AP Calculus AB
Rectilinear and Projectile Motion Worksheet #2

Name Key

1. The position of a skateboarder at any time t (in seconds) is given by the function $s(t) = t^3 - 8t^2 + 8t$ measured in feet.

a) What are the velocity and acceleration functions in terms of t?
b) When is the skateboarder at rest?
c) What is the position(s) of the skateboarder when at rest?
d) What are the position, velocity, and acceleration of the skateboarder at three seconds and at 5 seconds?
e) Sketch a motion schematics for the skateboarder. Make sure to label position and velocity at each critical time.
f) What was the total distance traveled in the first five seconds?
g) Find the displacement in the first 5 seconds.
h) When is the skateboarder moving to the right and left? Use interval notation for your answers.

a) $v(t) = 3t^2 - 16t + 8$

$a(t) = 6t - 16$

b) $0 = 3t^2 - 16t + 8$

$t = .558$ sec

$t = 4.775$ sec

c) $s(.558) = 2.147$ ft.

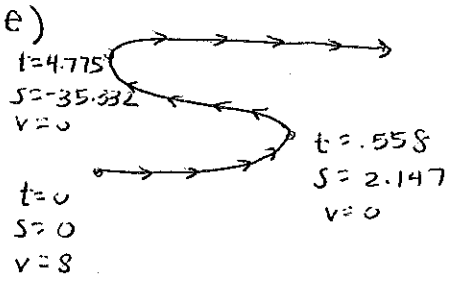
$s(4.775) = -35.332$ ft.

d) $s(3) = -21$ ft $\quad s(5) = -35$ ft

$v(3) = -13$ ft/sec $\quad v(5) = 3$ ft/sec

$a(3) = 2$ ft/sec^2 $\quad a(5) = 14$ ft/sec^2

e)



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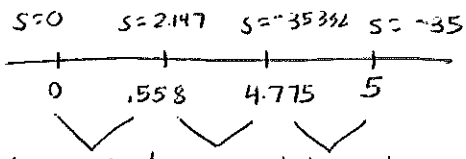


$|2.147| + |-37.479| + |.332| =$

39.958 ft.

g) $s(5) - s(0)$

$-35 - 0 = -35$ ft.

35 ft. to the left

h) left: $(.558, 4.775)$

right: $[0, .558) \cup (4.775, \infty)$

2. The position of a particle at any time t (in seconds) is given by the function $s(t) = 2t^3 - 27t + 15$ measured in feet.

a) What are the velocity and acceleration equation in terms of t?
b) When is the particle at rest?
c) What is the position(s) of the particle when it is at rest?
d) What are the initial position, velocity, and acceleration of the particle?
e) Sketch a motion schematics for the skateboarder. Make sure to label position and velocity at each critical time.
f) What is the total distance traveled from one second to six seconds?
g) What is the displacement for the same time frame?
h) When is the particle moving to the left and right? Use interval notation for your answers.

a) $v(t) = 6t^2 - 27$

$a(t) = 12t$

b) $0 = 6t^2 - 27$

$27 = 6t^2$

$\sqrt{t^2} = \sqrt{4.5}$

$t = 2.121$ sec

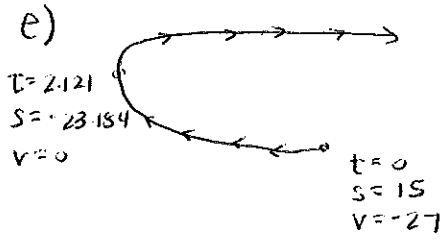
c) $s(2.121) = -23.184$ ft.

d) $s(0) = 15$ ft

$v(0) = -27$ ft/sec

$a(0) = 0$ ft/sec^2

e)



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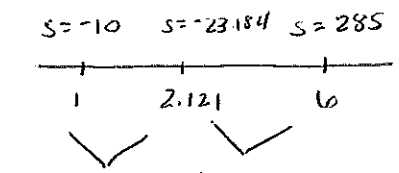


$|-13.184| + |308.184| =$

321.368 ft.

g) $s(6) - s(1)$

$285 - (-10)$

295 ft.

h) left: $[0, 2.121)$

right: $(2.121, \infty)$

3. A particle is moving with its position defined by $s(t) = t^3 - 6t^2 + 9t + 5$ where t is in seconds and s is in feet.

a) What are the particle's velocity and acceleration functions?
b) Find the displacement and the total distance traveled by the particle in the first four seconds.
c) What is the velocity of the particle when its position is 8 feet?
d) Sketch a motion schematic labeling position, velocity, and acceleration at the beginning, end, and at each change.

