Physics Unit 3: Projectile Motion - Review Key

1. Which equation would you use to find the time it takes for a projectile to reach the ground? Which equation would you use to find the horizontal distance that a projectile will travel? What's the difference between the horizontal and vertical motion?

Vertical: $\Delta d = v_i t + \frac{1}{2}at^2$

horizontal: $\Delta d = vt$

Gravity only accelerates the projectile in the vertical direction. Horizontal acceleration is zero

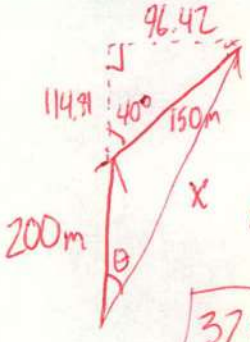
2. A cannonball is launched horizontally at 15 m/s from 20 m above the ground. How high would an identical cannonball need to be dropped from (at the moment the cannon is fired) in order to hit the ground at the same time? Why?

20 m. The vertical motion is the same whether the cannonball is dropped or launched horizontally.

3. A woman runs 200 m directly North, and then an additional 150 m at an angle of 40° East of North. What is her total displacement (magnitude and direction)?

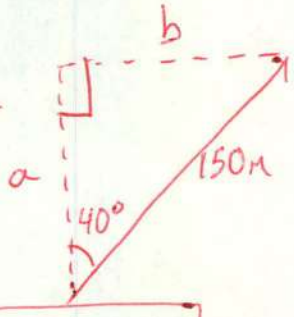
$\tan\theta = \frac{96.42}{314.91}$

$\theta = 17°$



$x^2 = 314.91^2 + 96.42^2$

$x = 329.34\ m$



$\sin 40° = \frac{b}{150m}$

$b = 96.42\ m$

$\cos 40° = \frac{a}{150m}$

$a = 114.91\ m$

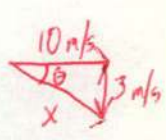
329.34 m, 17° East of North

4. A boat captain wants to cross a 200 m wide river. His boat can travel a maximum speed of 10 m/s. He steers directly across the river.

a) How long will it take him to cross? 20 s

b) If the current flows downstream at 3 m/s, how far downstream will the boat be pushed? 60 m

c) What is the resultant velocity (speed and direction) of the boat?



$x^2 = 10^2 + 3^2$

$x = 10.44\ m/s$

$\tan\theta = \frac{3}{10}$

$\theta = 16.7°$

$\vec{V} = 10.44\ m/s$ at 16.7° downstream

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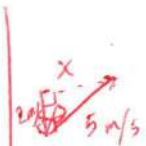
5. A boat captain wants to cross a 400 m wide river and end up at a dock directly on the opposite side. The boat's maximum speed is 5 m/s, and the river flows downstream at 2 m/s. At what angle should the captain steer in order to reach his destination? How long will it take to cross the river?



$x^2 + 2^2 = 5^2$

$x = 4.58$ m/s

$t = \frac{d}{v} = \frac{400}{4.58} = \boxed{87.3\text{ s}}$

$\cos\theta = \frac{2}{5}$

$\theta = \cos^{-1}\left(\frac{2}{5}\right) = \boxed{66.4^\circ \text{ from upstream}}$

6. Two marbles roll directly horizontally off of a table 1.25 m above the ground, one with a speed of 1.5 m/s and the other with a speed of 2 m/s. If the marbles travel in the same direction, how far apart do the marbles land?

Marble 1

Horizontal (x direction)	Vertical (y direction)
a= 0	a= -9.8 m/s^2
V_i= 1.5 m/s	V_i= 0 m/s
V_f= 1.5 m/s	V_f= -4.95 m/s
D= .758m	D= -1.25m
T= .505s	T= .505s

Marble 2

Horizontal (x direction)	Vertical (y direction)
a= 0	a= -9.8 m/s^2
V_i= 2 m/s	V_i= 0 m/s
V_f= 2 m/s	V_f= -4.95 m/s
D= 1.010m	D= -1.25m
T= .505s	T= .505s

$d = V_i t + \frac{1}{2}at^2$

$-1.25 = 0t + \frac{1}{2}(-9.8)t^2$

$-1.25 = -4.9t^2$

$t = 0.505$s

$D = (1.5)(.505)$

$= .758$m

$D = 2(.505)$

$= 1.010$m

$1.010\text{m} - .758\text{m} = \boxed{0.252\text{m}}$

$D = Vt$

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7. A baseball fan catches a home run ball hit by the opposing team and decides to throw it back onto the field. The fan's seat in the bleachers is 7 m above the field, and the fan throws the ball so that its velocity has an initial vertical component of 5 m/s upward and an initial horizontal component of 8 m/s toward the field.

   a. How long is the thrown ball in the air?

