KINEMATICS

Problems (5 pts each)

1. With full afterburners, the F-16 fighter jet has an acceleration of 12.7 m/s^2. It requires a velocity of 170 miles/hour to take off.

a. How long does it take the F-16 to reach take off speed if it starts from rest?

$a = 12.7 \frac{m}{s^2}$

$v_i = 0 \frac{m}{s}$

$v_f = 170 mph = 75.9 \frac{m}{s}$

$t = ?$ solve for t w/o x

$v_f = v_i + at$

$75.9 = 0 + 12.7t$

$t = 5.98 s$

b. How long (answer in feet) does its runway need to be?

$x = v_i t + \frac{1}{2} a t^2 = 0 + \frac{1}{2}(12.7)(5.98)^2$

$x = 227 m = 745 feet \approx 2$ football fields

Not Much!

2. A pebble is dropped into a well. The splash is heard 1.5 seconds after it was released. Neglecting the speed of sound, how far down is it to water level?

$y_0 = 0$

$y = ?$

$v_i = 0$

$v_y = ?$

$a = -9.8 \frac{m}{s^2}$

$t = 1.5 s$

$y = y_0 + v_i t - \frac{1}{2} g t^2$

$y = 0 + 0 - 4.9(1.5)^2$

$y = -11.0 m$

3. A soccer ball is kicked straight up in the air and takes 6.0 seconds to come back to Earth. Find out how high it went. only 3.0 second to highest point

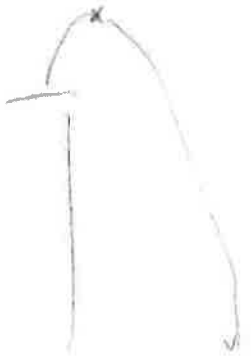
$y_0 = 0$	$y_0 = ?$
$y = ?$	$y = 0$
$v_i = ?$	$v_i = 0$
$v_f = 0$	$v_f = ?$
$a = -g$	$a = -g$
going up	going down

$y = y_0 + v_i t - \frac{1}{2} g t^2$

$0 = y_0 + 0 - 4.9(3)^2$

$y_0 = 44.1 m$

4. A stone is thrown vertically upward with a speed of +12.0 m/s from the edge of a cliff 75.0 m high. How much later does it reach the bottom of the cliff?



Going up

$y_0 = 0$
$y = ?$
$v_i = 12.0 \frac{m}{s}$
$v_f = 0$
$a = -g$
$t = ?$

$v_f = v_i - gt$
$0 = 12 - 9.8t$
$t = 1.22s$

$y = y_0 + v_i t - \frac{1}{2}gt^2$
$y = 0 + 12(1.22) - 4.9(1.22)^2$
$y = 7.35m$

Going down

$y_0 = 0$
$y = -82.4m$
$v_i = 0$
$v_f = ?$
$a = -g$
$t = ?$

$y = y_0 + v_i t - \frac{1}{2}gt^2$
$-82.4 = 0 + 0 - 4.9t^2$
$t = 4.10s$
$+1.22s$
$5.32s$

OR
$-75 = 12t - 4.9t^2$
quad formula

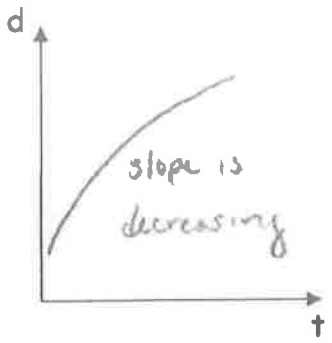
5. A speeding motorist traveling 35 m/s passes a stationary police officer. The officer immediately begins pursuit at a constant acceleration of 1.5 m/s^2. How much time will it take for the police officer to reach the speeder?

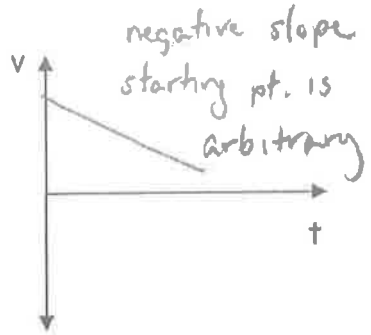
motorist: $x = 35t$
officer: $x = \frac{1}{2}(1.5)t^2$

