Problem 2.6

You are driving home from school steadily at 85 km/h for 150 minutes. It then begins to rain and you slow to 50 km/h. You arrive home after driving 3 hours and 20 minutes.

Part A

How far is your hometown from school?

Express your answer using two significant figures.

ANSWER:

\[ d = d_1 + v_2 \left( \frac{10}{3} - \frac{d_1}{v_1} \right) = 230 \text{ km} \]

Part B

What was your average speed?

Express your answer using two significant figures.

ANSWER:

\[ \bar{v} = \frac{d_1 + v_2 \left( \frac{10}{3} - \frac{d_1}{v_1} \right)}{\frac{10}{3}} = 69 \text{ km/h} \]

Problem 2.9

The position of a rabbit along a straight tunnel as a function of time is plotted in the figure.
Part A
At \( t = 17.0 \text{s} \), what is its instantaneous velocity?

Express your answer using two significant figures.
ANSWER:
\[
v_{f,0.0} = 0.28 \ \text{m/s}
\]

Part B
At \( t = 30.0 \text{s} \), what is its instantaneous velocity?

Express your answer using two significant figures.
ANSWER:
\[
v_{30.0s} = 1.2 \ \text{m/s}
\]

Part C
Between \( t = 0 \) and \( t = 4.0 \text{s} \), what is its average velocity?

Express your answer using two significant figures.
ANSWER:
\[
\overline{v}_1 = 0.28 \ \text{m/s}
\]

Part D
Between \( t = 30.0 \text{s} \) and \( t = 35.0 \text{s} \), what is its average velocity?

Express your answer using two significant figures.
ANSWER:
\[
\overline{v}_2 = v_{\text{avg}} = 0.80 \ \text{m/s}
\]

Part E
Between \( t = 40 \text{s} \) and \( t = 50.0 \text{s} \), what is its average velocity?

Express your answer using two significant figures.
ANSWER:
Problem 2.14

An airplane travels 3400 km at a speed of 700 km/h, and then encounters a tailwind that boosts its speed to 950 km/h for the next 2800 km.

Part A
What was the total time for the trip?

\[
t_{\text{total}} = \frac{d_1}{v_1} + \frac{d_2}{v_2} = 7.80 \text{ h}
\]

Part B
What was the average speed of the plane for this trip? [Hint: Does the equation \( \bar{v} = \frac{v + v_0}{2} \) apply or not?]

\[
\bar{v} = (d_1 + d_2) \left( \frac{d_1}{v_1} + \frac{d_2}{v_2} \right)^{-1} = 794 \text{ km/h}
\]

Problem 2.17

A dog runs 120 m away from its master in a straight line in 8.9 s, and then runs halfway back in one-third the time.

Part A
Calculate its average speed.

Express your answer using two significant figures.

\[ |\bar{v}| = \frac{3}{4} \frac{d}{t} = 15 \text{ m/s} \]

Part B
Calculate its average velocity.

Express your answer using two significant figures.

\[ \vec{\bar{v}} = \frac{1}{3} \frac{d}{t} = 5.1 \text{ m/s in original direction} \]

Problem 2.24
A sports car moving at constant speed travels $130\text{m}$ in $5.1\text{s}$, then brakes and comes to a stop in $3.8\text{s}$.

**Part A**

What is the magnitude of its acceleration in $\text{m/s}^2$?

Express your answer using two significant figures.

ANSWER:

$$a = \frac{d}{(t_1)(t_2)} = 6.7 \text{ m/s}^2$$

**Part B**

What is the magnitude of its acceleration in $\text{g's}$ ($g = 9.80 \text{ m/s}^2$)?

Express your answer using two significant figures.

ANSWER:

$$a = \frac{d}{9.80} = 0.68 \text{ g}$$

### Problem 2.25

A car moving in a straight line starts at $x = 0$ at $t = 0$. It passes the point $x = 25.0\text{m}$ with a speed of $11.0\text{m/s}$ at $t = 3.00\text{s}$. It passes the point $x = 360\text{m}$ with a speed of $48.0\text{m/s}$ at $t = 20.0\text{s}$.

**Part A**

Find the average velocity between $t = 3.00\text{s}$ and $t = 20.0\text{s}$.

ANSWER:

$$\bar{v} = \frac{48.0 - 25.0}{20.0 - 3.0} = 19.7 \text{ m/s}$$

**Part B**

Find the average acceleration between $t = 3.00\text{s}$ and $t = 20.0\text{s}$.

ANSWER:

$$\bar{a} = \frac{v_{2} - v_{1}}{20.0 - 3.0} = 2.18 \text{ m/s}^2$$

### Problem 2.27

A particle moves along the $x$ axis. Its position as a function of time is given by $x = 6.8t + 7.5t^2$, where $t$ is in seconds and $x$ is in meters.

**Part A**
What is the acceleration as a function of time?
Express your answer using two significant figures.

**ANSWER:**

\[ a = \frac{dv}{dt} = 15.0 \text{ m/s}^2 \]

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**Problem 2.33**

A baseball pitcher throws a baseball with a speed of 40 m/s.

**Part A**

Estimate the average acceleration of the ball during the throwing motion. In throwing the baseball, the pitcher accelerates the ball through a displacement of about 3.5 m, from behind the body to the point where it is released.

Express your answer using two significant figures.

**ANSWER:**

\[ \overline{a} = \frac{v_f^2 - v_i^2}{2 \Delta x} = 230 \text{ m/s}^2 \]

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**Problem 2.36**

An inattentive driver is traveling 18.0 m/s when he notices a red light ahead. His car is capable of decelerating at a rate of 4.17 m/s^2.

