



6 Materials and their properties

Criteria	Range	Resource identified
6.1 Physical and mechanical properties of materials	Physical properties – Density, melting point, thermal and electrical conductivity (resistivity), thermal expansivity, corrosion resistance, specific heat capacity, hardenability, permeability, ability to be recycled	https://www.stem.org.uk/resources/community/collection/20849/physical-properties-materials https://www.bbc.co.uk/bitesize/guides/zjgyb82/revision/1 https://www.bbc.co.uk/bitesize/guides/z2gjt4/revision/5
	Physical properties – weldability	https://www.tws.edu/blog/welding/what-does-weldability-mean-in-welding/ https://www.weldingdefects.in/2019/04/weldability-of-metals-and-factors.html https://en.wikipedia.org/wiki/Weldability
	Physical properties – permittivity	https://en.wikipedia.org/wiki/Permittivity
	Mechanical properties – Strength (tensile, compressive, shear, torsion)	https://www.strengthminded.com/tension-compression-shear-and-torsion/ https://en.wikipedia.org/wiki/Strength_of_materials https://www.azom.com/article.aspx?ArticleID=3426
	Mechanical properties – hardness, toughness, brittleness, ductility, plasticity, malleability, elasticity	https://www.bbc.co.uk/bitesize/guides/zk9g4qt/revision/1 https://www.bbc.co.uk/bitesize/guides/z9v8msg/revision/1 https://www.smartengineer.in/mechanical-properties-of-metals-elasticity-plasticity-ductility-brittleness-malleability-toughness-hardness/





<p>6.2 Types of material and their structures</p>	<p>Types – Ferrous metals (cast iron, low carbon steel, medium carbon steel, high carbon steel, stainless steel)</p>	<p>https://www.bbc.co.uk/bitesize/guides/z74bcj6/revision/3 https://www.twi-global.com/technical-knowledge/faqs/what-metals-are-ferrous https://www.metalsupermarkets.co.uk/what-is-a-ferrous-metal/</p>
	<p>Types – Non-ferrous metals (aluminium and alloys, copper, brass and bronze, nickel, zinc).</p>	<p>https://www.bbc.co.uk/bitesize/guides/z74bcj6/revision/3 https://www.colfox.org/wp-content/uploads/2019/09/1.8-Metals-knowledge-poster-and-questions.pdf</p>
	<p>Types – Thermoplastic polymers (ABS, HIPS sheet and polystyrene foam, PLA, polycarbonate, polypropylene, PMMA/acrylic).</p>	<p>https://www.bbc.co.uk/bitesize/guides/zrstng8/revision/1 https://www.bbc.co.uk/bitesize/guides/zvs392p/revision/4 https://www.plasticseurope.org/en/about-plastics/what-are-plastics/large-family/thermoplastics https://www.bpf.co.uk/plastipedia/polymers/polymer-thermoplastics.aspx</p>
	<p>Types – Thermosetting polymers (urea formaldehyde, melamine formaldehyde, phenol formaldehyde, epoxy resin, polyester resin)</p>	<p>https://www.bbc.co.uk/bitesize/guides/zrstng8/revision/1 https://www.bbc.co.uk/bitesize/guides/zvs392p/revision/4 https://www.bpf.co.uk/plastipedia/polymers/Default.aspx</p>
	<p>Types – Elastomers (rubber, neoprene)</p>	<p>https://www.infinitiaresearch.com/en/news/elastomers-what-they-are-types-and-applications/ https://en.wikipedia.org/wiki/Elastomer https://technologystudent.com/despro_fish/tpe1.html</p>