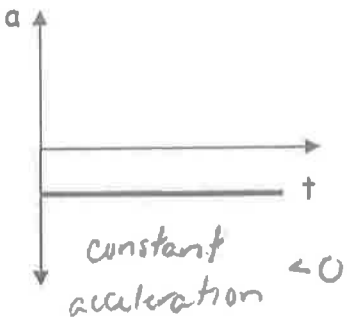
$35t = 0.75t^2$
$t = 47s$

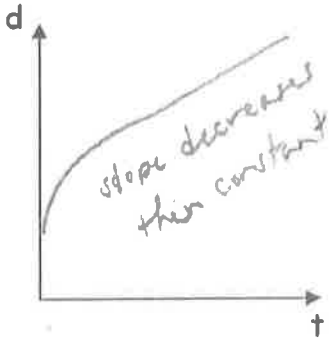
Graph Analysis (20 pts)

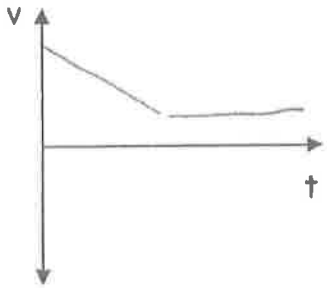
Using the information provided in one graph, complete the other 2.

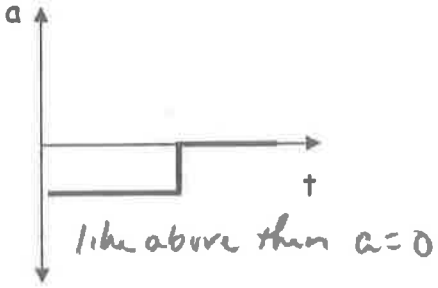


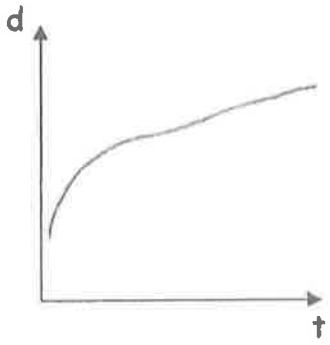


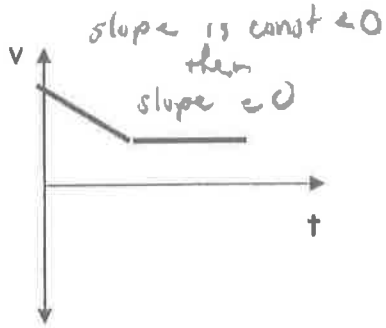


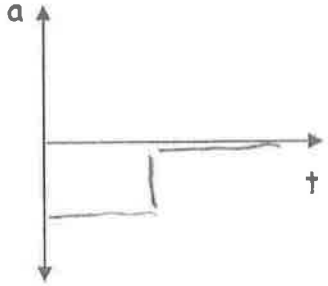


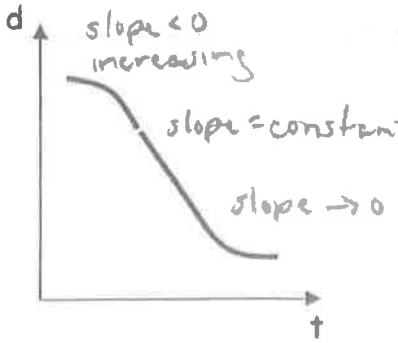


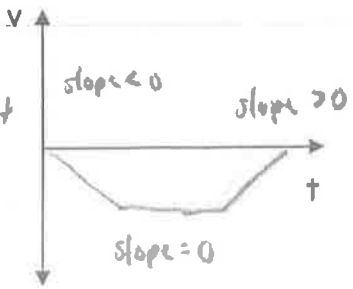


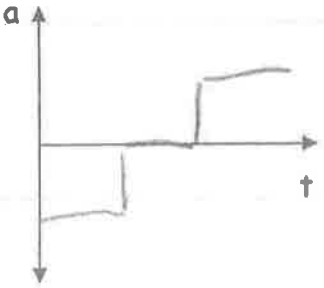












Extended Problem (10 pts)

A rocket rises vertically, from rest, with an acceleration of 3.2 m/s^2 until it runs out of fuel at an altitude of 1200 m. After this point, its acceleration is that of gravity, 9.8m/s^2 downward.

(a) What is the velocity of the rocket when it runs out of fuel?

$y_0 = 0$ $t = ?$
$y = 1200m$
$v_i = 0$
$v_f = ?$

$v_f^2 = v_i^2 + 2a\Delta y$

$v_f^2 = 0 + 2(3.2)(1200)$

$v_f = 87.6 m/s$

(b) How long does it take to reach this point?

$y = y_0 + v_i t + \frac{1}{2} a t^2$

$1200 = 0 + 0 + \frac{1}{2}(3.2)t^2$

$t = 27.4s$

(c) What maximum altitude does the rocket reach?

