AP Calculus AB

Unit 10 - Motion and Rates

AP Calculus AB - Worksheet 84 **Position, Velocity and Acceleration**

For #1-5, find velocity and acceleration, if *s* represents the position of the body at any time *t*. $\boxed{\begin{array}{l} v = \frac{ds}{dt} \\ a = \frac{dv}{dt} = \frac{d^2 s}{dt^2} \end{array}}$	
1.	$s = t^2 - 4t + 3$
2.	$s = 2t^3 - 5t^2 + 4t - 3$
3.	$s = 3 + 4t - t^2$
4.	$s = (2t+3)^2$
5	$s = gt^2 + v_0 t + s_0$ $(g, v_0$ and s_0 are constants$)$
6.	A particle projected vertically upward with a speed of $160\ \frac{\text{ft}}{\text{sec}}$ reaches an elevation $s = 160t - 16t^2$ at *t* seconds. a) How high does the particle rise? b) How fast is it traveling when it reaches an elevation of 256 feet?
7	A particle moves along the *x*-axis in such a way that its acceleration at time *t* for $t > 0$ is given by $a(t) = \frac{3}{t^2}$. When $t = 1$, the position of the particle is 6 and the velocity is 2. (Hint: this is an initial value/particular solution problem from a long, long time ago) a) Write an equation for the velocity, $v(t)$, of the particle for all $t > 0$. b) Write an equation for the position, $x(t)$, of the particle for all $t > 0$. c) Find the position of the particle when $t = e$.

Answers:

1. $v = 2t - 4;\ a = 2$	2. $v = 6t^2 - 10t + 4; a = 12t - 10$
3. $v = 4 - 2t;\ a = -2$	4. $v = 8t + 12;\ a = 8$
5. $v = 2gt + v_0;\ a = 2g$	6. a) 400 ft. b) $v_{up} = 96\frac{\text{ft}}{\text{sec}};\ v_{down} = -96\frac{\text{ft}}{\text{sec}}$
7. a) $v = -\frac{3}{t} + 5$ b) $x = -3\ln\lvert t\rvert + 5t + 1$ c) $x(e) = 5e - 2$	

AP Calculus AB – Worksheet 85 **Particle Motion**

1. A particle moves along a horizontal line so that its position at any time $t \geq 0$ is given by the function $s(t) = -t^3 + 7t^2 - 14t + 8$ where *s* is measured in meters and *t* is measured in seconds.
   (a) Find an equation that can be used to find the particle's velocity at any time *t*.
   (b) At what rate is the particle moving when $t = 4$ seconds? Indicate proper units. Using this value, identify the direction in which the particle is moving.
   (c) Find the particle's average velocity over the time interval $[0,12]$. Indicate proper units.
   (d) When is the particle at rest?

2. The height of a rock is given by $h(t) = 3 + 135t - 16t^2$. Is the rock speeding up or slowing down when $t = 3$ seconds.

3. A particle moves along a line by $s(t) = t^2 - 5t - 8$. Determine the displacement of the particle from $t = 1$ to $t = 7$.

4. The position of a moving body is represented by the differentiable function *s*. Selected values of s for various times *t* are given in the table below.

t (sec)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
s (ft)	3.5	−4	−8.5	−10	−8.5	−4	3.5	14	27.5

   Approximate the velocity of the moving body at $t = 2.3$.

5. **(Calculator Permitted)** A particle moves along a line so that at time *t*, where $0 \leq t \leq \pi$, its position is given by $s(t) = -4\cos t - \frac{t^2}{2} + 10$. What is the velocity of the particle when its acceleration is zero?

6. Suppose a car travels along a straight road according to the velocity function $v(t) = t^2 - 4$ for $0 \leq t \leq 5$, where v is measured in miles per hour and *t* is in hours. At what time does the car change directions? Explain.

7. A body's velocity at time *t* seconds is $v = 2t^3 - 9t^2 + 12t - 5$ m/sec. Find the body's speed each time the acceleration is zero.

