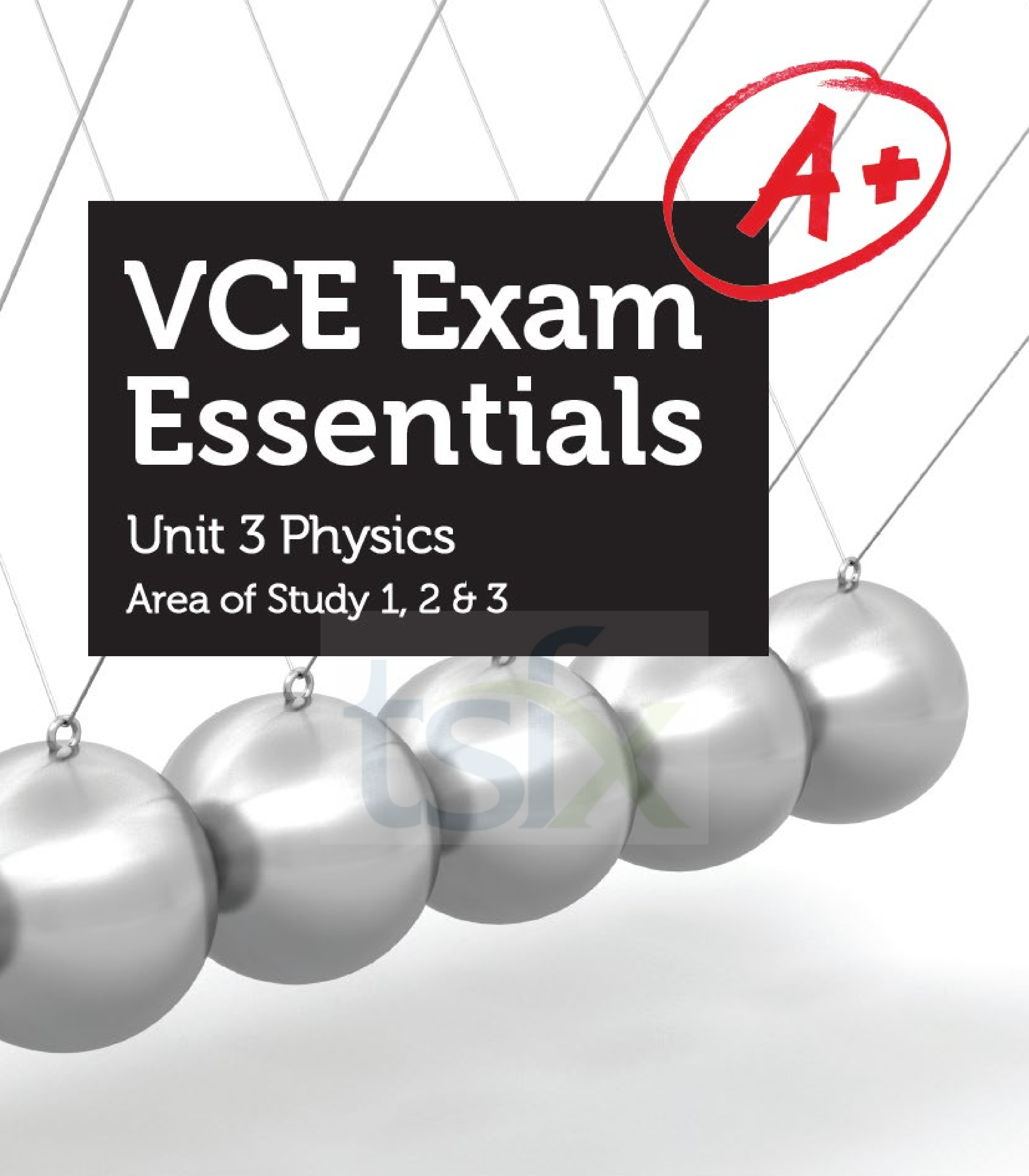

VCE Exam Essentials

Unit 3 Physics

Area of Study 1, 2 & 3

- ✓ A Complete Guide to the VCE Exams
- ✓ Comprehensive & Detailed A+ Notes
- ✓ VCE Exam Style Questions & Solutions
- ✓ Written by Experienced VCAA Examiners
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VCE EXAM ESSENTIALS

Unit 3 Physics

Area of Study 1

How Do Things Move Without Contact?

Area of Study 2

How Are Fields Used to Move Electrical Energy?

Area of Study 3

How Fast Can Things Go?

VCE Accreditation Period
2017 – 2023

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Errata & Bonus Resources

Although great care is taken to ensure that our books are mistake free, an error may appear from time to time. If you believe there is an error in this publication, please let us know asap **(admin@tsfx.edu.au)**.

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UNIT 3 PHYSICS
PART 1 – VCE STUDY DESIGN

PART 2 – AREA OF STUDY 3
HOW FAST CAN THINGS GO?

PART 1: VCE STUDY DESIGN

UNIT 3 PHYSICS

ACCREDITATION PERIOD
2017 – 2023

VCE STUDY DESIGN: UNIT 3 PHYSICS
ACCREDITATION PERIOD: 2017 – 2023

HOW DO FIELDS EXPLAIN MOTION & ELECTRICITY?

