Two-Dimensional Motion

By the end of this unit, you will be able to:

Explain why a 2D kinematics problem can be modeled as two 1D kinematics problem

Solve a 2D kinematics problem

Solve a projectile problem when the object is launched with an initial velocity at an angle above the ground

Solve a projectile problem when the object is launched with a horizontal initial velocity

- Two-Dimensional Motion
  - Two-dimensional motion is motion in two directions
    - Typically along the x and y directions
  - Kinematics equations apply to 2D motion as well as linear motion
    - As long as the acceleration is constant
      - If you remember, that is a requirement to use kinematics
  - When an object is moving, the motion along any axis is independent of all other axes.
    - The x and y axis are independent of each other
    - If they are independent then they do not affect/influence/impact the other direction
      - Say I have an object moving in the x and y directions
      - If I suddenly stop all motion in the y direction, the object will continue to move in the x direction since the y direction does not affect the x direction

- Knowing this, all 2D motion problems can be simplified to two linear motion problems
- Essentially, this is all there is to know about two-dimensional motion

- Projectile Motion
  - Projectile motion is the curved motion of an object that is given an initial velocity and then moves as though in free fall
    - What is true about an object in free fall?
  - Every projectile has a trajectory
    - The trajectory is just the curved path followed by a projectile
    - The shape of this path will always be a parabola
  - Projectile motion is a specific type of 2D motion
    - The projectile is moving in the x and y directions
    - So, like all 2D motion, the two dimensions are independent of each other
    - Meaning that I can solve a projectile problem be looking at two linear motion problems

– Acceleration
  - Since the object is in free fall, the only thing acting on the object is gravity
  - Gravity only acts in the y-direction
    - The acceleration in the y-direction is 9.8 m/s^2
    - I will use the symbol a_y to reference the acceleration in the y-direction
  - There is no acceleration in the x-direction
    - So, $a_x = 0$
    - What does this mean about the velocity in the x-direction?

