



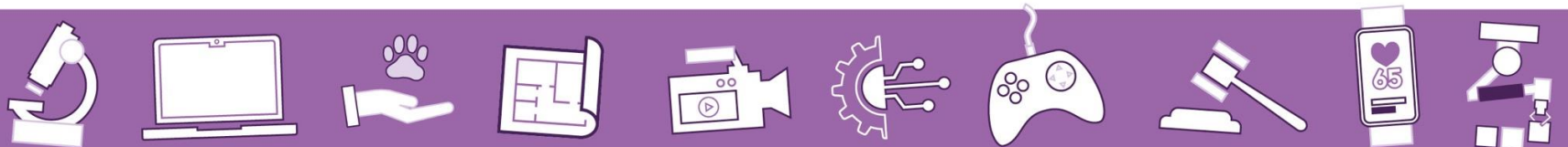
## 5 Essential science for engineering and manufacturing

Criteria	Range	Resource identified
5.1 Units of measurement used in engineering.	SI units: Metre (m), kilogram (kg), second (s), newton (N), metre cubed (m <sup>3</sup> ), metre per second (m s <sup>-1</sup> ), metre per second squared (m s <sup>-2</sup> ), newton metre (N m), Pascal (Pa or N m <sup>-2</sup> ), mass per unit volume (kg m <sup>-3</sup> ), unit multiples and submultiples (tera, giga, mega, kilo, milli, micro, nano, pico). Imperial units: Foot (ft), inches (in), yard (yd), ounce (oz), gallon (gal)	<a href="https://en.wikipedia.org/wiki/International_System_of_Units">https://en.wikipedia.org/wiki/International_System_of_Units</a> <a href="https://byjus.com/physics/si-units-list/">https://byjus.com/physics/si-units-list/</a> <a href="https://www.nist.gov/pml/weights-and-measures/metric-si/si-units">https://www.nist.gov/pml/weights-and-measures/metric-si/si-units</a>





<p>5.2 Vector and coordinate measuring systems.</p>	<p>Vectors and scalar quantities (distance, displacement, speed, velocity, acceleration), polar coordinates, Cartesian coordinates</p>	<p><a href="https://courses.lumenlearning.com/physics/chapter/2-2-vectors-scalars-and-coordinate-systems/">https://courses.lumenlearning.com/physics/chapter/2-2-vectors-scalars-and-coordinate-systems/</a>  <a href="https://www.bbc.co.uk/bitesize/guides/z2b9hv4/revision/6">https://www.bbc.co.uk/bitesize/guides/z2b9hv4/revision/6</a>  <a href="https://www.mathsisfun.com/algebra/scalar-vector-matrix.html">https://www.mathsisfun.com/algebra/scalar-vector-matrix.html</a></p>
<p>5.3 Scientific methods and approaches to scientific inquiry and research.</p>	<p>Concept of the scientific method (observation, questioning, making a hypothesis, prediction / simulation, testing, conclusion, iteration)</p>	<p><a href="https://en.wikipedia.org/wiki/Scientific_method">https://en.wikipedia.org/wiki/Scientific_method</a>  <a href="https://www.sciencemadesimple.com/scientific_method.html">https://www.sciencemadesimple.com/scientific_method.html</a>  <a href="https://www.khanacademy.org/science/biology/intro-to-biology/science-of-biology/a/the-science-of-biology">https://www.khanacademy.org/science/biology/intro-to-biology/science-of-biology/a/the-science-of-biology</a></p>
	<p>How to analyse, evaluate, synthesise and apply information, data, research findings, deliberation, and the processes, results and outcomes of testing, modelling and experimenting (accuracy, reliability, precision and replication)</p>	<p><a href="https://www.ncbi.nlm.nih.gov/books/NBK547523/">https://www.ncbi.nlm.nih.gov/books/NBK547523/</a>  <a href="https://www.nap.edu/read/10236/chapter/5#58">https://www.nap.edu/read/10236/chapter/5#58</a></p>