In this unit students explore the importance of energy in explaining and describing the physical world. They examine the production of electricity and its delivery to homes. Students consider the field model as a construct that has enabled an understanding of why objects move when they are not apparently in contact with other objects. Applications of concepts related to fields include the transmission of electricity over large distances and the design and operation of particle accelerators. They explore the interactions, effects and applications of gravitational, electric and magnetic fields. Students use Newton's laws to investigate motion in one and two dimensions and are introduced to Einstein's theories to explain the motion of very fast objects. They consider how developing technologies can challenge existing explanations of the physical world, requiring a review of conceptual models and theories. Students design and undertake investigations involving at least two continuous independent variables.

A student-designed practical investigation related to waves, fields or motion is undertaken either in Unit 3 or Unit 4, or across both Units 3 and 4, and is assessed in Unit 4, Outcome 3. The findings of the investigation are presented in a scientific poster format as outlined in the template on page 1 of the VCE Physics Study Design 2017 – 2022.

AREA OF STUDY 1: HOW DO THINGS MOVE WITHOUT CONTACT?

In this area of study students examine the similarities and differences between three fields: gravitational, electric and magnetic. Field models are used to explain the motion of objects when there is no apparent contact. Students explore how positions in fields determine the potential energy of an object and the force on an object. They investigate how concepts related to field models can be applied to construct motors, maintain satellite orbits and to accelerate particles.

FIELDS & INTERACTION

- Describe gravitation, magnetism and electricity using a field model.
- Investigate and compare theoretically and practically gravitational, magnetic and electric fields, including directions and shapes of fields, attractive and repulsive fields, and the existence of dipoles and monopoles.
- Investigate and compare theoretically and practically gravitational fields and electrical fields about a point mass or charge (positive or negative) with reference to:
    - the direction of the field
    - the shape of the field
    - the use of the inverse square law to determine the magnitude of the field
    - potential energy changes (qualitative) associated with a point mass or charge moving in the field
- Investigate and apply theoretically and practically a vector field model to magnetic phenomena, including shapes and directions of fields produced by bar magnets, and by current-carrying wires, loops and solenoids.
- Identify fields as static or changing, and as uniform or non-uniform.

EFFECTS OF FIELDS

- Analyse the use of an electric field to accelerate a charge, including:
  - Electric field and electric force concepts: $E = k\frac{Q}{r^2}$ and $F = k\frac{q_1 q_2}{r^2}$.
  - Potential energy changes in a uniform electric field: $W = qV$, $E = \frac{V}{d}$.
  - The magnitude of the force on a charged particle due to a uniform electric field: $F = qE$.
- Analyse the use of a magnetic field to change the path of a charged particle, including:
  - The magnitude and direction of the force applied to an electron beam by a magnetic field: $F = qvB$, in cases where the directions of v and B are perpendicular or parallel.
  - The radius of the path followed by a low-velocity electron in a magnetic field: $qvB = \frac{mv^2}{r}$
- Analyse the use of gravitational fields to accelerate mass, including:
  - Gravitational field and gravitational force concepts: $g = G\frac{M}{r^2}$ and $F_g = G\frac{m_1 m_2}{r^2}$.
  - Potential energy changes in a uniform gravitational field: $E_g = mg\Delta h$.
  - The change in gravitational potential energy from area under a force-distance graph and area under a field distance graph multiplied by mass.

APPLICATION OF FIELD CONCEPTS

- Apply the concepts of force due to gravity, F_g, and normal reaction force, F_N, including satellites in orbit where the orbits are assumed to be uniform and circular.
- Model satellite motion (artificial, Moon, planet) as uniform circular orbital motion: $a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$.
- Describe the interaction of two fields, allowing that electric charges, magnetic poles and current carrying conductors can either attract or repel, whereas masses only attract each other.
- Investigate and analyse theoretically and practically the force on a current carrying conductor due to an external magnetic field, $F = nIlB$, where the directions of I and B are either perpendicular or parallel to each other.
- Investigate and analyse theoretically and practically the operation of simple DC motors consisting of one coil, containing a number of loops of wire, which is free to rotate about an axis in a uniform magnetic field and including the use of a split ring commutator.
- Model the acceleration of particles in a particle accelerator (limited to linear acceleration by a uniform electric field and direction change by a uniform magnetic field).

AREA OF STUDY 2

HOW ARE FIELDS USED TO MOVE ELECTRICAL ENERGY?

The production, distribution and use of electricity has had a major impact on human lifestyles. In this area of study students use empirical evidence and models of electric, magnetic and electromagnetic effects to explain how electricity is produced and delivered to homes. They explore magnetic fields and the transformer as critical to the performance of electrical distribution systems.

GENERATION OF ELECTRICITY

- Calculate magnetic flux when the magnetic field is perpendicular to the area and describe the qualitative effect of differing angles between the area and the field: $\phi_B = B \perp A$.

- Investigate and analyse theoretically and practically the generation of electromotive force (emf) including AC voltage and calculations using induced emf: $\varepsilon = -N\dfrac{\Delta\phi_B}{\Delta t}$, with reference to:
    - Rate of change of magnetic flux
    - number of loops through which the flux passes
    - direction of induced emf in a coil

- Explain the production of DC voltage in DC generators and AC voltage in alternators, including the use of split ring commutators and slip rings respectively.

