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Teacher Development Program
Bringing schools and Engineering together

Year 12 – Aeronautical Engineering Module

Teacher Development Program
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- INTRODUCTION – Engineering Fundamentals

- The teacher development program provides current, industry related engineering context to the HSC engineering studies course.
- This module is part of a series of 8 modules providing relevant material to the course learning outcomes.
- The presentations provide a forum for teaches to network and interact with Engineers Australia.
- WE AIM TO BE A FACILITATOR IN SUPPORTING YOU.

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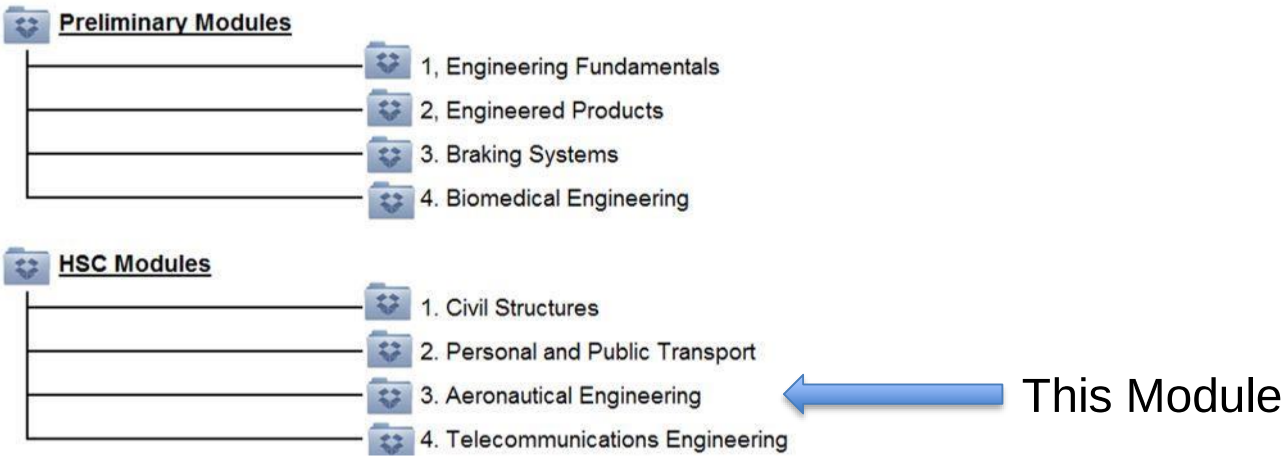
- **Drop box**

- We have created an “ENGINEERING STUDIES RESOURCE CENTRE” on Dropbox.
- This can be used by Teachers and Engineers Australia to share and communicate useful resources.

Dropbox



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Engineering Studies syllabus structure

Preliminary modules *120 hours indicative time	HSC modules *120 hours indicative time
Engineering application module 1 Engineering fundamentals	**Engineering application module** Civil structures
Engineering application module 2 Engineered products	**Engineering application module** Personal and public transport
Engineering application module 3 Braking systems	**Engineering focus module** Aeronautical engineering ← This Module
Engineering focus module 4 Biomedical engineering	**Engineering focus module** Telecommunications engineering

The Syllabus – Engineering Studies HSC course

Student Learnings

Engineering focus module: Aeronautical engineering

30 hours indicative time

One or more examples of aeronautical engineering must be used to develop an understanding of the scope and nature of this profession.

Some examples include: design and construction of recreational aircraft, general aviation aircraft, military aircraft, space craft, agricultural aircraft, helicopters and home-built aircraft.

Outcomes

A student:

- H1.1 describes the scope of engineering and critically analyses current innovations
- H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications
- H2.2 analyses and synthesises engineering applications in specific fields and reports on the importance of these to society
- H3.1 demonstrates proficiency in the use of mathematical, scientific and graphical methods to analyse and solve problems of engineering practice
- H3.2 uses appropriate written, oral and presentation skills in the preparation of detailed engineering reports
- H3.3 develops and uses specialised techniques in the application of graphics as a communication tool
- H4.1 investigates the extent of technological change in engineering
- H4.3 applies understanding of social, environmental and cultural implications of technological change in engineering to the analysis of specific engineering problems
- H5.2 selects and uses appropriate management and planning skills related to engineering
- H6.1 demonstrates skills in research, and problem-solving related to engineering