$$a_x = 0$$

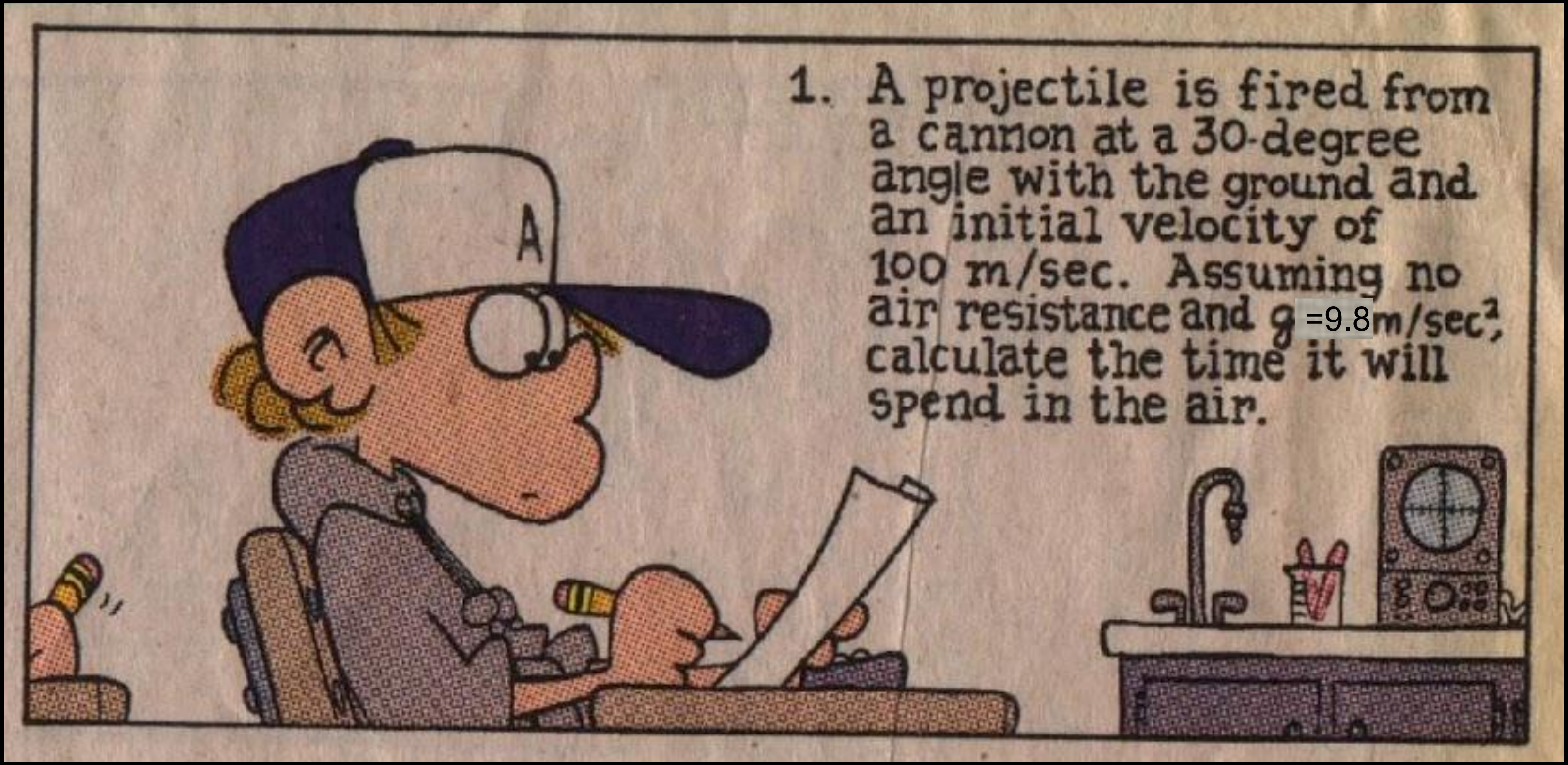
$$a_y = g = 9.8 m / s^2$$

- Initial Velocity
  - Projectile starts with an initial velocity that can be broken up into components.
    - v_{ox} and v_{oy} are the components of the given initial velocity v_o
- Vertical Velocity at the Top of the Trajectory
  - The speed in the y-direction at the top of the trajectory is always equal to zero
  - Why is this the case?
  - Depending on the problem, this could be v_{oy} or v_y
    - You have to determine which from the problem
- Final Velocity in the X-Direction
  - Since there is no acceleration in the x-direction, the velocity in the x-direction is constant
    - No acceleration means no change in the velocity
    - This means that v_x is always equal to v_{ox}

