0 - 20}{4 - 0} = -5\ \text{m/s}$$

c. What is the object's average speed in the last 1 s?

$$\text{Average speed} = |-5\ \text{m/s}| = 5\ \text{m/s}$$

d. What is the y-intercept? 20 m

e. Use your answers from part b and part d to find the position of the object after 10 s.

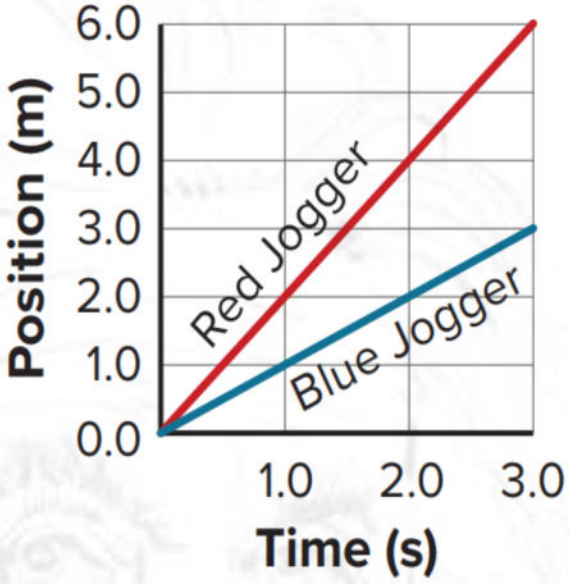
$$x_f = vt + x_i$$

$$x_f = (-5\ \text{m/s})(10\ \text{s}) + 20\ \text{m} = -30\ \text{m}$$

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The position-time graph below represents the motion of two joggers.





a. Which jogger has a higher speed? Explain why.

Answer:
The red jogger has a higher speed because the line is steeper, meaning it covers more distance in the same time.

b. Will the blue jogger catch up to the red jogger during the motion shown in the graph? How can you tell?

Answer:
No, the lines representing the blue jogger and the red jogger get farther apart as time increases.

c. How far apart were the two runners at t = 2.0 s?

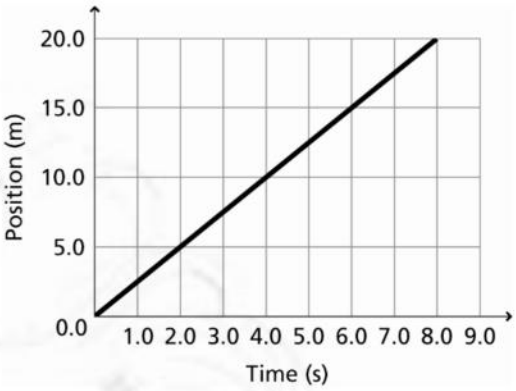
$$\Delta x = x_{\text{red}} - x_{\text{blue}}$$

$$\Delta x = 4.0\ \text{m} - 2.0\ \text{m} = 2.0\ \text{m}$$

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Refer to the diagram below to answer the questions:



a. Find Δt for the change in position from x = 5 m to x = 15 m.

$$\Delta t = t_f - t_i = 6.0\text{ s} - 2.0\text{ s} = 4.0\text{ s}$$

b. Find Δx for the time interval from t = 2.0 s to t = 8.0 s.

$$\Delta x = 20.0\text{ m} - 5.0\text{ m} = 15.0\text{ m}$$

c. What is the slope of this line?

$$\text{Slope} = v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

$$v_{av} = \frac{20.0\text{ m} - 5.0\text{ m}}{8.0\text{ s} - 2.0\text{ s}} = \frac{15\text{ m}}{6.0\text{ s}} = 2.5\text{ m/s}$$

d. What does the absolute value of the slope represent?

Answer: Average speed = $|v_{av}|$

e. What is the speed of this object in m/s?

Answer: Average speed = $|v_{av}|$ = 2.5 m/s

f. If this object continues at the same speed, how long would it take to reach x = 150 m?

$$v_{av} = \frac{\Delta x}{\Delta t}$$

$$\Delta t = \frac{\Delta x}{v_{av}} = \frac{150\text{ m}}{2.5\text{ m/s}} = 60\text{ s}$$

g. If this object continues at the same speed, how far will it have traveled when t = 200 s?

$$\Delta x = v_{av} \times \Delta t = 2.5\text{ m/s} \times 200\text{ s} = 500\text{ m}$$

h. What formula would you use to determine the position of this object if it had an initial position vector and then traveled at a fixed velocity for a certain amount of time?