Background

- Air Force trained engineer (RNZAF);
- Manufacturing of aircraft components such as F-18 control surfaces and launch tubes for the seasparrow surface-to-air missile system;
- Development of a personal Jetpack;
- Qualified pilot with approvals on 5 aircraft types;
- Currently involved in development of unmanned rotorcraft;

The Aeronautical Engineer

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- Degree in Aeronautical Engineer.   Mechanical Engineering, Mechatronics and Electrical Engineering also possible paths;
- Aeronautical Engineers employed outside aircraft – Rail vehicles, automotive, wind turbines;

Where are Aeronautical Engineers & Opportunities

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- Military – serve in the RAAF to provide technical management of aircraft, testing of new products, developing repairs and improvements;
- Military support – work for manufacturers like Boeing and Bae Systems. Development of new aircraft systems, upgrading of older aircraft;
- Sport and recreational aircraft – design, testing, manufacturing and improvement of sport aircraft.
- Other industries – car manufacturers, yachts etc

- Limited opportunities in Australia, graduates in diverse roles or travel overseas;
- Defence projects traditionally large employers;

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Australian Company Example

- Developed in Melbourne Australia from 1995;
- First unmanned aircraft to fly across the Atlantic (3270km) totally autonomously;
- Currently employ engineers to develop engines, airframe, avionics and software.

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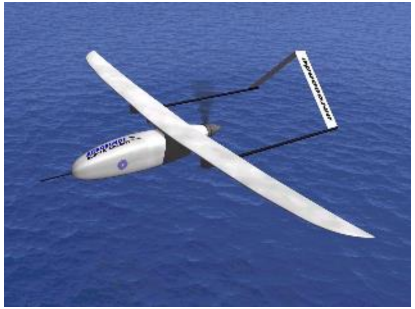

Ethics and Morals

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- Aeronautical Engineers potentially create weapons – do you want your skills to be used for war?
- Aeronautical Engineers make life critical decisions – is this aircraft safe for passengers?
- Money and Time pressures – always pressure to make a decision that helps your employer. Are you strong enough to say “No”? Are you experienced enough to say “Yes”?

Example – ANZAC Class Frigate Seasparrow Missile System

- Ship and launch systems designed and built in Australia (based on older designs);
- If its used in war, an attacking pilot will likely die;
- Is the engineer who designed it responsible for how it is used?

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Seasparrow Launch Tubes

Aircraft Industries

- Sport and Recreational Aircraft;
- Military;
- Airlines;
- Unmanned Systems;

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Sport Aircraft Example: Jabiru

H1.1 describes the scope of engineering and critically analyses current innovations

- Developed in Bundaberg, Australia in the early 90's;
- Over 2000 aircraft and 6000 engines produced (in perspective, there are only about 2500 sport aircraft in Australia);

http://jabiru.net.au/

Sport Aircraft Example : Airborne

H1.1 describes the scope of engineering and critically analyses current innovations

- Designed and developed in Newcastle, Australia.
- Factory in Redhead (soon to move to Aeropelican at Belmont).

http://www.airborne.com.au/

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Military Example: BAE Systems

H1.1 describes the scope of engineering and critically analyses current innovations

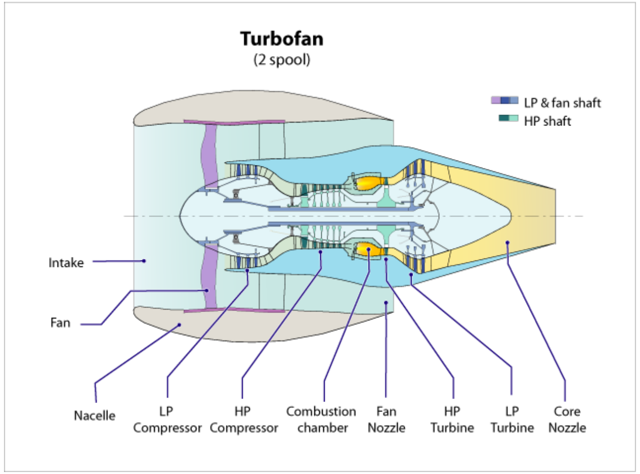
- Based at Williamtown, Newcastle.
- Design modifications to Hawk and F-18 airframe and computer systems for Australian unique requirements.