Types – Composites (GRP, CRP)	https://www.bbc.co.uk/bitesize/guides/ztxnsbk/revision/3 https://www.twi-global.com/technical-knowledge/faqs/what-is-a-composite-material https://compositesuk.co.uk/composite-materials/introduction
Types – Engineering ceramics (silicon carbide, glass)	https://www.bbc.co.uk/bitesize/guides/ztxnsbk/revision/1 https://www.twi-global.com/technical-knowledge/faqs/faq-what-types-of-engineering-ceramics-are-there https://great-ceramic.com/introduction-to-engineering-ceramics/
Types – Wood (soft wood, hard wood, MDF)	https://www.bbc.co.uk/bitesize/guides/zjgyb82/revision/3 https://www.bbc.co.uk/bitesize/guides/zdj8jty/revision/2
Types – Smart materials: shape memory alloys, quantum tunnelling composite, thermochromic materials, photochromic materials, piezoelectric crystals	https://www.bbc.co.uk/bitesize/guides/zfq8jty/revision/2 https://www.engineerlive.com/content/what-smart-material https://www.iberdrola.com/innovation/smart-materials-applications-examples
Structures – Bonding mechanisms (metallic, covalent, ionic, van der Waal’s forces)	https://www.bbc.co.uk/bitesize/guides/zjfkw6f/revision/2 https://www.bbc.co.uk/bitesize/guides/zjfkw6f/revision/5 https://en.wikipedia.org/wiki/Van_der_Waals_force
Structures – microstructure (grains), crystalline and non-crystalline (amorphous) materials	https://en.wikipedia.org/wiki/Microstructure https://mechanicalbase.com/non-crystalline-materials-and-their-features/



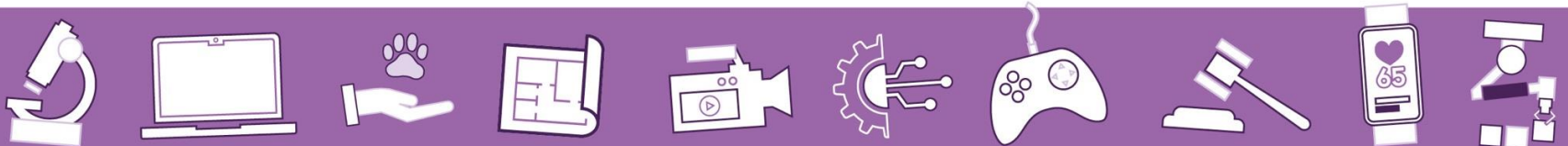


	Structures – lattice structure in metals (dislocation movement and pinning)	https://en.wikipedia.org/wiki/Dislocation https://www.youtube.com/watch?v=cpvTwYAUeA8
	Structures – crosslinking of polymers	https://www.bbc.co.uk/bitesize/guides/ztrwng8/revision/5 https://www.pslc.ws/macrog/xlink.htm
6.3 The effects of processing techniques on materials	Techniques – Metals – forming (rolling, forging, moulding/press forming), welding, brazing, casting, sintering, coating, hot working, cold working	https://blog.dahlstromrollform.com/metal-forming-processes-guide https://en.wikipedia.org/wiki/Forming_(metalworking) https://mechanicaljungle.com/forming/ https://www.bbc.co.uk/bitesize/guides/zn2w7p3/revision/9 https://en.wikipedia.org/wiki/Sintering
	Techniques – Thermoplastic polymers – temperature, mould/injection pressure	https://www.bbc.co.uk/bitesize/guides/zrstng8/revision/5 https://www.linkedin.com/pulse/main-process-parameters-injection-molding-injection-molding-machine/?articleId=6658179134545637376
	Techniques – Thermosetting polymers – curing	https://www.bbc.co.uk/bitesize/guides/zrstng8/revision/5 https://compositeskn.org/KPC/A162
	Techniques – Ceramics – sintering pressing force and firing temperature	https://www.substech.com/dokuwiki/doku.php?id=sintering_of_ceramics https://www.bbc.co.uk/bitesize/guides/zsnbg82/revision/6