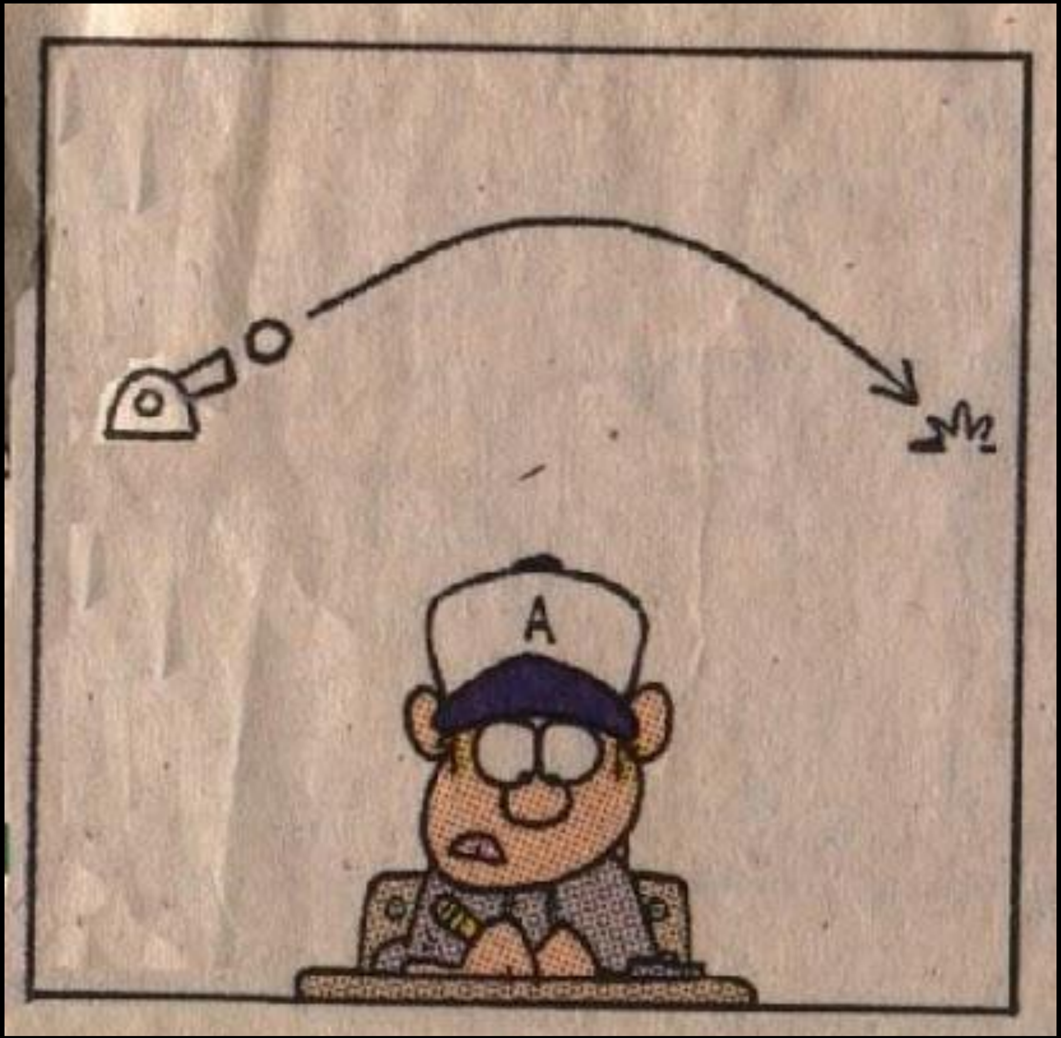
- Time
  - How long something is in the air (hang time) is only determined by the height of the object
  - Since the height is in the y-direction, only the y-direction determines the time
    - As we work projectile problems, finding time from the y-direction (if possible) is a great place to start
  - Time is also the only quantity that links the x and y-directions together
    - Because of this, finding time is a wise thing to do first
- Range
  - The range is how far the projectile will travel in the x-direction