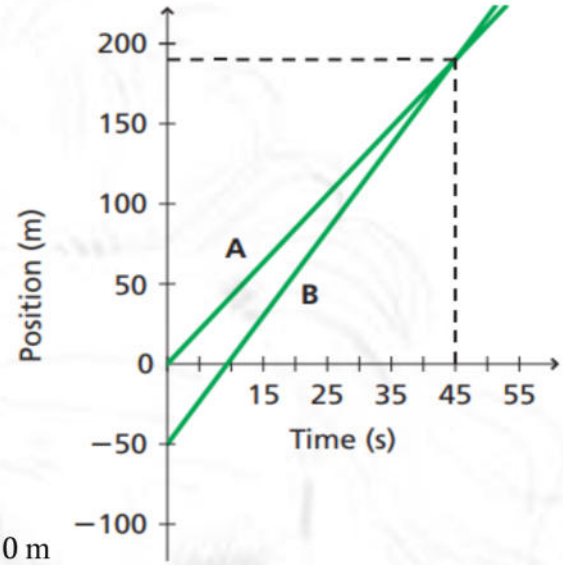
$$x = v_{av} \times t + x_i$$

i. How far will this object have traveled if it had an initial position of 220 m and traveled at a speed of 2.5 m/s for 48 s?

$$x = v_{av} \times t + x_i = (2.5\text{ m/s})(48\text{ s}) + 220 = 340\text{ m}$$

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The graph describes the motion of two runners moving along a straight path. The lines representing their motion are labeled **A** and **B**.



1. When and where does runner B pass runner A?
Answer: at t = 45 s

2. Where was runner A located at t = 0 s?
Answer: at x = 0 m

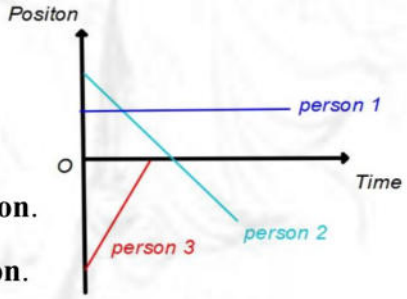
3. Which runner was ahead at t = 48.0 s?
Answer: B

4. When runner A was at 0.0 m, where was runner B?
Answer: xB = –50 m

5. How far apart were runners A and B at t = 20.0 s?

$$\Delta x = 90\text{ m} - 60\text{ m} = 30\text{ m}$$

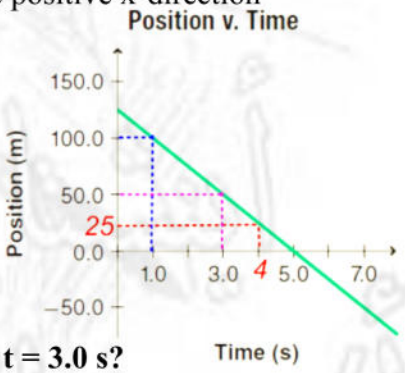
The graph shows the position-time relationship for three individuals: **person 1**, **person 2**, and **person 3**.



Describe the motions of person 1, person 2, and person 3:

- **Person 1** is **at rest**.
- **Person 2** is moving at a **constant speed in the negative direction**.
- **Person 3** is moving at a **constant speed in the positive direction**.

Answer the following questions about the car's motion. Assume that the positive x-direction is **east** of the origin and the negative x-direction is **west** of the origin.



a. At what time was the car's position 25.0 m east of the origin?

$$t = 4\text{ s}$$

b. Where was the car at time t = 1.0 s?

$$x = 100\text{ m}$$

c. What was the displacement of the car between times t = 1.0 s and t = 3.0 s?

