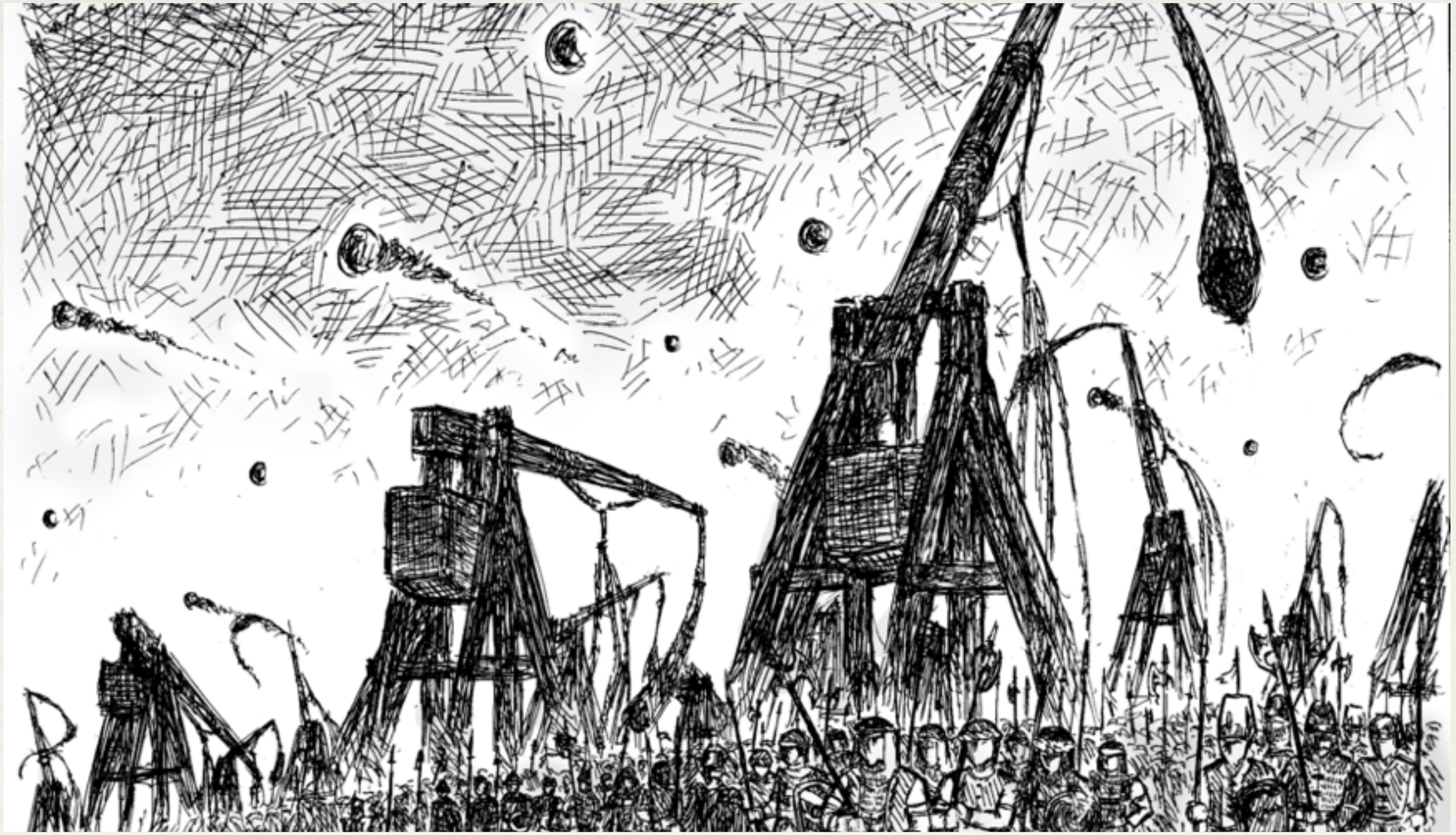


2D Kinematics

Honors Physics

Vectors

- Often helpful to draw out vectors when depicting physics situations

- Arrows show direction

- Length of the arrow represents relative magnitude

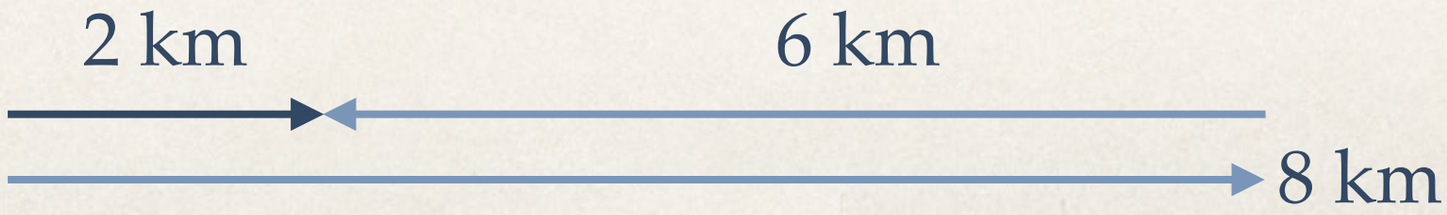
Adding Vectors

- In one dimension, adding vectors is a simple matter of adding or subtracting values

- Sven the Irresponsible walks 8 km east, realizes he left his kid at the ice cream stand, then walks 6 km west to retrieve her

  - The scalar distance traveled is 8 km + 6 km = 14 km

  - The *net* or *resultant* displacement accounts for the change in direction. 8 km - 6 km = 2 km east

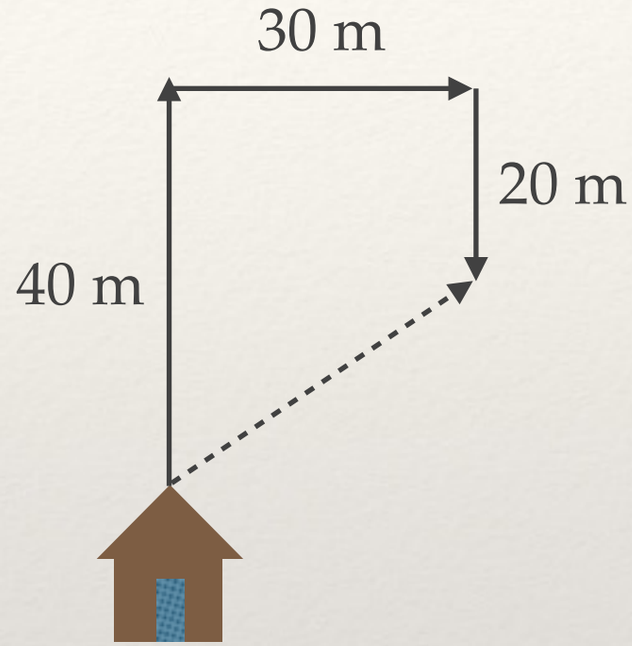


Adding Vectors

- However, simple arithmetic cannot be used if the two vectors are not along the same line