8. If the position of a particle on a line at time *t* is given by $s(t) = t^3 + 3t$, determine the interval on which the velocity of the particle is decreasing.

9. Fill in the blanks so that each statement below is true.
   (a) If velocity is negative and acceleration is positive, then speed is ______________________.
   (b) If velocity is positive and speed is decreasing, then acceleration is ______________________.
   (c) If velocity is positive and decreasing, then speed is _________________________.
   (d) If speed is increasing and acceleration is negative, then velocity is ________________________.
   (e) If velocity is negative and increasing, then speed is _____________________________.
   (f) If the particle is moving to the left and speed is decreasing, then acceleration is _________________________.

AP Calculus AB – Worksheet 86 **Particle Motion and Graphs of Velocity**

1) A particle moves along a horizontal line so that its position at any time $t \geq 0$ is given by the function $x(t) = t^2 - 4t + 3$, where x is measured in feet and t is measured in seconds.

(a) Find the displacement of the particle during the first 3 seconds. Explain its meaning.

(b) Find the average velocity of the particle during the first 3 seconds. Explain its meaning.

(c) Find the particle's initial velocity and its velocity at $t = 3$ seconds. Explain the meanings of each in terms of the particle's movement.

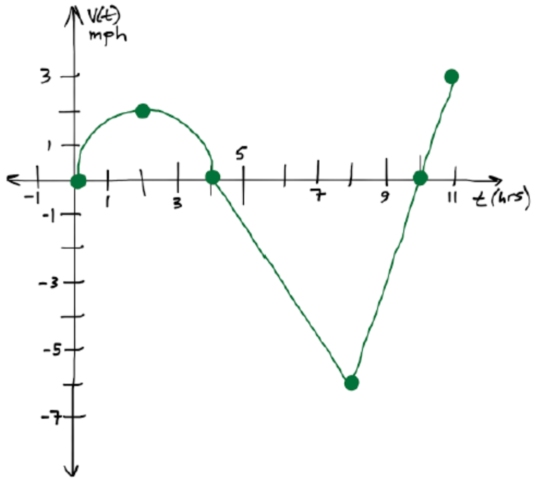
(d) Find the acceleration of the particle when $t = 3$ seconds. Explain its meaning in terms of the particle's velocity.

(e) At $t = 3$ seconds, is the speed of the particle increasing or decreasing? Justify.

(f) During what times is the particle moving to the right? Left? At what values of t does the particle change direction? Justify.

(g) Find the total distance the particle travels during the first 3 seconds. Are you as exhausted as the particle?

2)



The graph above shows the velocity, $v(t)$, in miles per hour of a particle moving along the x-axis for $0 \le t \le 11$ hours. It consists of a semi circle and two line segments. Use the graph and your knowledge of motion to answer the following questions.

(a) At what time, $0 \le t \le 11$ hours, is the speed of the particle the greatest?

(b) At which of the times, $t = 2$, $t = 6$, or $t = 9$ hours, is the acceleration of the particle greatest? Justify.

(c) Over what open time interval(s) $0 < t < 11$ hours is the particle moving to the left? Justify.

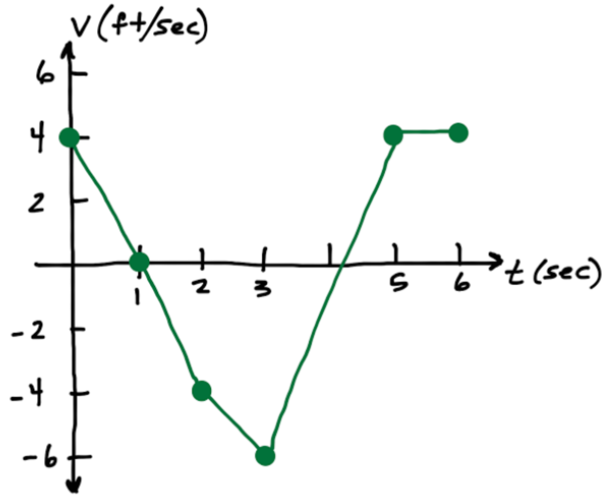
(d) Over what open time interval(s) $0 < t < 11$ hours is the velocity of the particle increasing? Justify.