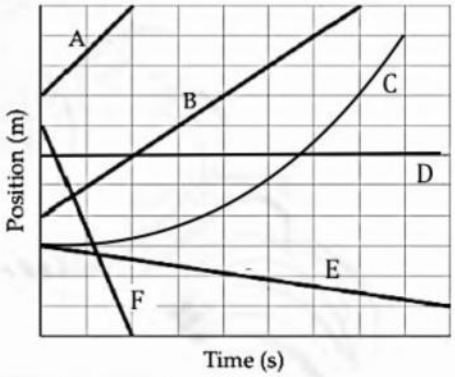
$$\Delta x = x_f - x_i$$

$$\Delta x = 50 - 100 = -50\text{ m or } 50\text{ m west}$$

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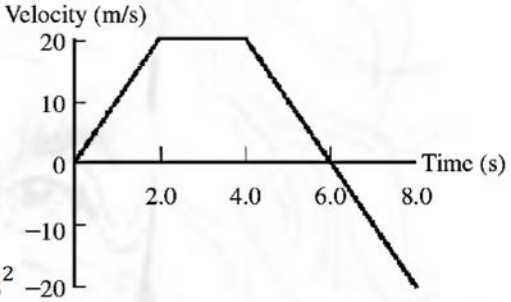
The position-time graphs in the figure below show different motions, labeled A, B, C, D, E and F.
Describe the motion for each of the objects listed below:



A: Constant positive velocity
B: Constant positive velocity
C: Accelerating
D: At rest
E: Constant negative velocity
F: Constant negative velocity/ also most negative

The figure shows a graph of the velocity of an object as a function of time.

a. What is the average acceleration from t = 0 s to t = 5.0 s?



$$\text{Average acceleration} = \frac{\Delta v}{\Delta t} = \frac{10\ \text{m/s}}{5\ \text{s}} = 2.0\ \text{m/s}^2$$

b. What is the average acceleration from t = 0 s to t = 8.0 s?

$$\text{Average acceleration} = \frac{-20\ \text{m/s}}{8\ \text{s}} = -2.5\ \text{m/s}^2$$

c. Calculate the total distance covered by the object in 8 s.

$$\text{Total distance} = \frac{1}{2}(2.0 + 6.0)(20) + \frac{1}{2}(2.0)(20) = 100\ \text{m}$$

d. Calculate the total displacement of the object in 8 s.

$$\text{Displacement} = [\frac{1}{2}(2.0 + 6.0)(20)] - [\frac{1}{2}(2.0)(20)] = 60\ \text{m}$$

Describe the motion for the above graph.

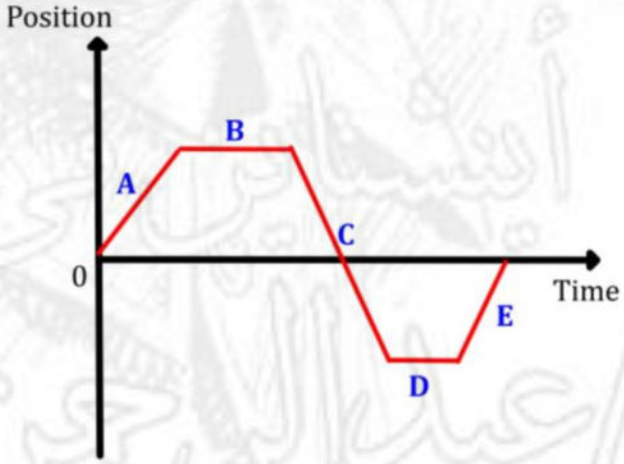
A: positive constant velocity

B: at rest

C: negative constant velocity

D: at rest

E: positive constant velocity



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Two cars travel along a straight road. When a stopwatch reads **t = 0.00 h**, car **A** is at $\mathbf{d_a}$ **= 48.0 km**, moving at a constant **36.0 km/h**. Later, when the watch reads **t = 0.50 h**, car **B** is at $\mathbf{d_\beta}$ **= 0.00 km**, moving at **48.0 km/h**.

Answer the following questions, first graphically by creating a position-time graph, and second, algebraically by writing equations for the positions $\mathbf{d_a}$ and $\mathbf{d_\beta}$ as a function of the stopwatch time **t**.

a. What will the watch read when car B passes car A?