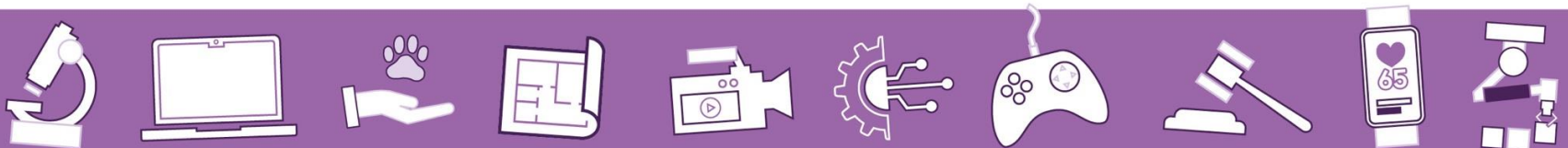


5.4 Measurement equipment, techniques and principles	Equipment – Rule, callipers (digital Vernier), micrometers (inside, outside, depth), gauges (angle, slip, go/no-go), dial test indicator (DTI), coordinate measuring machines (CMM)	<a href="https://gaugehow.com/2019/10/08/30-measuring-instruments-for-mechanical-engineer/">https://gaugehow.com/2019/10/08/30-measuring-instruments-for-mechanical-engineer/</a> <a href="https://www.youtube.com/watch?v=lou9kAFGOjk">https://www.youtube.com/watch?v=lou9kAFGOjk</a> <a href="https://www.mitutoyo.co.uk/">https://www.mitutoyo.co.uk/</a> <a href="https://www.engineersupply.com/measuring-tools.aspx">https://www.engineersupply.com/measuring-tools.aspx</a>
	Principles – Precision, accuracy, uncertainty, resolution, calibration, tolerance	<a href="https://www.omsmeasure.com/blog/accuracy-tolerance-uncertainty-primer">https://www.omsmeasure.com/blog/accuracy-tolerance-uncertainty-primer</a> <a href="https://www.mccdaq.com/TechTips/TechTip-1.aspx">https://www.mccdaq.com/TechTips/TechTip-1.aspx</a> <a href="https://instrumentationtools.com/difference-between-accuracy-tolerance-uncertainty-and-error/">https://instrumentationtools.com/difference-between-accuracy-tolerance-uncertainty-and-error/</a>
5.5 Chemical composition and behaviours.	Chemical composition – Atomic structure (atom, nucleus, electron, proton, neutron, valence, valence shell, ion, element, molecule),	<a href="https://www.bbc.co.uk/bitesize/guides/z9sdmp3/revision/1">https://www.bbc.co.uk/bitesize/guides/z9sdmp3/revision/1</a> <a href="https://courses.lumenlearning.com/boundless-chemistry/chapter/the-structure-of-the-atom/">https://courses.lumenlearning.com/boundless-chemistry/chapter/the-structure-of-the-atom/</a> <a href="https://www.youtube.com/watch?v=cpBb2bgFO6I">https://www.youtube.com/watch?v=cpBb2bgFO6I</a> <a href="https://manoa.hawaii.edu/exploringourfluidearth/chemical/chemistry-and-seawater/atoms-and-molecules">https://manoa.hawaii.edu/exploringourfluidearth/chemical/chemistry-and-seawater/atoms-and-molecules</a>
	Chemical composition – chemical structure (solutions, suspensions, solubility, compound and mixture), periodic table	<a href="https://www.youtube.com/watch?v=FbaXQ8u6IP8">https://www.youtube.com/watch?v=FbaXQ8u6IP8</a> <a href="https://en.wikipedia.org/wiki/Chemical_structure">https://en.wikipedia.org/wiki/Chemical_structure</a> <a href="https://www.rsc.org/periodic-table/?gclid=CjwKCAjw2bmLBhBREiwAZ6ugoy7S55Z8H4Xzj8rd2Mi-WbGfH86m9KTkBsteHf-l6QRZXo-XX2BrXoCUUwQAvD_BwE">https://www.rsc.org/periodic-table/?gclid=CjwKCAjw2bmLBhBREiwAZ6ugoy7S55Z8H4Xzj8rd2Mi-WbGfH86m9KTkBsteHf-l6QRZXo-XX2BrXoCUUwQAvD_BwE</a> <a href="https://en.wikipedia.org/wiki/Periodic_table">https://en.wikipedia.org/wiki/Periodic_table</a>



