Q1

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A tank holds 1000 gallons of water, which drains from the bottom of the tank in half an hour. The values in the table show the volume V of water remaining in the tank (in gallons) after t minutes.

t (min)	5	10	15	20	25	30
V (gal)	698	431	240	118	28	0

(a) If P is the point (15, 240) on the graph of V, find the slopes of the secant lines PQ when Q is the point on the graph with the following values. (Round your answers to one decimal place.)

Q	slope
(5, 698)	✔
(10, 431)	✔
(20, 118)	✔
(25, 28)	✔
(30, 0)	✔

(b) Estimate the slope of the tangent line at P by averaging the slopes of two adjacent secant lines. (Round your answer to one decimal place.)

✔

$P = (15, 240)$

a)

Q	Slope
(5, 698)	-45.8
(10, 431)	-38.2
(20, 118)	-24.4
(25, 28)	-21.2
(30, 0)	-16

$$\frac{698-240}{5-15} = -45.8$$

$$\frac{431-240}{10-15} = -38.2$$

$$\frac{118-240}{20-15} = -24.4$$

$$\frac{28-240}{25-15} = -21.2$$

$$\frac{0-240}{30-15} = -16$$

b) Average slope of 10 and 20

$$\frac{1}{2}(-38.2 + -24.4) = \boxed{-31.2}$$

Q2

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A cardiac monitor is used to measure the heart rate of a patient after surgery. It compiles the number of heartbeats after t minutes. When the data in the table are graphed, the slope of the tangent line represents the heart rate in beats per minute.

t (min)	36	38	40	42	44
Heartbeats	2513	2655	2788	2918	3058

The monitor estimates this value by calculating the slope of a secant line. Use the data to estimate the patient's heart rate after 42 minutes using the secant line between the points with the given values of t. (Round your answers to one decimal place.)

(a) $t = 36$ and $t = 42$

(b) $t = 38$ and $t = 42$

(c) $t = 40$ and $t = 42$

(d) $t = 42$ and $t = 44$

a) $\frac{2918 - 2513}{42 - 36} = \boxed{67.5}$

b) $\frac{2918 - 2655}{42 - 38} = \boxed{65.8}$

c) $\frac{2918 - 2788}{42 - 40} = \boxed{65}$

d) $\frac{3058 - 2918}{44 - 42} = \boxed{70}$

Q3.1

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If a ball is thrown into the air with a velocity of 38 ft/s, its height in feet t seconds later is given by $y = 38t - 16t^2$.

(a) Find the average velocity for the time period beginning when $t = 2$ and lasting for each of the following.

(i) 0.5 seconds
___ ft/s

(ii) 0.1 seconds
___ ft/s

(iii) 0.05 seconds
___ ft/s

(iv) 0.01 seconds
___ ft/s

(b) Estimate the instantaneous velocity when $t = 2$.
___ ft/s

$t = 2 \rightarrow t = 2 + h$, where $h \neq 0$

h = time difference

$y = 38t - 16t^2$

Plug in t to $y()$ function

$$\text{Average Velocity } \left(\frac{\Delta y}{\Delta t}\right) = \frac{y(2+h) - y(2)}{(2+h) - (2)}$$

$$= \frac{38(2+h) - 16(2+h)^2 - [38(2) - 16(2)^2]}{(2+h) - (2)}$$

$$= \frac{76 + 38h - 16(h^2 + 4h + 4) - [76 - 64]}{h}$$

$$= \frac{\cancel{76} + 38h - 16h^2 - 64h \cancel{-64} \cancel{-76} + \cancel{64}}{h}$$

$$= \frac{-16h^2 - 26h}{h} = \frac{\cancel{h}(-16h - 26)}{\cancel{h}}$$

$$\text{Average Velocity} = \underline{\underline{-16h - 26}}$$

Q3.2

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Average Velocity $= 16h - 26$

i) 0.5 seconds

$-16(0.5) - 26 = \boxed{-34 \text{ ft/s}}$

ii) 0.1 seconds

$-16(0.1) - 26 = \boxed{-27.6 \text{ ft/s}}$

iii) 0.05 seconds

$-16(0.05) - 26 = \boxed{-26.8 \text{ ft/s}}$

iv) 0.01 seconds

$-16(0.01) - 26 = \boxed{-26.16}$

b) $t = 2$

	A.V.
$t = 2 \to 2.5$	-34 ft/s
$2 \to 2.1$	-27.6 ft/s
$2 \to 2.05$	-26.8 ft/s
$2 \to 2.01$	-26.16 ft/s
$t = 2$	$\boxed{-26 \text{ ft/s}}$