Cars pass when the distances are equal:

$d_A = d_B$

$d_A = 48.0 + (36.0)(t)$

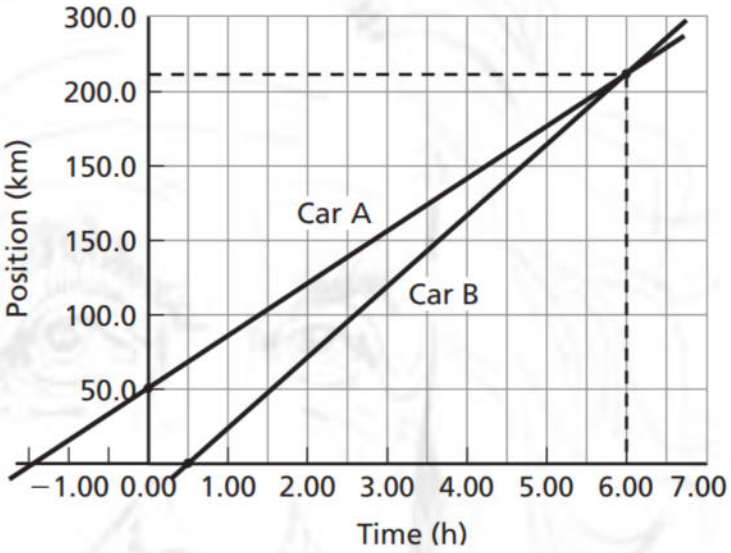
$d_B = (48.0)(t - 0.50)$

So:

$48.0 + (36.0)t = (48.0)t - 24.0$

$72.0 = (12.0)t$

$t = 6.0\ \text{h}$



b. At what position will car B pass car A?

$$d_A = 48.0 + (36.0)(6.0) = 48.0 + 216.0 = 264.0\ \text{km}$$

c. When the cars pass, how long will it have been since car A was at the reference point?

$$d = vtsot = \frac{d}{v} = \frac{48.0}{36.0} = 1.33\ \text{h}$$

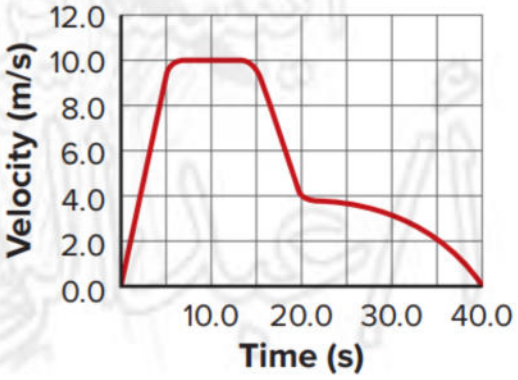
Car A started **1.33 h before the clock started**.
Total time since reference point:

