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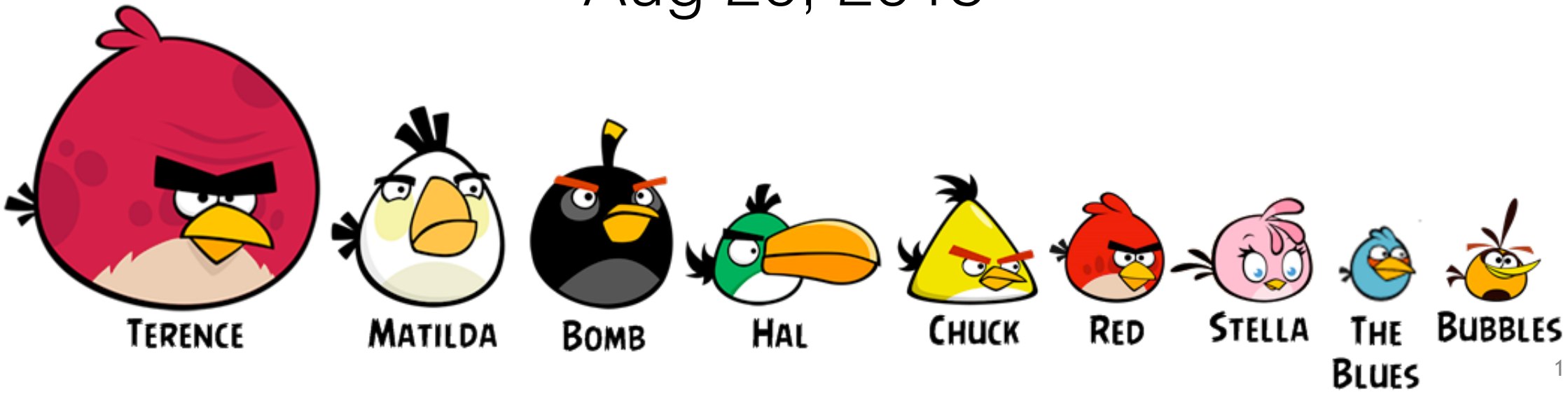
Angles of Angry Birds!

Aug 20, 2015



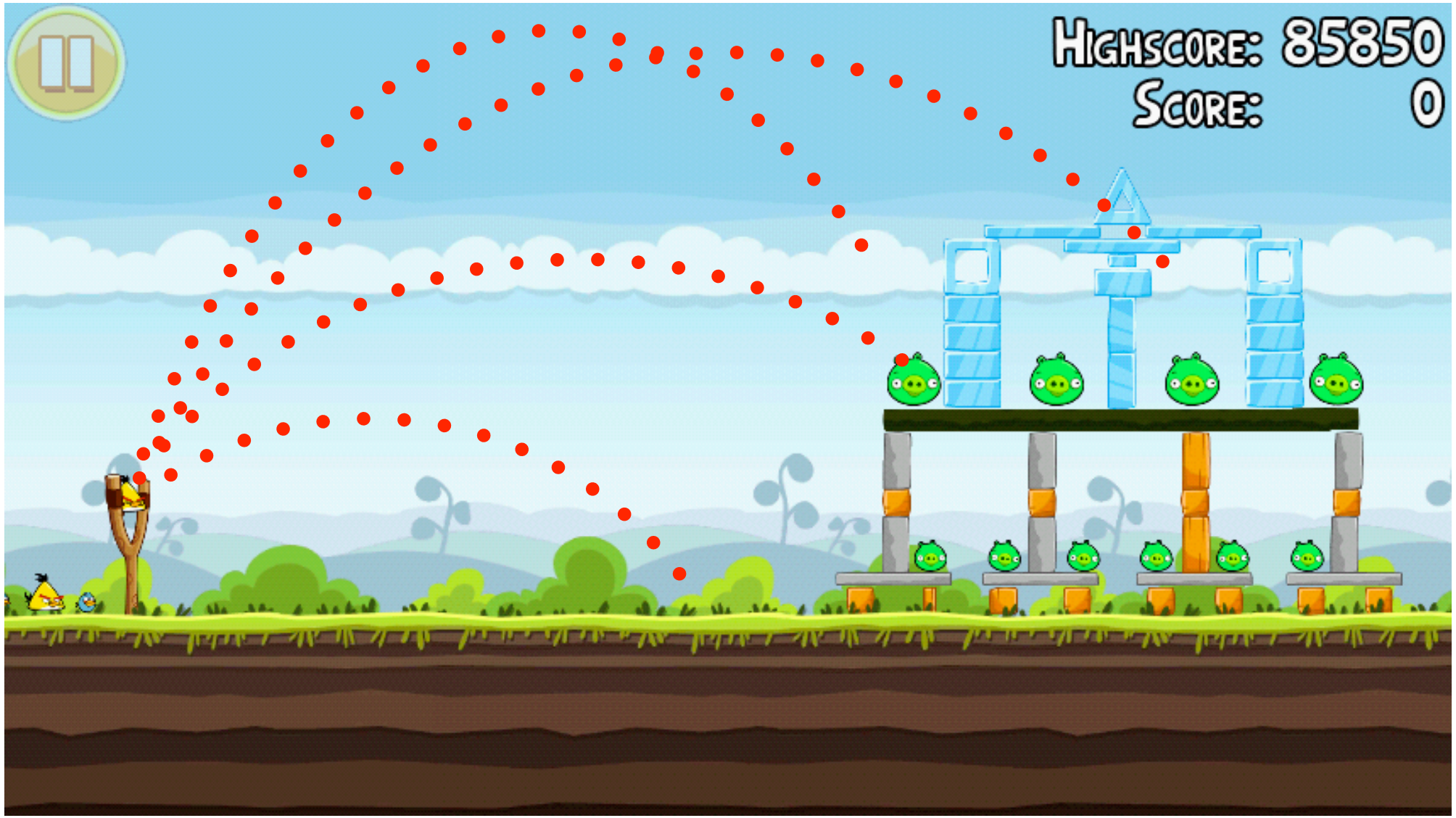
Lesson Plan

- ANGRY BIRDS!
- Discuss Projectile Equations (describing things with math)
- Discuss Trigonometry of a Sling Shot (more describing things)
- Attack! (using math)

Angry Birds
=
math + programming

Angry Birds!

Angry Birds!

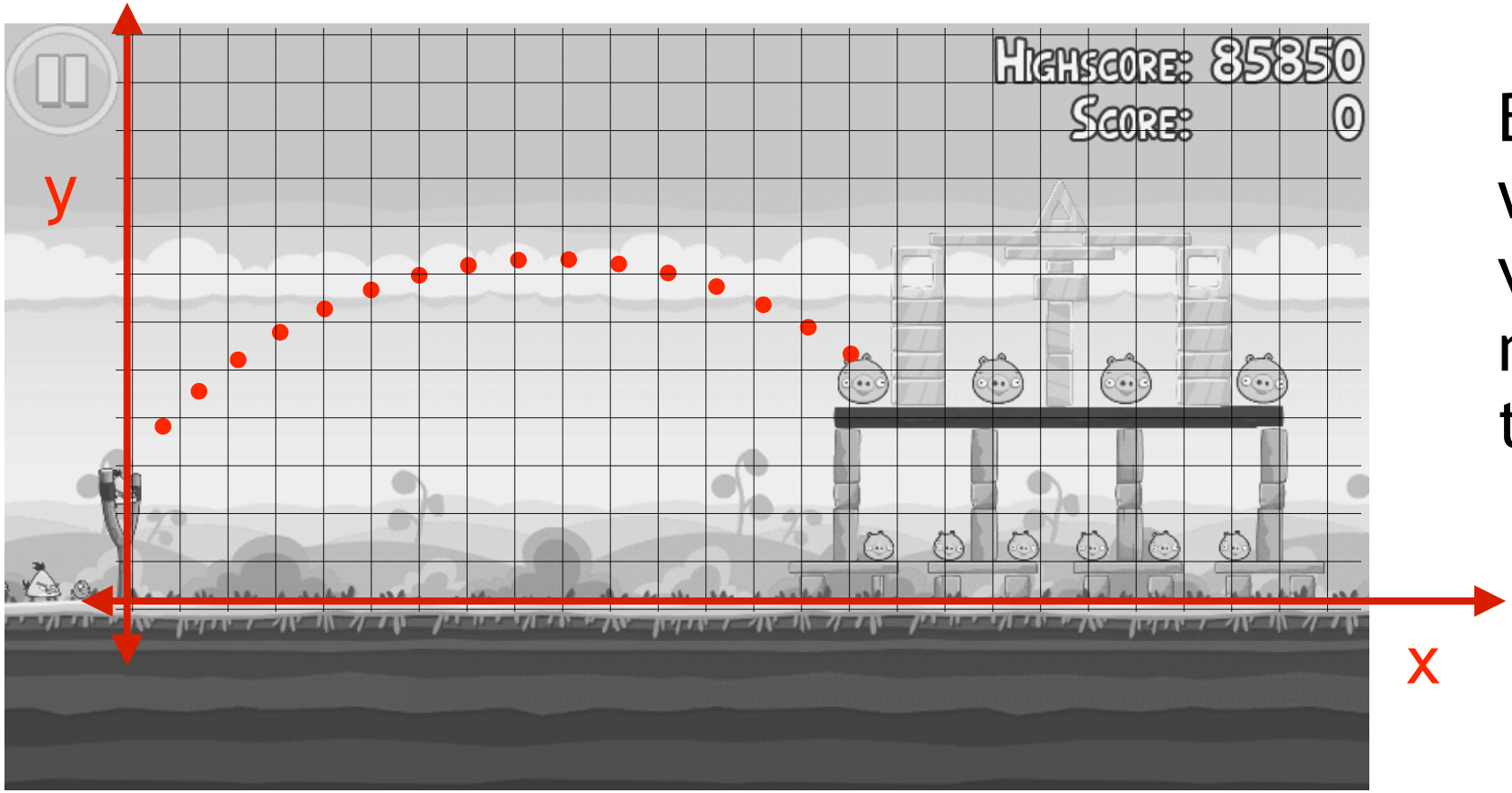


Projectile Equations

Math is actually a language (!) that is really good at describing things (very specifically)