FoxTrot
BILL AMEND

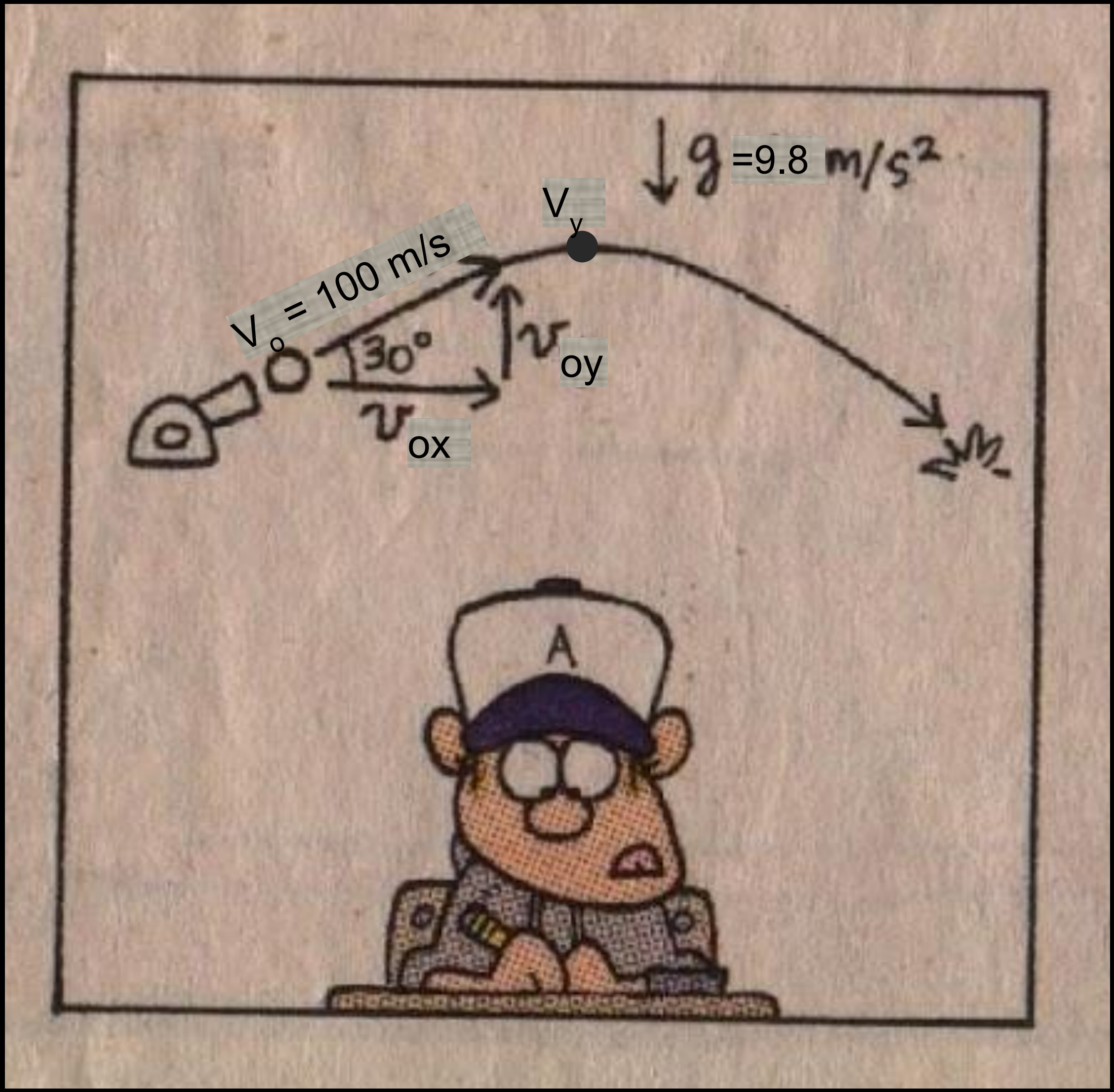

Date: Not as often as I'd like to, sadly.
A



Let’s use this problem as an example



He has a picture, which is great



He has some of his given information written down

Let's finish it off

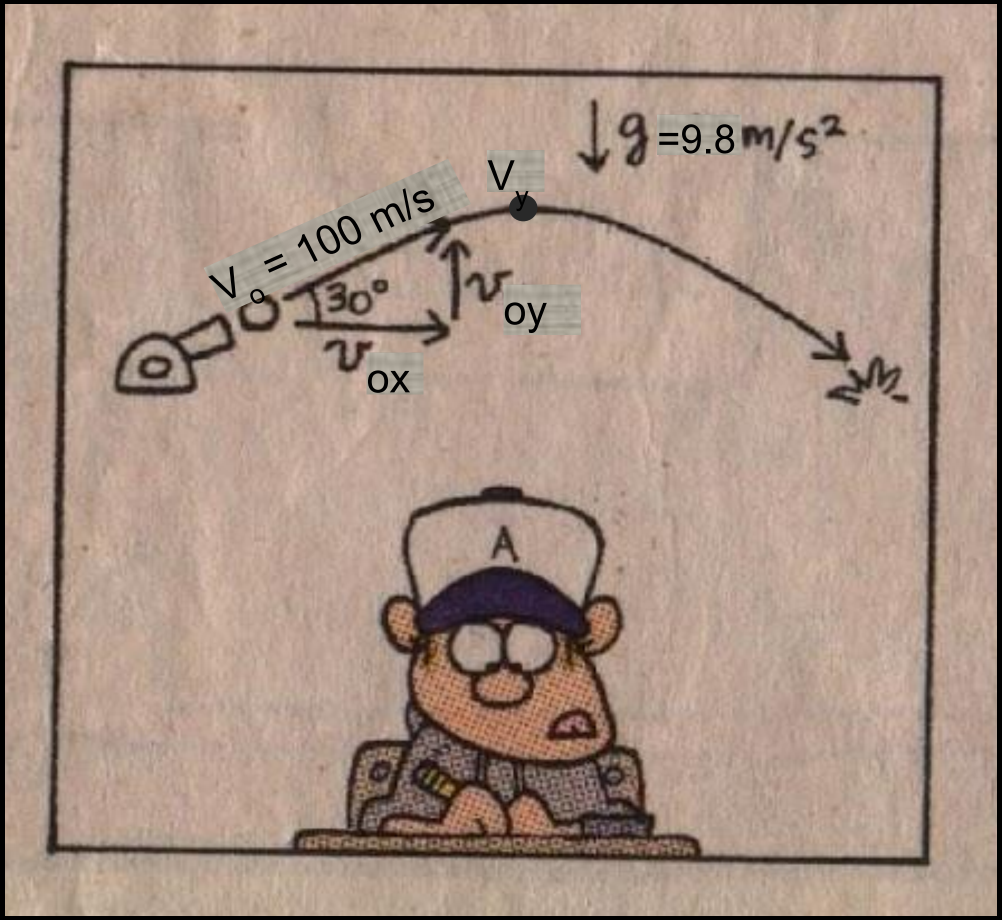
When writing out your given for a projectile problem, it is helpful to organize it like I have below