Distance vs. Displacement

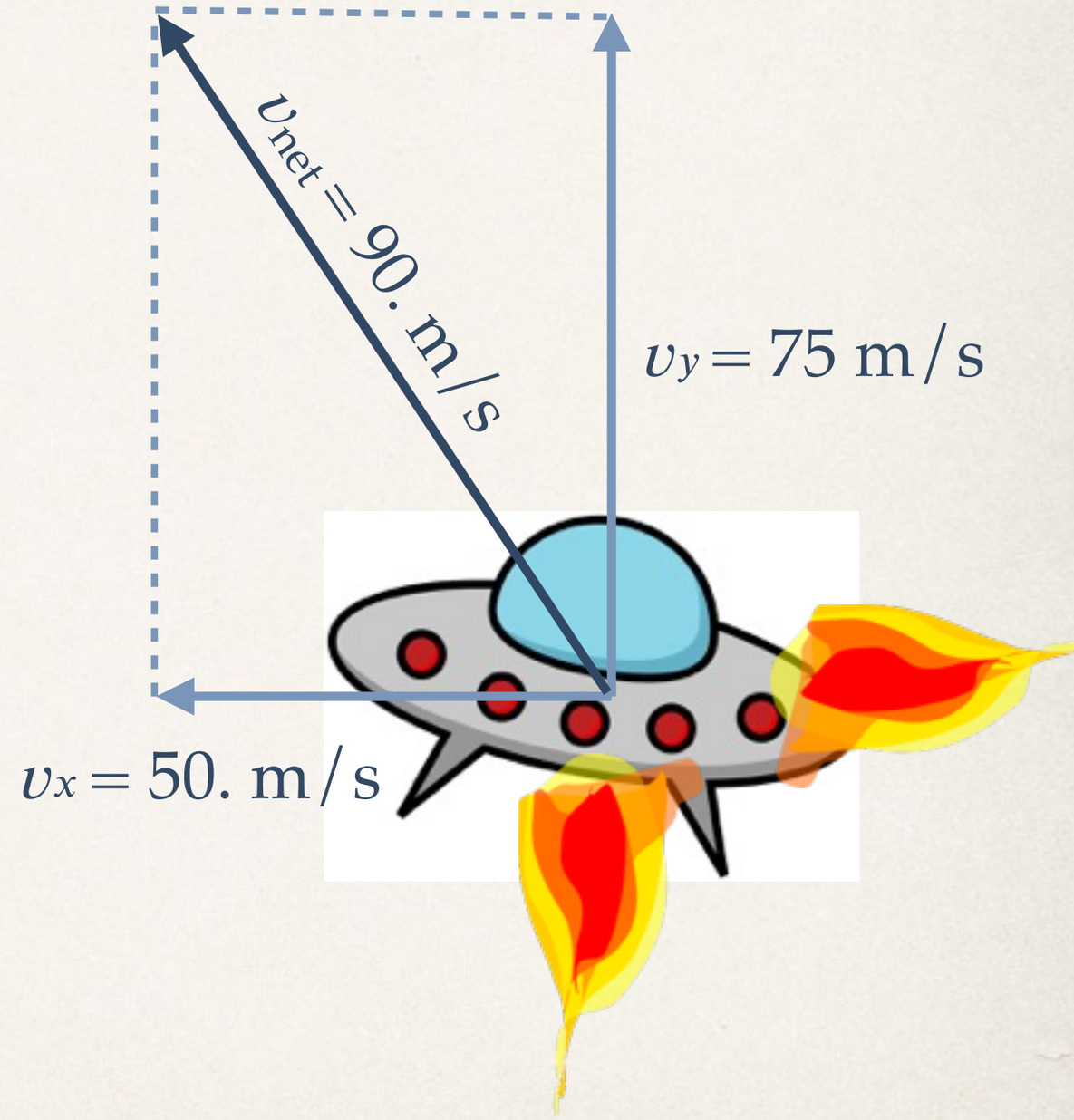
- Little Sally leaves her home, walks 40 m north, 30 m east, and 20 m south
- How far is Sally from home?



- $\sqrt{(20^2 + 30^2)} = 36$ m
- In what direction?
- $\tan^{-1}(20/30) = 34^\circ$ North of East
- **36 m @ 34° N of E**
- This is Sally's *displacement*

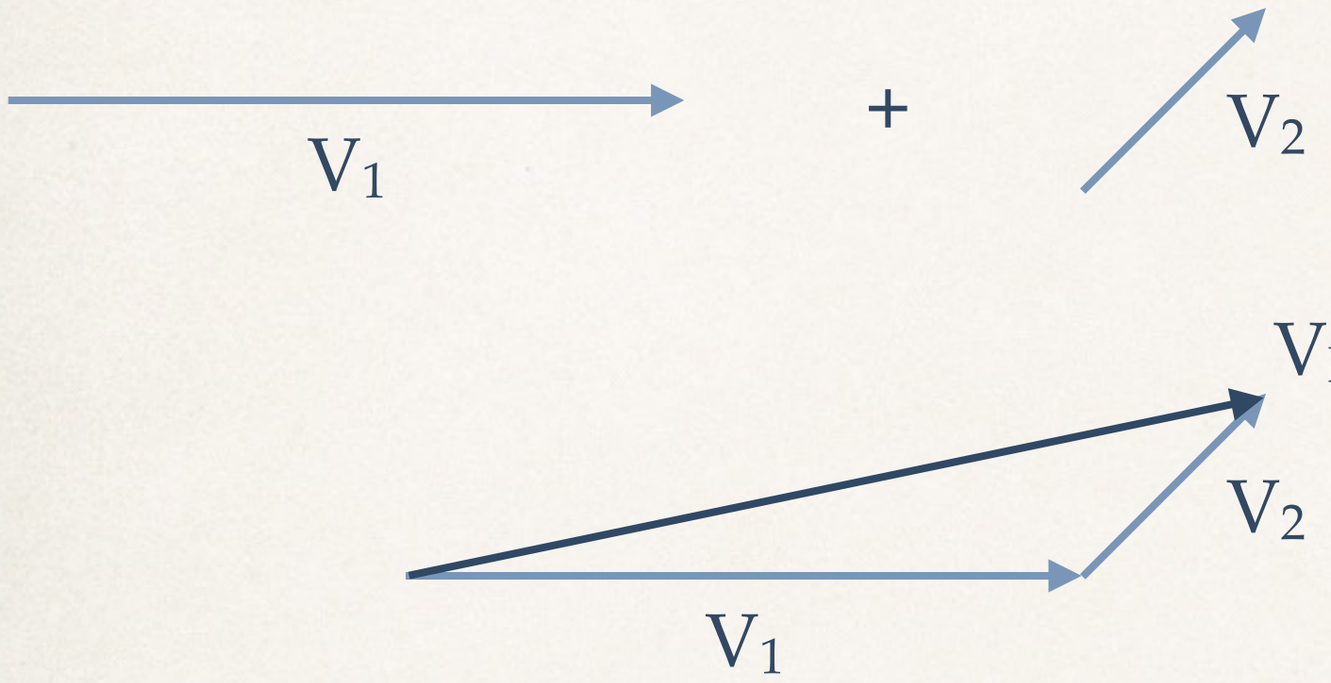
Adding Vectors

- The same idea applies to all vectors
- An alien spaceship cranks on two trusters, one launching it to the left at 50. m/s, the other propelling it up at 75 m/s.
- What is the *net* velocity of the spaceship?
- $v_{net} = \sqrt{(v_x^2 + v_y^2)}$