$t = 6.0 + 1.33 = 7.33\ \text{h}$

a. When is the train's speed constant?
5.0 to 15.0 s

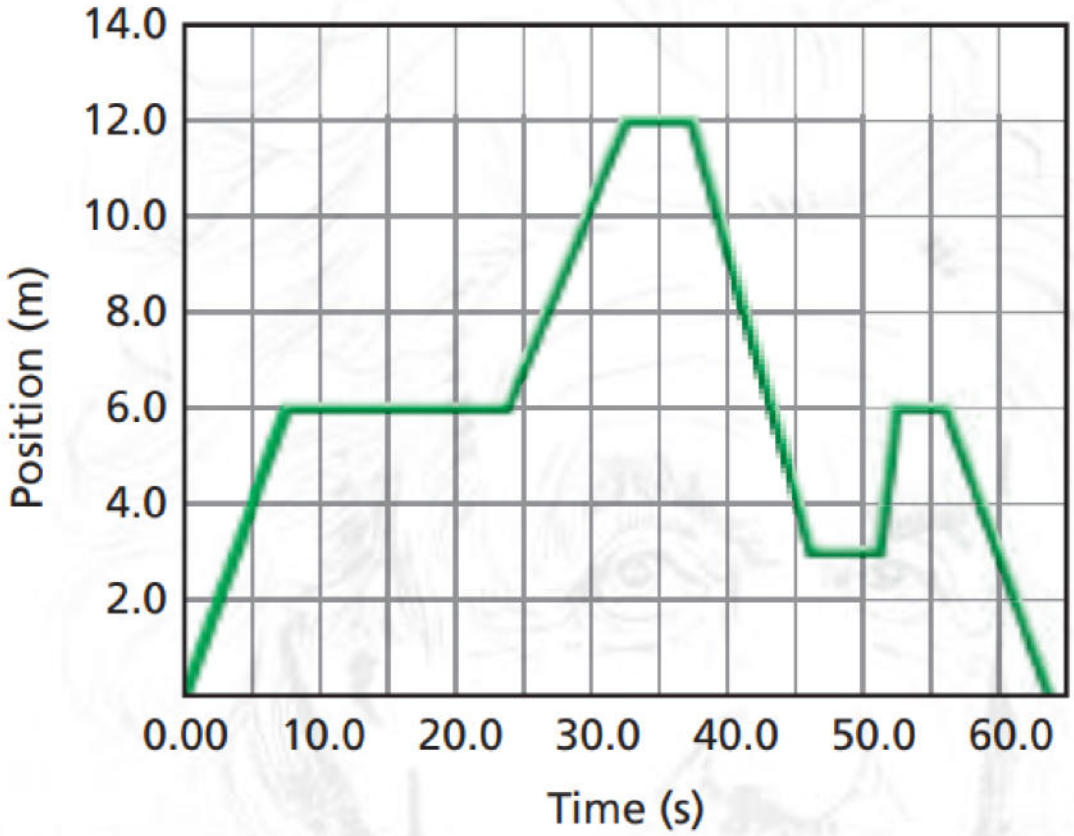
b. During which time interval is the train's acceleration positive?
0.0 to 5.0 s

c. When is the train's acceleration most negative?
15.0 to 20.0 s



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Figure shows the position-time graph depicting Jim's movement up and down the aisle at a store. The origin is at one end of the aisle.



a. Write a story describing Jim's movements at the store that would correspond to the motion represented by the graph.

b. When does Jim have a position of 6.0 m?
From 8.0 to 18.0 s, at 43.0 s, and from 53.0 to 56.0 s.

c. How much time passes between when Jim enters the aisle and when he gets to a position of 12.0 m? What is Jim's average velocity between 37.0 s and 46.0 s?

$$t = 33.0\ \text{s}$$

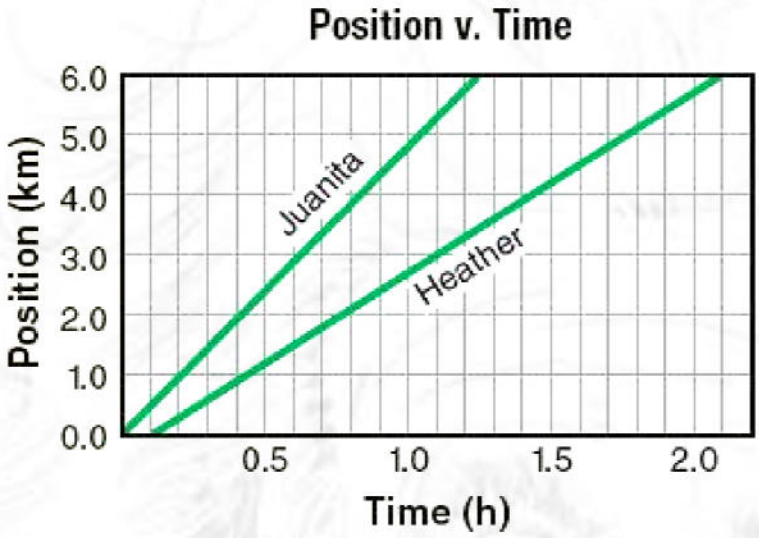
Using the points (37.0 s, 12.0 m) and (46.0 s, 3.0 m):

$$v = \frac{x_f - x_i}{t_f - t_i} = \frac{3.00 - 12.0}{46.0 - 37.0} = -1.00\ \text{m/s}$$

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Juanita goes for a walk. Later her friend Heather starts to walk after her. Their motions are represented by the position-time graph below.