$y_0 = 1200m$
$y = ?$
$v_i = 87.6 m/s$
$a = -g$ $v_f = 0$

$v_f = v_i - gt$

$0 = 87.6 - 9.8t$

$t = 8.94s$

$y = y_0 + v_i t - \frac{1}{2} g t^2$

$y = 1200 + (87.6)(8.94) - 4.9(8.94)^2$

$y = 1592m$

(d) How much time (total) does it take to reach maximum altitude?

27.4 under power
+ 8.94 coasting to max height
36.3s

(e) With what velocity does the rocket strike the Earth?

$y = 0$
$y_0 = 1592$
$v_i = 0$
$v_f = ?$ $t = ?$

$v_f^2 = v_i^2 - 2g(y - y_0)$

$v_f^2 = 0 - 2(9.8)(-1592)$

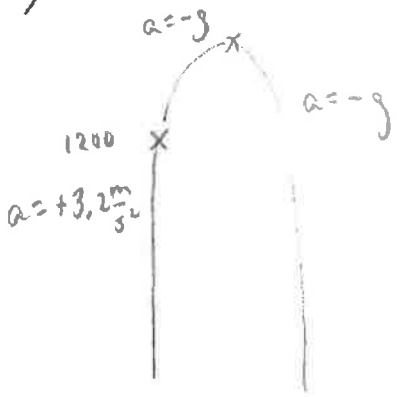
$v_f = 177 m/s$

(f) How long (total) is it in the air?

$y = y_0 + v_i t - \frac{1}{2} g t^2$

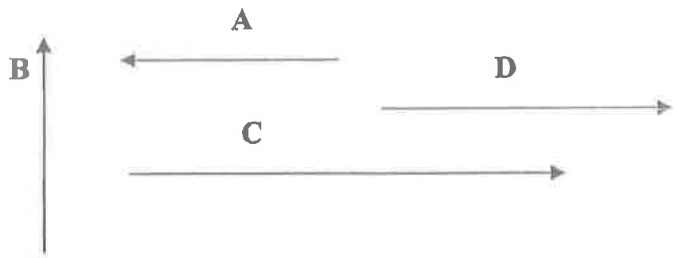
$-0 = 1592 + 0 - 4.9t^2$

$t = 18.0s$



Problems

1. Find the vector sum of **A** + **B** + **C** + **D**. (6 pts) **A** = 3.0cm, **B** = 3.0 cm, **C** = 6.0cm, and **D** = 4.0cm



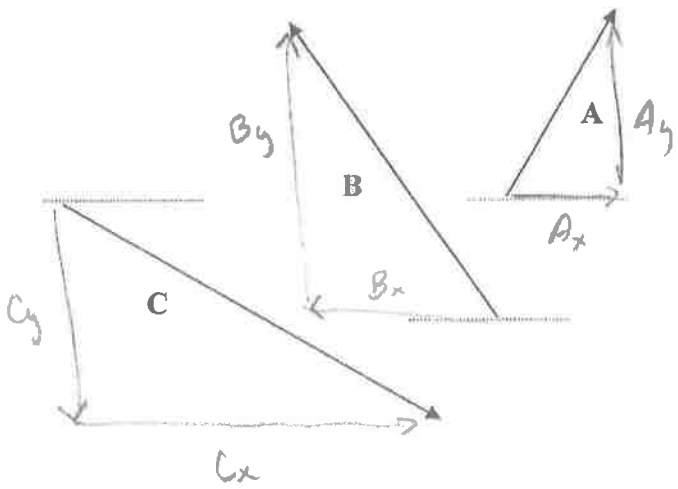
	x-comp	y-comp
$\vec{A}$:	-3	0
$\vec{B}$:	0	3
$\vec{C}$:	6	0
$\vec{D}$:	4	0
	7	3

$\sqrt{7^2+3^2} = 7.6$

$\theta = \tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{3}{7}\right) = 23°$

2. Find the vector sum of **A** + **B** + **C**. (6 pts)

A = 3.0cm @ 45°
B = 3.0 cm @ 60°
C = 6.0cm @ 30°



	x-comp	y-comp
$\vec{A}$:	2.1	+ 2.1
$\vec{B}$:	-1.5	+ 2.6
$\vec{C}$:	-5.2	-3.0
	-4.6	1.7

$\sqrt{4.6^2 + 1.7^2} = 4.90$

$\theta = \tan^{-1}\left(\frac{1.7}{4.6}\right) = 20°$ in quadrant 2

5. A horizontal projectile is shot from desk height (1.0 meters). Is the time it takes to hit the ground dependent on the horizontal velocity? Why or why not?

No.