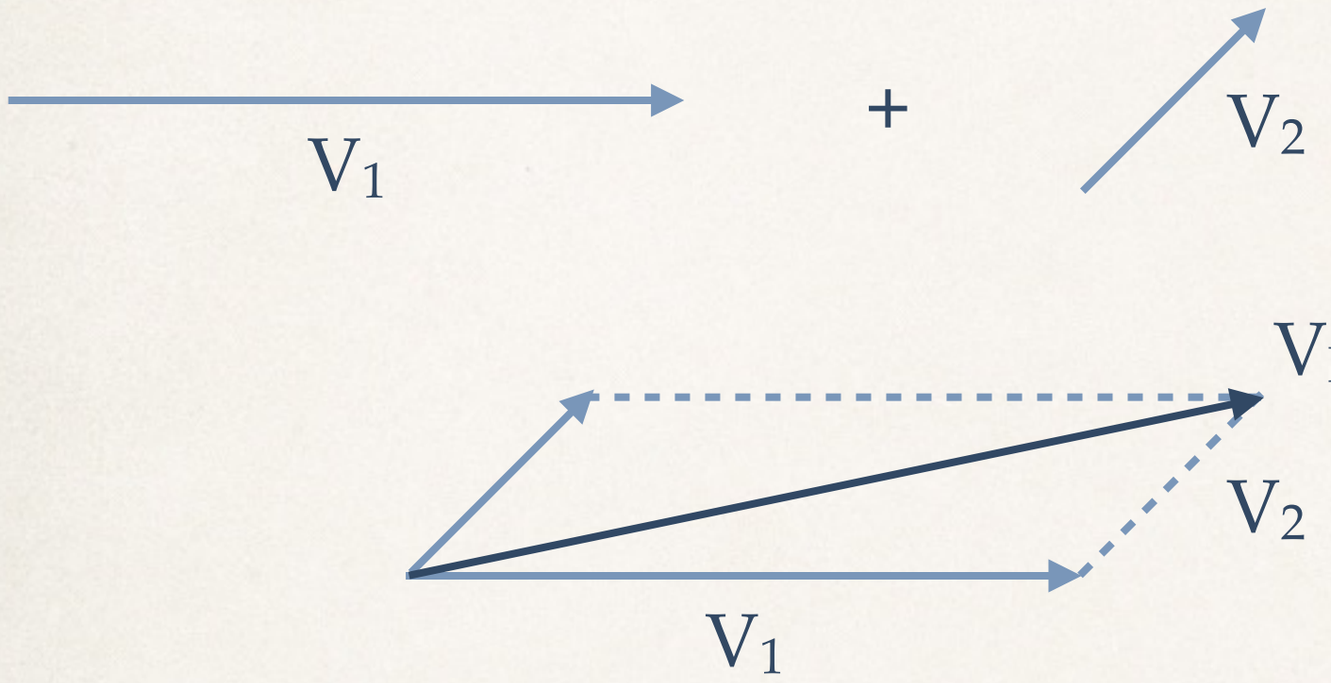
Methods of Adding Vectors

Methods of Adding Vectors



Tail-to-Tip Method

Methods of Adding Vectors

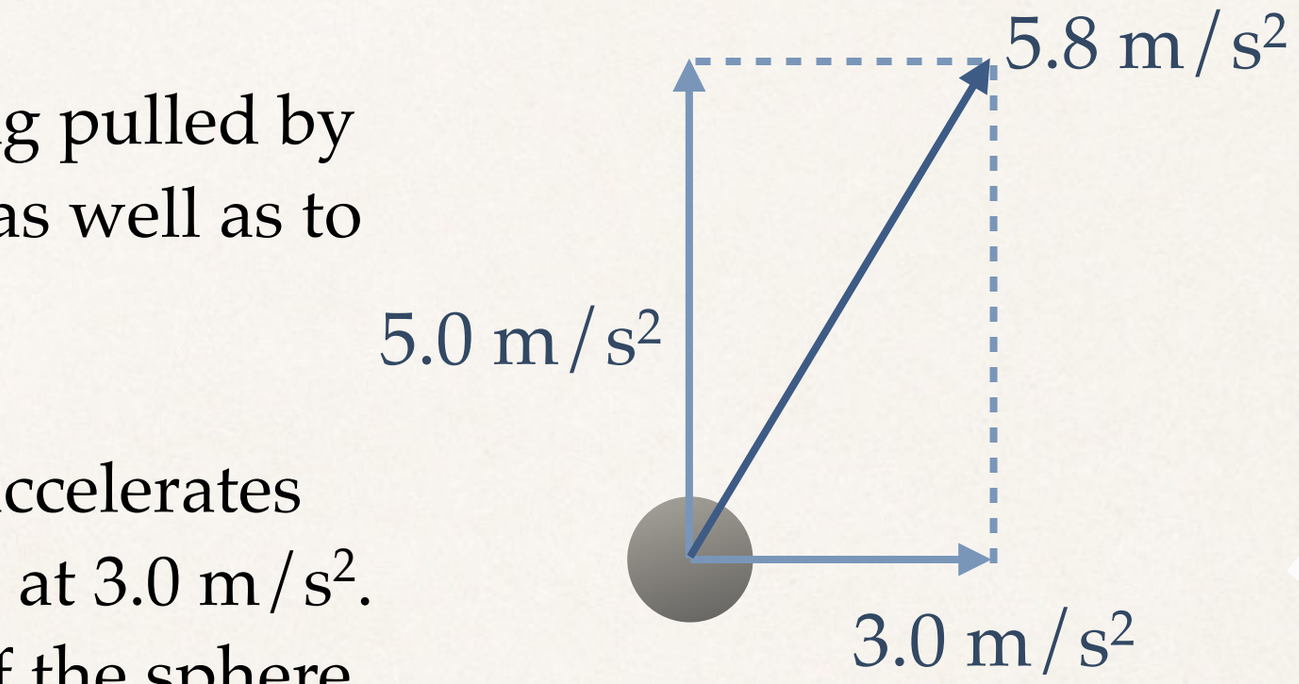


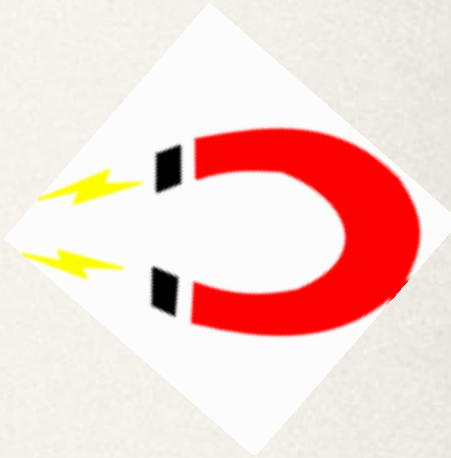
Parallelogram Method

Example 1

- A metal sphere is being pulled by magnets in front of it as well as to its right.

