1. Vectors

What is a vector?

A vector is a quantity that has a magnitude (size) and direction.

What is a scalar?

A scalar is a quantity that has only magnitude.

You need to know how to:

- Add two vectors
- Subtract two vectors
- Multiply a vector by a scalar
- Decompose a vector

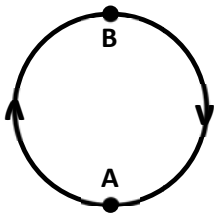
2. Newton's laws of motion

What is the difference between distance and displacament?

Distance is the length of the path you have to travel to get from A to B. Displacement is the straight line distance from A to B.

Speed and velocity?

Speed is the measure of how far an object gets in a unit of time. Velocity, apart from having mangitude, also has direction.



Example:
A person walks from point A to point B, and then back to point A. The length of the road from A to B is 3 km and it takes him/her exactly 1 hour to get there and back. Therefore the average speed of the person in this hour is:

$v = \frac{distance}{time} = 6\ \frac{km}{h}$, his/her average velocity though is zero!

Most dynamics problems are based on one or a combination of **Newton's Laws of Motion**:

NEWTON'S FIRST LAW

*when **no forces** act on a body, the body will either **remain at rest** or **continue to move along a straight line** with constant speed.*

NEWTON'S SECOND LAW

$$\boldsymbol{Force = mass \cdot acceleration}$$

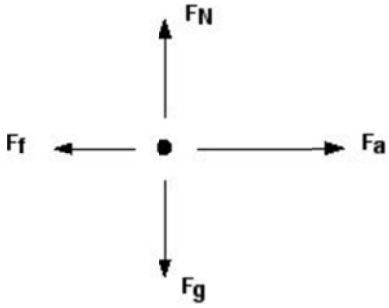
NEWTON'S THIRD LAW

*If body a **exerts a force** on body b, then body b exerts **an equal but opposite force** on body a.*

Free body diagram

A free body diagram is a drawing of a physical situation with all the forces acting upon it clearly shown.

Net force is the unbalanced force acting on an object. When two or more forces act on an object, the resultant (vector sum) of the forces is the net force. In the **free body diagram** on the right, the net force is to the right, so the object will accelerate to the right.



Examples

1.1 A 4kg object is moving across a frictionless surface with a constant velocity of 2 m/s. Determine the force necessary to maintain this state of motion

Answer: Zero. Applying Newton's First Law of Motion, this object will continue its state of uniform speed in a straight line until a net (unbalanced) force acts upon it.

1.2 An object sits on a frictionless surface. There is a 16 N force being applied to an object and its acceleration is at 2 m/s/s. What is its mass?

$F = ma$
$16\ N = m(2\ m/s^2)$
$m = 8\ kg$

Forces

Fundamental forces :	**- gravitational** **- electromagnetic** **- nuclear**
Non-fundamental forces and their origin:	- *elastic* (electromagnetic force) - *friction* (electromagnetic force) - *tension* (electromagnetic force) - *normal force* (gravity) - *centrifugal* (ficticious force, concequence of Newton's first law,happens with circular motion)

Formulas

a) Gravity $\boldsymbol{F = G\frac{m \cdot M}{r^2}}$

G = grav. Constant = $6.67300 \times 10^{-11}\ \frac{m^3}{kg*s^2}$
m – mass of first object
M – mass of second object
r – distance between the **centers** of objects

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b) Elastic $\boldsymbol{F = -k * x}$

k – spring constant (depends on given spring)
x – displacement from equilibrium position

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c) Friction $\boldsymbol{F = \mu * N}$

μ – coefficient of friction (depends on surface)
N – normal force (force of reaction of the surface as describen in Newton's third law. On a flat surface is equal to the **weight** of the object)

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d) Centrifugal $\boldsymbol{F = \frac{m*v^2}{r}}$

m- mass of the object
v – velocity of the object
r – distance of the object from the point around which it is spinning