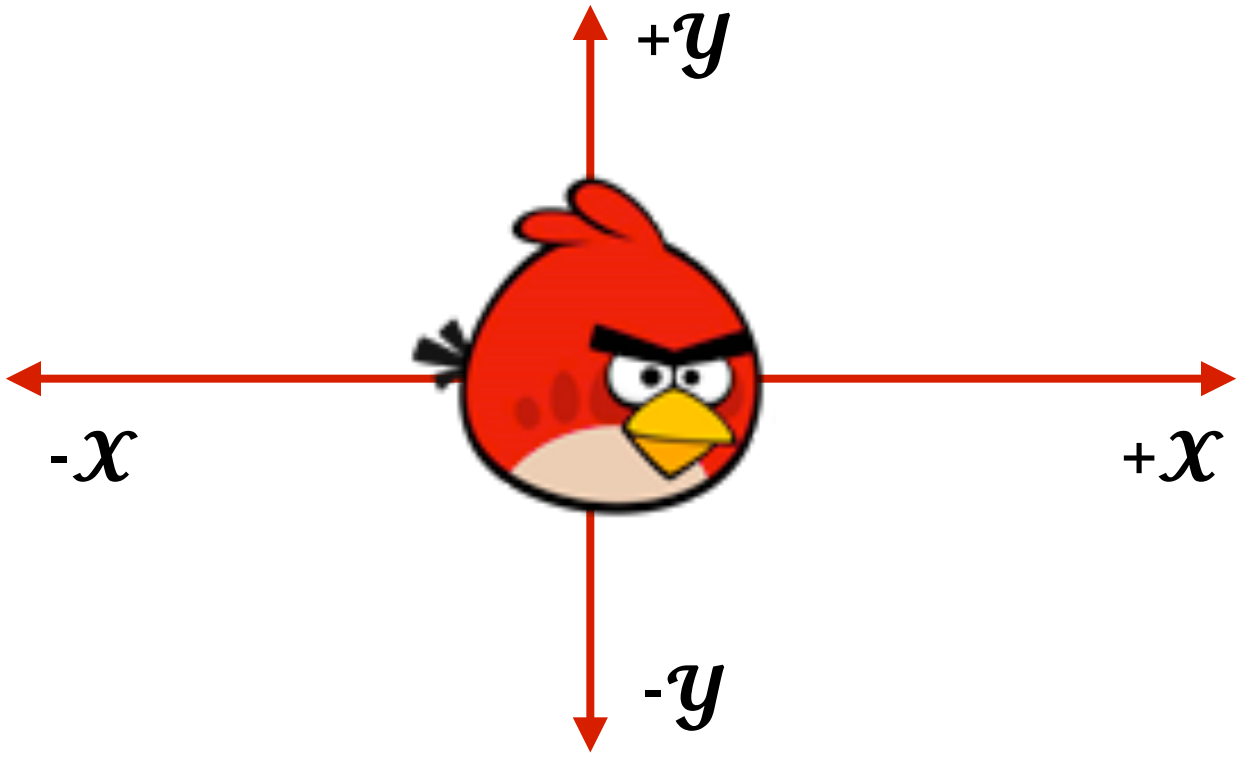
Let's try to describe this using math!

Projectile Equations



Besides x and y, what kind of variables do we need to describe this?

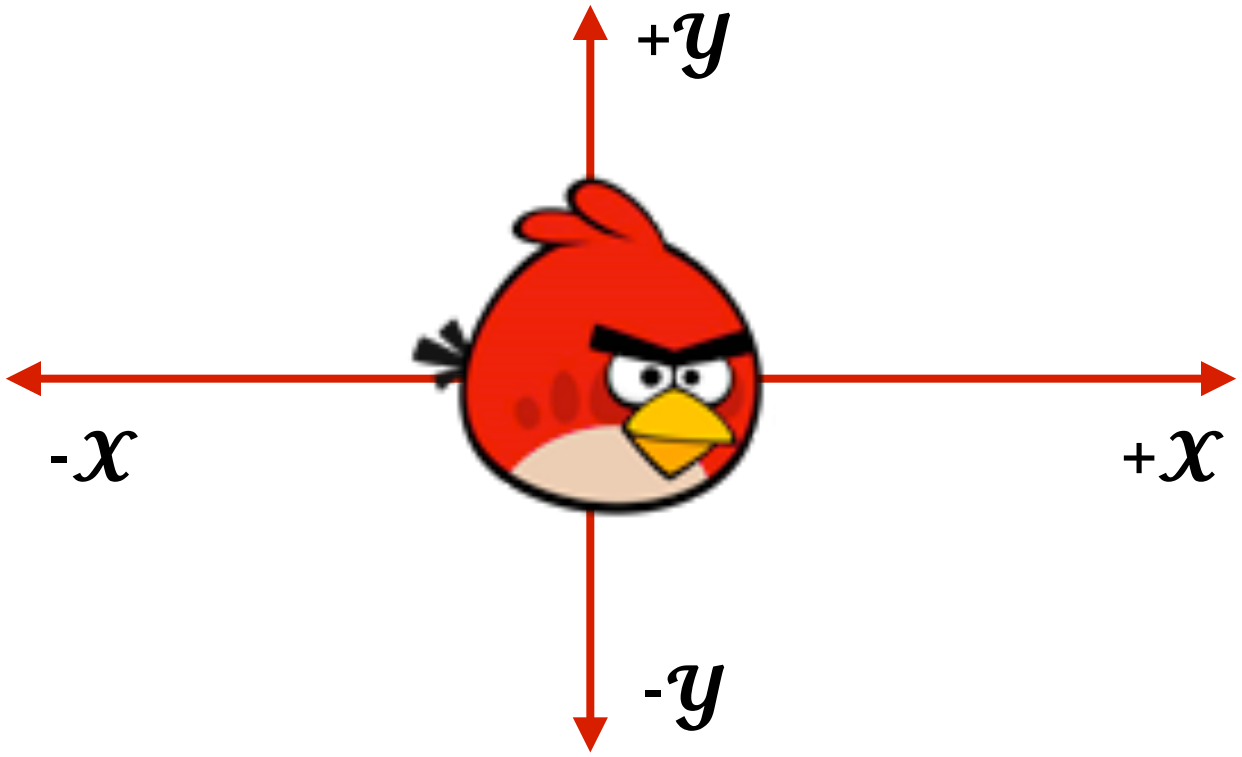
Projectile Equations



we need to know where it is going

- x velocity (x)
- y velocity (y)

Projectile Equations

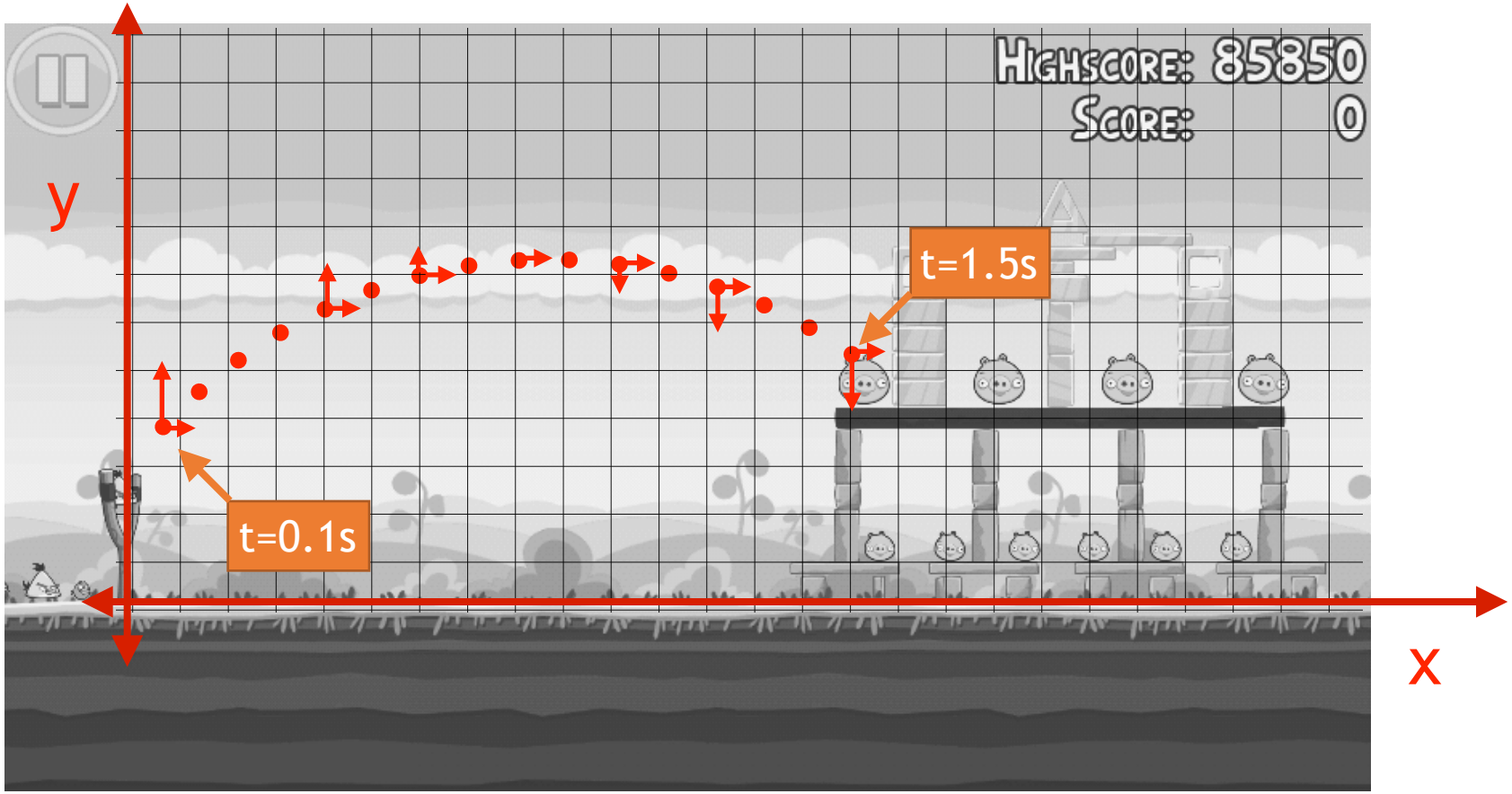


we need to know where it is going

- x velocity (x)
- y velocity (y)

If y = -2 and x = 3 which way is the bird going?

