Formulas and More

Forces

Newton's first Law of Motion: An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an external force.

$F_{net} = m \times a$ *[Symbol] Newton's Second Law of Motion*: for a given mass m, the acceleration is proportional to the force applied.

Force in this equation represents the sum of all forces acting on an object or what might be called "net force". The more mass an object has, the more force required to move it. To cause an object to accelerate, force needs to be applied. We can determine any one of these 3 variables if we have the other 2, simply by rearranging the equation like you would in algebra.

Example: If a bowling ball is already rolling, it does not require any new force to cause it to continue rolling, meaning it does not accelerate. To make it accelerate, force is required. The more mass the bowling ball has, the more force required for it to move.

Note: Average acceleration due to gravity on Earth is -9.81 m/s2

$F_A = -F_B$ *[Symbol] Newton's Third Law of Motion:* For every action force, there is an equal and opposite reactionary force.

Example: If you drop a bowling ball on a surface, depending on the surface, the ball could bounce, break, produce sound or even produce heat. Any combination of these reactions would have to be proportional to the force exerted by the bowling ball on the surface. If for example, you dropped a bowling ball on grass, the ball might bounce slightly as well as dent the ground. The force exerted on the ball by the ground would be equivalent and opposite to the force of exerted on the ground by the ball.

$a = \frac{\Delta V}{\Delta t}$ *[Symbol] Acceleration = Change in velocity/Change in time*

If you know how many seconds or minutes have passed, and you know how much velocity has increased (or decreased) within that time, you can simply plug those values in to find the acceleration. Again, this equation only has 3 variables, so if 2 are known, rearrange the formula to find the other.

Example: A bowling ball is rolling down a small hill. To find the acceleration, you take the final velocity, and subtract the initial velocity, and then divide that by the time it took for the ball to get from where it started to where it stops.

$v = \frac{\Delta d}{\Delta t}$ *[Symbol] Velocity = Change in distance/Change in time*

Example: If you measure the distance from release of a bowling ball to the pins, and you measure the time it takes to get there, you can find the velocity.

Kinematic Equations of Motion

Note: *You will only be using the kinematic equation highlighted in red

$$V_f = V_i + at$$

$$d = \left(\frac{V_i + V_f}{2}\right) \times t$$

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

$$V_f^2 = V_i^2 + 2ad$$

Where:

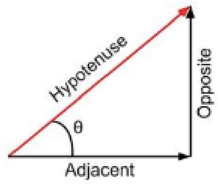
V_f is the final velocity
V_i is the initial velocity
d is the displacement
d_i is the initial displacement
a is the acceleration
t is the time

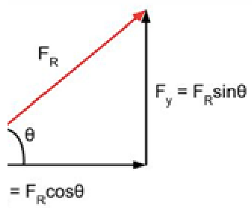
Each equation is missing a different variable. When evaluating a problem, you must first determine which variables you have and which ones you want to solve for.

Example: If you do not have any information about time (t), then you should first try to employ the formula Vf 2 = Vi2 +2ad. This formula excludes time and so you do not need it to use the equation. Using this method, you can often do your calculations with just one of the Kinematic equations.

Law of Conservation of Energy: The law of conservation of energy states that energy can not be created or destroyed; it can only change forms or transfer from one place or thing to another.

Trigonometry



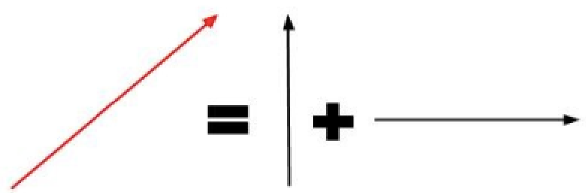


$$\sin\theta = \frac{Opposite}{Hypotense}$$

$$\cos\theta = \frac{Adjacent}{Hypotense}$$

$$\tan\theta = \frac{Opposite}{Adjacent}$$

A vector is a quantity that has both magnitude and direction. It is easy to imagine a force as either straight north-south (y-axis) or straight east-west (x-axis). If you push a box to the east, it will move precisely to the east. But what if you move a box at an angle somewhere between true north and east, northeast? How do you determine how far it will travel in each the x and y axes?



A vector that has direction in two dimensions (x and y coordinates) has two perpendicular components in these axes that describe the direction of the vector. This is precisely why the catapult simulation must involve angles and trigonometry.

Think about if you were to walk to a position right now. You could go straight to it or walk as far as you need to in one direction, make a 90° turn then continue to the destination. The combined influence of the two components is equivalent to the influence of the single two-dimensional vector. When comparing two vectors, they must be broken up into their respective components before they can be added or subtracted.

We use trigonometry to relate the two forms of expressing a vector by calculating the angle between the vector and one of its component arms.