$x =$	$y =$
v_{ox} = Find	v_{oy} = Find
$v_x =$	$v_y = 0$ m/s
$a_x = 0\ m/s^2$	$a_y = -9.8\ m/s^2$

$t =$

$t_{total} = ?$

How do I go about finding the initial velocities?



Resolve the given initial velocity into components

$x =$

$y =$

v_{ox} = 86.6 m/s

v_{oy} = 50 m/s

$v_x =$

v_y = 0 m/s

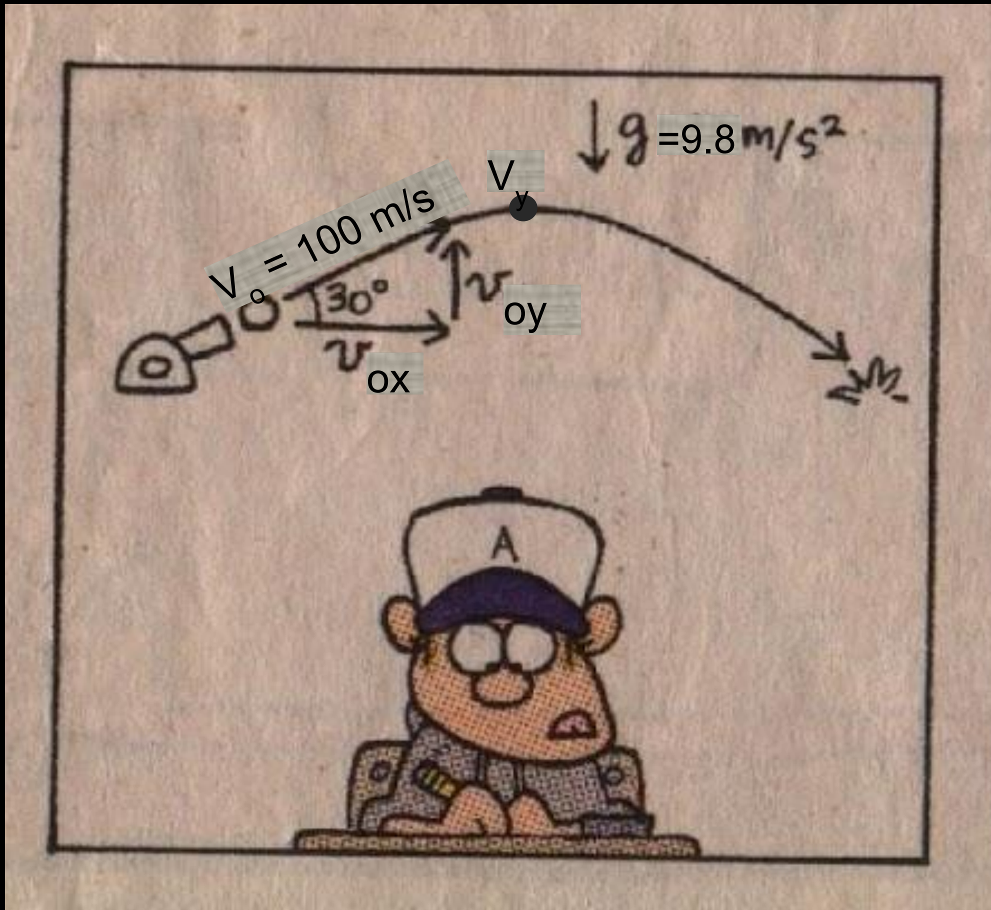
a_x = 0 m/s^2

a_y = -9.8 m/s^2

$t =$

t_{total} = ?