(e) Over what open time interval(s) $0 < t < 11$ hours is the speed of the particle increasing? Justify.

(f) At what times on $0 < t < 11$ is the acceleration of the particle undefined?

(g) Find the area of the semicircle on the interval $0 \le t \le 4$ bounded by the curve and the x-axis, then find the area of the triangle on the interval $4 \le t \le 10$ bounded by the curve and the x-axis, and finally, find the area of the triangle on the interval $10 \le t \le 11$ bounded by the curve and the x-axis. If all of these areas were positive and added together, propose what quantity this might be in terms of the particle's movement on $0 \le t \le 11$ hours.

3)



The graph above shows the velocity $v(t)$ of a particle, in ft/sec, moving along a horizontal line for $0 \le t \le 6$ seconds.

(a) On what open intervals or at what time(s) $0 < t < 6$ is the particle at rest? Justify.

(b) On what open intervals $0 < t < 6$ is the particle moving to the right? Justify.

(c) On what open intervals or at what time(s) $0 < t < 6$ is the particle moving at its greatest speed? Greatest velocity?

(d) On what open intervals or at what time(s) $0 < t < 6$ is the particle's speed increasing? Decreasing? Justify.

(e) What is the particle's acceleration at $t = 4.8$ second? Explain what this number means in terms of the particle's velocity.

(f) On what open intervals or at what time(s) $0 < t < 6$ is the acceleration of the particle the greatest?

(g) (is for "genius") What is the particle's displacement during the 2 seconds? Justify.

2015 AB3/BC3 – No Calculator

t (minutes)	0	12	20	24	40
$v(t)$ (meters per minute)	0	200	240	–220	150

3. Johanna jogs along a straight path. For $0 \le t \le 40$, Johanna's velocity is given by a differentiable function v. Selected values of $v(t)$, where t is measured in minutes and $v(t)$ is measured in meters per minute, are given in the table above.

(a) Use the data in the table to estimate the value of $v'(16)$.

(b) Using correct units, explain the meaning of the definite integral $\int_0^{40} |v(t)|\, dt$ in the context of the problem. Approximate the value of $\int_0^{40} |v(t)|\, dt$ using a right Riemann sum with the four subintervals indicated in the table.

(c) Bob is riding his bicycle along the same path. For $0 \le t \le 10$, Bob's velocity is modeled by $B(t) = t^3 - 6t^2 + 300$, where t is measured in minutes and $B(t)$ is measured in meters per minute. Find Bob's acceleration at time $t = 5$.

(d) Based on the model B from part (c), find Bob's average velocity during the interval $0 \le t \le 10$.

2014 – AB4/BC4

t (minutes)	0	2	5	8	12
$v_A(t)$ (meters/minute)	0	100	40	–120	–150

4. Train A runs back and forth on an east-west section of railroad track. Train A's velocity, measured in meters per minute, is given by a differentiable function $v_A(t)$, where time t is measured in minutes. Selected values for $v_A(t)$ are given in the table above.

(a) Find the average acceleration of train A over the interval $2 \le t \le 8$.

(b) Do the data in the table support the conclusion that train A's velocity is -100 meters per minute at some time t with $5 < t < 8$? Give a reason for your answer.

(c) At time $t = 2$, train A's position is 300 meters east of the Origin Station, and the train is moving to the east. Write an expression involving an integral that gives the position of train A, in meters from the Origin Station, at time $t = 12$. Use a trapezoidal sum with three subintervals indicated by the table to approximate the position of the train at time $t = 12$.

(d) A second train, train B, travels north from the Origin Station. At time t the velocity of train B is given by $v_B(t) = -5t^2 + 60t + 25$, and at time $t = 2$ the train is 400 meters north of the station. Find the rate, in meters per minute, at which the distance between train A and train B is changing at time $t = 2$.