- The magnet on right accelerates the sphere to the right at 3.0 m/s^2. The magnet in front of the sphere accelerates it forward at 5.0 m/s^2



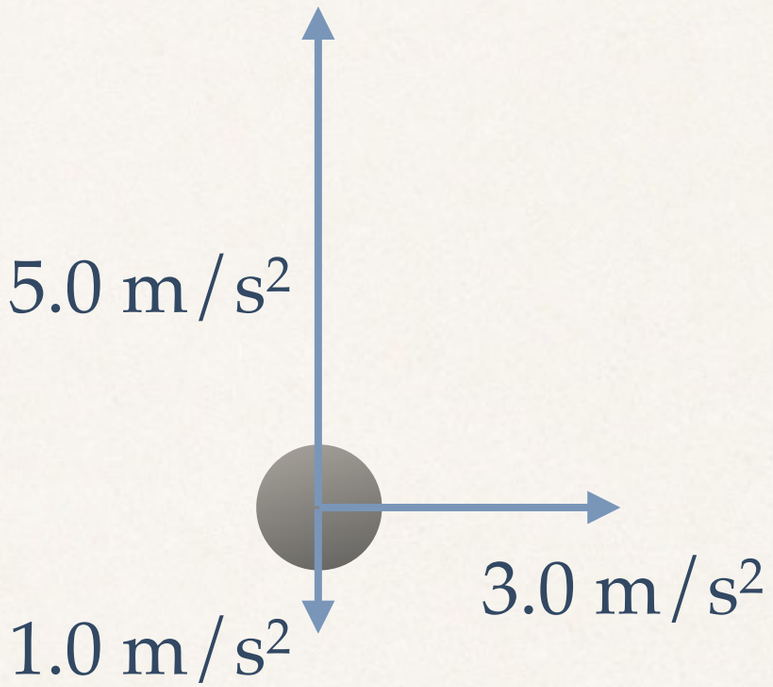


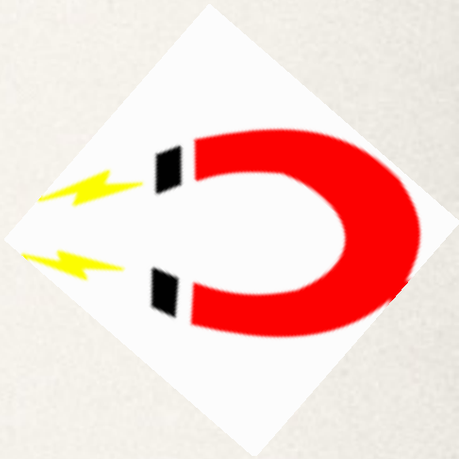
- What is the magnitude of the sphere's net acceleration?

- *Ans.* $a_{net} = 5.8\ m/s^2$

Example 2

- A third magnet is added behind the sphere, pulling it at a rate of 1.0 m/s²

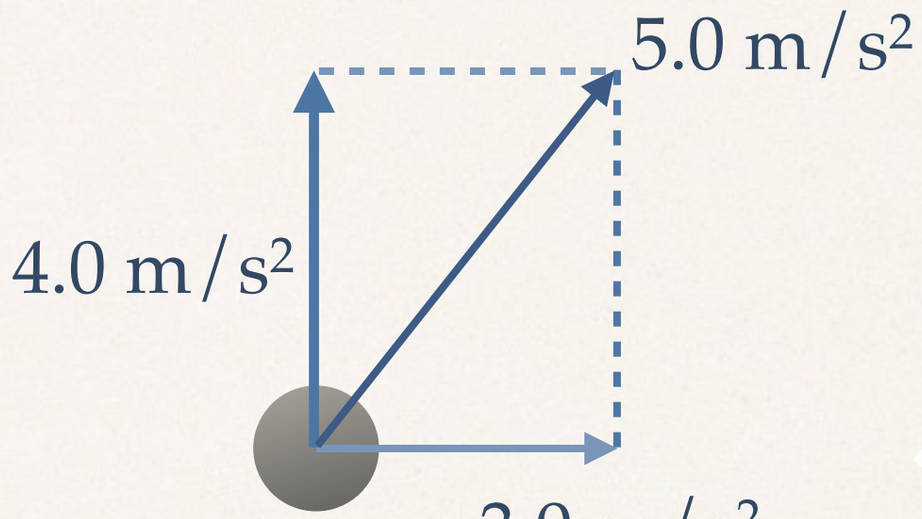




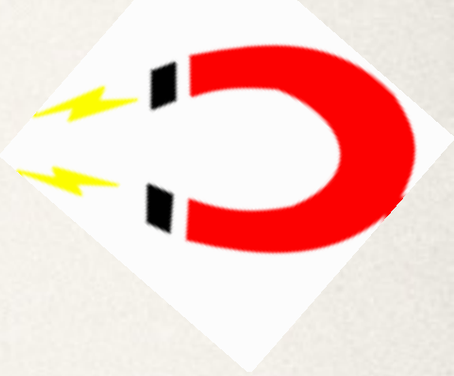
- What is the magnitude of the new net acceleration?

Example 2

- A third magnet is added behind the sphere, pulling it at a rate of 1.0 m/s²



- What is the magnitude of the new net acceleration?

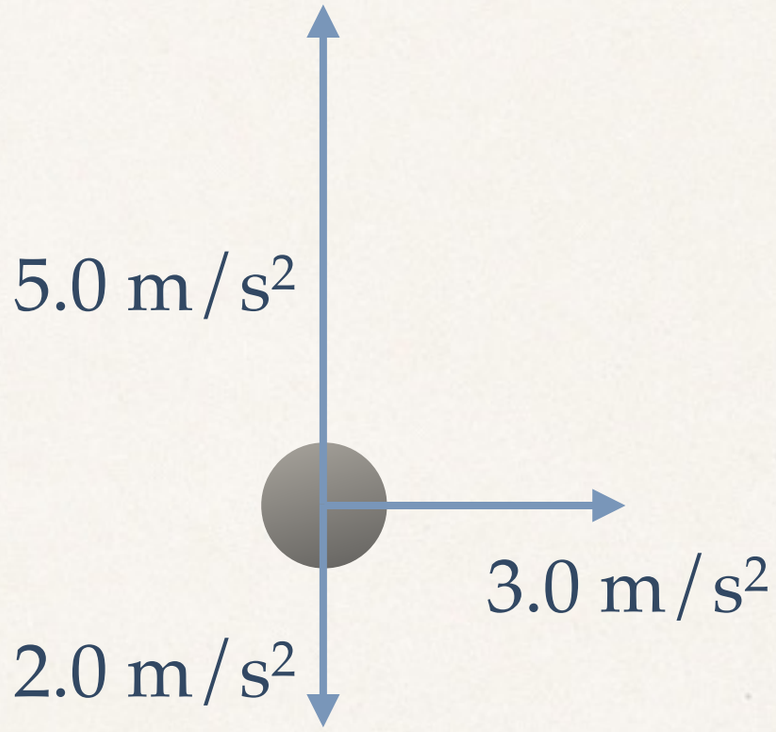


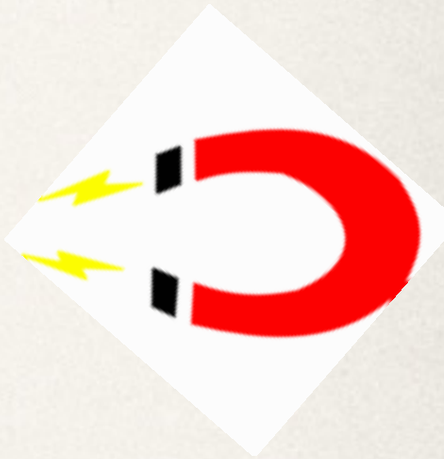
- $a_y = 5.0\ m/s^2 - 1.0\ m/s^2$
- $a_y = 4.0\ m/s^2$
- *Ans.* $a_{net} = 5.0\ m/s^2$

