Unit 2: Dynamics

causes of changing motion

⇓

apply a **force**

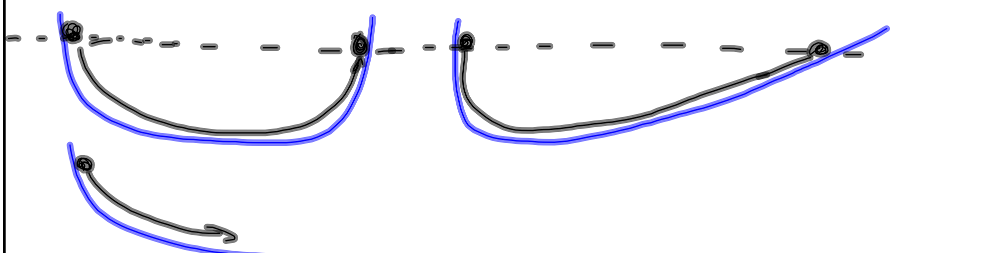
4 Fundamental Forces

1. Strong Nuclear Force *
2. Electromagnetic Force *
3. Weak Nuclear Force
4. Gravitational Force *

More commonly known types of forces...

- gravity, F_g
- magnetic
- friction, F_f
- electric, F_e
- applied, F_A
- tension, F_T
- normal force, F_N

Newton's Laws of Motion



1st law: An object maintains its velocity unless acted on by an external, unbalanced force.

(law of inertia)

Inertia is the property of matter that resists changes in motion.

2nd Law:

An object that undergoes a net force will accelerate in the direction of that force.

The acceleration is proportional to the net force, and inversely proportional to the object's mass.

$\vec{a} \propto \vec{F}$, $a \propto \frac{1}{m}$ } $a \propto \frac{F}{m}$, $a = C \times \frac{F}{m}$, $a = \frac{F}{m}$

$$\boxed{\vec{F} = m\vec{a}}$$

m → in kg

a → in $\frac{m}{s^2}$

F → in Newtons (N)

1 N is the force required to accelerate a 1 kg mass by 1 $\frac{m}{s^2}$.

Ex. How much force is required to accelerate a 900 kg car from 60 $\frac{km}{h}$ to 90 $\frac{km}{h}$ over 1 km.

$m = 900$ kg

$F = ?$

$a = ?$

$v_i = 60 \frac{km}{h} = 16.7 \frac{m}{s}$

$v_f = 90 \frac{km}{h} = 25 \frac{m}{s}$

$d = 1$ km $= 1000$ m

$v_f^2 = v_i^2 + 2ad$

$v_f^2 - v_i^2 = 2ad$

$a = \frac{v_f^2 - v_i^2}{2d}$

$= \frac{(25)^2 - (16.7)^2}{2(1000)}$

$= 0.17 \frac{m}{s^2}$

$\vec{F} = m\vec{a}$

$= (900)(0.17)$

$= 156$ N

3rd Law

If object A exerts a force on object B, then B exerts a force on A that is equal in magnitude and opposite in direction.

Example: A bowling ball (7 kg) hits a stationary pin (1.6 kg). If the ball was moving at 6.5 $\frac{m}{s}$ [E] before hitting the pin, and 2.2 $\frac{m}{s}$ after, how fast will the pin be moving?

Ball	Pin
$m_b = 7$ kg	$m_p = 1.6$ kg
$v_{ib} = 6.5 \frac{m}{s}$	$v_{ip} = 0$
$v_{fb} = 2.2 \frac{m}{s}$	$v_{fp} = v$
$a_b =$	$a_p =$
$d_b =$	$d_p =$
$t_b = T$ ⟷	$t_p = T$
$F_b = F$ ⟷	$F_p = -F$

$a = \frac{v_f - v_i}{t}$

$= \frac{2.2 - 6.5}{T}$

$a_b = -\frac{4.3}{T}$

$\therefore F_b = m_b a_b$

$= (7)\left(-\frac{4.3}{T}\right)$

$= -\frac{30.1}{T}$

$\therefore F_p = -\left(-\frac{30.1}{T}\right)$

$= \frac{30.1}{T}$

$F = ma$

$a = \frac{F}{m} = \frac{\left(\frac{30.1}{T}\right)}{1.6}$

$= \frac{30.1}{1.6T} = \frac{18.8}{T}$

so $v_f = v_i + at$

$= 0 + \frac{18.8}{T} T$

$= 18.8 \frac{m}{s}$

FBDs

Free Body Diagram