The data in the table below gives selected values for the velocity, in meters/minute, of a particle moving along the *x*-axis. The velocity *v* is a differentiable function of time *t*.

Time t (min)	0	2	5	6	8	12
Velocity $v(t)$ (meters/min)	-3	2	3	5	7	5

a) At $t = 5$, is the particle moving to the right or to the left? Justify.

b) Is there a time during the time interval $0 \le t \le 12$ at which the particle is at rest? Explain your reasoning.

c) Use the data from the table to approximate the acceleration of the particle at $t = 10$. Show the computations that lead to your answer.

d) Find the average acceleration of the particle over the time interval $8 \le t \le 12$. Explain what this answer means in terms of the particle's velocity.

e) Use a right Riemann sum with 5 subintervals to find the value of $\int_0^{12} v(t)\,dt$. Using correct units, explain the meaning of $\int_0^{12} v(t)\,dt$ in terms of the particle.

f) Explain why there must be a value, *c*, in the interval $0 \le t \le 12$ such that $a(c) = 0$

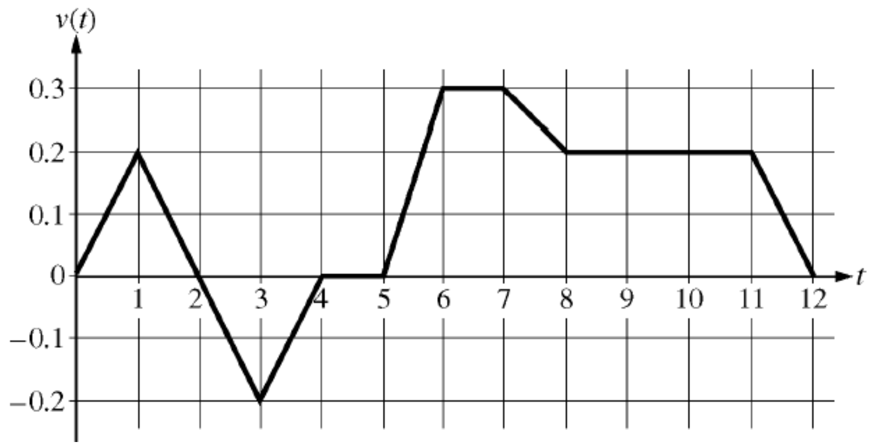
AP Calculus AB - Worksheet 88 **Motion Review – QUIZ coming up!**

1.	A particle moves along a line so that its position *s* at time *t* is given by $s(t)=\int_0^t (3w^2-6w)\,dw$ a) Find its acceleration at any time *t*. b) Determine the values of *t* for which the particle is moving in a positive direction. c) Find the values of *t* for which the particle is slowing down.
2.	A particle moves in a straight line with velocity $v(t)=t^2$. How far does the particle move between times $t=1$ and $t=2$? A) $\frac{1}{3}$ B) $\frac{7}{3}$ C) 3 D) 7 E) 8
3.	The acceleration *a* of a body moving in a straight line is given in terms of time *t* by $a=8-6t$. If the velocity of the body is 25 at $t=1$ and if $s(t)$ is the distance of the body form the origin at time *t*, what is $s(4)-s(2)$? A) 20 B) 24 C) 28 D) 32 E) 42
4.	Given the function defined by $f(x)=3x^5-20x^3$, find all values of *x* for which the graph of *f* is concave up? A) $x>0$ B) $-\sqrt{2}<x<0$ or $x>\sqrt{2}$ C) $-2<x<0$ or $x>2$ D) $x>\sqrt{2}$ E) $-2<x<2$
5.	The acceleration at time $t>0$ of a particle moving along the *x*-axis is $a(t)=3t+2$ ft/sec^2. If at $t=1$ seconds the velocity is 4 ft/sec and the position is $x=6$ ft , then at $t=2$ the position $x(t)$ is A) 8 ft. B) 11 ft. C) 12 ft. D) 13 ft. E) 15 ft.
6.	For what value of *x* does the function $f(x)=(x-2)(x-3)^2$ have a relative maximum? A) -3 B) $-\frac{7}{3}$ C) $-\frac{5}{2}$ D) $\frac{7}{3}$ E) $\frac{5}{2}$
7.	**(Calculator Permitted)** The first derivative of the function *f* is given by $f'(x)=x-4e^{-\sin(2x)}$. How many points of inflection does the graph of *f* have on the interval $0<x<2\pi$ A) Three B) Four C) Five D) Six E) Seven
8.	If $f(x)=(x^2-2x-1)^{2/3}$, then $f'(0)=$ A) $\frac{4}{3}$ B) 0 C) $-\frac{2}{3}$ D) $-\frac{4}{3}$ E) -2

