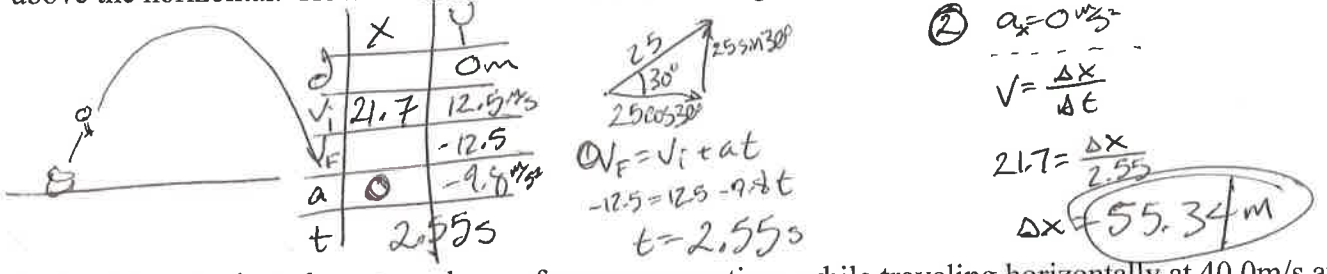
Projectile Motion – Key Ideas

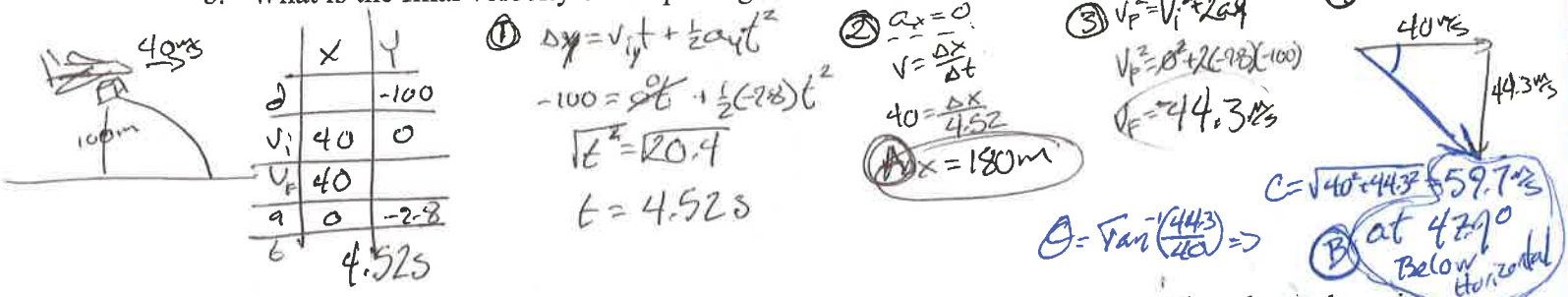
1. An object's motion in one dimension does not affect its motion in any other dimension (e.g. vertical motion affecting horizontal motion).
2. Projectile motion problems are easiest to solve if you break the object's motion into "horizontal" and "vertical" components.
3. Horizontal velocity is constant (and thus, acceleration = 0).
4. Vertical acceleration is -9.8 m/s^2 directed downward.
5. The vertical component of velocity equals v(sin θ). (θ is measured with the horizontal.)
6. The horizontal component of velocity equals v(cos θ).
7. Time (t) is the link between vertical and horizontal components. Time (t) is the same for both components for the duration of the flight of the projectile.

Examples:

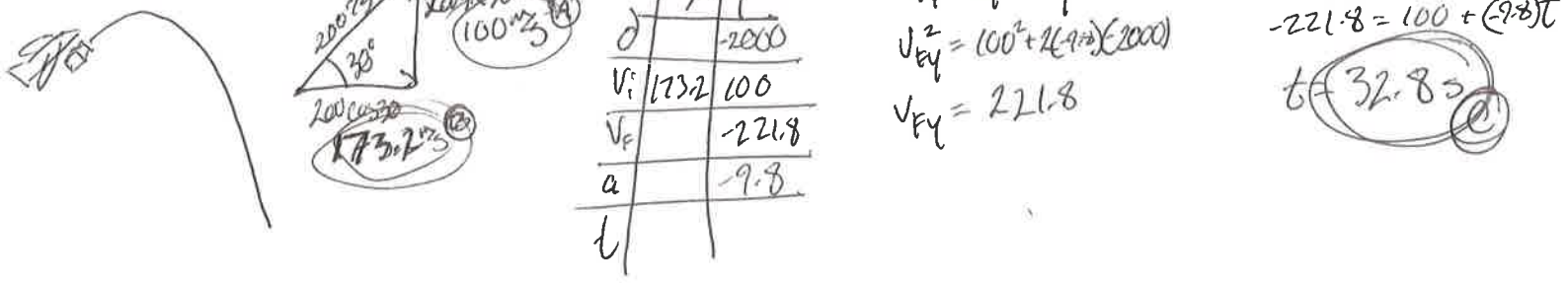
1) A Brady Quinn bobblehead doll is shot at a velocity 25 m/s from a cannon pointed at an angle of θ = 30° above the horizontal. How far does it travel before hitting the level ground?