Projectile Equations



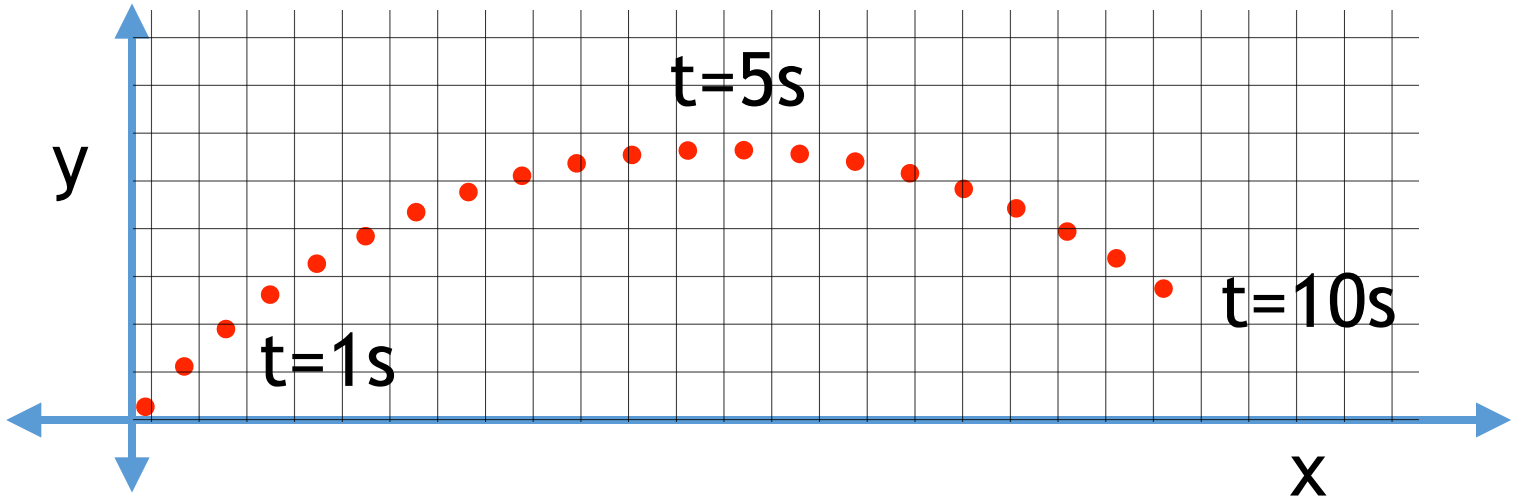
at each time t, we need to know

where it is
- x position
- y position

where it is going
- x velocity (x)
- y velocity (y)

4 functions

Projectile Equations (Physics)



Constants:

v_x = initial x velocity
v_y = initial y velocity
a = gravity (-9.8 m/s^2)

Position

$x(t) = v_x t$
$y(t) = v_y t + 0.5at^2$

Velocity

$\dot{x}(t) = v_x$
$\dot{y}(t) = v_y + at$

Projectile Equations (Physics)

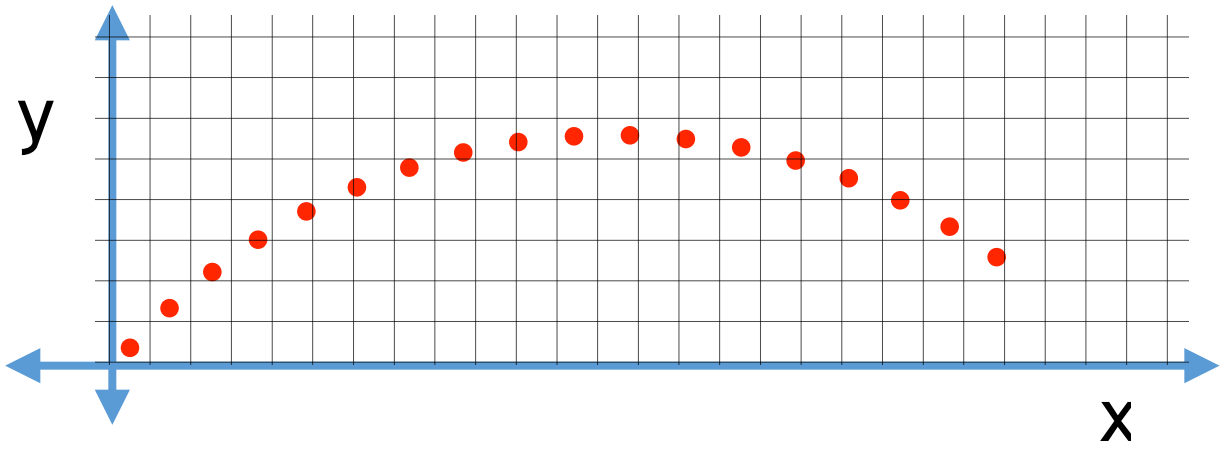
$v_x = 10$ m/s
$v_y = 10$ m/s

Position

$x(t) = 10t$
$y(t) = 10t - 4.9t^2$

Velocity

$\dot{x}(t) = 10$
$\dot{y}(t) = 10 - 9.8t$



t=0	t=1	t=2
$x(0) =$ $y(0) =$	$x(1) =$ $y(1) =$	$x(2) =$ $y(2) =$
$\dot{x}(0) =$ $\dot{y}(0) =$	$\dot{x}(1) =$ $\dot{y}(1) =$	$\dot{x}(2) =$ $\dot{y}(2) =$

Projectile Parameters

at each time t, we know

- x position x(t)
- y position y(t)
- x velocity $x'(t)$
- y velocity $y'(t)$

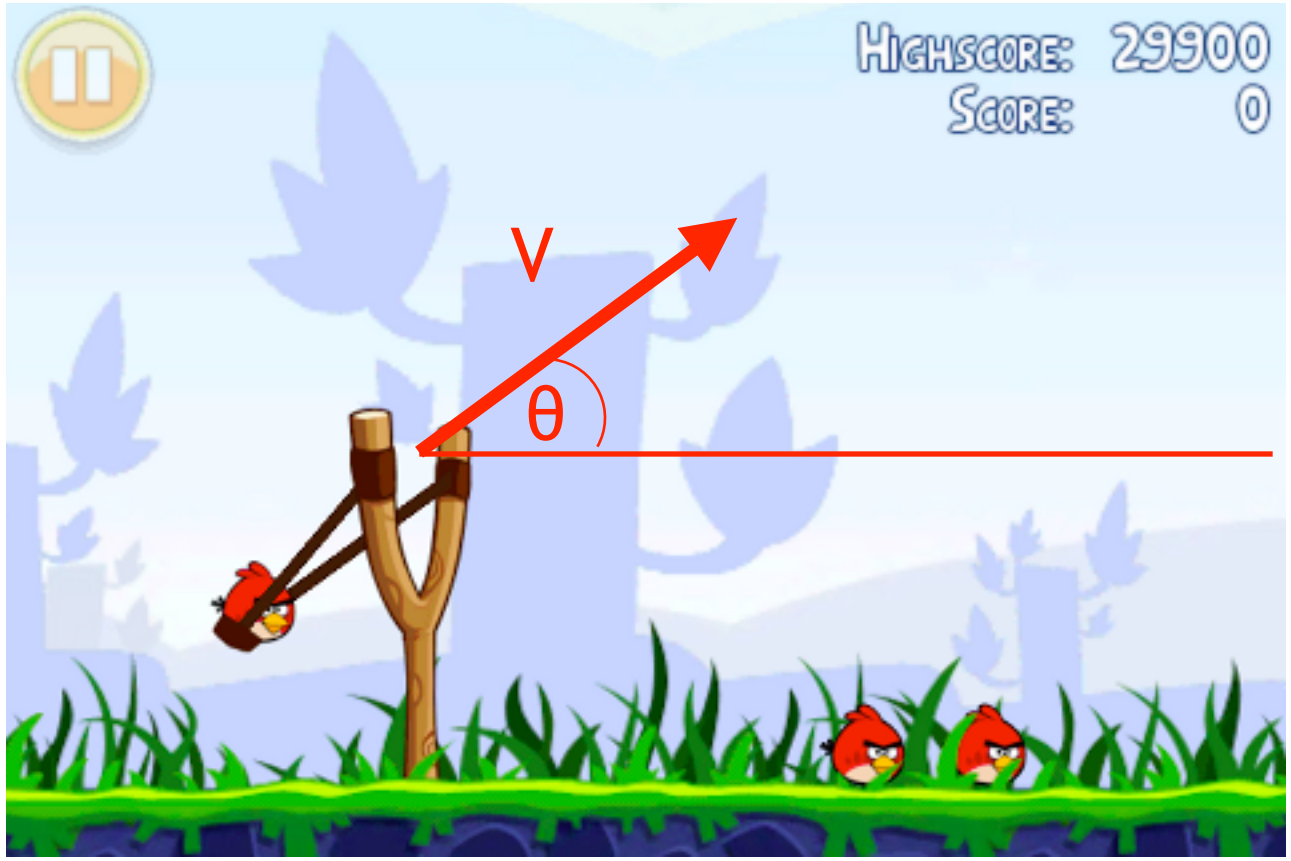
depend on

v_x = initial x velocity

v_y = initial y velocity

But what do you control?

