Thermal Physics

Potential energy	The energy the particles of a substance have due to stretching of the bonds between them.
(Particle) kinetic energy	The energy the particles of a substance have due to their motion.
Internal energy	The sum of the potential and kinetic energy of the particles in a substance.
Temperature	Measure of average kinetic energy of the particles in a substance>
Absolute zero	Coldest temperature that can theoretically exist. Particles have zero kinetic energy. 0 K or -273(.15) °C
Thermal equilibrium	A state in which two objects are at the same temperature; the net flow of energy between them is zero.
Heat	Flow of energy from a substance at a higher temperature to a substance at lower temperature until thermal equilibrium is reached.
Specific heat capacity	The energy change required to change the temperature of 1 kg of a substance by 1 K.
- water high specific heat capacity	Amongst solids and liquids water has a notably high specific heat capacity. This means that large changes in energy are needed for small changes in temperature.
Latent heat	The energy change required to change 1 kg of a substance from one state to another. The energy absorbed/released by a substance as it changes states.
Conduction	Transfer of energy through matter by passing energy from particle to particle by collisions, dominant energy transfer method in solids. Very weak in gases, very strong in metals.
Convection	Transfer of energy through matter by particles carrying energy, dominant energy transfer method in fluids.
- *free convection*	convection where the particle movement occurs naturally due to density/pressure gradients in the fluid e.g. hot air rising
- *forced convection*	convection where the particle movement occurs due to an artificial driver e.g. fan-driven computer cooling
Radiation	Transfer of energy by emitted electromagnetic radiation, dominant energy transfer method in a vacuum.
-promoting radiation	Rough (high surface area), black surfaces are the best at absorbing and emitting radiation.
-minimising radiation	Smooth (low surface area), white/silver surfaces are the worst at absorbing and emitting radiation.

-minimising conduction/convection	Insulation typically traps pockets of air. As a gas, the air is a very poor conductor and since it is trapped it cannot convect. E.g. jumper, ceiling batts, fur.
Conservation of energy	The total energy in a system cannot change, it can be transferred between objects and transformed into different forms.
Change of state (melting, boiling, subliming)	At a specific temperature, the substance does not gain kinetic energy, so temperature remains constant, it only gains potential energy as the bonds between particles are stretched and then broken as it changes states.
Change of state (freezing, condensing, depositing)	At a specific temperature, the substance does not lose kinetic energy, so temperature remains constant, it only loses potential energy as new bonds form between particles as it changes states.
Thermal expansion	As matter gains potential energy the particles stretch further apart, causing the substance to expand.
Thermal contraction	As matter loses potential energy the particles relax closer together, causing the substance to contract.

Electrical Physics

Charge	Fundamental property of some matter. Like charges repel, opposite charges attract.
Neutral	Object with equal amounts of positive and negative charge. Low energy, stable state.
Separation of charge	If negative charges are separated from positive charges, both gain electrostatic potential energy, unstable state.
Voltage/ potential difference	Change in potential energy for charged particles between two points.
Static electricity	Stationary build-up of positive or negative charge. Stores large amount of electrostatic potential energy, unstable state.
Electromotive force	Increase in potential energy for charged particles between two points.
Potential drop	Decrease in potential energy for charged particles between two points.
Volts	Units for voltage, potential difference, electromotive force, potential drop. $1 \text{ V} = 1 \text{ J C}^{-1}$
Current electricity	Flow of charged particles from high electrostatic potential energy to low electrostatic potential energy. E.g. electrons flowing towards lone protons.
Current	Rate of flow of charge.
Amperes (Amps)	Units for current. $1 \text{ A} = 1 \text{ C s}^{-1}$
Resistance	Measure of how difficult it is for current to pass through a substance.
- decreasing resistance	Lower temperature, increase diameter of wire, decrease length of wire, change material e.g. Au<Cu<Fe.
Ohms	Units for resistance. $1\ \Omega = 1 \text{ V A}^{-1}$
Power	The rate that a circuit component transfers or transforms energy.
Watts	Units for power. $1 \text{ W} = 1 \text{ J s}^{-1}$
Series circuits	Circuits (or parts of a circuit) with only 1 path for current to flow through.
- voltage in series	Each component in series add to/takes from the total voltage for the circuit.
- current in series	Current is constant in series.
- resistance in series	Each component in series adds to the total resistance for the circuit.
Parallel circuits	Circuits (or parts of a circuit) with 2 or more paths for current to