Questions

a. How long had Juanita been walking when Heather started her walk?
b. Will Heather catch up to Juanita? How can you tell?
c. What was Juanita's position at $t = 0.2$ h?
d. At what time was Heather 5.0 km from the start?

Solution

a.
Heather joined the walk 0.1 h after Juanita started.

$$0.1 \text{ h} \times 60 \text{ min/h} = 6 \text{ min}$$

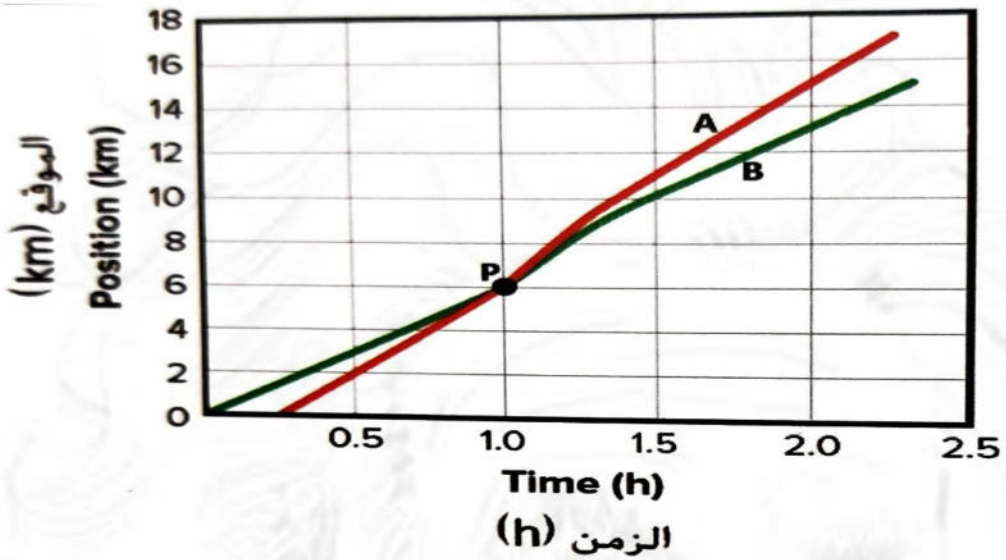
b.
No, Heather will not catch up to Juanita because the lines representing their motions get farther apart as time increases. The lines will not intersect.

c.
At $t = 0.2$ h, Juanita's position = 1.0 km.

d.
Heather reaches 5.0 km at $t = 1.8$ h.

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The graph represents the motion of two runners, (A) and (B).



a. How long had runner B already been running when runner A started to run?

b. How long had runner B been running when he was 10 km away from his starting point?

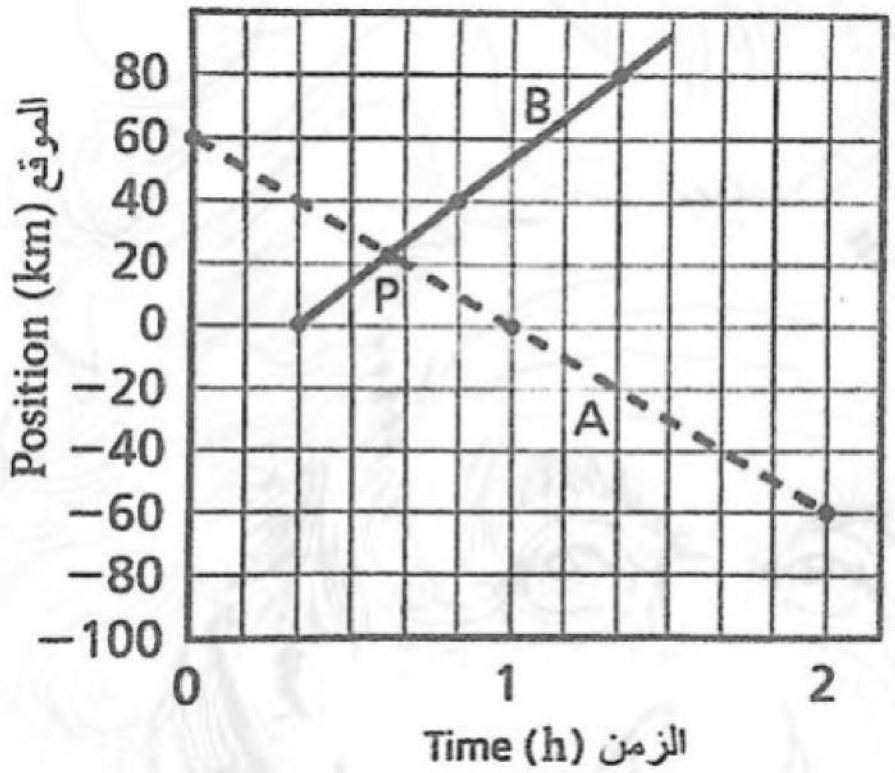
c. Which runner is slower?