Projectile Parameters



at each time t, we know

- x position x(t)
- y position y(t)
- x velocity $\mathcal{X}$(t)
- y velocity $\mathcal{X}$(t)

depend on

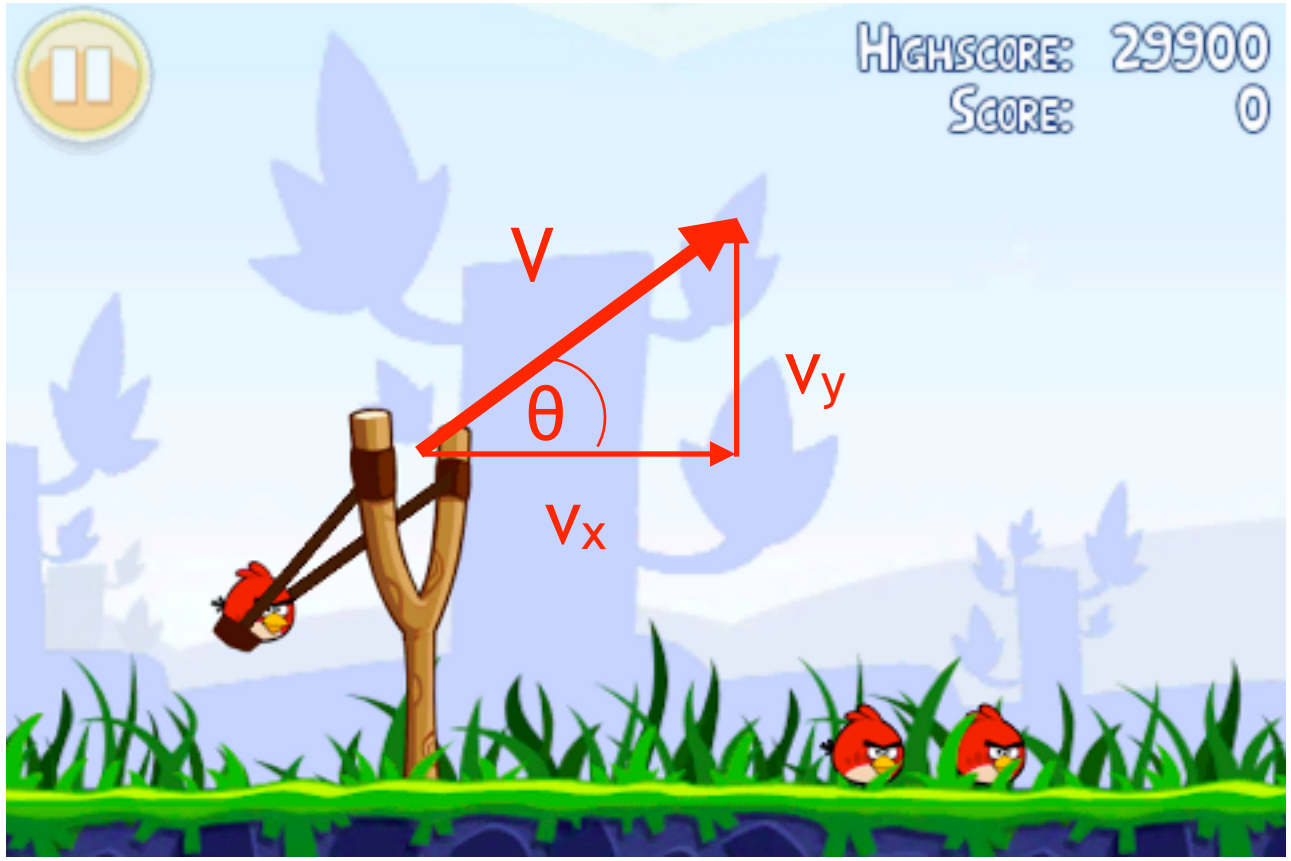
v_x = initial x velocity

v_y = initial y velocity

But what do you control?

1. Angle
2. Initial Velocity

Projectile Trigonometry

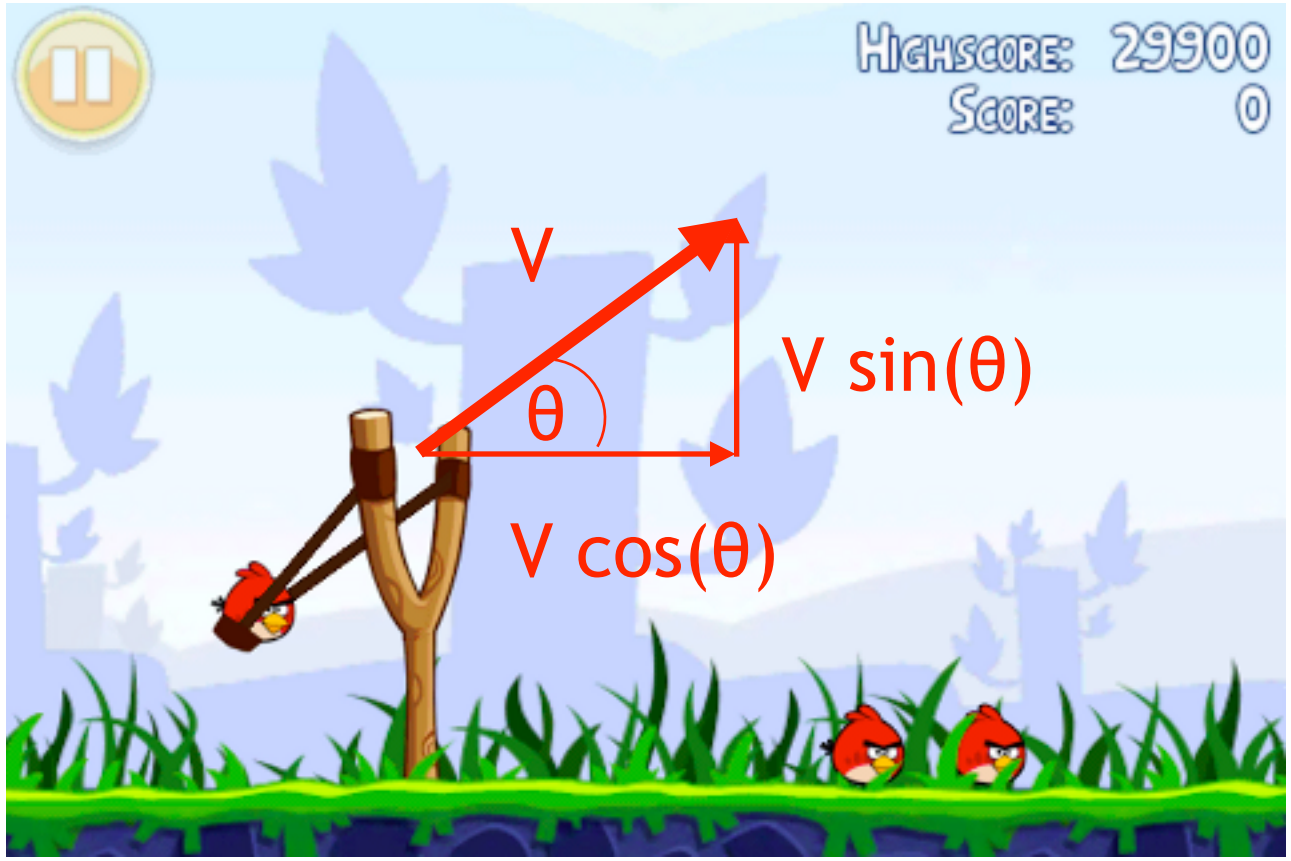


Need to break V into two parts using V and our angle θ.