2) An Iraqi rescue plane drops a package of emergency rations while traveling horizontally at 40.0m/s at a height of 100m above the ground.
   a. Where does the package strike the ground relative to the point at which it is released?
   b. What is the final velocity of the package?



3) An airplane attempts to drop a package of relief aid on a target in a hot zone. When the package is released, the plane is flying upward at an angle of 30° above the horizontal at a velocity of 200 m/s. At the point of release, the plane's altitude is 2,000m.
   a. Determine the magnitude of the vertical component of the package's velocity at the point of release.
   b. Determine the magnitude of the horizontal component of the package's velocity at the point when the package hits the target.
   c. Determine how much time it takes for the package to hit the target after it is released.



4) A gazelle leaves the ground at an angle of 20 to the horizontal and a speed of 11.0 m/s.

a. How long does it take the gazelle to reach maximum height?

b. What is the maximum height?

c. How far does the gazelle jump?

max height

	x	y
d		?
V_i	10.34	3.76
V_F	10.34	0
a	0	-9.8
t		?

① $V_F = V_i + at$

$0 = 3.76 + (-9.8)t$

$t = 0.38\,s$ (A)

② $V_{F_y}^2 = V_{i_y}^2 + 2ay$

$0^2 = 3.76^2 + 2(-9.8)y$

$y = 0.72\,m$ (B)

whole jump

	x	y
d		
V_i	10.34	3.76
V_F	10.34	-3.76
a	0	-9.8
t		

③ $V_F = V_i + at$

$-3.76 = 3.76 - 9.8t$

$t = 0.767\,s$

④ $*a_x = 0$

$V = \frac{\Delta x}{\Delta t}$

$10.34 = \frac{\Delta x}{0.767}$

$\Delta x = 7.93\,m$ (C)

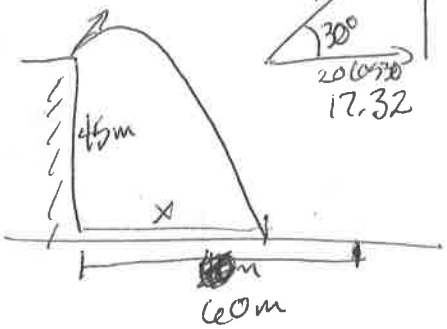
5. A mischievous and naughty student launches an egg from the top of the football bleachers at an angle of 30° to the horizontal having an initial speed of 20m/s attempting to strike an innocent Mr. Friel who is having a picnic 60.0m away. The point of release is 45.0m above the ground.

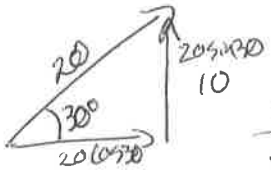
a) How long does it take for the egg to hit the ground?

b) What is the egg's speed upon impact with the ground?

c) What is the horizontal range of the egg?

d) Will Mr. Friel get clocked in the head with the egg, thus transforming him into a raging lunatic?





	x	y
d		-45
V_i	17.32	10
V_F	17.32	-31.34
a	0	-9.8
t		

① $V_{F_y}^2 = V_{i_y}^2 + 2ay$

$V_{F_y}^2 = 10^2 + 2(-9.8)(-45)$

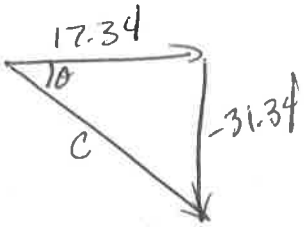
$V_{F_y} = 31.3$

② $V_F = V_i + at$

$-31.34 = 10 - 9.8t$

$t = 4.22\,s$ (A)

③



$c = \sqrt{17.34^2 + (-31.34)^2}$

$c = \sqrt{1282.87}$

$c = 35.8\,m/s$ (B)

④ $*a_x = 0$

$V = \frac{\Delta x}{\Delta t}$

$17.34 = \frac{\Delta x}{4.22}$

$\Delta x = 73.2\,m$ (C)

⑤ NO, the $\Delta x \neq 60m$

landed 13.2m to far from Base of Bleachers

Answers:

1. 57m
2. a. 181 m b. 59.7m/s, 312°
3. a. 100m/s b. 170m/s c. 32s
4. a. 0.38s b. 0.722m c. 7.94m
5. a. 4.22s b. 35.9m/s c. 73.1m