TRANSMISSION OF ELECTRICITY

- Compare sinusoidal AC voltages produced as a result of the uniform rotation of a loop in a constant magnetic field with reference to frequency, period, amplitude, peak-to-peak voltage (V_{p-p}) and peak-to-peak current (I_{p-p}).

- Compare alternating voltage expressed as the root-mean-square (rms) to a constant DC voltage developing the same power in a resistive component.

- Convert between rms, peak and peak-to-peak values of voltage and current.

- Analyse transformer action with reference to electromagnetic induction for an ideal transformer: $\dfrac{N_1}{N_2} = \dfrac{V_1}{V_2} = \dfrac{I_2}{I_1}$.

- Analyse the supply of power by considering transmission losses across transmission lines.

- Identify the advantage of the use of AC power as a domestic power supply.

AREA OF STUDY 3: HOW FAST CAN THINGS GO?

In this area of study students use Newton's laws of motion to analyse relative motion, circular motion and projectile motion. Newton's laws of motion give important insights into a range of motion both on Earth and beyond. At very high speeds, however, these laws are insufficient to model motion and Einstein's theory of special relativity provides a better model. Students compare Newton's and Einstein's explanations of motion and evaluate the circumstances in which they can be applied. They explore the relationships between force, energy and mass.

NEWTON'S LAWS OF MOTION

- Investigate and apply theoretically and practically Newton's three laws of motion in situations where two or more coplanar forces act along a straight line and in two dimensions.
- Investigate and analyse theoretically and practically the uniform circular motion of an object moving in a horizontal plane: $F_{net} = \frac{mv^2}{r}$, including:
    - A vehicle moving around a circular road
    - A vehicle moving around a banked track
    - An object on the end of a string
- Model natural and artificial satellite motion as uniform circular motion.
- Investigate and apply theoretically Newton's second law to circular motion in a vertical plane (forces at the highest and lowest positions only).
- Investigate and analyse theoretically and practically the motion of projectiles near Earth's surface, including a qualitative description of the effects of air resistance.
- Investigate and apply theoretically and practically the laws of energy and momentum conservation in isolated systems in one dimension.

EINSTEIN'S THEORY OF SPECIAL RELATIVITY

- Describe Einstein's two postulates for his theory of special relativity that:
    - The laws of physics are the same in all inertial (non-accelerated) frames of reference.
    - The speed of light has a constant value for all observers regardless of their motion or the motion of the source.
- Compare Einstein's theory of special relativity with the principles of classical physics.
- Describe proper time (t_0) as the time interval between two events in a reference frame where the two events occur at the same point in space.
- Describe proper length (L_0) as the length that is measured in the frame of reference in which objects are at rest.
- Model mathematically time dilation and length contraction at speeds approaching c using the equations: $t = t_0\gamma$ and $L = \frac{L_0}{\gamma}$ where $\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2}$
- Explain why muons can reach Earth even though their half-lives would suggest that they should decay in the outer atmosphere.

RELATIONSHIPS BETWEEN FORCE, ENERGY & MASS

- Investigate and analyse theoretically and practically impulse in an isolated system for collisions between objects moving in a straight line: $F\Delta t = m\Delta v$
- Investigate and apply theoretically and practically the concept of work done by a constant force using:
  - Work done = Constant force × Distance moved in direction of net force
  - Work done = Area under force-distance graph
- Analyse transformations of energy between kinetic energy, strain potential energy, gravitational potential energy and energy dissipated to the environment (considered as a combination of heat, sound and deformation of material):
  - Kinetic energy at low speeds: $E_k = \frac{1}{2}mv^2$; elastic and inelastic collisions with reference to conservation of kinetic energy.
  - Strain potential energy: area under force-distance graph including ideal springs obeying Hooke's Law: $E_s = \frac{1}{2}k\Delta x^2$.
  - Gravitational potential energy: $Eg = mg\Delta h$ or from area under a force-distance graph and area under a field distance graph multiplied by mass.
- Interpret Einstein's prediction by showing that the total 'mass-energy' of an object is given by: $E_{tot} = E_k + E_0 = \gamma mc^2$ where $E_0 = mc^2$, and where kinetic energy can be calculated by: $E_k = (\gamma - 1)mc^2$.
- Describe how matter is converted to energy by nuclear fusion in the Sun, which leads to its mass decreasing and the emission of electromagnetic radiation.

FORCE

A force is any **interaction that, when unopposed, will change the motion of an object.** It can also be viewed as a **push or pull upon an object** resulting from the object's interaction with another object. Whenever there is an interaction between two objects, there is a force upon each of the objects.

The unit of force is the Newton (N).

Forces between objects can be grouped as **contact forces** or **non-contact** forces.

For example:

Contact Forces	Non Contact Forces
Air Resistance Applied Force Friction Normal Force Spring Force Tension	Electrical Force Gravitational Force Magnetic Force

Force is measured in newtons (N) and represented by the symbol F. One Newton is the amount of force required to give a 1 kg mass an acceleration of 1 m/s^2.