a) $v(t) = 3t^2 - 12t + 9$

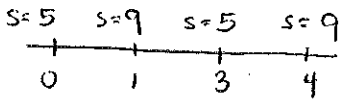
$a(t) = 6t - 12$

b) $0 = 3t^2 - 12t + 9$

$0 = 3(t^2 - 4t + 3)$

$0 = 3(t-3)(t-1)$

$t = 3 \quad t = 1$



$|9-5| + |5-9| + |9-5|$

$4 + 4 + 4 = 12$ ft

↳ total distance

$s(4) - s(0)$

$9 - 5 = 4$ ft

↳ displacement

c) $8 = t^3 - 6t^2 + 9t + 5$

$0 = t^3 - 6t^2 + 9t - 3$

$t = .468$ sec

$t = 1.653$ sec

$t = 3.879$ sec

$v(.468) = 4.041$ ft/sec

$v(1.653) = -2.639$ ft/sec

$v(3.879) = 7.592$ ft/sec

4. An object has its position defined by $s(t) = t^3 - 9t^2 + 24t + 20$ in feet.

a) What are the velocity and acceleration functions?
b) What are the position and velocity of the object when its acceleration is $-6.5\,ft/\sec^2$?
c) Find the displacement and the total distance traveled by the particle from t = 1.5 seconds to t = 7 seconds.

a) $v(t) = 3t^2 - 18t + 24$

$a(t) = 6t - 18$

b) $-6.5 = 6t - 18$

$11.5 = 6t$

$t = 1.917$ sec

$s(1.917) = 39.979$ ft. $\quad v(1.917) = .519$ ft/sec

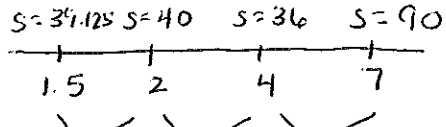
$0 = 3t^2 - 18t + 24$

$0 = 3(t^2 - 6t + 8)$

$0 = 3(t-4)(t-2)$

$t = 4 \quad t = 2$

c)



$|1.875| + |-4| + |54| = 58.875$ ft

↳ total distance

displacement:

$s(7) - s(1.5)$

$90 - 39.125 = 50.875$ ft.

5. A person is standing on top of the Tower of Pisa and throws a ball directly upward with an initial velocity of 96 feet per second. The Tower of Pisa is 176 feet high.

a) What are the functions for position, velocity, and acceleration of the ball?
b) When does the ball hit the ground and with what velocity?
c) How far does the ball travel during its flight?

a) $s(t) = -16t^2 + 96t + 176$

$v(t) = -32t + 96$

$a(t) = -32$

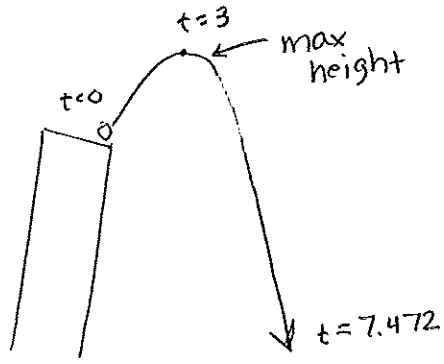
b) $0 = -16t^2 + 96t + 176$

$t = 7.472$ sec

$v(7.472) = -143.104$

143.104 ft/sec

c)



max height:

$0 = -32t + 96$

$t = 3$ sec

$|s(3) - s(0)| + |s(7.472) - s(3)|$

$|320 - 176| + |0 - 320|$

$144 + 320$

464 ft.

6. A person is standing on top of a building that is 112 feet high. This person throws a rock vertically upward with an initial velocity of 84 feet per second.

a) What are the functions for position, velocity, and acceleration of the rock?
b) When does the rock hit the ground and what is its impact velocity?
c) When is the velocity zero? What is the significance of this time?
d) How far does the rock travel during its flight?

a) $s(t) = -16t^2 + 84t + 112$

$v(t) = -32t + 84$

$a(t) = -32$

b) $0 = -16t^2 + 84t + 112$

$t = 6.352$ sec

$v(6.352) = -119.264$

119.264 ft/sec

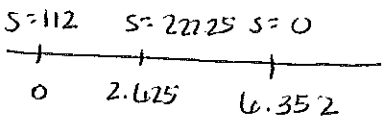
c) $0 = -32t + 84$

$-84 = -32t$

$t = 2.625$ sec

* rock reaches max height

d)



$|110.25| + |-222.25| = 332.5$ ft.

7. A ball is thrown vertically upward from the ground with an initial velocity of 160 feet per second.
   a) What are the position, velocity, and acceleration functions?
   b) When will the ball hit the ground?
   c) When will the ball reach its maximum height?
   d) What is the speed of the ball when it hits the ground?

a) $s(t) = -16t^2 + 160t$
$v(t) = -32t + 160$
$a(t) = -32$

b) $s(t) = 0$
$t = 10$ sec

c) $v(t) = 0$
$t = 5$ sec

d) $v(10) = -160$
160 ft/sec.

8. A projectile is launched vertically upward from an initial height of 129 feet with an initial velocity of 87 feet per second.
   a) What are the position, velocity, and acceleration functions?
   b) When will the projectile hit the ground?
   c) What is its impact velocity?
   d) When will the projectile reach its maximum height?
   e) What is the maximum height?

a) $s(t) = -16t^2 + 87t + 129$
$v(t) = -32t + 87$
$a(t) = -32$

b) $0 = -16t^2 + 87t + 129$
$t = 6.650$ sec

c) $v(6.650) = -125.8$
125.8 ft/sec

d) $0 = -32t + 87$
$-87 = -32t$
$t = 2.719$ sec

e) $s(2.719) = 247.266$ ft.