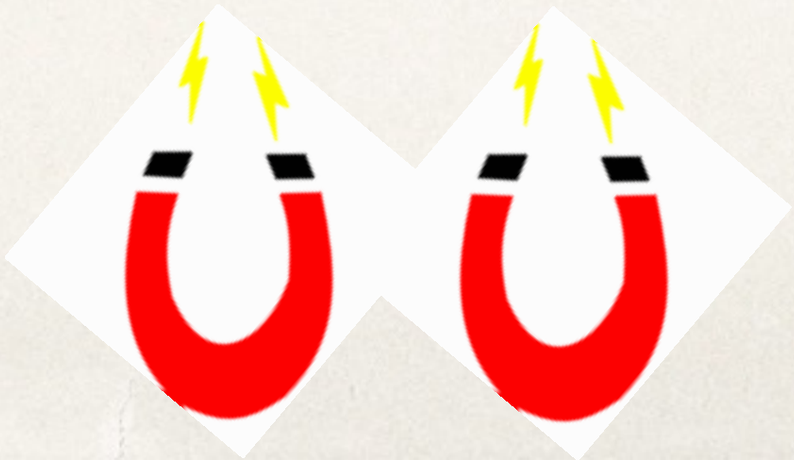
Example 3

- The magnet behind the metal sphere is doubled, doubling the rate acceleration in that direction.

- Now what is the magnitude of the net acceleration?







Example 3

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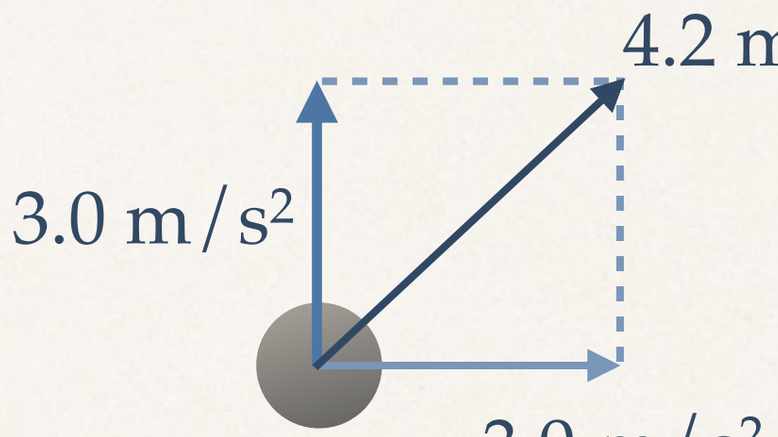
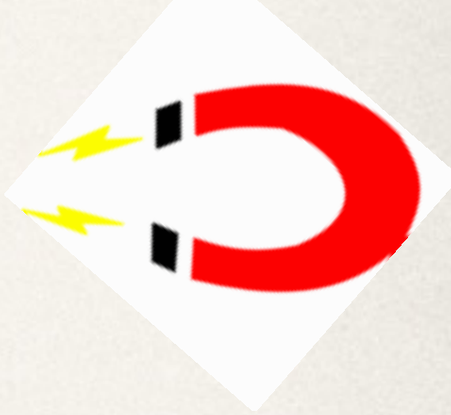
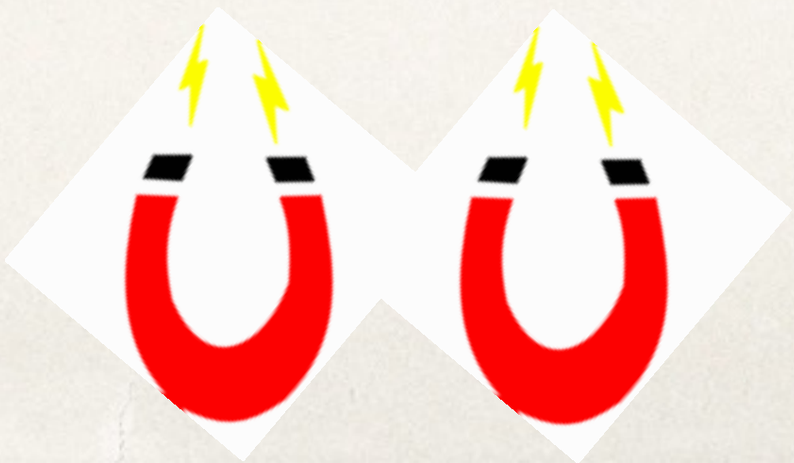


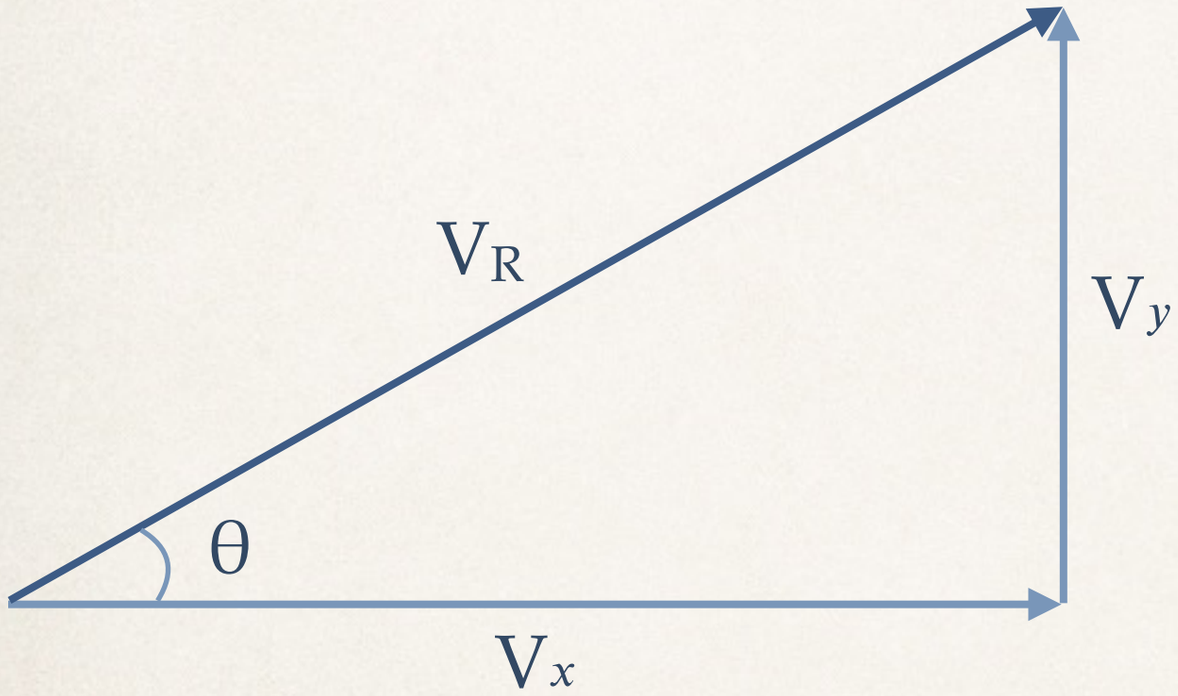


- Now what is the magnitude of the net acceleration?