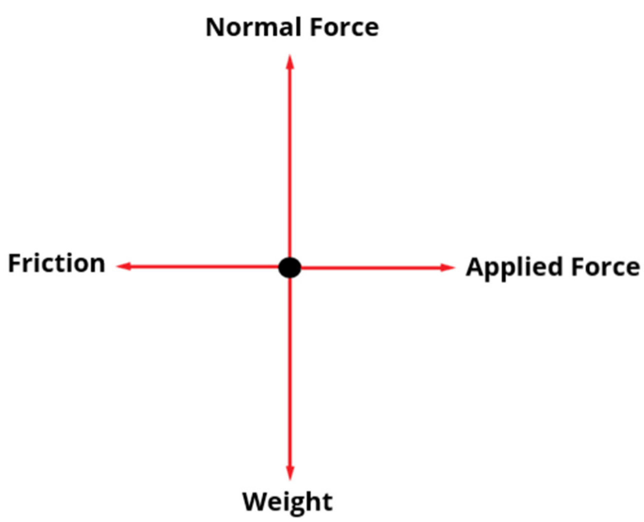
Therefore:

$$1 \text{ Newton} = 1 \text{ kg} \bullet m/s^2$$

Force is a vector quantity with both magnitude and direction.

When adding up forces to find the **net or overall force**, positive and negative signs <u>**must be used**</u> to account for the directions of the forces.

COMMON FORCES INVOLVED IN STRAIGHT LINE MOTION



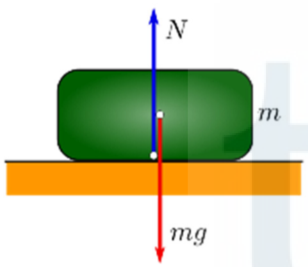
WEIGHT (FORCE DUE TO GRAVITY)

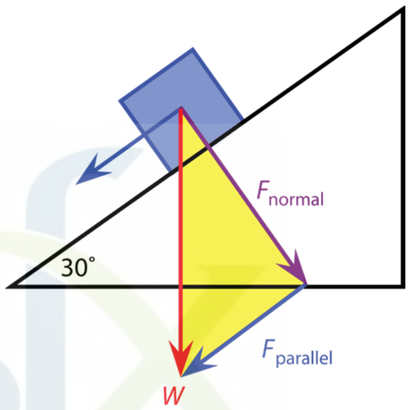
- **Symbol is W.**
- The weight of a body is simply the effect of gravity on the mass of the body, i.e. the measure of the attraction that the Earth exerts on a body.
- A mass of ***m kg*** experiences a gravitational force of ***m kg wt*** or ***gm ≈ 9.8 m*** Newton.
- $W = m \times g$

  Where: W = weight (N)
  m = mass (kg)
  g = gravitational acceleration $\left(m/s^2\right)$

  For example: The weight of a 10 kg mass is 10 kg wt or 10 g ≈ 10 x 9.8 N = 98 N.

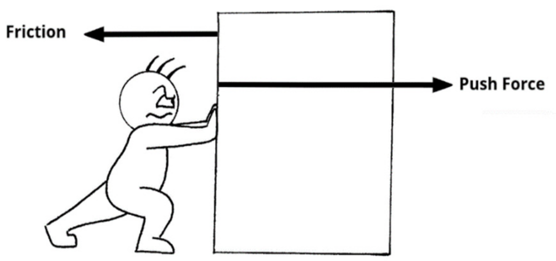
- Weight forces **always** act straight down (vertically).

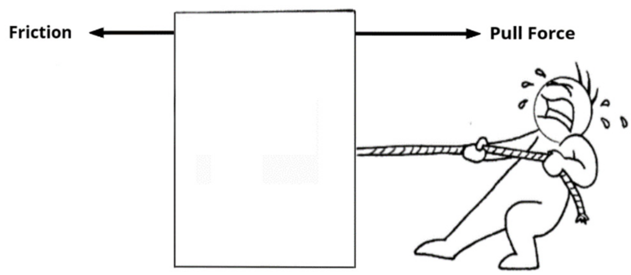




APPLIED FORCE

- Symbol is F.
- This force exists when two objects interact with each other and will be either a “push” or “pull” type frorce.
- The direction of the force depends on the situation (eg. the angle at which force is applied, whether the force is a push or pull type force etc).



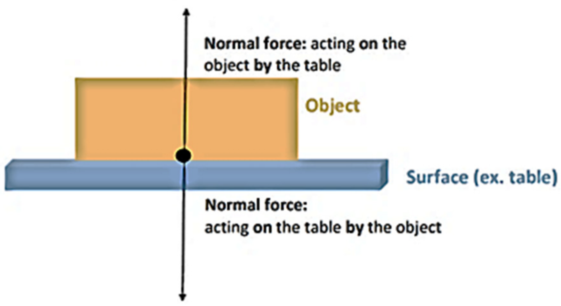


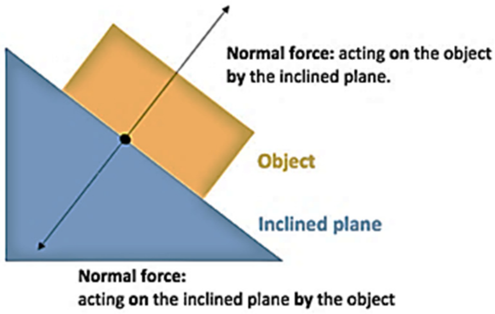
THE NORMAL REACTION FORCE

- Symbol is N.

- Newton's third law of motion states that for every action there is an equal but opposite reaction.