Answers:

1. a. $a(t)=6t-6$ b. $t<0$ and $t>2$ c. $1<t<2$	2. B	3. D	4. B	5. D	6. D
7. B	8. A				

A calculator is required for this problem.



Steve rides his skateboard along a straight road from home to school, starting at home at time $t = 0$ minutes and arriving at school at time $t = 12$ minutes. During the time interval $0 \le t \le 12$ minutes, his velocity $v(t)$, in miles per minute, is modeled by the piecewise-linear function whose graph is shown above.

(a) Find the acceleration of Steve's skateboard at time $t = 7.5$ minutes. Show the work that leads to your answer and indicate units of measure.

(b) Using correct units, explain the meaning of $\int_0^{12} |v(t)|\,dt$ in terms of Steve's trip. Find the value of $\int_0^{12} |v(t)|\,dt$.

(c) Shortly after leaving home, Steve realizes he left his calculator at home, and he returns to get it. At what time does he turn around and go back home? Give a reason for your answer.

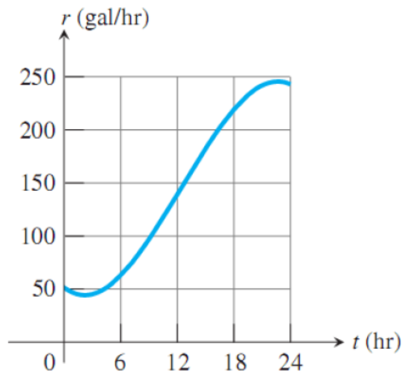
(d) Chuck also rides his skateboard along a straight road from home to school in 12 minutes. His velocity is modeled by the function w given $w(t) = \frac{\pi}{15}\sin\left(\frac{\pi}{12}t\right)$, where $w(t)$ is in miles per minute for $0 \le t \le 12$ minutes. Who lives closer to school, Steve or Chuck? Show the work that leads to your answer.

AP Calculus AB - Worksheet 89 Integral as Net Change

1

The graph at right shows the rate at which water is pumped from a storage tank. Approximate the total gallons of water pumped from the tank in 24 hours.

(A) 600 (B) 2400 (C) 3600 (D) 4200 (E) 4800



2

The data for the acceleration $a(t)$ of a car from 0 to 15 seconds are given in the table below. If the velocity at $t = 0$ is 5 ft/sec, which of the following gives the approximate velocity at $t = 15$ using a Trapezoidal sum?

t (sec)	0	3	6	9	12	15
$a(t)$ (ft/sec^2)	4	8	6	9	10	10

(A) 47 ft/sec (B) 52 ft/sec (C) 120 ft/sec (D) 125 ft/sec (E) 141 ft/sec

3

The rate at which customers arrive at a counter to be served is modeled by the function F defined by $F(t) = 12 + 6\cos\left(\frac{t}{\pi}\right)$ for $t \in [0, 60]$, where $F(t)$ is measured in customers per minute and t is measured in minutes. To the nearest whole number, how many customers arrive at the counter over the 60-minute period?