**Part A**

If it takes him 0.190 s to get the brakes on and he is 67.0 m from the intersection when he sees the light, will he be able to stop in time?

**ANSWER:**

When he uses brake, he is \( 67.0 - 18.0 \times 0.190 = 63.6 \text{ m} \) away from the light. He needs \( \frac{v_f^2 - v_i^2}{2a} = \frac{0 - 18.0^2}{2 \times 4.17} = 38.8 \text{ m} \) to fully stop. So he is fine.

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**Problem 2.40**

A car traveling at 110 km/h strikes a tree. The front end of the car compresses and the driver comes to rest after traveling 0.85 m.
Part A

What was the magnitude of the average acceleration of the driver during the collision? Express the answer in terms of “g’s,” where 1.00 g = 9.80 m/s².

Express your answer using two significant figures.

ANSWER:

\[ a = \frac{v^2}{2g} = 56 \text{ g} \]

Problem 2.44

An unmarked police car traveling a constant 80 km/h is passed by a speeder traveling 130 km/h.

Part A

Precisely 3.00 s after the speeder passes, the police officer steps on the accelerator; if the police car’s acceleration is 1.70 m/s², how much time passes before the police car overtakes the speeder after the speeder passes (assumed moving at constant speed)?

ANSWER:

\[ t = \frac{v_2 - v_1 + \sqrt{(v_2 - v_1)^2 + 2a(v_2 - v_1)t_0}}{a} + t_0 = 21.9 \text{ s} \]

Problem 2.52

A ball player catches a ball 3.5 s after throwing it vertically upward.

Part A

With what speed did he throw it?

Express your answer using two significant figures.

ANSWER:

\[ v = \frac{9.80t}{2} = 17 \text{ m/s} \]

Part B

What height did it reach?

Express your answer using two significant figures.

ANSWER:

\[ h = \frac{9.80 (\frac{t}{2})^2}{2} = 15 \text{ m} \]

Problem 2.55
A helicopter is ascending vertically with a speed of $5.10 \text{ m/s}$. At a height of $105 \text{ m}$ above the Earth, a package is dropped from a window.

**Part A**

How much time does it take for the package to reach the ground? [Hint: $v_i$ for the package equals the speed of the helicopter.]

\[
t = \frac{v_i}{9.80} \left( \sqrt{1 + \frac{2 \cdot 9.80 h}{v_i^2}} + 1 \right) = 5.18 \text{ s}
\]

**Problem 2.57**

A baseball is seen to pass upward by a window $23 \text{ m}$ above the street with a vertical speed of $14 \text{ m/s}$.

**Part A**

If the ball was thrown from the street, what was its initial speed?

Express your answer using two significant figures.

\[
v_0 = \sqrt{(v_f)^2 + 2 \cdot 9.80 h} = 25 \text{ m/s}
\]

**Part B**

If the ball was thrown from the street, what altitude does it reach?

Express your answer using two significant figures.

\[
H_{\text{max}} = \frac{(v_f)^2}{2 \cdot 9.80} + h = 33 \text{ m}
\]

**Part C**

If the ball was thrown from the street, when was it thrown? (That is time elapsed from throwing to reaching the window.)

Express your answer using two significant figures.

\[
t_1 = \frac{v_f - v_{i1}}{-g} = 1.2 \text{ s}
\]

**Part D**

If the ball was thrown from the street, when does it reach the street again? (That is time elapsed from the reaching the window on the way up to reaching the street.)

Express your answer using two significant figures.

\[
\text{ANSWER:}
\]
Problem 2.64

A ball is dropped from the top of a 51.0 \text{ m} -high cliff. At the same time, a carefully aimed stone is thrown straight up from the bottom of the cliff with a speed of 26.0 \text{ m/s}. The stone and ball collide part way up.

**Part A**

How far above the base of the cliff does this happen?

\[
y = h \left(1 - \frac{9.8 t}{2v_i^2}\right) = 32.1 \text{ m}
\]

\[
y_1 = h - \frac{1}{2}gt^2
\]

\[
y_2 = v_i t - \frac{1}{2}gt^2
\]

\[
y_1 = y_2 \Rightarrow t = \frac{h}{v_i}
\]

Problem 2.61

A falling stone takes 0.33 \text{ s} to travel past a window 2.2 \text{ m} tall.

\[
\Delta y = -2.2 \text{ m} = v_i t - \frac{1}{2}gt^2
\]

\[
v_i = \frac{\Delta y + \frac{1}{2}gt^2}{t} = -2.2 + \frac{1}{2} \times 9.8 \times (0.33)^2 = -5.05 \text{ m/s}
\]

This is caused by dropping from a height \(y_W\)

Stage 1: \(v_{i_0} = 0\), \(\Delta y = -y_W\), \(v_{f_0} = -5.05 \text{ m/s}\)

\[
y_W = \frac{(v_{f_0})^2}{2g} = 1.30 \text{ m}
\]

**Part A**

From what height above the top of the window did the stone fall?

Express your answer using two significant figures.

\[
y_W = 1.3 \text{ m}
\]

Problem 2.46

A runner hopes to complete the 10,000-\text{ m} run in less than 30.0 \text{ min}. After running at constant speed for exactly 27.0 \text{ min}, there are still 1100 \text{ m} to go.

**Part A**
The runner must then accelerate at 0.20 m/s² for how many seconds in order to achieve the desired time?

Express your answer using two significant figures.

ANSWER:

\[ t = 3.1 \text{ s} \]