d. What happens at point P?

e. How far did runner A cover within 45 minutes of starting his motion?

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Two drivers (A) and (B) are traveling on a long straight road in opposite directions. The figure below shows the position-time graph for both drivers.



a. How long had driver A already been driving when driver B started to drive?

b. How long had driver A been driving when he was 60 km away from his starting point?

c. Which driver is faster?

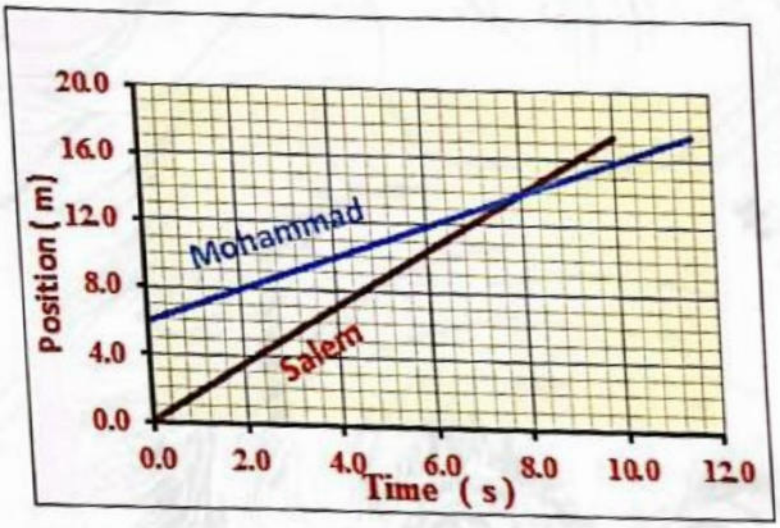
d. What happens at point P?

e. What is the position of driver (B) one hour after he has started moving?

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According to the position-time graph of two children, Mohammad and Salem begin to move together at the same time from two different positions.



a. What is the distance between Mohammad and Salem at the beginning?

b. Determine both the time and the position where the two children meet.

- **Time: _____**
- **Position: _____**

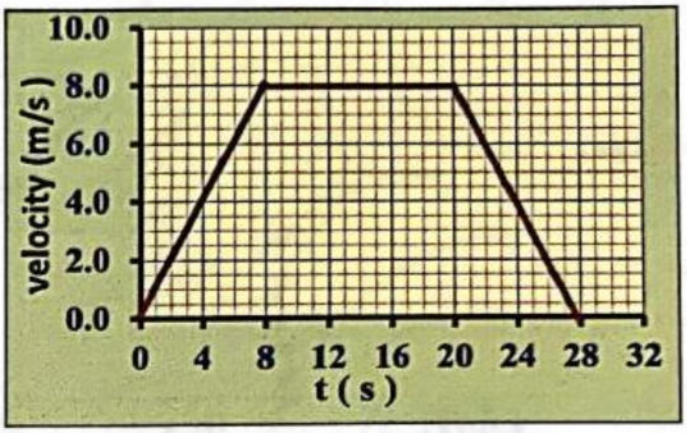
c. Find the average velocity of Mohammad.

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Depending on the velocity-time graph for the motion of Rashid on a bicycle, Rashid began his motion to the east.

Answer the following:



What is the time interval that Rashid moves at a constant velocity?

Calculate the acceleration of Rashid's motion during the time interval (20 s to 28 s).

Calculate the total displacement of Rashid from (0 s) to (28 s).

دمتم موفقين

اينشتاين عبد الرحمن عصام

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