	flow through.
- voltage in parallel	Each parallel path receives the total voltage for the circuit.
- current in parallel	Each parallel path allows more current to flow, adding to the total current for the circuit.
- resistance in parallel	Each parallel path decreases the total resistance for the circuit.
Advantages of parallel over series	Each device can be turned on/off independently, if one breaks the others continue functioning. Each device receives the full voltage from the power supply.
Disadvantage of parallel	Each additional parallel path increases total current, can eventually lead to dangerous levels of current.
Dangers of current electricity	Large current cause heating in wires which can start fires. Exposure to high voltage wires can allow current to flow through humans to the ground causing burns, stopping the heart and creating toxins in the body.
Direct current (DC)	Current electricity in which the direction of current remains constant.
Alternating current (AC)	Current electricity in which the direction rapidly oscillates.
Mains power in Australia	Alternating current in Australia changes direction with a frequency of 50 Hz.
Electron flow	The direction that negatively charged particles move in a circuit (negative to positive).
Conventional current	The direction that positively charged particles move in a circuit (positive to negative).
Short circuit	If the load in a circuit is bypassed the resistance will be too low, leading to dangerously high currents.
Fuse	Function as normal part of active wire during normal operation. If current becomes too high (e.g. short circuit) it rapidly breaks, cutting the circuit, preventing a fire.
Circuit breaker	If current in active wire becomes too high (e.g. short circuit) it rapidly turns off the circuit using an electromagnet, preventing a fire.
Residual current device	Compares current in active and neutral wires, if there is a difference (e.g. accidental grounding) it rapidly turns off the circuit using an electromagnet, preventing electrocution.
Double insulation	Device where there is no way for active wire to come in contact with case of device, no need for Earth wire.
Active wire	Supplies 240 V, 50 Hz AC voltage, part of the circuit.

Neutral wire	Completes circuit, grounded.
Earth wire	Not part of the circuit, connects metal case of device to ground to prevent electrocution.

Nuclear Physics

Atom	Particle made of protons, (neutrons) and electrons.
Element	Type of atom with a specific number of protons.
Nucleus	Core of an atom, consisting of protons and neutrons held together by the strong force.
Nucleon	Particle in the nucleus i.e. protons and neutrons.
Proton	Particle with 1 mass and 1 charge.
Neutron	Particle with 1 mass and 0 charge.
Electron	Particle with approximately 0 mass and -1 charge.
Atomic number	Z, number of protons in the nucleus of a specific atom.
Mass number	A, number of nucleons in the nucleus of a specific atom.
Isotope	Type of atom, with specific numbers of protons and neutrons. Isotopes of an element have the same chemical properties due to having the same number of protons but have different physical properties due to differing numbers of neutrons.
Nuclide	Specific nucleus, with certain numbers of protons and neutrons.
Nuclear reaction	Any process causing changes to a nucleus. Mass number and charge must be conserved.
Stable nuclide	Specific nucleus that will remain the same indefinitely. Strong force is enough to overcome electrostatic repulsion between protons. For light elements ($Z<21$), require 1:1 ratio of protons to neutrons. For medium elements, require slightly more neutrons than protons. Heavy elements ($Z>82$) cannot be stable – size of nucleus is too great for the very short ranged strong force to hold it together.
Stable isotope	Specific atom with a nucleus that will remain the same indefinitely.
Unstable nuclide	Specific nucleus that will spontaneously change to become more stable.
Radioisotope/unstable isotope	Specific atom with a nucleus that will spontaneously change to become more stable.
Radioactive	Material containing unstable nuclei.
Nuclear decay	Emission of particles (or energy) from a nucleus to become more stable.
Activity	Number of decay events per second for a radioactive substance.
Half-life	Measure of exponential decay rate for a nuclide. Time for