(A) 720 (B) 725 (C) 732 (D) 744 (E) 756

4

Pollution is being removed from the lake at a rate modeled by the function $y = 20e^{-0.5t}$ tons/year, where t is the number of years since 2010. Estimate the amount of pollution removed from the lake between the years 2010 and 2020.

(A) 40 (B) 47 (C) 56 (D) 61 (E) 71

5

A developing country consumes oil at a rate given by $r(t) = 20e^{0.2t}$ million barrels per year, where t is time measured in years, for $0 \le t \le 10$. Which of the following expressions gives the amount of oil consumed by the country during the time interval $0 \le t \le 10$?

(A) $r(10)$ (B) $r(10) - r(0)$ (C) $\int_0^{10} r'(t)\,dt$ (D) $\int_0^{10} r(t)\,dt$ (E) $10 \cdot r(10)$

AP Calculus AB – Worksheet 90 **Integral as Net Change**

Please answer all questions in the context of the specific problems.

1. A particle moves along a line so that its position at any time $t \geq 0$ is given by the function $s(t) = -t^3 + 7t^2 - 14t + 8$ where *s* is measured in meters and *t* is measured in seconds.
   (a) Find an equation that can be used to find the particle's rate of change at any time *t*.
   (b) At what rate is the particle moving when $t = 4$ seconds? Indicate proper units. Using this value, identify the direction in which the particle is moving.
   (c) Find the particle's average rate of change over the time interval $[0,12]$. Indicate proper units.
   (d) When is the particle not moving?

2. The number of gallons of water in a tank *t* minutes after the tank has started to drain is $Q(t) = 200(3-t)^2$.
   (a) How fast is the water running out at the end of 10 minutes? Indicate units of measure.
   (b) What is the average rate at which the water flows out in the time interval $[0,10]$?

3. A spherical tank contains 81.637 gallons of water at time $t = 0$ minutes. For the next 6 minutes, water flows out of the tank at a rate of $9\sin\left(\sqrt{t+1}\right)$ gallons per minute.
   (a) Find the rate at which water flows out of the tank when $t = 4$ minutes. Indicate units of measure.
   (b) Write a function $W(t)$ that can be used to determine the amount of water in the tank at any time, *t*.
   (c) How many gallons of water are in the tank at the end of 6 minutes?

4. The rate at which water is sprayed on a field of vegetables is given by $R(t) = 2\sqrt{t + 5t^3}$, where *t* is in minutes and $R(t)$ is in gallons per minute.
   (a) Write a function $W(t)$ that can be used to determine the amount of water sprayed on the field at any time, *t*.
   (b) How much water has been sprayed on the field during the first 10 minutes?

5. The rate at which raw sewage enters a treatment tank is given by $E(t) = 850 + 715\cos\left(\frac{\pi t^2}{9}\right)$ gallons per hour for $0 \leq t \leq 4$ hours. Treated sewage is removed from the tank at a constant rate of 645 gallons per hour. The treatment tank is empty at time $t = 0$.
   (a) At what rate is the sewage entering the tank when $t = 3$ hours?
   (b) How many gallons of sewage enter the treatment tank during the time interval $0 \leq t \leq 4$? Round your answer to the nearest gallon.
   (c) How many gallons of sewage are in the tank at $t = 3$ hours?

1

A particle moves along the x-axis with velocity at time $t \geq 0$ given by $v(t) = -1 + e^{1-t}$.

(a) Find the acceleration of the particle at time $t = 3$.

(b) Is the speed of the particle increasing at time $t = 3$? Give a reason for your answer.

(c) Find all values of t at which the particle changes direction. Justify your answer.

(d) Find the total distance traveled by the particle over the time interval $0 \leq t \leq 3$.

2

t (seconds)	0	8	20	25	32	40
$v(t)$ (meters per second)	3	5	–10	–8	–4	7

The velocity of a particle moving along the x-axis is modeled by a differentiable function v, where the position x is measured in meters, and time t is measured in seconds. Selected values of $v(t)$ are given in the table above. The particle is at position $x = 7$ meters when $t = 0$ seconds.