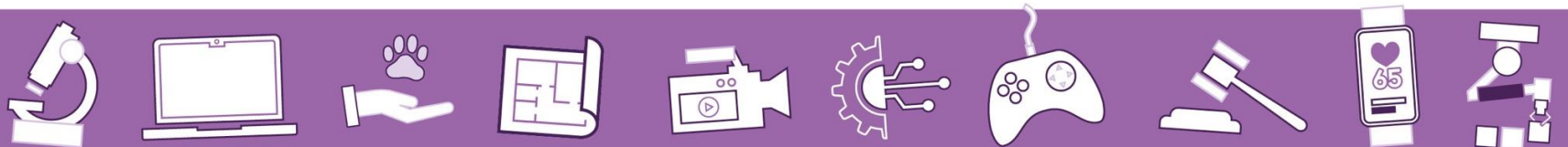


	<p>Behaviours – Chemicals in electricity (cells (simple, primary and secondary), capacity, internal resistance), electrolysis (anode, cathode, electrolyte, anion, cation, dissociation, plating, galvanic protection), reactions of metals and alloys with weak and strong acids and alkalis</p>	<p><a href="https://edu.rsc.org/resources/electricity-from-chemicals/392.article">https://edu.rsc.org/resources/electricity-from-chemicals/392.article</a>  <a href="https://en.wikipedia.org/wiki/Electrochemistry">https://en.wikipedia.org/wiki/Electrochemistry</a>  <a href="https://socratic.org/questions/what-are-some-examples-of-electrochemical-processes">https://socratic.org/questions/what-are-some-examples-of-electrochemical-processes</a>  <a href="https://intl.siyavula.com/read/science/grade-12/electrochemical-reactions/13-electrochemical-reactions-07">https://intl.siyavula.com/read/science/grade-12/electrochemical-reactions/13-electrochemical-reactions-07</a></p>
<p>5.6 Forces and motion in engineering.</p>	<p>Forces and motion – Types of motion (rotary, linear, reciprocating, oscillating), pressure, vector representation of forces, balanced and unbalanced forces, moments about a force, torque, conditions for equilibrium, coplanar forces</p>	<p><a href="https://engineeringlibrary.org/reference/force-and-motion-doe-handbook">https://engineeringlibrary.org/reference/force-and-motion-doe-handbook</a>  <a href="https://en.wikipedia.org/wiki/Force">https://en.wikipedia.org/wiki/Force</a>  <a href="https://www.drfrostmaths.com/resource.php?rid=343">https://www.drfrostmaths.com/resource.php?rid=343</a>  <a href="https://www.youtube.com/watch?v=2eNOIXC4UMs">https://www.youtube.com/watch?v=2eNOIXC4UMs</a>  <a href="https://www.alevelphysicsonline.com/forces">https://www.alevelphysicsonline.com/forces</a></p>