Q4.1

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If an arrow is shot upward on Mars with a speed of 56 m/s, its height in meters t seconds later is given by $y = 56t - 1.86t^2$. (Round your answers to two decimal places.)

(a) Find the average speed over the given time intervals.

(i) [1, 2]

m/s

(ii) [1, 1.5]

m/s

(iii) [1, 1.1]

m/s

(iv) [1, 1.01]

m/s

(v) [1, 1.001]

m/s

(b) Estimate the speed when $t = 1$.

m/s

$y = 56t - 1.86t^2$

plug-in arguments into y function

t = time in seconds

$$\text{Average Velocity}\left(\frac{\Delta y}{\Delta t}\right) = \frac{y(t+h) - y(h)}{(t+h) - t}$$

where $h \neq 0$ and is the time difference

time interval

i) [1, 2] : $V_{ave} = \dfrac{y(2) - y(1)}{2-1} =$

$$\frac{56(2) - 1.86(2)^2 - [56(1) - 1.86(1)^2]}{2-1} = \boxed{50.42 \text{ m/s}}$$

Q4.2

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ii) $[1, 1.5]$

$$\frac{56(1.5)-1.86(1.5)^2-[56(1)-1.86(1)^2]}{1.5-1} = \boxed{51.35 \text{ m/s}}$$

iii) $[1, 1.1]$

$$\frac{56(1.1)-1.86(1.1)^2-[56(1)-1.86(1)^2]}{1.1-1} = \boxed{52.09 \text{ m/s}}$$

iv) $[1, 1.01]$

$$\frac{56(1.01)-1.86(1.01)^2-[56(1)-1.86(1)^2]}{1.01-1} = \boxed{52.26 \text{ m/s}}$$

v) $[1, 1.001]$

$$\frac{56(1.001)-1.86(1.001)^2-[56(1)-1.86(1)^2]}{1.001-1} \approx \boxed{52.28 \text{ m/s}}$$

b) $\boxed{52.28 \text{ m/s}}$

Q 5.1

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The displacement (in centimeters) of a particle moving back and forth along a straight line is given by the equation of motion $s = 3\sin(\pi t) + 5\cos(\pi t)$, where t is measured in seconds. (Round your answers to two decimal places.)

(a) Find the average velocity during each time period.

(i) [1, 2]

cm/s

(ii) [1, 1.1]

cm/s

(iii) [1, 1.01]

cm/s

(iv) [1, 1.001]

cm/s

(b) Estimate the instantaneous velocity of the particle when $t = 1$.

cm/s

$$s = 3\sin(\pi t) + 5\cos(\pi t)$$

s = time in seconds

$$\text{Average Velocity}\left(\frac{\Delta y}{\Delta s}\right) = \frac{y(s+h) - y(h)}{(s+h) - s}$$

where $h \neq 0$ and is the time difference

i) [1, 2]: $V_{ave} = \dfrac{y(2) - y(1)}{2-1}$

$$= \frac{3\sin(\pi 2) + 5\cos(\pi 2) - [3\sin(\pi 1) + 5\cos(\pi 1)]}{2-1} = \boxed{10 \text{ m/s}}$$

ii) [1, 1.1] $= \boxed{-6.82 \text{ m/s}}$

iii) [1, 1.01] $= \boxed{-9.18 \text{ m/s}}$

iv) [1, 1.001] $= \boxed{-9.40 \text{ m/s}}$

b) $= \boxed{-9.40 \text{ m/s}}$

NOTE: Make sure to switch to radians mode when using calculator to for radian expressions such as π.