	half of the remaining particles to decay.
Transmutation	Changing of one nuclide into another through nuclear decay.
Daughter nuclide/isotope	Product nucleus of nuclear decay.
Decay series	A sequence of nuclear decays through multiple unstable nuclides to an eventual stable nuclide.
Nuclear radiation	Particle or energy emitted from a nucleus.
Alpha decay	Emission of an alpha particle from a nucleus that is too large to be stable.
Beta (minus) decay	Emission of a beta (minus) particle from a nucleus that has too many neutrons as a neutron becomes a proton.
Beta plus decay	Emission of a beta plus particle from a nucleus that has too few neutrons as a proton becomes a neutron.
Gamma decay	Emission of a gamma ray from a nucleus that has too much energy to be stable. Commonly occurs after an alpha or beta decay.
Ionising radiation	Radiation capable of adding electron to or removing electrons from atoms, turning them into ions. Alpha, beta and gamma radiation.
Alpha particle/radiation	He-4 nucleus (2 protons, 2 neutrons). 2+ charge, travels at 0.1c, highly ionizing, weakly penetrating.
Beta (minus) particle/radiation	Electron. -1 charge, travels at 0.9c, moderately ionizing, moderately penetrating.
Beta plus particle/radiation	Antielectron/positron. +1 charge, travels at 0.9c, moderately ionizing, moderately penetrating. If it collides with an electron they will mutually annihilate emitting gamma radiation.
Gamma ray/radiation	High energy photon of light. 0 charge, travels at c, weakly ionizing, highly penetrating.
Neutron radiation	Neutron. Not ionizing but can be absorbed by a nucleus, potentially transforming it into an unstable nuclide.
Mass defect	The difference in mass between a number of free nucleons and that many nucleons as a nucleus. Mass of the binding energy.
Binding energy	The energy lost by free nucleons in order to bond together as a nucleus. The energy required to separate all the nucleons in a nucleus into free particles.
Binding energy per nucleon	The average energy lost by each nucleon in a nucleus. Measure of stability of the nucleus. Higher binding energy

	per nucleon – more stable nuclide. Peaks at Fe-56.
(Nuclear) fusion	Joining of light nuclei to form heavier nuclei. Releases energy if the binding energy per nucleon increases, i.e. if moving towards Fe-56.
Fusion reactor	Machine maintain stable fusion reaction to generate heat to generate electricity. Requires enormous temperatures and pressures to cause collisions between nuclei, overcoming the electrostatic repulsion. Currently consumes more energy than is produced – developing technology.
(Nuclear) fission	Splitting of heavy nuclei into multiple lighter nuclei (and free neutrons). Releases energy if the binding energy per nucleon increases, i.e. if moving towards Fe-56. Can be spontaneous or triggered by absorption of free neutron.
Fissile	Nuclides that will readily undergo fission reactions.
Fission reactor	Machine maintaining stable fission reaction, typically to generate heat to generate electricity. Relies on stable chain reaction, fission can be triggered by neutrons and it emits neutrons.
- fuel rods	Fuel must be enriched to contain a higher proportion of fissile material.
- control rods	Material that absorbs free neutrons to control reaction rate in reactor. Control rods inserted if reaction rate too high.
- moderator	Slows neutrons so that they can be more easily absorbed by nuclei to trigger further fission reactions.
- shielding	Fission reaction and radioactive fission products emit radiation dangerous to workers. Reaction chamber must be shielded by metres of lead and concrete to absorb radiation, protecting plant workers.
- waste	Fuel lasts a long time but produces waste that remains radioactive for extremely long timespans – must be stored safely.
Critical mass	The minimum mass of fuel required to sustain a fission chain reaction. Shape dependent, sphere is most efficient.
Absorbed dose	Measure of amount of radiation exposure, based on energy of radiation and mass of target.
Dose equivalent	Measure of amount of radiation exposure, based on absorbed dose and type of radiation.
Stochastic effects	Small doses of radiation have mild and random effects, nausea, burns, hair loss, anemia, increased risk of future

	cancer, increased risk of birth defects in future offspring.
Deterministic effects	Large doses of radiation have extreme and definite effects, burns, hair loss, sterility, cataracts, death.

Motion

Scalar	Quantity described fully by a magnitude.
Vector	Quantity described by both a magnitude and a direction.
Resultant	Sum of vectors of the same type, e.g. net force
Distance	Length of space travelled, scalar.
Displacement	Shortest length of space between two points, vector. Interchangeable with distance for motion in one direction.
Speed	Rate of change of distance, scalar.
Velocity	Rate of change of displacement, vector. Interchangeable with speed for motion in one direction.
Instantaneous speed/velocity	Rate of change of position in space at one instant in time, difficult to measure.
Average speed/velocity	Average rate of change of position in space over a whole journey, simple to measure.
Acceleration	Rate of change of velocity, vector.
Gravitational acceleration	All objects in a gravitational field accelerate towards the center of mass of the field at the same rate.
Vertical motion	velocity at the peak is zero, time up equals time down if distance up equals distance down.
Mass	Measure of amount of matter an object is made of.
Force	Push or pull, vector.
Free body diagram	Diagram showing all forces acting on an object as arrows from centre of mass.
Weight	Force exerted on an object because of its mass experiencing a gravitational acceleration. Force exerted by an object on an object below it.
Normal	Reaction force against weight, acts on an object resting on another object. Acts perpendicular to the surface.
Friction	Force acting against motion.
Thrust	Forwards force acting on a vehicle or launching (but not launched) projectile.
Lift	Upwards force acting on an aircraft.
Buoyancy	Vertical force acting on object due to density contrast.
Momentum	Abstract vector quantity that is conserved in all interactions.
Vector component	Forces can be broken into parts acting in different directions, typically used to consider horizontal and vertical effects of a force separately.
Conservation of momentum	Total momentum before an interaction must equal total momentum after an interaction for any system.