<p>5.7 Fluid dynamics in engineering.</p>	<p>Fluid dynamics – Hydrostatic pressure (<math>p = \rho g h</math>), hydrostatic thrust on an immersed plane surface (<math>F = \rho g A x</math>), viscosity,</p>	<p><a href="https://www.sciencedirect.com/topics/engineering/fluid-mechanics">https://www.sciencedirect.com/topics/engineering/fluid-mechanics</a>  <a href="https://engineering.fandom.com/wiki/Fluid_dynamics">https://engineering.fandom.com/wiki/Fluid_dynamics</a>  <a href="https://en.wikipedia.org/wiki/Fluid_dynamics">https://en.wikipedia.org/wiki/Fluid_dynamics</a>  <a href="https://www.youtube.com/watch?v=SNZSQLu4tZQ">https://www.youtube.com/watch?v=SNZSQLu4tZQ</a>  <a href="https://www.youtube.com/watch?v=zA4g9oVur88">https://www.youtube.com/watch?v=zA4g9oVur88</a>  <a href="https://www.khanacademy.org/science/physics/fluids">https://www.khanacademy.org/science/physics/fluids</a>  <a href="https://www.youtube.com/watch?v=Eo0sGKYDz-o">https://www.youtube.com/watch?v=Eo0sGKYDz-o</a></p>
	<p>Bernoulli's principle</p>	<p><a href="https://www.youtube.com/watch?v=DW4ritB20h4">https://www.youtube.com/watch?v=DW4ritB20h4</a>  <a href="https://www.youtube.com/watch?v=UJ3-Zm1wbIQ">https://www.youtube.com/watch?v=UJ3-Zm1wbIQ</a>  <a href="https://en.wikipedia.org/wiki/Bernoulli%27s_principle">https://en.wikipedia.org/wiki/Bernoulli%27s_principle</a></p>
	<p>flow characteristics around a two-dimensional shape (laminar, turbulent, vortices, separation points)</p>	<p><a href="https://www.ldeo.columbia.edu/~martins/hydro/lectures/fluid_dynamics.html">https://www.ldeo.columbia.edu/~martins/hydro/lectures/fluid_dynamics.html</a>  <a href="https://www.youtube.com/watch?v=9A-uUG0WR0w">https://www.youtube.com/watch?v=9A-uUG0WR0w</a>  <a href="https://www.tec-science.com/mechanics/gases-and-liquids/flow-separation-boundary-layer-separation/">https://www.tec-science.com/mechanics/gases-and-liquids/flow-separation-boundary-layer-separation/</a></p>
	<p>principles of aerodynamics (drag, thrust, lift)</p>	<p><a href="https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-aerodynamics-k4.html">https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-aerodynamics-k4.html</a>  <a href="https://en.wikipedia.org/wiki/Aerodynamics">https://en.wikipedia.org/wiki/Aerodynamics</a>  <a href="https://www.youtube.com/watch?v=ZFEzMKYjShc">https://www.youtube.com/watch?v=ZFEzMKYjShc</a></p>







<p>5.8 Thermodynamics in engineering.</p>	<p>Thermodynamics – Heat transfer mechanisms (conduction, convection, radiation), systems (open, closed, temperature, pressure, volume), sensible heat, latent heat of fusion, latent heat of vaporisation, expansivity, coefficient of heat, equations (absolute temperature, absolute pressure, volume, mass, density, Boyle’s law (<math>pV = \text{constant}</math>), Charles’ law (<math>V/T = \text{constant}</math>), general gas equation (<math>pV/T = \text{constant}</math>), characteristic gas equation (<math>pV = mRT</math>))</p>	<p><a href="https://www.accessscience.com/content/thermodynamic-principles/690700">https://www.accessscience.com/content/thermodynamic-principles/690700</a>  <a href="https://en.wikipedia.org/wiki/Laws_of_thermodynamics">https://en.wikipedia.org/wiki/Laws_of_thermodynamics</a>  <a href="https://www.youtube.com/watch?v=7O2XIdi1ZWw">https://www.youtube.com/watch?v=7O2XIdi1ZWw</a>  <a href="https://www.youtube.com/watch?v=F07SJRTzb0Q">https://www.youtube.com/watch?v=F07SJRTzb0Q</a>  <a href="https://www.grc.nasa.gov/www/k-12/airplane/boyle.html">https://www.grc.nasa.gov/www/k-12/airplane/boyle.html</a>  <a href="https://www.khanacademy.org/science/in-in-class11th-physics/in-in-phy-kinetic-theory/in-in-phy-ideal-gas-laws/v/boyles-law">https://www.khanacademy.org/science/in-in-class11th-physics/in-in-phy-kinetic-theory/in-in-phy-ideal-gas-laws/v/boyles-law</a>  <a href="https://en.wikipedia.org/wiki/Charles%27s_law">https://en.wikipedia.org/wiki/Charles%27s_law</a>  <a href="https://www.thoughtco.com/formula-for-charles-law-604281">https://www.thoughtco.com/formula-for-charles-law-604281</a></p>
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