v_x =

v_y =

Projectile Trigonometry



$V = 10$

$v_x = V \cos(\theta)$

$v_y = V \sin(\theta)$

$\theta = 0°$
$v_x = 10$
$v_y = 0$

$\theta = 30°$
$v_x = 8.7$
$v_y = 5$

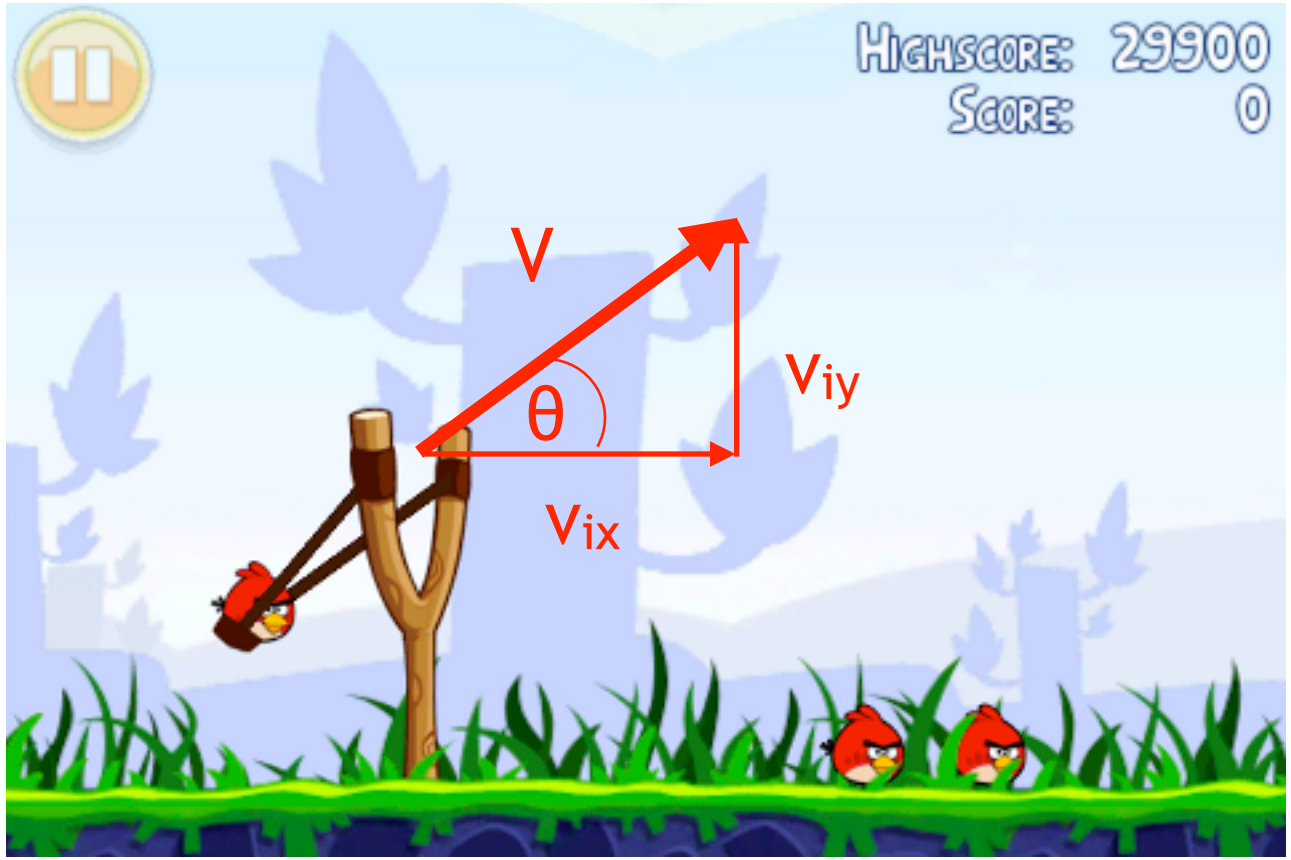
$\theta = 60°$
$v_x = 5$
$v_y = 8.7$

$\theta = 15°$
$v_x = 9.6$
$v_y = 2.6$

$\theta = 45°$
$v_x = 7.1$
$v_y = 7.1$

$\theta = 90°$
$v_x = 0$
$v_y = 10$

Projectile Trigonometry



$v_x = V \cos(\theta)$
$v_y = V \sin(\theta)$

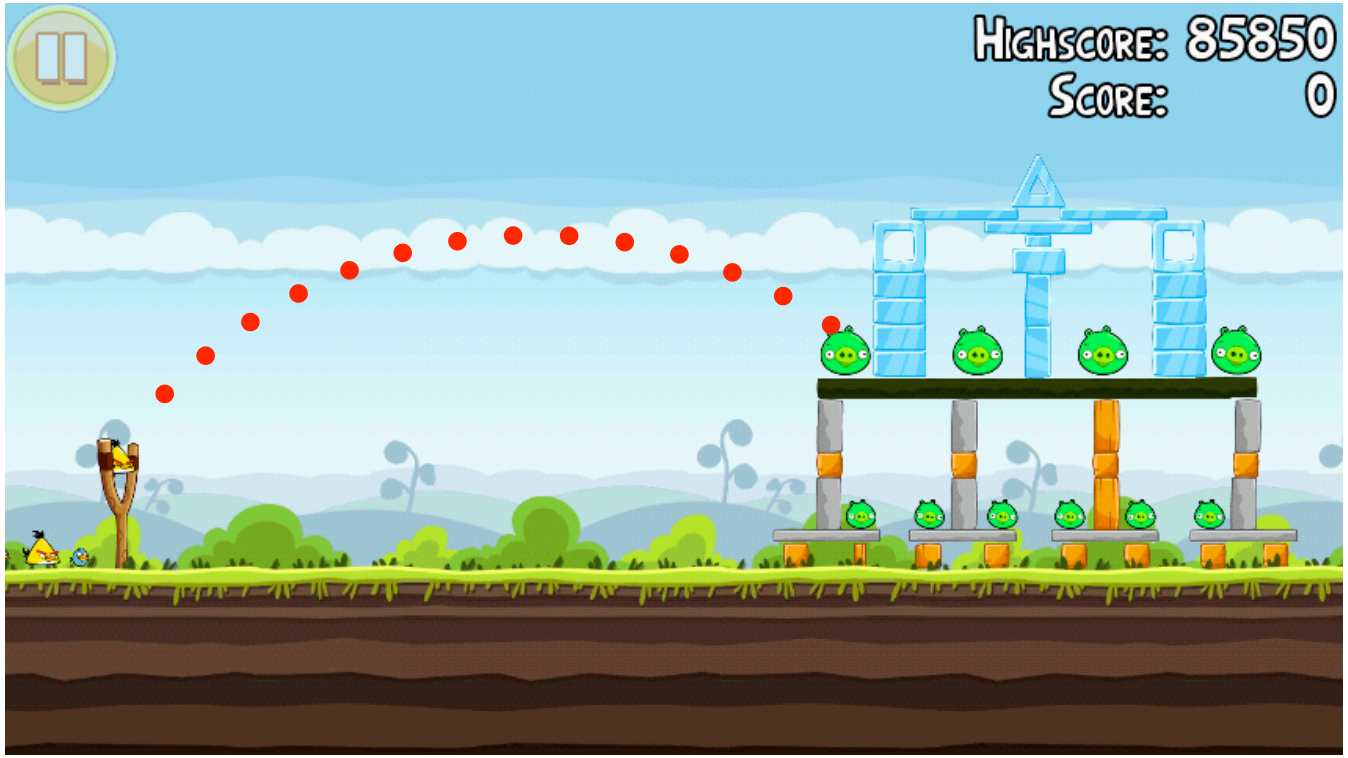
Position

$x(t) = v_x t$
$y(t) = v_y t - 4.9t^2$

Velocity

$x'(t) = v_x$
$y'(t) = v_y - 9.8t$

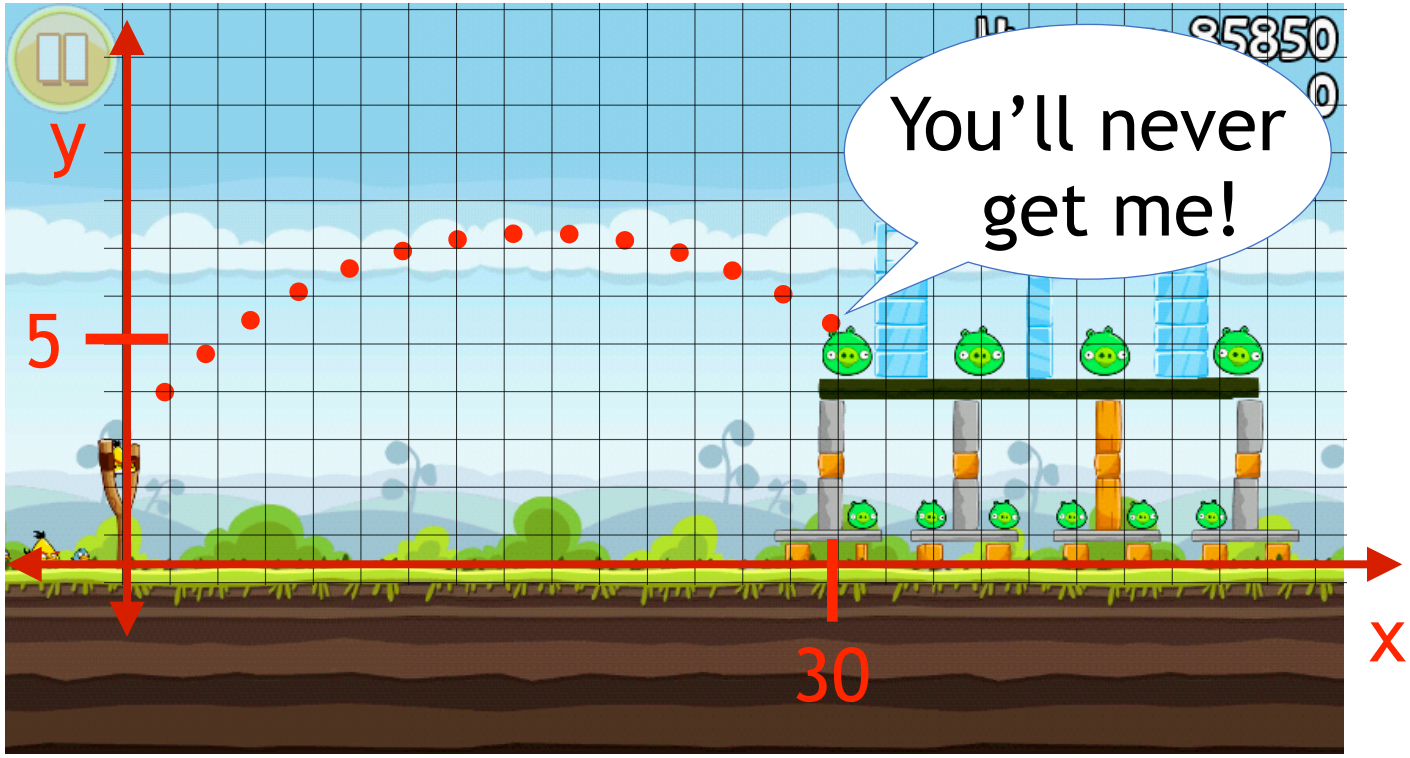
Let's Get Angry!