Impulse	Change in momentum.
- collision safety	For any given collision the impulse is fixed, so increasing the time it takes for an object to come to a stop reduces the average force it experiences. Crumple zones, airbags, padding, bending knees.
Energy	Abstract scalar quantity that is conserved in all interactions. Can be though of as measure of capacity to cause change.
Conservation of energy	Total energy before an interaction must equal total energy after an interaction, however it can change from one form to another.
Kinetic energy	Form of energy associated with moving mass.
Gravitational potential energy	Form of energy associated with mass raised against a gravitational field.
Work	Change in energy, quantity of energy transferred or transformed.
Power	Rate of work, rate of change of energy.
Elastic collision	Collision in which kinetic energy is conserved.
Inelastic collision	Collision in which kinetic energy is not conserved, some of the kinetic energy becomes other forms, typically sound and particle kinetic energy.
Efficiency	Percentage of input energy transformed to desired output energy in an energy transformation.
Newton's 1st law	Objects will maintain constant velocity unless they experience a net force greater than zero.
Inertia	The tendency of matter to maintain constant velocity. Proportional to mass.
- collision safety	In a sudden stop, body will attempt to keep moving due to inertia. Seatbelt provide unbalanced force to restrain body and keep passenger in vehicle. In a sudden start, body pushed forwards by seat while head attempts to remain stationary due to inertia, causes neck injuries as head whips back relative to body. Headrest provides unbalanced force to push head forward with body preventing injuries.
Newton's 2nd law	Objects that experience a net force greater than zero will accelerate in the direction of the net force, proportional to the force and inversely proportional to the mass of the object.
Balanced forces	If the net force on an object is zero, the forces acting on it are said to be balanced.
Unbalanced forces	If the net force on an object is non-zero, the forces acting on it are said to be unbalanced.
Newton's 3rd law	If one object exerts a force on another, the second object will exert a reaction force of the same size on the first object in the exact

	opposite direction.
Ticker timers	Device for measuring motion. 50 dots made on tape each second.
Displacement-time graph	Gradient=velocity, horizontal lines=stationary
Velocity-time graph	Gradient=acceleration, area under curve=displacement, horizontal lines=constant velocity
Acceleration-time graph	Area under curve=Δv, all horizontal lines (at our level)

Waves

Oscillation	Repeating variation of a quantity (e.g. displacement, pressure, density electric field strength, magnetic field strength) about a mean value. Often a repeated transformation between potential and kinetic energy.
Propagation	Movement of a wave.
Wave	A travelling oscillation that carries energy without carrying matter.
Transverse wave	A wave in which the direction of oscillation is perpendicular to the direction of propagation, e.g. light.
Longitudinal wave	A wave in which the direction of oscillation is parallel to the direction of propagation, e.g. sound.
Mechanical wave	A wave that require matter to propagate through, e.g. sound.
Medium	The substance that a wave is propagating through.
Electromagnetic wave	A wave that self-propagates, not requiring a medium, e.g. light.
Period	The time for one complete oscillation of a wave. Inverse of frequency.
Frequency	The number of complete oscillation in one second. Inverse of period.
Pitch	Human perception of frequency in sound, high pitch is high frequency.
Wavelength	Length of one complete oscillation at one point in time.
Colour	Human perception of frequency/wavelength in light, red end of the rainbow (ROYGBIV) is lower frequency, longer wavelength.
Amplitude	Magnitude of variation of the oscillating quantity (particle displacement, pressure, density, electric field strength, magnetic field strength).
Intensity	Energy density of a wave at a point in space, related to amplitude. Inversely proportional to the square of the distance from the wavesource.
Loudness	Human perception of amplitude of sound.
Brightness	Human perception of amplitude of light.
Medium boundary	When a wave strikes a boundary between media the wave will be transmitted, reflected and absorbed. The greater the difference in wavespeeds in the two media, the larger the percentage of energy that will be