(a) Estimate the acceleration of the particle at $t = 36$ seconds. Show the computations that lead to your answer. Indicate units of measure.

(b) Using correct units, explain the meaning of $\int_{20}^{40} v(t)\,dt$ in the context of this problem. Use a trapezoidal sum with the three subintervals indicated by the data in the table to approximate $\int_{20}^{40} v(t)\,dt$.

(c) For $0 \leq t \leq 40$, must the particle change direction in any of the subintervals indicated by the data in the table? If so, identify the subintervals and explain your reasoning. If not, explain why not.

(d) Suppose that the acceleration of the particle is positive for $0 < t < 8$ seconds. Explain why the position of the particle at $t = 8$ seconds must be greater than $x = 30$ meters.

3

Water is pumped into an underground tank at a constant rate of 8 gallons per minute. Water leaks out of the tank at the rate of $\sqrt{t+1}$ gallons per minute, for $0 \leq t \leq 120$ minutes. At time $t = 0$, the tank contains 30 gallons of water.

(a) How many gallons of water leak out of the tank from time $t = 0$ to $t = 3$ minutes?

(b) How many gallons of water are in the tank at time $t = 3$ minutes?

4 **Calculator Permitted**

A tank contains 125 gallons of heating oil at time $t = 0$. During the time interval $0 \leq t \leq 12$ hours, heating oil is pumped into the tank at the rate

$$H(t) = 2 + \frac{10}{(1 + \ln(t+1))} \text{ gallons per hour.}$$

During the same time interval, heating oil is removed from the tank at the rate

$$R(t) = 12 \sin\left(\frac{t^2}{47}\right) \text{ gallons per hour.}$$

(a) How many gallons of heating oil are pumped into the tank during the time interval $0 \leq t \leq 12$ hours?

(b) Is the level of heating oil in the tank rising or falling at time $t = 6$ hours? Give a reason for your answer.

(c) How many gallons of heating oil are in the tank at time $t = 12$ hours?

2. For $0 \le t \le 31$, the rate of change of the number of mosquitoes on Tropical Island at time t days is modeled by $R(t) = 5\sqrt{t}\cos\left(\frac{t}{5}\right)$ mosquitoes per day. There are 1000 mosquitoes on Tropical Island at time $t = 0$.

   (a) Show that the number of mosquitoes is increasing at time $t = 6$.

   (b) At time $t = 6$, is the number of mosquitoes increasing at an increasing rate, or is the number of mosquitoes increasing at a decreasing rate? Give a reason for your answer.

   (c) According to the model, how many mosquitoes will be on the island at time $t = 31$? Round your answer to the nearest whole number.

   (d) To the nearest whole number, what is the maximum number of mosquitoes for $0 \le t \le 31$? Show the analysis that leads to your conclusion.

2. The number of gallons, $P(t)$, of a pollutant in a lake changes at the rate $P'(t) = 1 - 3e^{-0.2\sqrt{t}}$ gallons per day, where t is measured in days. There are 50 gallons of the pollutant in the lake at time $t = 0$. The lake is considered to be safe when it contains 40 gallons or less of pollutant.

(a) Is the amount of pollutant increasing at time $t = 9$? Why or why not?

(b) For what value of t will the number of gallons of pollutant be at its minimum? Justify your answer.

(c) Is the lake safe when the number of gallons of pollutant is at its minimum? Justify your answer.

(d) An investigator uses the tangent line approximation to $P(t)$ at $t = 0$ as a model for the amount of pollutant in the lake. At what time t does this model predict that the lake becomes safe?

Solutions

(a) Since $R(6) = 4.438 > 0$, the number of mosquitoes is increasing at $t = 6$.

(b) $R'(6) = -1.913$

Since $R'(6) < 0$, the number of mosquitoes is increasing at a decreasing rate at $t = 6$.

(c) $1000 + \int_0^{31} R(t)\,dt = 964.335$

To the nearest whole number, there are 964 mosquitoes.