Attack!

(Warning you are about to enter into a battle where math will be required)

Projectile Equations



We spotted a pig at (30,5)!

You fire a bird with
V = 30 and θ = 17°
at <u>what time</u> will your bird reach x=30?

Position

$x(t) = v_x t$

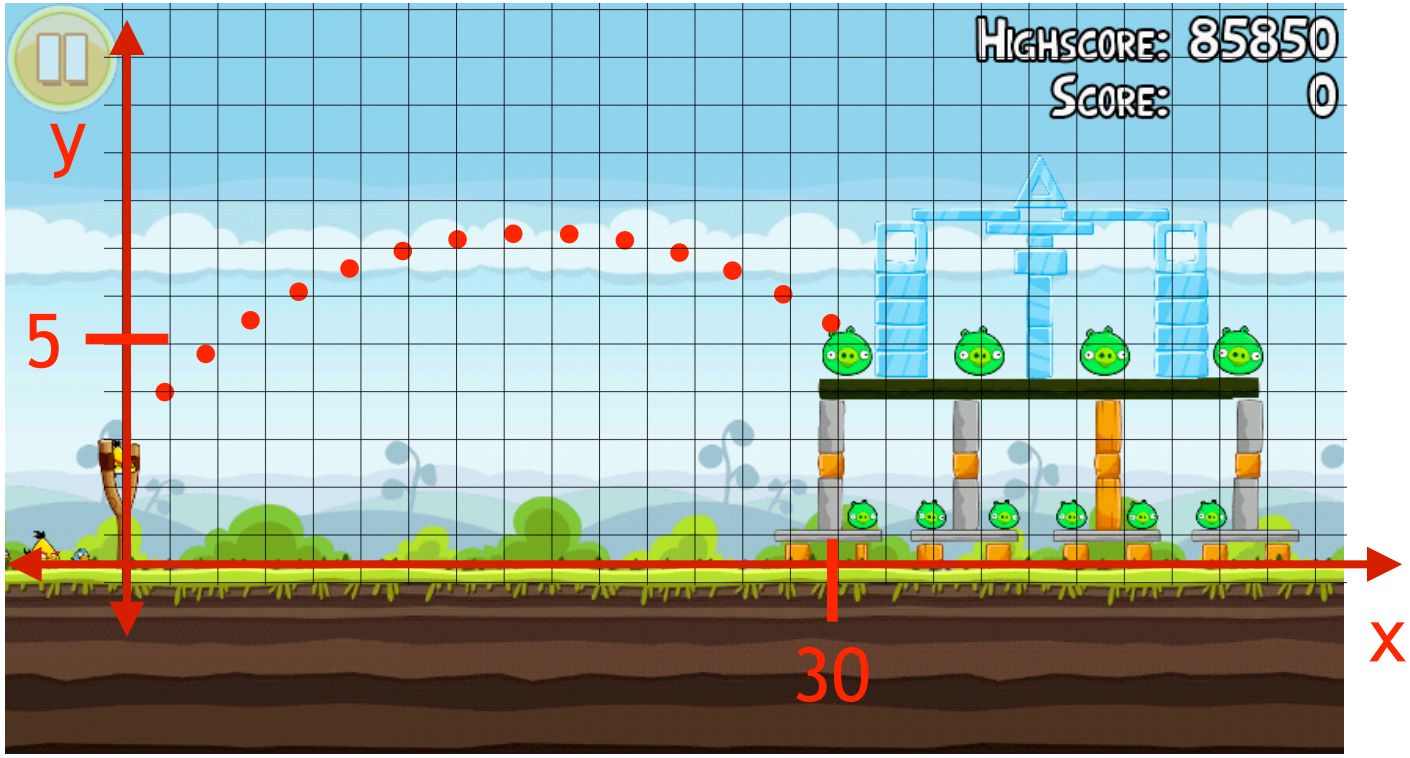
$y(t) = v_y t - 4.9t^2$

Trig Relationships

$v_x = V \cos(\theta)$

$v_y = V \sin(\theta)$

Projectile Equations



Did we get him?

For your bird with
V = 30 and θ = 17°
will you hit the pig located at x=30 and y = 5?

Position

$x(t) = v_x t$

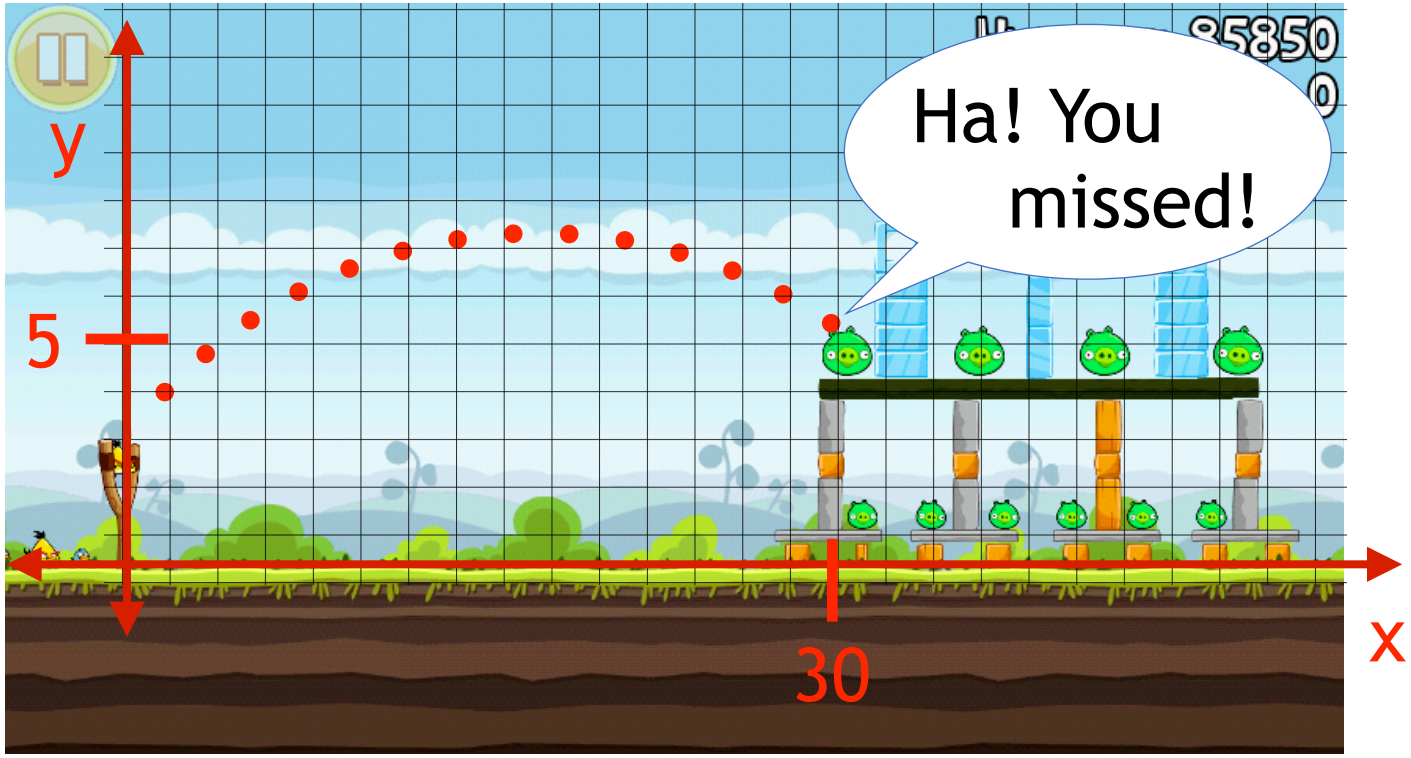
$y(t) = v_y t - 4.9t^2$

Trig Relationships

$v_x = V \cos(\theta)$

$v_y = V \sin(\theta)$

Projectile Equations



Learning your shot was too low, you raise the angle.

You fire another bird with V = 30 and θ = 20°
will you hit the pig located at x=30 and y = 5?