- *Ans.* $a_{net} = 4.2\ m/s^2$

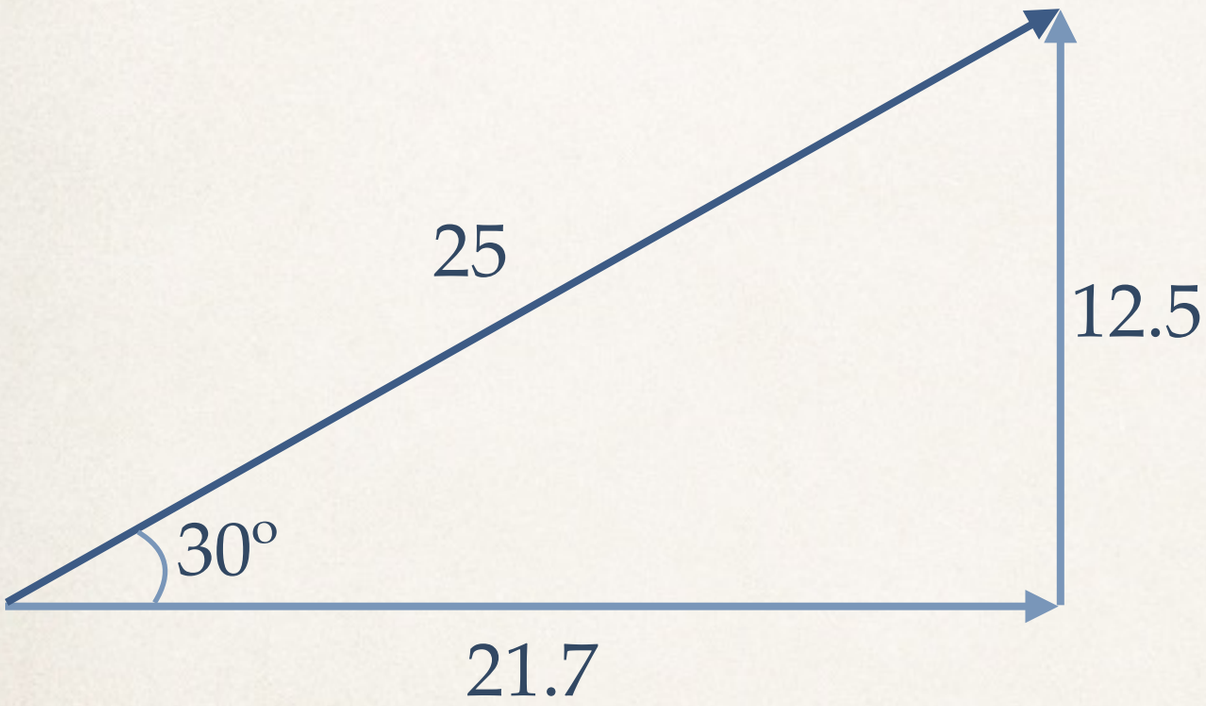


Angle of the Resultant Vector



- What is the direction of the resultant vector?
- SOH CAH TOA
- $\sin\theta = \text{opposite}/\text{hypotenuse}$
- $\sin\theta = V_y/V_R$
- $\cos\theta = V_x/V_R$
- $\tan\theta = V_y/V_x$

Angle of the Resultant Vector



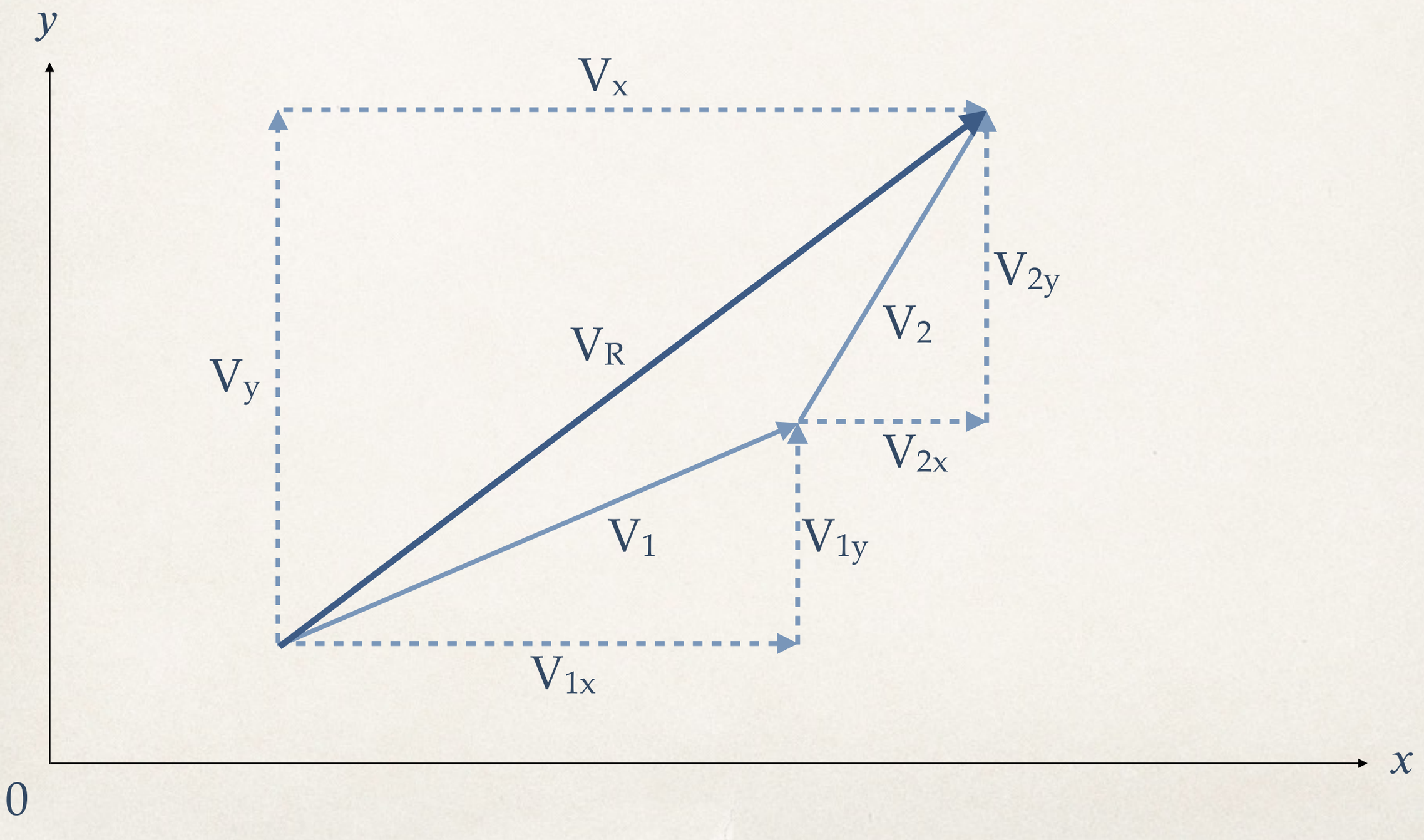
- Can you break the resultant vector back into its x and y components?
- $V_x = V_R \cos\theta$
- $V_x = 25 \cos 30^o = 21.7$
- $V_y = 25 \sin 30^o = 12.5$
- MAKE SURE YOUR CALCULATOR IS IN DEGREE MODE

Vector Components

- Two ways to specify a vector in a given coordinate system:

