Newton's Laws of Motion

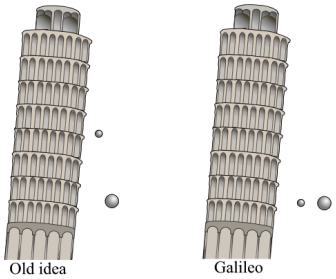
September 8, 2015 1:16 PM

Kinematics was the study of how objects move. Dynamics is the study of why they move. It explains where accelerations come from.

There are four fundamental forces in nature.

- Strong Nuclear: holds the nucleus together
- Weak Nuclear: determines nuclear radiation
- Electromagnetic: A repulsive or attractive force that is determined by electric charges
- Gravitational: Only attractive force (that we know of) of two pieces of matter on each other.

A force is a push or pull experienced by an object. Before Galileo, people thought that heavier objects fell faster than light ones. Galileo showed this was wrong.



Old idea

Galileo

Galileo died the same year Isaac Newton was born (1642). Isaac Newton published his famous laws of motion describing the study of kinematics and dynamics. In his work, he noted three laws of motion.

Newton's FIRST Law of Motion
If no net force acts on an object, it maintains its state of rest OR its constant speed in a straight line.

An object in motion tends to Stay in motion.
And, an object at rest tends to Stay at rest.

Newton's SECOND Law of Motion
If an unbalanced force acts on an object, the object accelerates in the direction of the force.

$\sum F = ma$ $\quad$ $F_{net} = ma$

Add up all the forces on the object

Variables
Force
Symbol: $\vec{F}$
SI Unit: Newton (N direction)
Mass
Symbol: m
SI Unit: kilogram (kg)

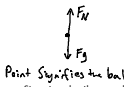
The acceleration varies directly with the unbalanced force.
The acceleration varies inversely with the mass of the object

Newton's THIRD Law of Motion
For every action force, there is an equal and opposite reaction force.
http://www.youtube.com/watch?v=XjwO9InuFJk

Kinematics and Dynamics have one variable in common - **acceleration.**
This is the only thing that we can tie to the topics together. Kinematics is still important as many questions we will be trying will require you to use acceleration.

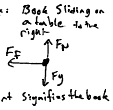
Force Diagrams: We represent the forces acting on an object by drawing an arrow. The arrows length signifies the magnitude of the force and the arrow will point in the direction that the forces act on an object.

Ex: Stationary ball



Point Signifies the ball

Ex: Book Sliding on a table to the right



Point Signifies the book

Ex: Pushing down on a book

Steps to solve these problems
Step 1: Draw a picture
Step 2: Draw a force diagram
Step 3: Write out your Fnet equations for the vertical and horizontal and solve

Example 1: What net force is needed to accelerate a 5kg object at a rate of 2m/s^2?

5kg 2m/s^2

$F_{Net} = ma$
$= (5)(2)$
$F_{Net} = 10N$

Example 2: The Incredible Hulk and Ironman are in an epic battle. The Hulk pushes Ironman with a force of 50N to the right. Ironman uses his thrusters to push back with a force of 40N to the left.

a) What direction will they move in?

40N 50N

Move to the Right

b) If the Hulk has a mass of 160kg and Ironman has a mass of 130kg what is their acceleration? (assume the stick together)

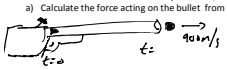
$F_{net} = ma$
$50 + (-40) = (160 + 130)a$
$\frac{10}{290} = \frac{290a}{290}$
$0.0345 m/s^2 = a$

* 40N is negative because it is to the left

Example 3: A gun is fired and a 75g bullet is accelerated in the gun barrel, which is 1 m long. The bullet leaves the barrel with a velocity of 900 m/s.

75g = 0.075kg

a) Calculate the force acting on the bullet from the expansion of gases.



$V_i = 0 m/s$
$V_f = 900 m/s$
$a =$
$d = 1m$
$t =$

$V_f^2 = V_i^2 + 2ad$
$\frac{900^2}{2} = \frac{2a(1)}{2}$
$405000 m/s^2 = a$

$F_{net} = ma$
$= (0.075)(405000)$
$F_{Net} = 30375N$

b) If the gun weighs 5kg then what is the acceleration of the gun?

$F_{net} = -30375N$
$m = 5kg$
$a =$

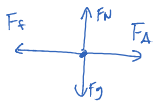
Newton's 3rd law

$$\frac{-30375}{5} = \frac{5a}{5}$$

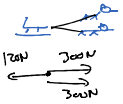
$$-6075\ m/s^2 = a$$

Practice

① An object is being pushed along a desk at a constant speed. Draw the force diagram. (use F_g, F_N, F_A, F_f)



② Two dogs are attached to a 50kg sled. A 70kg person hops on the sled. If each dog can pull with 300N and must fight against a frictional force of 120N, then how fast does the sled accelerate?



$F_{Net} = ma$

$300 + 300 - 120 = (50+70)a$

$\frac{480}{120} = \frac{120a}{120}$

$4\ m/s^2 = a$

③ Derive an equation for F_g. (Ignore air resistance)

Consider a falling object

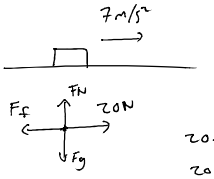
$F_{Net} = ma$

$F_g = ma$

$F_g = mg$

all objects fall at $g = 9.8\ m/s^2$

④ A 5kg book is pushed on a desk with a force of 20N. It accelerates @ $7\ m/s^2$. Find the frictional force. If $F_f = \mu F_N$, Find μ.



Horizontal

$F_{Net} = ma$

$20 - F_f = (5)(7)$

$20 - F_f = 35$

$-F_f = 15N$

$F_f = -15N$

Vertical ($a=0$)

$F_{Net} = ma$

$F_N - F_g = 0$

$F_N = F_g$

$F_f = mg$

$F_f = \mu F_N$

$\frac{F_f}{\mu} = F_N$

μ

$\left|\frac{-15}{(5)(9.8)}\right| = \mu$

$|-0.306| = \mu$

$0.306 = \mu$

1in = 200m