Position

$x(t) = v_x t$

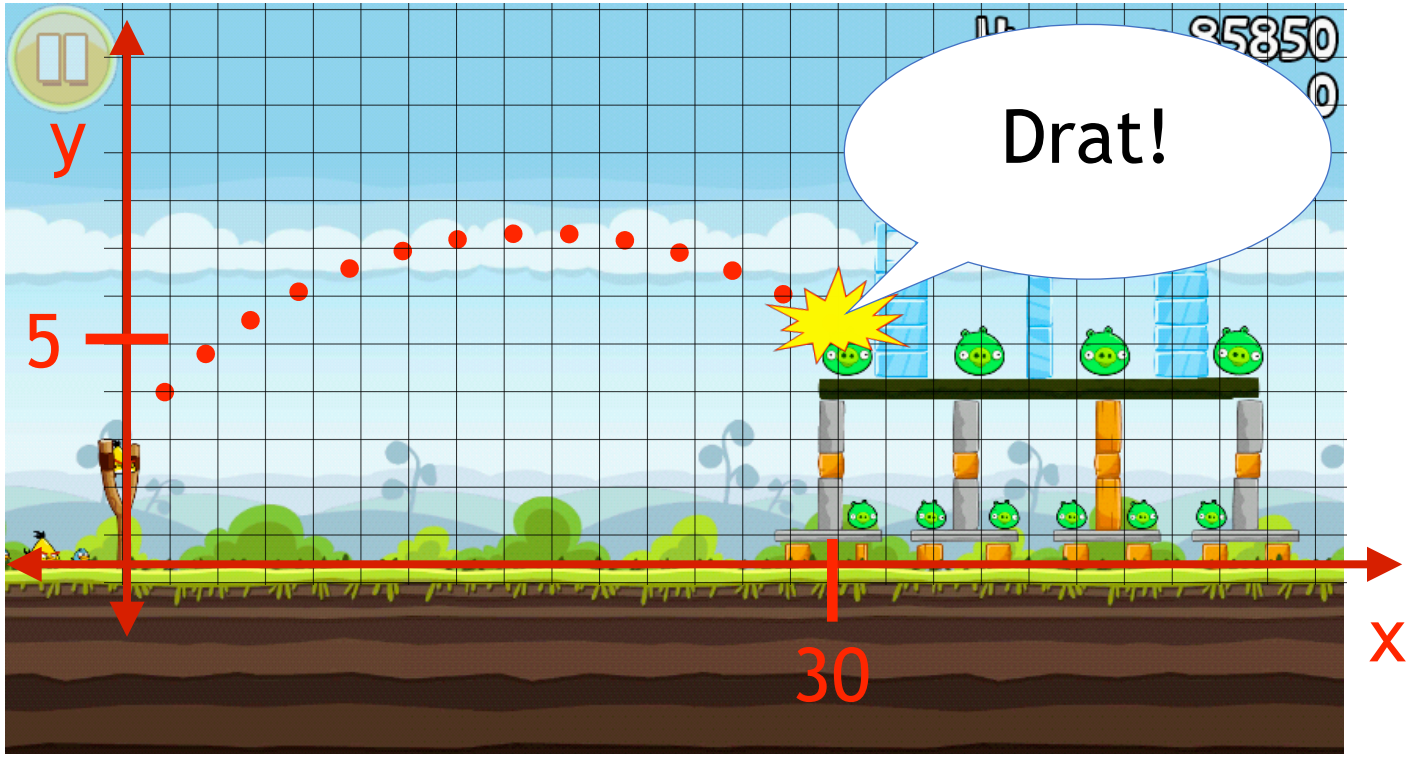
$y(t) = v_y t - 4.9t^2$

Trig Relationships

$v_x = V \cos(\theta)$

$v_y = V \sin(\theta)$

Projectile Equations



Success! Lets find out more about our amazing shot.

For your bird with
V = 30 and θ = 20°
what is the x,y velocity when impact happens?

Velocity

$x(t) = v_x$

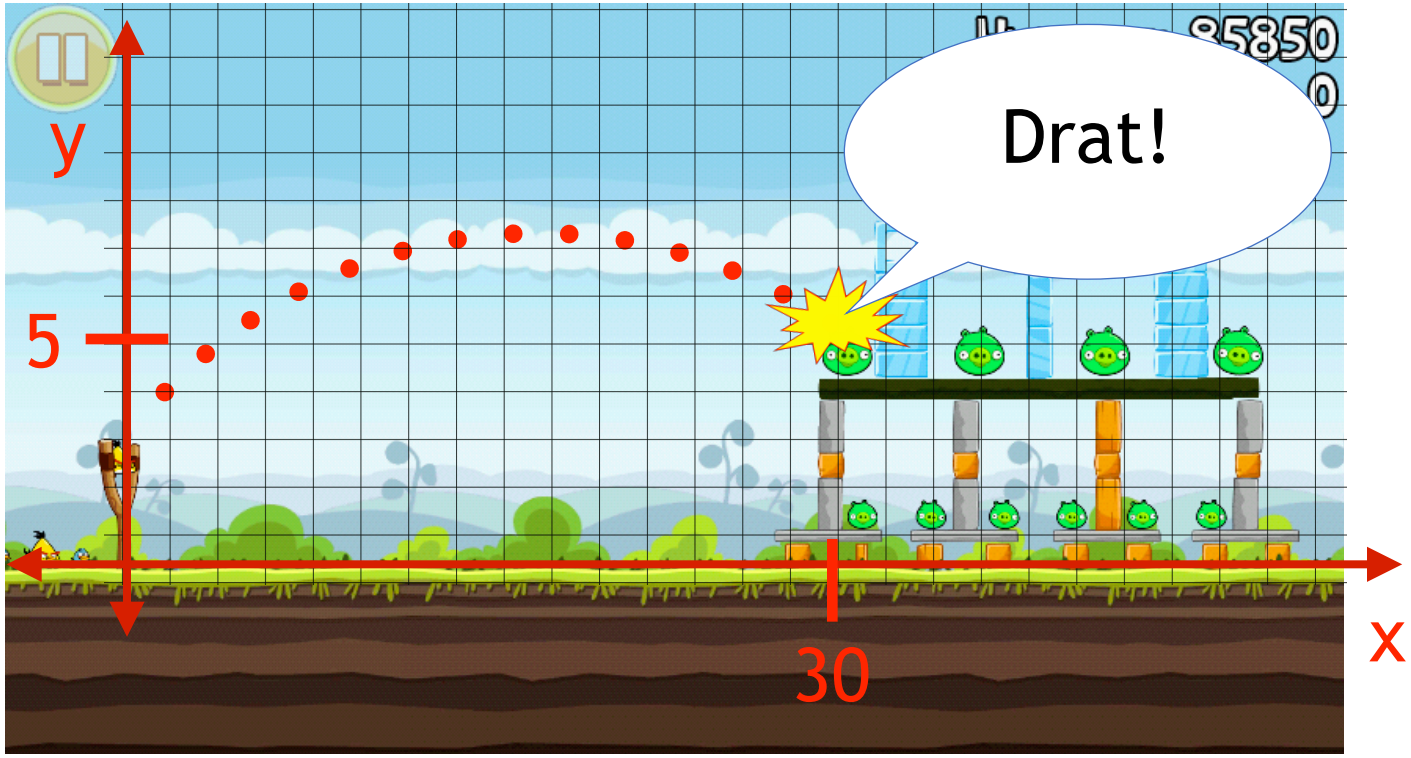
$y(t) = v_y - 9.8t$

Trig Relationships

$v_x = V \cos(\theta)$

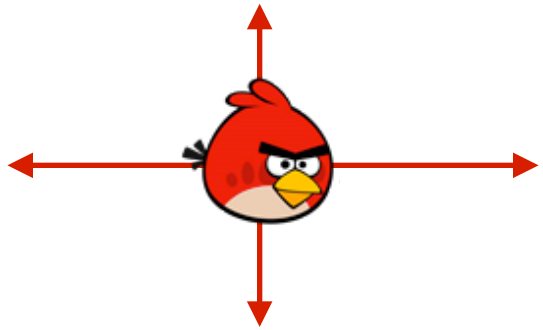
$v_y = V \sin(\theta)$

Projectile Equations



Lets find out even more about our amazing shot.

For your bird
V = 30 and θ = 20°
what is the velocity angle when x=30 and y = 15?