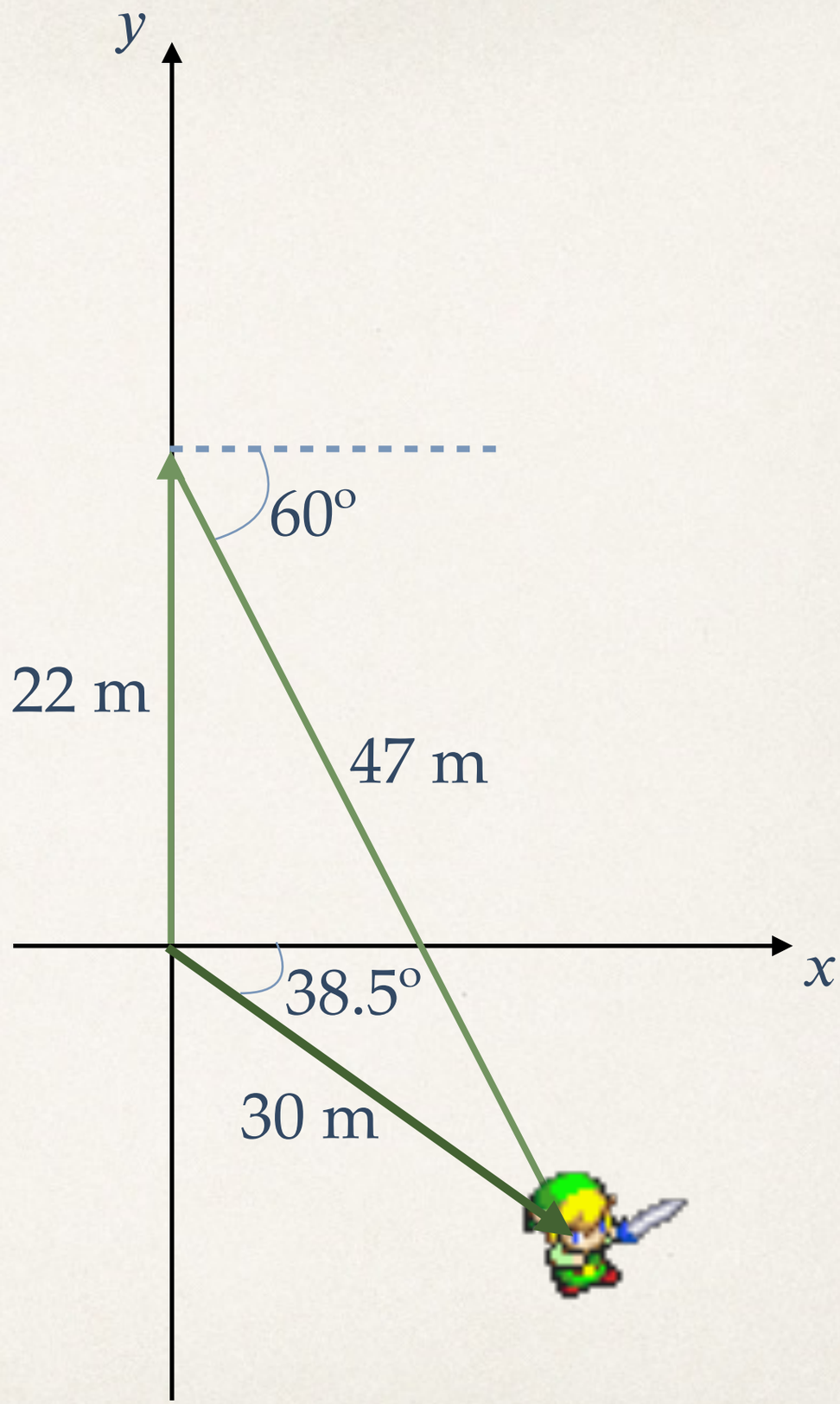
1. Give its x and y components
   - $\mathbf{V} = 21.7\,\hat{x} + 12.5\,\hat{y}$
2. Give its magnitude V and the angle θ it makes with the positive x-axis
   - $\mathbf{V} = 25 \text{ @ } 30^\circ$

Vector Decomposition and Resolution



Example 4

- Link goes out to Hyrule Field to do some treasure hunting.
- Link walks 22.0 m north and plucks a hidden rupee.
- He then runs at a direction 60° south of east for 47.0 m to snag another rupee.
- What is Link's displacement from his starting point?
- *Ans. D = 30.0 m @ -38.5°*



Rules for Resolving Vectors

1. Decompose all vectors into x and y components

2. Add the x components together to get the x component of the resultant. Ditto for y

   - $\sum V_x = V_{1x} + V_{2x} + \ldots$

   - $\sum V_y = V_{1y} + V_{2y} + \ldots$

3. If you want to know the magnitude and direction of the resultant vector:

   - $V = \sqrt{(V_x^2 + V_y^2)}$ $\qquad$ $\tan\theta = V_y / V_x$

- *Note: pay attention to signs! Any components that point along the negative x or y axis get a negative sign*