$\Delta d = V_i t + \frac{1}{2} a t^2$

$-7 = 5t - 4.9t^2$

$4.9t^2 - 5t - 7 = 0$

$t = \frac{5 \pm \sqrt{5^2 - 4(4.9)(-7)}}{2(4.9)}$

$t = 1.81\text{ s}$

Horizontal (x direction)	Vertical (y direction)
a= $0\ m/s^2$	a= $-9.8\ m/s^2$
V_i= $8\ m/s$	V_i= $5\ m/s$
V_f= $8\ m/s$	V_f= $-12.74\ m/s$
D= $14.48\ m$	D= $-7\ m$
T= $1.81\ s$	T= $1.81\ s$

   b. What is the maximum height of the ball?

$0^2 = 5^2 + 2(-9.8)(\Delta d)$

$-25 = -19.6\,\Delta d$

$\Delta d = 1.28$

1.28 m above where it's thrown from

Horizontal (x direction)	Vertical (y direction)
a= $0\ m/s^2$	a= $-9.8\ m/s^2$
V_i= $8\ m/s$	V_i= $5\ m/s$
V_f= $8\ m/s$	V_f= $0\ m/s$
D= $4.08\ m$	D= $1.28\ m$
T= $0.51\ s$	T= $0.51\ s$

   c. How far does the ball travel horizontally before hitting the field?

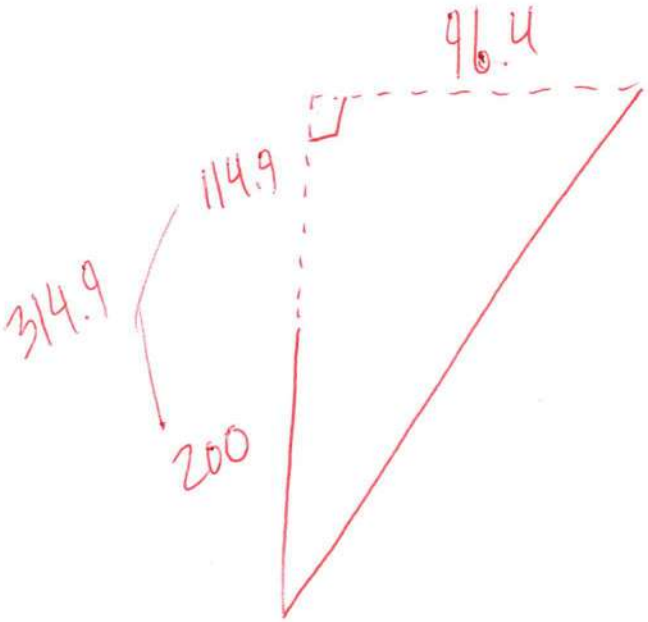
$d = vt = (8)(1.81)$

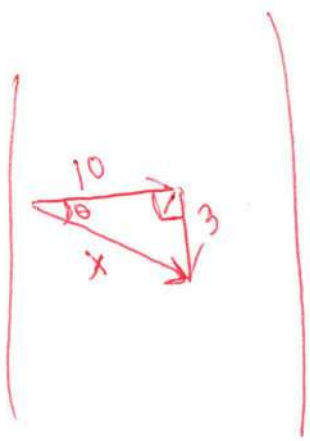
$d = 14.48\ m$

Horizontal (x direction)	Vertical (y direction)
a= $0\ m/s^2$	a= $-9.8\ m/s^2$
V_i= $8\ m/s$	V_i= $5\ m/s$
V_f= $8\ m/s$	V_f= $-12.74\ m/s$
D= $14.48\ m$	D= $-7\ m$
T= $1.81\ s$	T= $1.81\ s$

$\frac{d}{v} = \frac{vt}{v}$ $\quad d = vt$

$\frac{d}{v} = t$





$\tan\theta = \frac{10}{3} = 3.3$

$\theta = \tan^{-1}(3.3)$