Which direction (x or y) do I have enough information to solve for t?



$x =$ | $y =$
$v_{ox} = 86.6$ m/s | $v_{oy} = 50$ m/s
$v_x =$ | $v_y = 0$ m/s
$a_x = 0$ m/s^2 | $a_y = -9.8$ m/s^2

$t =$

$t_{total} = ?$

Using the y-direction, I can solve for t

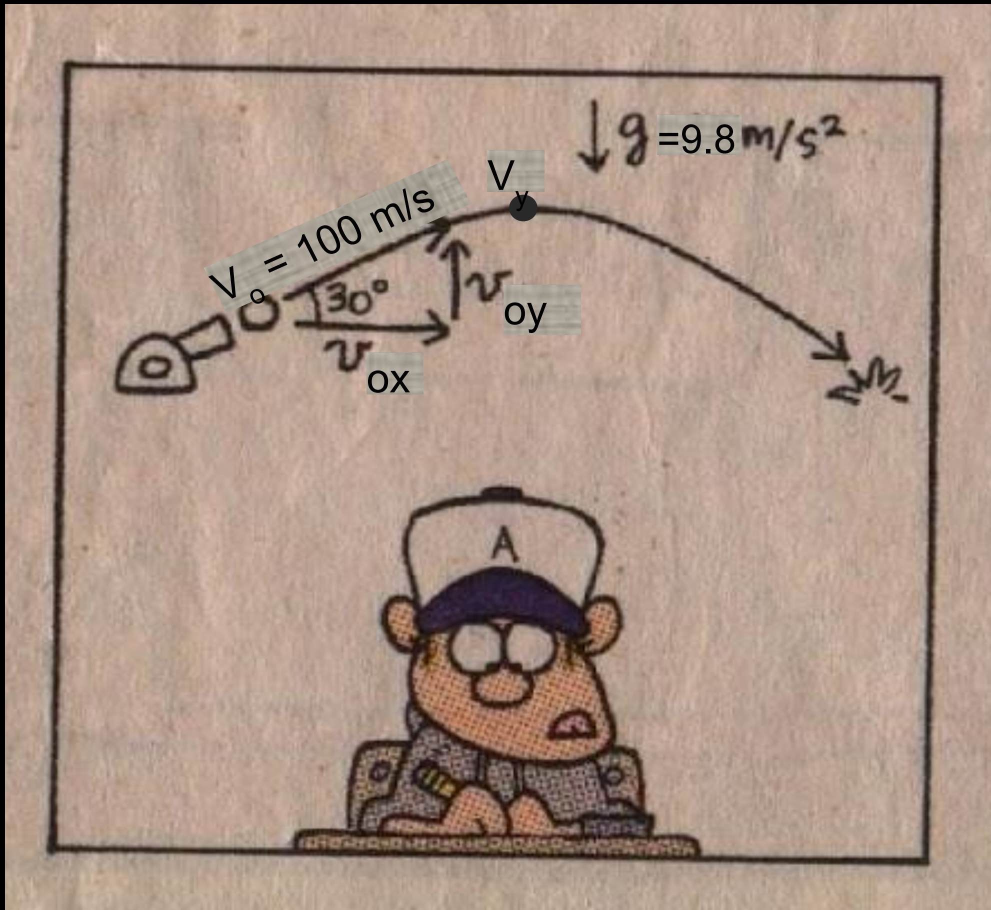
$$v = v_o + at$$

$$t = \frac{-v_o}{a}$$

$$t = \frac{-50}{-9.8}$$

$$t = 5.1s$$

Is this the total time in the air?