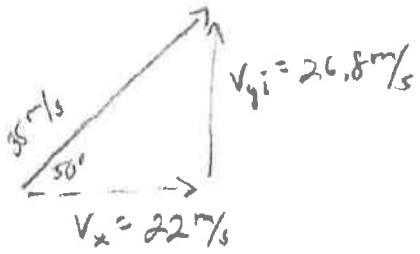
$x = v_x t$ $\quad y = y_0 - v_{yi}t - \frac{1}{2}gt^2$ ($v_{yi} = 0$)

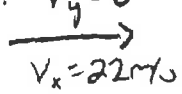
$0 = 1 - \frac{1}{2}gt^2$

$t = 0.45\,s$

because the velocity is horizontal, it has no impact on vertical motion

6. An arrow is shot from ground level with speed of 35 m/s at an angle 50° above the horizontal. What is the vertical component of its velocity at its highest point? How far does it go? How long is it in the air?





How far: $R = \frac{V_0^2 \sin 2\theta}{g} = 123\,m$

How long: $V_y = V_{yi} - gt$

$0 = 26.8 - 9.8t$

$t = 2.73\,s$

$\times 2$

$5.46\,s$

OR

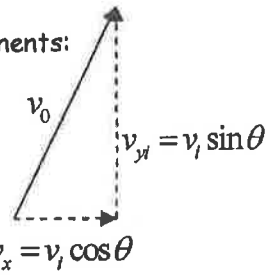
$x = v_x t$

$123 = (22)t$

$t = 5.59\,s$

Good Stuff

Resolving into x & y components:



Range formula: $Range = \frac{v_i^2 \sin 2\theta}{g}$

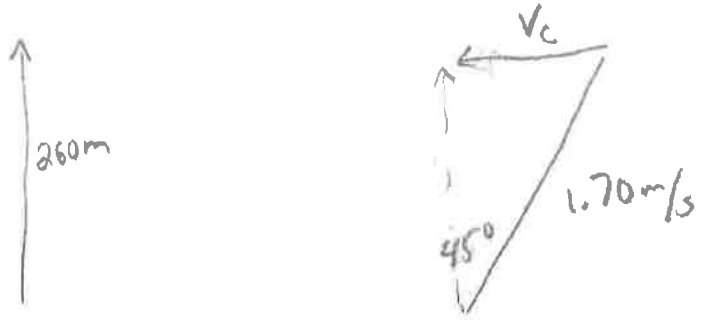
Horizontal motion: $x = v_x t = v_i(\cos\theta)t$

Vertical Motion: $\Delta y = v_{yi}t - \frac{1}{2}gt^2 = v_i(\sin\theta)t - \frac{1}{2}gt^2$

$v_y = v_{yi} - gt = v_i \sin\theta - gt$

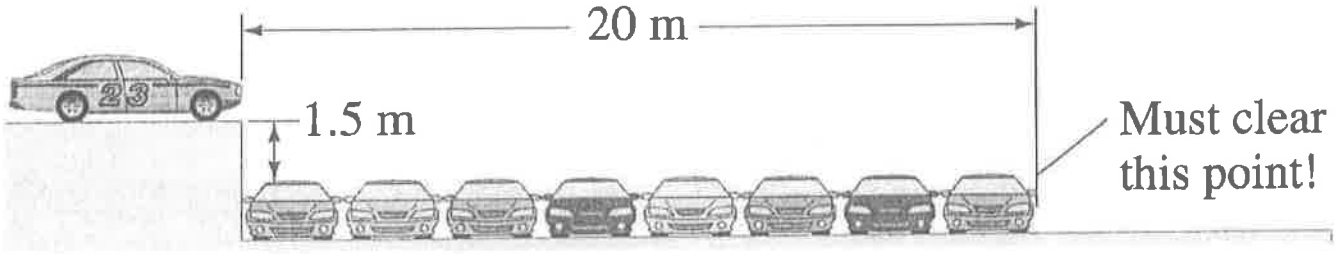
Quadratic formula: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

3. A boat, whose speed in still water is 1.70 m/s, must cross a 260-m-wide river and arrive at a point 0 m upstream from where it starts. To do so, the pilot must head the boat at a 45° upstream angle. What is the speed of the river's current? (6 pts)



$V_c = 1.70 \sin 45^\circ = 1.20 \frac{m}{s}$

4. What minimum speed will car #23 need to make this jump successful? (6 pts)



$y = 0$
$y_0 = 1.5$
$V_{yi} = 0$
$V_y = ?$

$y = y_0 + v_i t - \frac{1}{2} g t^2$

$0 = 1.5 + 0 - 4.9t^2$

$t = 0.55\,s$

$x = v_x t$

$20 = v_x (0.55)$

$v_x = 36 \frac{m}{s}$