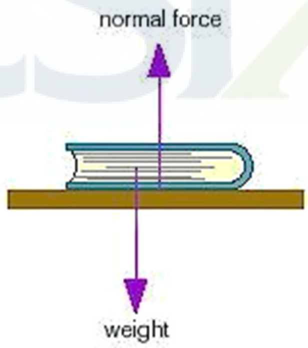
- Whenever an object is in contact with a surface, there is a normal reaction which acts in a perpendicular direction to the surface upon which the object is resting on or sliding across, usually to counteract the force of gravity.





- Consider a book of mass m resting on the surface of a flat desk. The book experiences a force of ***m kg wt*** towards the Earth (the Earth's gravitational force) i.e. The book exerts a force on the desk equivalent to the weight force.

  The desk in turn exerts an equal and opposite force on the book. This force, known as the **Normal Reaction** acts upwards and perpendicular to the surface of the bodies in contact.



(Normal is desk on book)

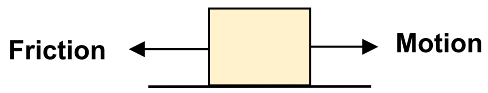
(The weight force, W, is earth on book)

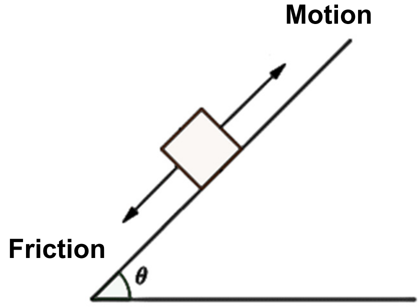
As the book is not moving in the vertical plane, the weight force and the normal reaction force have balanced each other out.

Note:

The Normal force is **not always equal and opposite** to the weight!

FRICTIONAL FORCE





Friction is a **contact force** that opposes motion and occurs when relative motion of two bodies in contact occurs.

For example: An object travelling across a rough surface (e.g. a table) will slow down due to the effects of friction.

Friction acts:

- In a direction parallel to the surface along which motion is occurring (or is trying to occur).
- In the opposite direction to the motion of the object.
- In the opposite direction to an applied force on a stationary object, slowing or preventing the motion of the object.

OTHER IMPORTANT FORCES INVOLVED IN MOTION OF OBJECTS

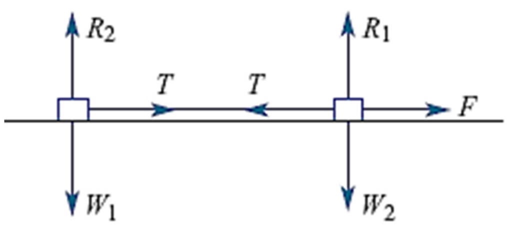
TENSION

- Tension is a **pulling force** exerted on an object by strings, ropes, etc.
- The tension force always acts in the direction parallel to the rope.
- If one string is involved, then the size of the tension force is the same in all directions.

  (Actually, when the string hangs over a pulley this is only true if the pulley is smooth and has negligible mass and the string or rope is inextensible.)

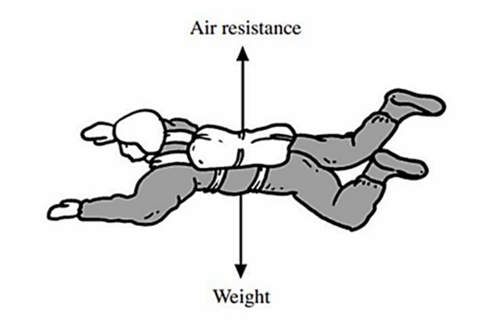
  For example:

  Two particles connected by a taut rope moving on a smooth plane.



AIR RESISTANCE

Air resistance is a force that acts in the opposite direction to that of an object moving through the air. This force opposes an object's motion and is caused by the flow of air over the surface of an object.

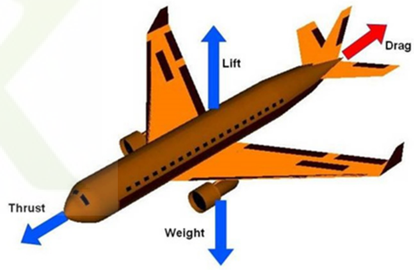


DRAG

Drag is a mechanical force that is generated by the contact and interaction of a solid body with a liquid or gas. Drag acts in the opposite direction to an object's motion, causing it to slow down.

THRUST

Thrust is a mechanical force generated by engines to move an airplane through the air. Engines expel gas at high speed causing thrust back on the engine in the opposite direction.



DRAWING FORCE DIAGRAMS (FREE BODY DIAGRAMS)

A force diagram is simply a diagram showing all the forces acting on an object including the magnitudes and directions.

METHOD:

Step 1: Identify the object or objects of interest and draw a picture of the situation.

Draw a dot or square to represent the object(s) and include any ropes, springs and surfaces that are in contact with the objects(s).

Step 2: Mark all forces acting on the objects and on the objects exerting the forces.