$x =$ $y =$

$v_{ox} = 86.6$ m/s $v_{oy} = 50$ m/s

$v_x =$ $v_y = 0$ m/s

$a_x = 0$ m/s^2 $a_y = -9.8$ m/s^2

$t = 5.1$ s

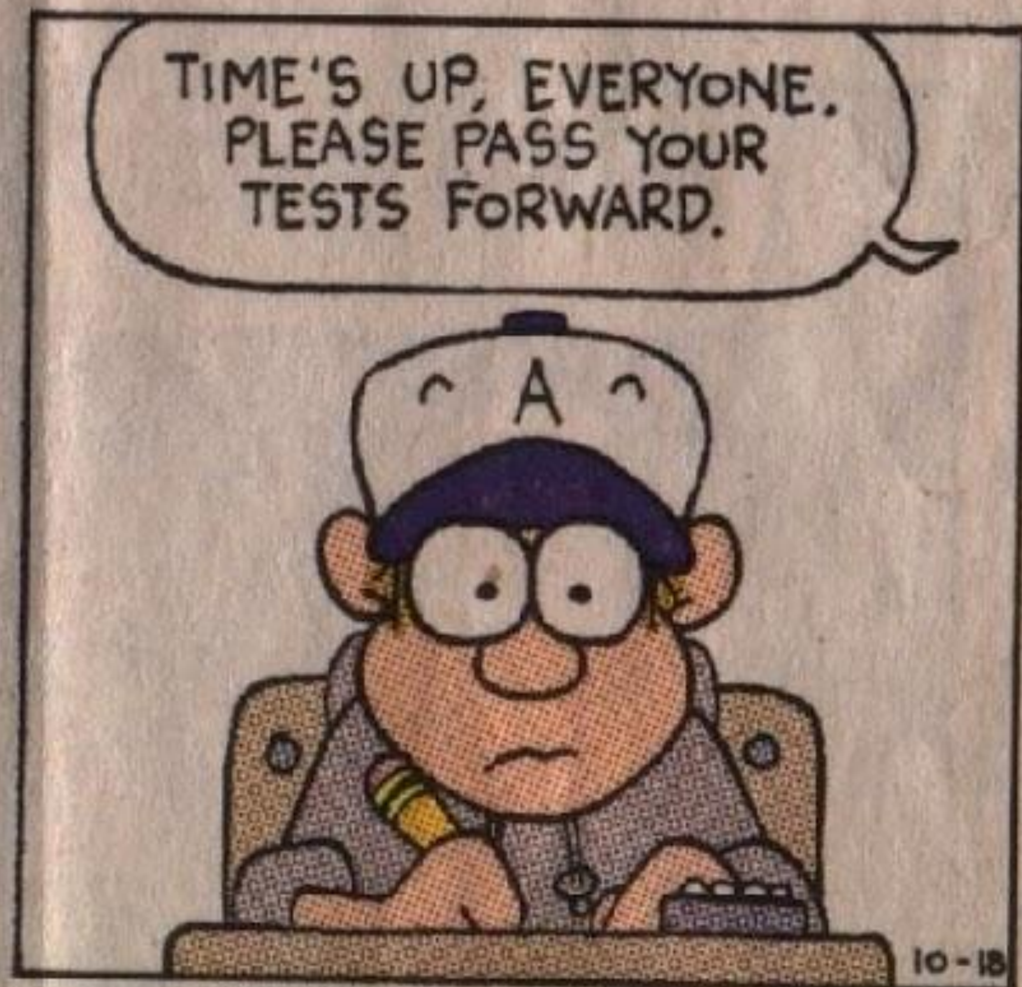
$t_{total} = ?$

To find the total time in the air I need to double the time to the top

$$t_{total} = 10.2s$$

Let’s see how Peter did…

Give me yar treasure! Arg! Arg!
$\downarrow g$ =9.8 m/s²
Never!
V_o = 100 m/s
30°
v_{oy}
V_y
v_{ox}
Ka-BOOM!..
A


TIME'S UP, EVERYONE. PLEASE PASS YOUR TESTS FORWARD.
10-18


DOODLERS SHOULD NOT TAKE PHYSICS.
SHOOTING FOR AN "A" FOR "APPALLING," ARE WE, MR. FOX?
AMEND
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