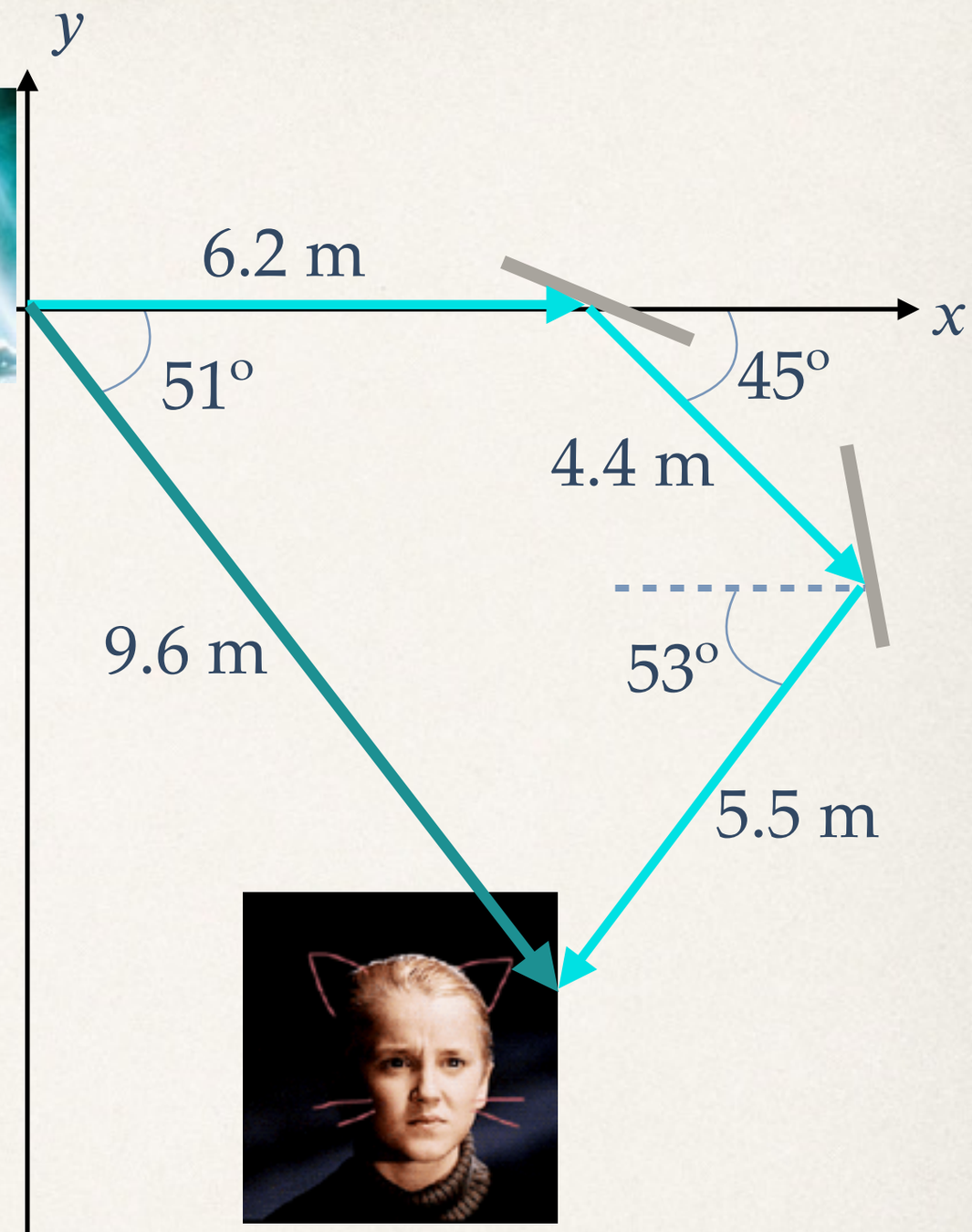
Example 5

- Hermione Granger, being the clever one, uses mirrors to bounce her spell around the room and hit Draco Malfoy in his dumb face.

- Her spell rockets due east for 6.2 m, bounces southeast (45°) for 4.4 m, and reflects off a second mirror at 53° south of east for 5.5 m.

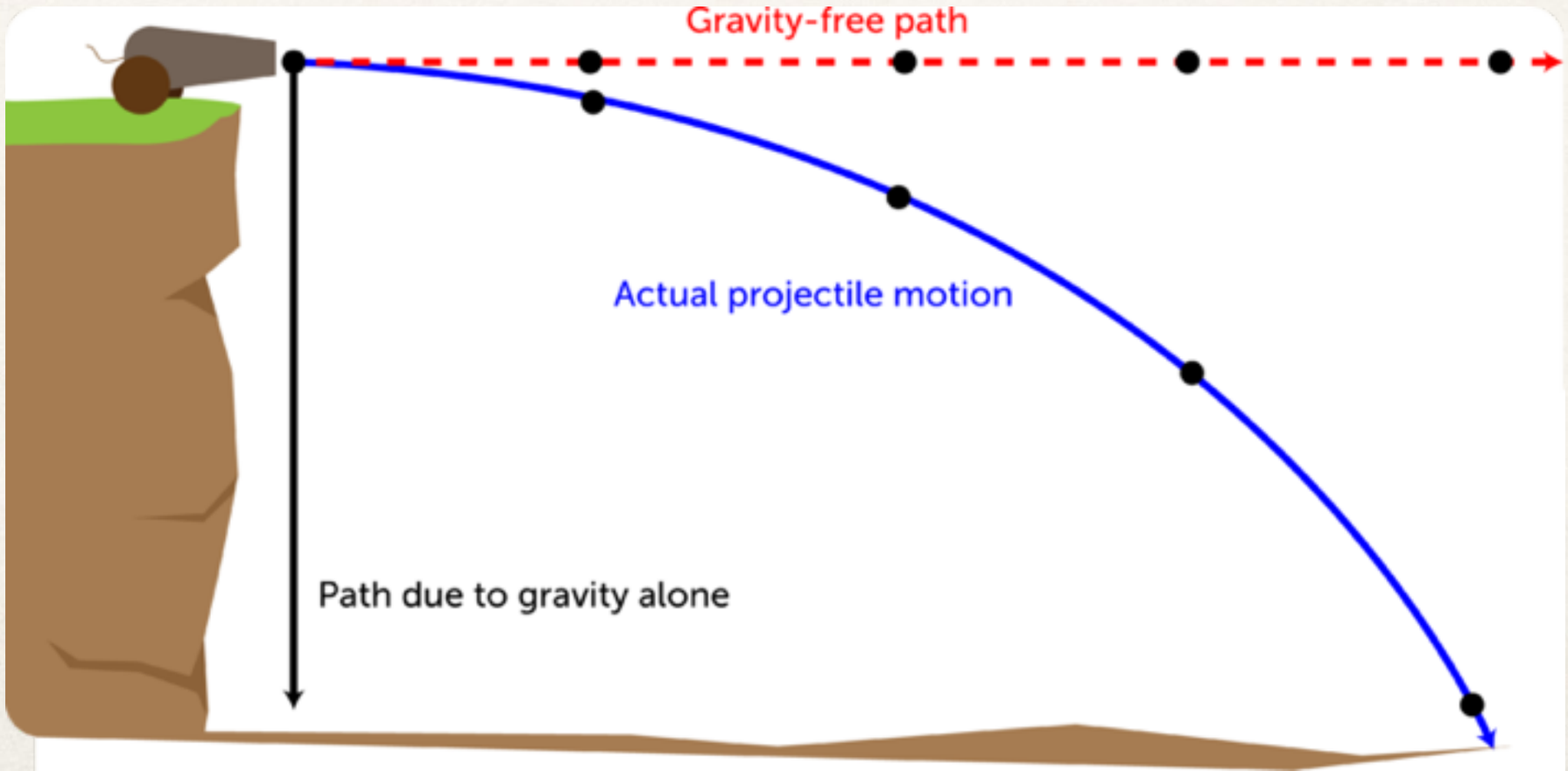
- What is the total displacement of Hermione's spell?

- *Ans. D = 9.6 m @ -51°*



Projectile Motion

- Much like free fall, but now the falling object also has a horizontal component to its motion as well.
- Per usual, we will ignore air resistance

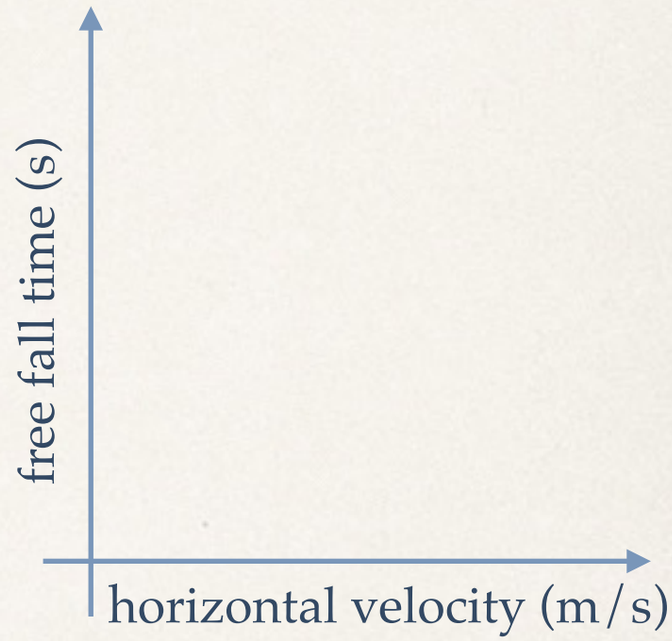


Projectile Motion

- We already know that the force of gravity imparts a vertical acceleration onto objects in free fall
- What about its horizontal velocity?

Projectile Lab 1

- Research Question: How does the horizontal velocity affect the time spent in free fall?



- Claim: (Your conclusion here)
- Evidence: Create a *time vs* v_x graph
- Justification: If there is a correlation between horizontal velocity and free time, why is it the way it is? If there isn't a correlation, why not?