Possible forces include:

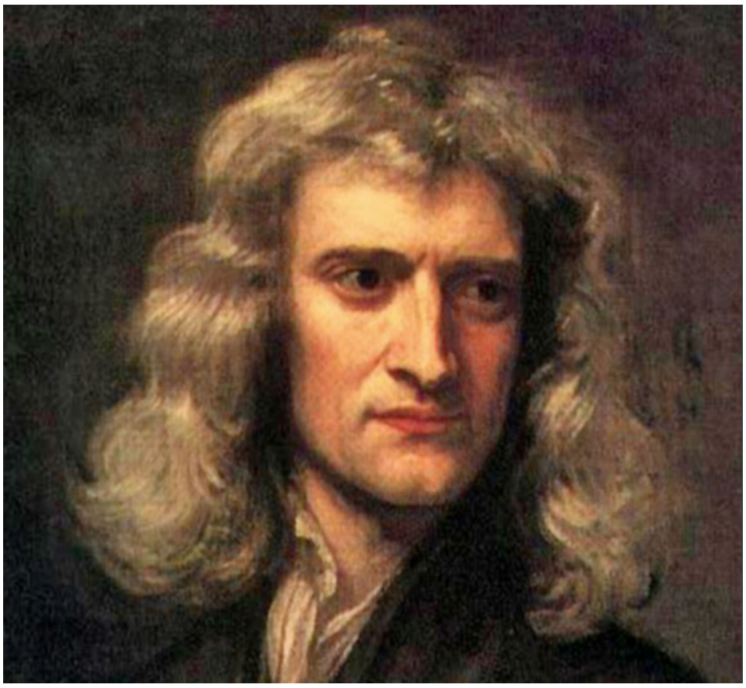
- Weight (which always acts vertically).
- The normal reaction (which acts at a right angle to the surface of the bodies in contact).
- Friction (which acts in the opposite direction to the direction of motion, or the direction of tendency of motion).
- Tension.
- Thrust (a push/pull force which acts in the direction of motion)/driving force.

Draw a vector to represent each force. Draw each vector in the direction the force is being exerted or the direction it is acting in.

Note:

- If the object is stationary or is moving at a constant velocity, the vectors should graphically add up to zero.
- If the object is accelerating, the sum of the vectors should produce a vector in the same direction as the acceleration.
- The force arrows must be drawn to scale and be pointing in the correct direction.

NEWTON'S LAWS OF MOTION



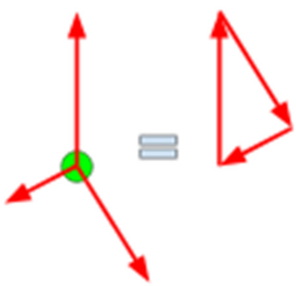
NEWTON'S FIRST LAW

An object continues in its state of rest or uniform speed in a straight line unless acted on by an external, unbalanced force.

When the net force is zero, objects at rest stay at rest and objects in motion keep moving with the same speed and direction.

- **An unbalanced force is required to change the motion of a body**, be that the **speed** of the body and/or the **direction** of its motion.
- There can be no change in motion without a **net force.**
- The term **'net force'** refers to the sum of all the forces acting on a body.
- When the **net force is zero**, the sum of the forces acting on a body is equal to zero.

$\Sigma F = 0$
Acceleration = 0



The three forces acting on the central body are in equilibrium. There is no resultant force acting on the body i.e. The net force acting on the body is zero.

The three vectors will join from head to tail to form a zero vector.

- The forces are said to be **balanced** and in **equilibrium and** have **zero acceleration.**

  This means that the body is either **stationary** or is **moving at a constant velocity.**

- An object in motion will maintain constant speed and direction in the absence of a net force. The term **'inertia'** is often used to describe this phenomenon.

  Inertia is simply an object's **tendency to resist change** and can be viewed as a measure of an object's **"laziness"**. The greater the mass of an object, the more inertia it has.

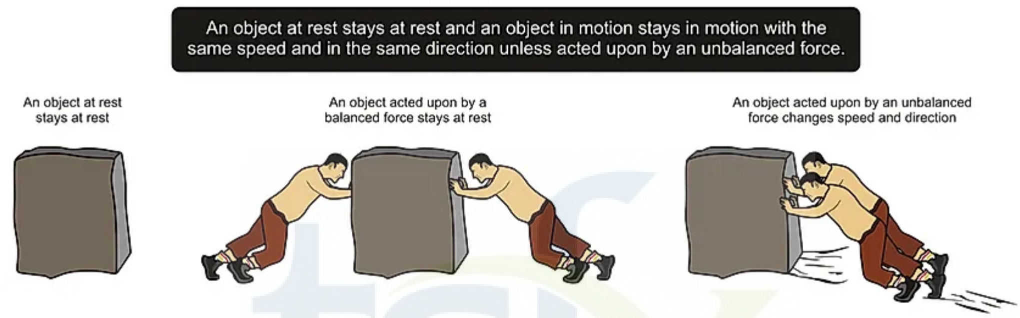
  Some examples of inertia include:

  The sensation of being 'thrown' sideways when the bus you are travelling in turns a bend.

  Being jolted backwards when the train departs the station.

  The old magician's trick of pulling the tablecloth from the table set with cutlery and crockery.

SUMMARY



- **If the body is stationary:**

  $\Sigma F = 0$
  Forces are in equilibrium
  Forces are balanced
  No net force is acting on the body

  Acceleration = 0
  Velocity = 0

  Position is not changing. Changes in motion come from unbalanced forces, therefore, an object at rest remains at rest.