(d) $R(t) = 0$ when $t = 0$, $t = 2.5\pi$, $t = 7.5\pi$

$R(t) > 0$ on $0 < t < 2.5\pi$

$R(t) < 0$ on $2.5\pi < t < 7.5\pi$

$R(t) > 0$ on $7.5\pi < t < 31$

The absolute maximum number of mosquitoes occurs at $t = 2.5\pi$ or at $t = 31$.

$1000 + \int_0^{2.5\pi} R(t)\,dt = 1039.357,$

There are 964 mosquitoes at $t = 31$, so the maximum number of mosquitoes is 1039, to the nearest whole number.

(a) $P'(9) = 1 - 3e^{-0.6} = -0.646 < 0$

so the amount is not increasing at this time.

(b) $P'(t) = 1 - 3e^{-0.2\sqrt{t}} = 0$

$t = (5\ln 3)^2 = 30.174$

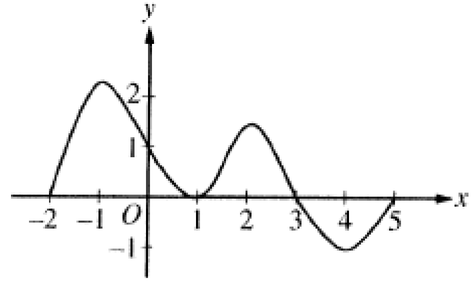
$P'(t)$ is negative for $0 < t < (5\ln 3)^2$ and positive for $t > (5\ln 3)^2$. Therefore there is a minimum at $t = (5\ln 3)^2$.

(c) $P(30.174) = 50 + \int_0^{30.174} \left(1 - 3e^{-0.2\sqrt{t}}\right)dt$

$= 35.104 < 40$, so the lake is safe.

(d) $P'(0) = 1 - 3 = -2$. The lake will become safe when the amount decreases by 10. A linear model predicts this will happen when $t = 5$.

AP Calculus AB - Worksheet 93 **Applications of Derivatives Review**



Graph of f'

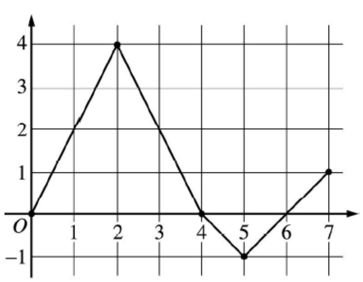
Given the graph of f' above. Answer the following questions for $-2 \le x \le 5$. Justify each answer.

1	On which interval is $f(x)$ increasing?
2	Determine the *x*-coordinates of any relative maxima on the graph of $f(x)$.
3	On which interval is $f(x)$ concave down?
4	Determine the *x*-coordinates of any points of inflection on the graph of $f(x)$.

5.

x	-4	-3	-2	-1
$f(x)$	0.75	−1.5	−2.25	−1.5
$f'(x)$	−3	−1.5	0	1.5

The table above gives values of a function *f* and its derivative at selected values of *x*. If f' is continuous on the interval $[-4,-1]$, what is the value of $\int_{-4}^{-1} f'(x)\,dx$?



A particle moves along the *x*-axis so that its velocity at time *t*, for $0 \le t \le 7$, is given by a continuous function *v* whose graph is shown at left. At time $t = 0$, the particle is at $x = 2$

6	When is the particle moving towards the right? Justify your answer.
7	Find the position of the particle at $t = 6$.
8	Is the speed of the particle increasing or decreasing at $t = 3$. Justify your answer.
9	Find the total distance that particle traveled over the time interval. Be sure to show correct integral notation.

10. A particle moves along the *x*-axis so that its velocity is given by $v(t) = t^2 + 3t + 2$. If the particle is at $x = 1$ when $t = 0$, determine the position of the particle at $t = 4$.

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11. A factory produces bicycles at a rate of $R(t) = 95 + 0.1t^2 - t$ bicycles per day (in *t* days).

a) How many bicycles were produced from day 8 to 21?

b) How fast are bicycles being produced on day 10?