	Techniques – Composites – influence of alignment of reinforcement on anisotropy of properties, influence of matrix/reinforcement ratio on tensile strength	https://ta-netzsch.com/why-knowledge-about-anisotropy-is-crucial-when-designing-high-performance-composite-parts https://www.asminternational.org/documents/10192/1849770/05287G_Sample_Chapter.pdf https://www.compositesworld.com/articles/the-matrix
6.4 Heat treatments and surface treatments	Heat treatments – Case hardening, quench hardening, tempering, normalising, annealing and precipitation hardening	https://en.wikipedia.org/wiki/Heat_treating https://cea.org.uk/downloads/docs/Support/Factfile/2019/Fact%20File%3A%201.2%20Heat%20treatment_0.pdf https://inversesolutionsinc.com/5-types-of-heat-treating-and-their-purpose-in-precision-machining/
	Surface treatments – Painting, plastic coating, galvanising and electrolytic (galvanic) protection	https://www.bbc.co.uk/bitesize/guides/zn2w7p3/revision/12 https://gaa.com.au/how-galvanizing-protects-steel/ https://www.galvanizing.org.uk/cathodic-protection/
6.5 Causes of material failure and their prevention	Causes – Corrosion (oxidation of metals including rusting of ferrous metals, chemical composition and attack, stress corrosion), aging,	https://en.wikipedia.org/wiki/Corrosion https://www.bbc.co.uk/bitesize/guides/ztrwng8/revision/1 https://www.materials.unsw.edu.au/study-us/high-school-students-and-teachers/online-tutorials/corrosion/types-corrosion/stress-corrosion https://www.sciencedirect.com/topics/materials-science/aging-of-materials
	Causes – physical (deformation, fracture, fatigue, creep, erosion).	https://www.mvorganizing.org/what-are-the-3-types-of-deformation/ https://en.wikipedia.org/wiki/Fracture https://www.designingbuildings.co.uk/wiki/Failure_of_metals





	Prevention – Coatings, sacrificial anodes and cathodes, galvanising	https://en.wikipedia.org/wiki/Cathodic_protection https://en.wikipedia.org/wiki/Coating https://www.bbc.co.uk/bitesize/guides/zqjsgk7/revision/6 https://www.bbc.co.uk/bitesize/clips/zqpd2hv
6.6 Materials testing methods and interpretation of results	Methods – Visual inspection	https://www.flyability.com/visual-inspection https://en.wikipedia.org/wiki/Visual_inspection
	Methods – tensile testing	https://www.twi-global.com/technical-knowledge/faqs/what-is-tensile-testing https://en.wikipedia.org/wiki/Tensile_testing
	Methods – toughness testing	https://en.wikipedia.org/wiki/Toughness https://technologystudent.com/joints/toughness1.html https://gearsolutions.com/departments/hot-seat/back-to-basics-toughness-testing-of-material/
	Methods – corrosion resistance	https://en.wikipedia.org/wiki/Salt_spray_test https://www.pacificmagnetic.com/basics-testing-corrosion-resistance.html
	Methods – wear resistance	http://weartesting.com/ https://www.materials.co.uk/wear_test.htm
	Methods –fatigue (Wohler)	https://www.twi-global.com/technical-knowledge/job-knowledge/fatigue-testing-078 https://yenaengineering.nl/metal-fatigue-wohler-plot-and-mechanisms/
	Methods – electrical conductivity	https://www.trl.com/electrical-properties-testing/





	<p>Interpretation of results – Hooke’s law</p>	<p>https://www.bbc.co.uk/bitesize/guides/z9hk3k7/revision/2</p>
	<p>Interpretation of results – load-extension graphs (tensile strength, elastic limit, ultimate tensile strength, maximum plastic deformation, calculation of stress, strain and Young’s modulus), characteristic graphs of different materials, necking and transition zone in steel.</p>	<p>https://en.wikibooks.org/wiki/A-level_Physics_%28Advancing_Physics%29/Stress,_Strain_%26_Young%27s_Modulus https://www.birmingham.ac.uk/teachers/study-resources/stem/Physics/youngs-modulus.aspx</p> <p>https://www.sciencedirect.com/topics/engineering/necking-region https://www.researchgate.net/figure/The-necking-zone-surface-topology-transition-zone-topology-after-tensile-test_fig8_348157937 https://www.instron.com/en/our-company/library/glossary/n/necking?region=Global%20Site&lang=en</p>