Velocity

$x(t) = v_x$

$y(t) = v_y - 9.8t$

Trig Relationships

$v_x = V \cos(\theta)$

$v_y = V \sin(\theta)$

Follow-Up Questions

$v_x = V \cos(\theta)$
$v_y = V \sin(\theta)$

Position

$x(t) = v_x t$
$y(t) = v_y t - 4.9t^2$

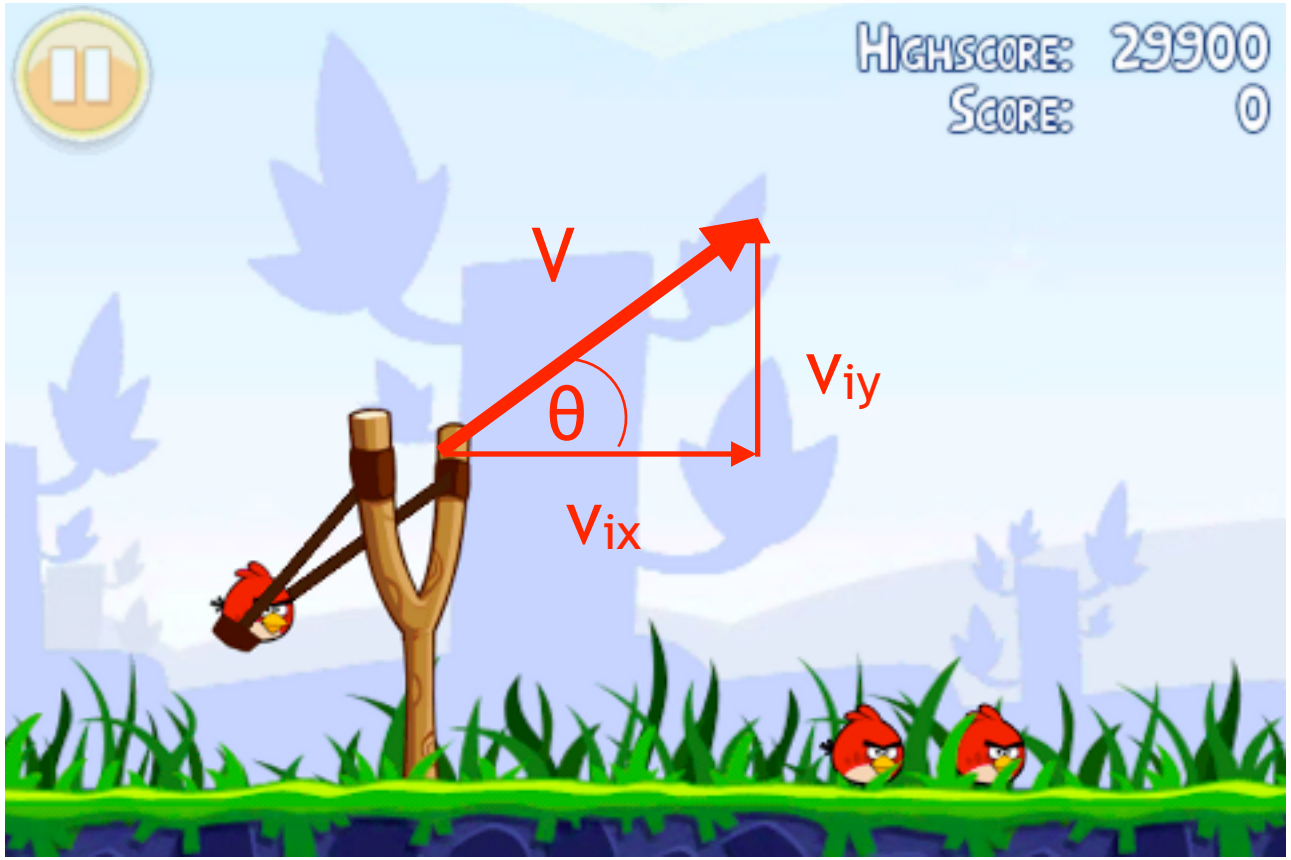
Velocity

$x'(t) = v_x$
$y'(t) = v_y - 9.8t$

Our position is not on the ground, but a little bit above. So $y(0) \neq 0$.

How do we change the equations?

Follow-Up Questions



$v_x = V \cos(\theta)$
$v_y = V \sin(\theta)$

Position

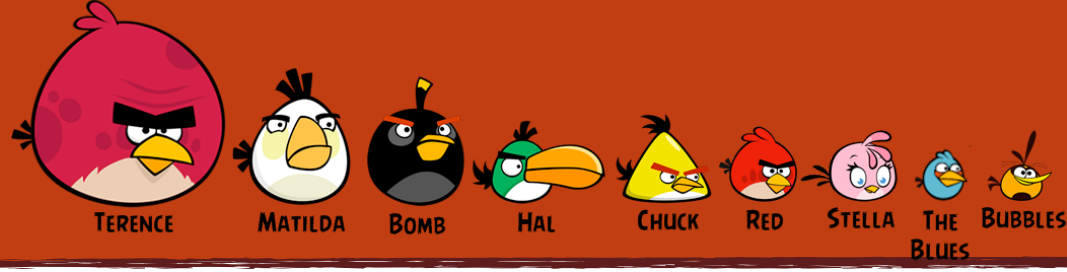
$x(t) = v_x t$
$y(t) = v_y t - 4.9t^2$

Velocity

$x'(t) = v_x$
$y'(t) = v_y - 9.8t$

What about heavy birds?
How are those accounted for?

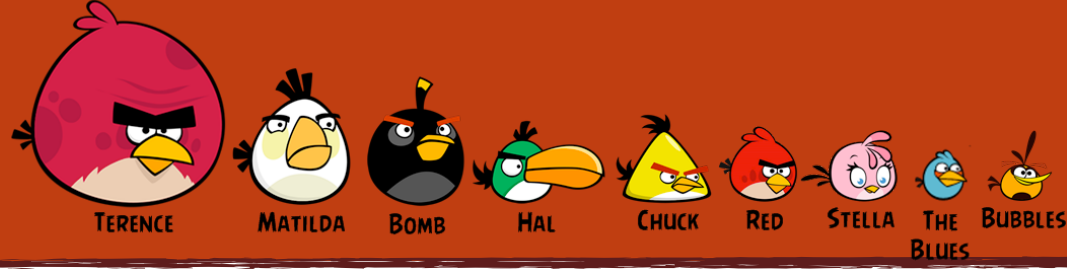
Summary



We Learned

- Why trigonometry is important for angry birds!
- A velocity arrow can be split into x and y components
- How the trajectories of the birds are mathematically modeled
- How to predict if a bird will hit a pig based on 2 things: V and θ

Summary


Terence
Matilda
Bomb
Hal
Chuck
Red
Stella
The Blues
Bubbles

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https://www.surveymonkey.com/s/gtexploration

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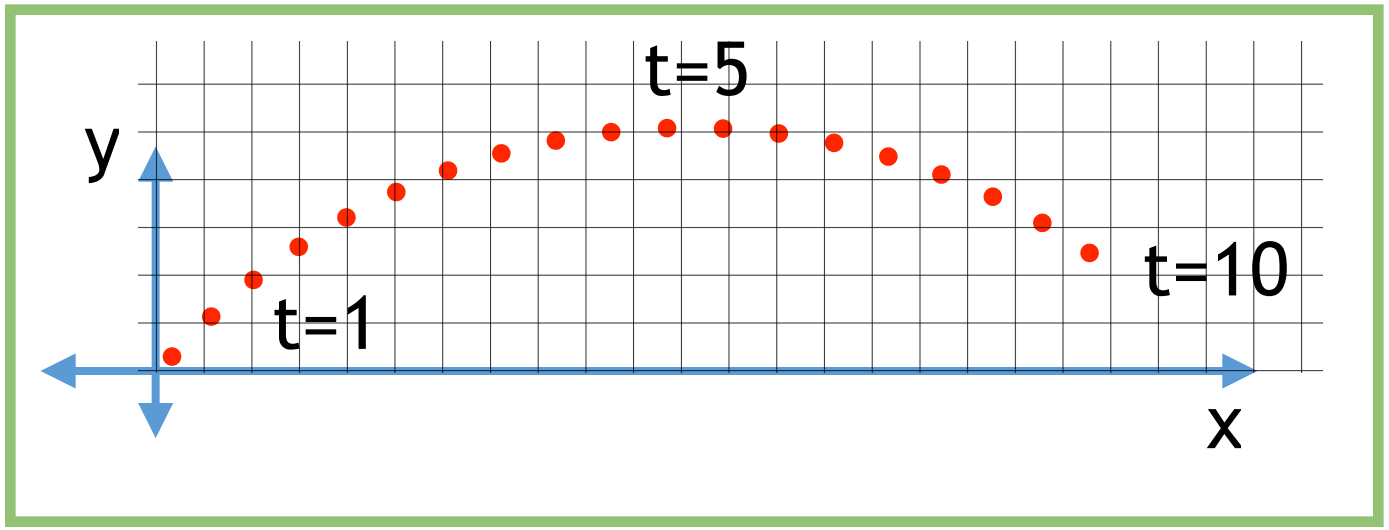
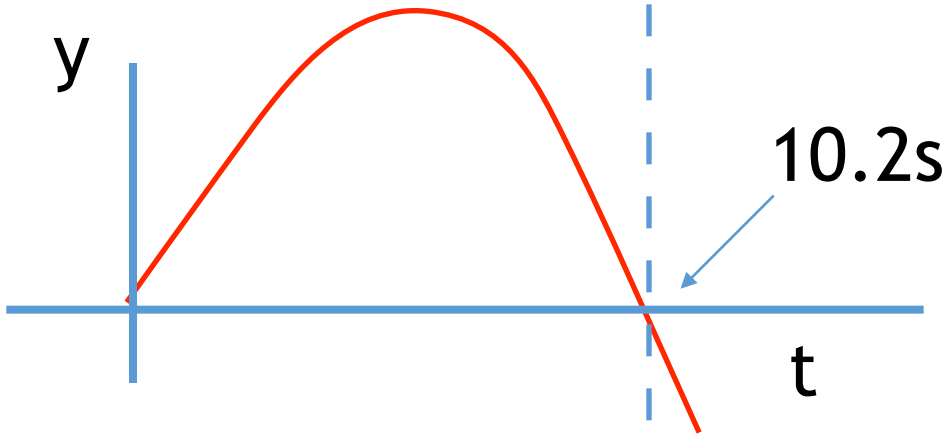
Projectile Equations (Physics)

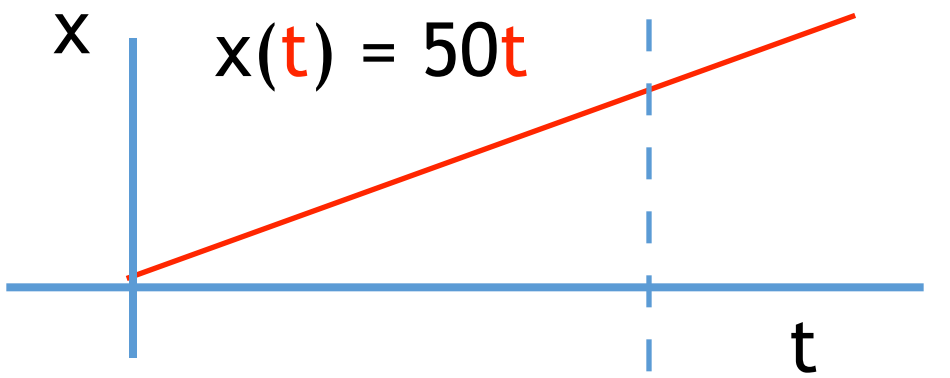
Example

$v_{ix} = 50$ m/s
$v_{iy} = 50$ m/s



$y(t) = 50t - 4.9t^2$





Equations are only valid while projectile is in the air ($y \geqq 0$).