AP Physics Study Guide

2D Kinematics

From Simple Studies, https://simplestudies.edublogs.org & @simplestudiesinc on Instagram

All images are from the Openstax college physics textbook

A **vector** is a quantity that has magnitude and direction

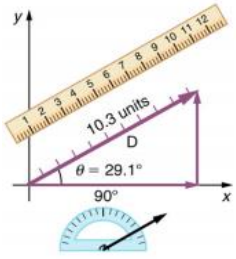
- Displacement, velocity, acceleration, and force are all vectors
- In two dimensions, we specify the direction of a vector using an arrow
    - The length of the arrow is proportional to the vector's magnitude

The **Head-to-Tail** method is a graphical way to add vectors

- The **tail** of the vector is the starting point of the vector
- The **head** of the vector is the final, pointed end of the arrow

These are the steps to take for the head-to-tail method

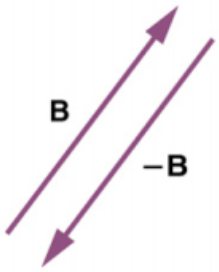
- Draw an arrow to represent the first vector using a ruler and protractor
- Draw an arrow to represent the second vector
    - Place the tail of the second vector at the head of the first vector
- If there are more than two vectors, continue this process for each vector to be added
- Draw an arrow from the tail of the first vector to the head of the last vector
    - This is the **resultant**, or sum, of the other vectors
    - To get the **magnitude** of the resultant, measure its length with a ruler
    - To get the **direction** of the resultant, measure the angle it makes with the reference frame using a protractor



Vector subtraction is a straightforward extension of vector addition

- The negative of any vector has the same magnitude but is in the opposite direction

- The subtraction of vector B from vector A is simply the addition of -B to A

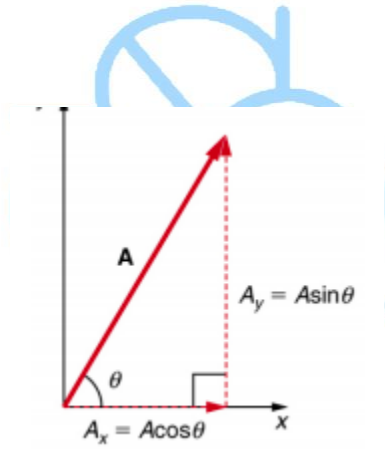


We often multiply vectors by a positive **scalar**

- The magnitude changes, but the direction stays the same

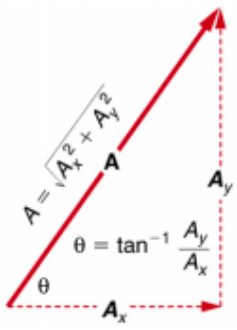
In order to split a vector into two, we determine its perpendicular **components**

- We can use pythagorean identities to do this
  - $A_x = A\ cos\theta$
  - $A_y = A\ sin\theta$



If we are only given the perpendicular components, we can also find the resultant

- $A = \sqrt{A_x^2 + A_y^2}$
  - This is just the pythagorean theorem
- $\theta = tan^{-1}(A_y/A_x)$



Projectile Motion is the motion of an object thrown or projected into the air, subject only to the acceleration of gravity

- The object is called a **projectile**
- The object's path is called its **trajectory**

- We consider **air resistance** to be negligible

These are equations that are applied to kinematic problems (they are given on your reference sheet)

- $x = x_0 + vt$
- $v = \frac{v_0+v}{2}$
- $v = v_0 + at$
- $x = x_0 + v_0t + \frac{1}{2}at^2$
- $v^2 = v_0^2 + 2a(x - x_0)$

These are the steps to solve projectile motion problems

- Resolve or break the motion into horizontal and vertical components along the x and y axes
- Treat the motion as two independent one-dimensional motions, one horizontal and the other vertical. The kinematic equations now look like this:
    - Horizontal: $x = x_0 + vt$
    - Horizontal: $v_x = v_{0x} = v_x$ =velocity is a constant
    - Vertical: $v_y = v_0 - gt$
    - Vertical: $y = y_0 + .5(v_{0y} + v_y)t$
    - Vertical: $y = y + v_{0y}t + \frac{1}{2}gt^2$
    - Vertical: $v_y^2 = v_{0y}^2 + 2g(y - y_0)$

- Solve for the unknowns in the two separate motions
    - The only common variable between the motions is time
    - The problem solving procedures here are the same as for one-dimensional **kinematics**
- Recombine the two motions to find the total displacement
    - We do this by using the resultant vectors equations

Velocities in two dimensions are added using the same analytical vector techniques:

- $v_x = v\,cos\theta$
- $v_y = v\,sin\theta$
- $v = \sqrt{v_x^2 + v_y^2}$
- $\theta = tan^{-1}(v_y/v_x)$

Relative Velocity is velocity relative to some reference frame

- Relative velocities are one aspect of **relativity**, the study of how different observers moving relative to each other measure the same phenomenon
- **Classical relativity** is limited to situations where speeds are less than about 1% of the speed of light