  If the body is moving at constant velocity:

  $\Sigma F = 0$
  Forces are in equilibrium
  Forces are balanced
  No net force is acting on the body

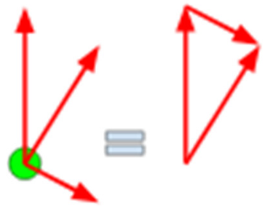
  Acceleration = 0
  Velocity $= k \text{ where } k \neq 0$

  Position is changing at a steady (constant) rate (i.e. velocity is constant and acceleration = 0)
  Direction of travel does not change

- If the forces **don't cancel** out, they are said to be **"unbalanced"**. There will be a **resultant force** acting on the body causing it to accelerate.

$\Sigma F \neq 0$

Acceleration $\neq 0$ ms^{-2}



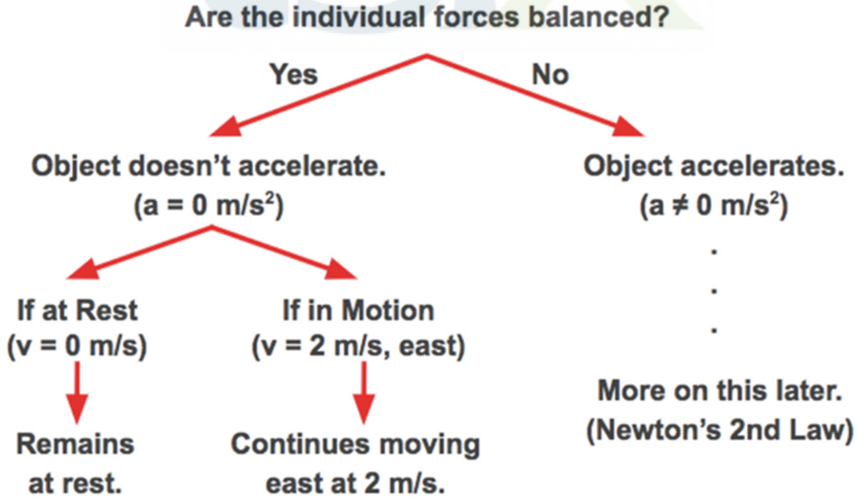
The arrangement of the three forces that are acting on the central body on side gives a resultant force that is greater than zero. The forces are therefore NOT in equilibrium.

The three vectors can be joined to form a closed triangle, however, only two of these vectors will join from head to tail. As the third vector joins another from head to head, a zero vector can't be formed.

Why don't moving objects keep moving forever?

Objects don't keep moving forever as there's almost always an unbalanced force acting upon them.

For example: A ball thrown upwards will eventually slow down and fall because of the force of gravity. A book sliding across a table slows down and stops because of the force of friction.



NEWTON'S SECOND LAW

Newton's Second Law of motion explains the effect of the net force on an object's motion.

This law states that the acceleration of an object is directly proportional to the net force acting on it and inversely proportional to an object's mass.

- **Acceleration is the result of unbalanced forces.**

  If an object is accelerating, it is being acted upon by a net force.

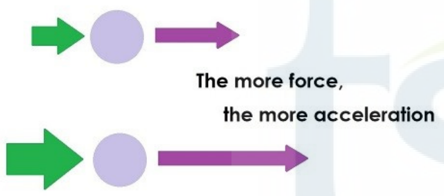
  If there is no acceleration, the net force must be zero. The object is either stationary or travelling at a constant velocity.

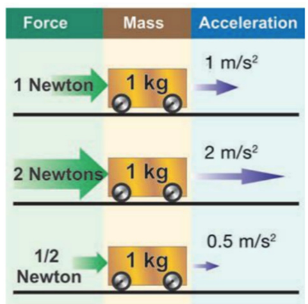
  Any time there is a change in speed or direction, there must be an unbalanced force acting. i.e. Unbalanced forces cause changes in speed, direction, or both

- **The acceleration of an object is directly proportional to the net force acting on it.**

  The greater the net force acting on an object, the greater the acceleration for a given force.

  When the force is increased or decreased, acceleration will be increased or decreased by the same factor.





  When an object experiences a constant net force, it will have a constant acceleration.

- **Acceleration is inversely proportional to mass.**

  Therefore, the greater the mass, the smaller the acceleration for a given force.

  For example: An object with twice the mass will have half the acceleration if the same force is applied. An object with half the mass will have twice the acceleration.

- **When a net force acts on an object,** $F_{net} = ma$ **or** $F_{net} \propto acceleration$

  While this is a neat and convenient relationship to know, Newton actually defined it a slightly different manner:

$$F_{net} \propto \frac{\Delta momentum}{time}$$

(We will revisit this later in the section on momentum)

- **Force can be viewed as an action capable of causing an object to accelerate.**

OUTCOMES OF A NET FORCE ACTING ON AN OBJECT

- A net force acting on an object at rest will cause it to move.
- A net force acting on an object in motion will cause it to speed up (to accelerate).
- A force acting on an object in motion will cause it to slow down (to decelerate) if it acts in a direction that opposes the object's motion (eg. when a force is applied in the opposite direction to motion).
- A net force acting perpendicular to an object's motion will cause the object to change direction.

OTHER IMPORTANT POINTS

- Velocity refers to both speed and direction.
- Acceleration means a change in velocity (either magnitude (speed), or direction or both).
- A constant acceleration means that the object's velocity is changing at a constant rate.