	reflected. The rougher and more flexilble the boundary, the larger the percentage of energy that will be absorbed.
Reflection	A wave bouncing off a boundary. Changing direction but not anything else.
Normal	Imaginary line perpendicular to a boundary between media.
Ray	Arrow showing direction of propagation of wave.
Wavefront	Lines in 2D showing parts of wave that are in phase.
Incident ray	Ray striking the boundary.
Reflected ray	Ray reflected from boundary.
Angle of incidence	Angle between incident ray and the normal.
Angle of reflection	Angle between reflected ray and the normal.
Law of reflection	The angle of reflection is equal to the angle of incidence.
Echo	If a reflection of a sound wave reaches an observer 0.1 s after the original sound wave was observed, it will be heard as a distinct sound, an echo.
Ultrasound	Sound too high frequency for humans to hear >20 kHz.
Infrasound	Sound too low frequency for humans to hear <20 Hz.
Echolocation/ultrasound imaging/seismic imaging	Sound waves can be used to form an image by measuring time for reflected waves to return and calculating distance. Multiple layers in an object will produce multiple reflections, more distant boundaries will have longer times. Used by bats/dolphins to 'see', used in medical imaging and geophysics. Wavelength of wave used should be roughly the same as scale of detail needed in image.
Transmission	Transfer of wave from one medium to another at a boundary, wavelength will change if there is a difference in wavespeeds in the two media, but frequency will be unchanged.
Wavespeed (mechanical)	Speed of mechanical waves is greatest in rigid, hot substances. E.g. $v_{steel}>v_{water}>v_{air}$, $v_{hot\ air}>v_{cold\ air}$.
Wavespeed (electromagnetic wave)	Speed of electromagnetic waves is greatest in vacuum, decreases with increasing (optical) density of medium. E.g. $v_{vacuum}>v_{air}>v_{water}>v_{glass}$.
Refraction	Change in direction of a transmitted wave when it strikes at an angle of incidence greater than 0. If the wave speeds up it bends away from the normal, if it slows down, it bends towards the normal.

Critical angle	Angle of incidence at which the transmitted ray would be refracted to pass along the boundary.
Total internal reflection	At angles of incidence greater than the critical angle (if passing from slow medium to fast medium), there will be literally no transmission, all of the wave will be reflected.
Refraction through a gradient	Change in direction of a wave as it passes through a speed gradient. It bends towards slow end of gradient.
Absorption	Conversion of the wave energy to other forms, typically random particle kinetic energy (heat).
Superposition/ Interference	When two waves are in the same place at the same time, the result is the vector sum of both waves.
In phase	Points in waves that are in the same stage of an oscillation. E.g. two peaks.
Out of phase	Points in waves that are in different stages of an oscillation. E.g. a peak and a trough.
Constructive interference	When two in phase waves interfere, the result is increased amplitude.
Destructive interference	When two out of phase waves interfere, the result is decreased amplitude. If the two waves are exactly the same amplitude and are exactly half a wavelength out of phase, the cancel to zero amplitude.
Persistent interference in 2D	If two separate speakers play the same frequency at similar amplitudes, they will interfere creating persistent zones of constructive and destructive interference.
Standing wave	If a wave interferes with an identical wave travelling in the opposite direction (often its own reflection), it will create a standing wave, a wave that appears not to move.
- displacement node	Points in a standing wave where there is no particle movement. Always half a wavelength apart.
- displacement antinode	Points in a standing wave where there is maximum particle movement. Always half a wavelength apart.
- pressure node	Points in a longitudinal standing wave where there is no variation in pressure. Always half a wavelength apart.
- pressure antinode	Points in a longitudinal standing wave where there is maximum variation in pressure. Always half a wavelength apart.
- strings	Displacement nodes at each end.

- open pipes	Displacement antinodes/pressure nodes at each end.
- closed pipes	Displacement node/pressure antinode at closed end, displacement antinode/pressure node at open end.
Harmonic/resonant frequencies	Frequencies that an object is efficient at vibrating at. Determined by objects physical properties. When disturbed, an object will naturally vibrate at a resonant frequency.
- harmonics in strings/open pipes	In strings and open pipes the frequency of each harmonic is an integer multiple of the fundamental frequency. Each relates to a standing wave in the string/pipe.
- harmonics in closed pipes	In closed pipes the frequency of each harmonic is an odd integer multiple of the fundamental frequency. Each relates to a standing wave in the pipe.
Resonance	When driven to vibrate at a resonant frequency an object will vibrate with increasing amplitude.
Forced vibrations	A vibrating object touching another object can force the second object to vibrate at the same frequency even if it is not a resonant frequency.
Noise	Unwanted sound is noise. Persistent noise can cause psychological and physiological damage.
Noise management	Ensure vibrating objects are rigidly fixed in place, e.g. welded rather than bolted. Include soft furnishings (e.g. carpet, curtains) in rooms to increase absorption of sound. Noise-cancelling headphones can use interference to locally cancel out noise.