  For example: If the acceleration is parallel the direction of motion:

  - The speed of the object must change.

    The speed will increase if the acceleration is in the direction of motion.
    The speed will decrease if the acceleration is against the direction of motion.

  - The speed changes by the same amount in each time interval (e.g., second)

    If the speed changes by 3 metres per second each second, the acceleration is 3 metres per second or 2 m/s^2.

- **Mass** is the measure of **how much matter is in an object** and is measured in kilograms (kg).

  Mass is a quantity that is **solely dependent upon the inertia** of an object. The more inertia that an object has, the more mass it has and therefore, more force is needed to change this object's motion.

- Weight is a measurement of the **gravitational force** (force of gravity) on an object.

  As weight depends on an object's mass and its location, weight is a measure of force.

- **Mass and weight are not the same.**

  The **mass of an object stays the same**, irrespective of where it is. The **weight of an object, will however, change with location**, because of differences in how hard gravity at different sites will pull on act on an object.

  For example:

  A 40 kg mass on earth weighs 40 kg on Earth, but will weigh 8.16 kg on the moon, 99.80 kg on Jupiter and 0 kg on a space station. But the object's mass would stay the same at 40 kg at each location.

NEWTON'S THIRD LAW

Where Newton's first two laws apply to the motion of an individual object, his third law applies to pairs of objects.

All forces come in pairs as every action force creates a reaction force.

Some examples include:

- Forces of repulsion between two north magnetic poles.
- The force of gravity between you and the Earth.
- When the garden hose is turned on too hard it thrashes backwards.

> **Newton's third law states that:**
>
> ***"Every action force creates a reaction force that is equal in strength and opposite in direction."***

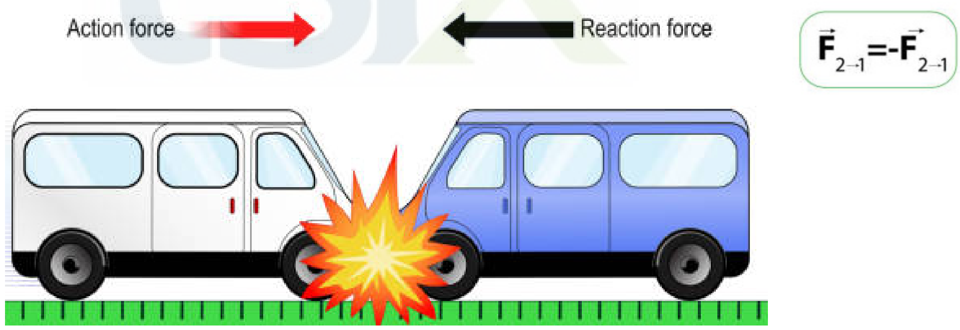
This is the most difficult of the three laws to understand:

If Object A pushes on Object B, then Object B will push back on Object A.

Newton's third law can also be expressed as:

'For every action, there is an equal and opposite reaction.'

Although two objects in contact exert equal and opposite forces on each other, the effect of the force is usually different due to differences in each object's mass.



As an example, a collision between two cars travelling at the same speed towards each other will result in the same force being exerted on each car during the collision. If one car is twice the mass of the other, it would experience a smaller change in velocity and much more slowly than the lighter car, as objects with greater mass have more inertia and require more force to change an object's motion.

In summary:

The force on each car during a collision is the same strength, but the cars have different changes in motion as they have different amounts of inertia, not because the forces are different.

Not only will there be differences in the effects on the motion of two objects of different mass when they collide, the degree of damage sustained is also directly proportional to an object's mass.

IMPORTANT PROPERTIES OF ACTION & REACTION FORCES

- Both action and reaction forces are always present whenever any force appears.
- Both forces can cause changes in motion.
- Action and reaction forces always have the exact same strength (they are equal in magnitude).
- They always act in opposite directions.
- They always act on different objects (i.e. one force acts on Object A, the other force acts on Object B).
- Although action and reaction forces always have the exact same strength, they don't always cancel each other out.

  Forces can only cancel out when they act on the same object.

  When the objects are different, such as when a ball is thrown through the air (one object is the hand, the other is the ball), the action force is applied to the ball (by the hand, resulting in the ball's acceleration), however, the reaction is the ball pushing back against your hand. The action force is acting on the ball and the reaction force is acting on your hand and can't cancel each other out.

With a book sitting on a bench, is the weight force and the normal force an action/reaction pair?

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QUESTION 29

(a) What action/reaction pairs of forces do you think are involved in walking?

(b) What is the direction of the frictional force between the shoe and the ground when walking in a northerly direction?

(c) A 1 kg trolley, which is initially at rest, is acted on by a force of 20 N. Calculate the distance that it will move in a time of 2 s.

QUESTION 30

(a) A car with mass 1400 kg has an engine that produces a force of 2300 N. Calculate its acceleration (assume friction/air resistance is negligible).

(b) What force is required to accelerate a 450 kg satellite at 3.4 ms^{-2}?

(c) A ball experiences a force of 390 N, and accelerates at 0.02 ms^{-2}. Calculate its mass.

(d) A toy rocket (mass 3kg) is given an upward thrust of 20N. Describe what will happen. The thrust is now increased to 60 N. Calculate what will happen.