History

H1.1 describes the scope of engineering and critically analyses current innovations

H4.1 investigates the extent of technological change in engineering

- One invention by aeronautical engineers changed the world – High Ratio Bypass Turbofan Engine.



Importance

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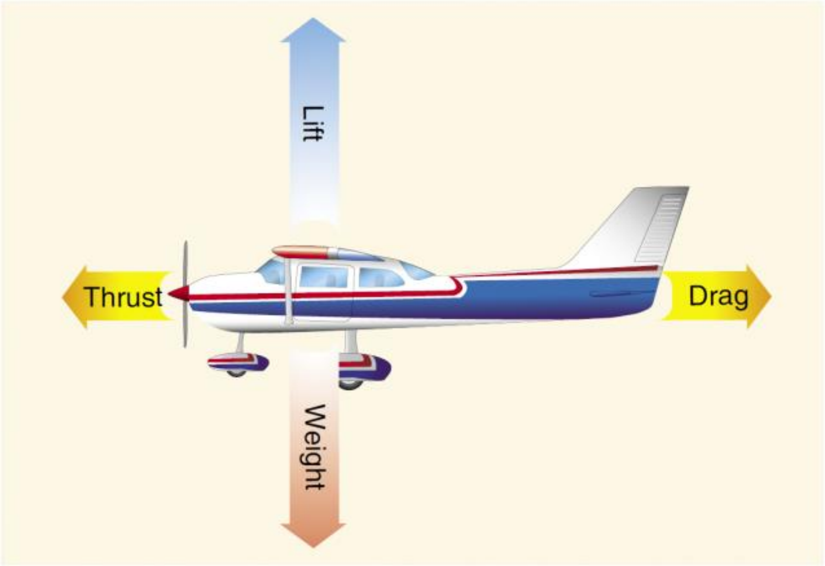
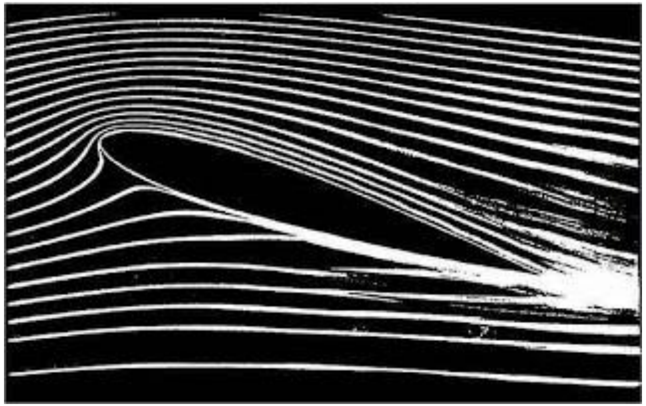
- Turbojet engines were developed during WW2;
- The turbofan engine was developed after WW2;
- Importance of the invention? Fuel efficiency;
- Could produce large amounts of thrust with significantly low fuel consumption;
- Can fly further, carry more;
- The main reason that air travel became affordable.
- Social effect of globalization.

Flight Principles

H2.2 analyses and synthesises engineering applications in specific fields and reports on the importance of these to society

H3.1 demonstrates proficiency in the use of mathematical, scientific and graphical methods to analyse and solve problems of engineering practice





Bernoulli's Equation

$$L = C_l \times \frac{1}{2} \times \rho \times V^2 \times A$$

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Bernoulli Principle

- Not too bad a movie on YouTube: https://youtu.be/Qz1g6kqvUG8
- See provided resources.

Propulsion

H1.1 describes the scope of engineering and critically analyses current innovations
H4.1 investigates the extent of technological change in engineering

- Piston Engines

Smaller aircraft
Lower altitude
Subsonic speed

Propulsion

H1.1 describes the scope of engineering and critically analyses current innovations

H4.1 investigates the extent of technological change in engineering

- Turboshaft/Turboprop Engine

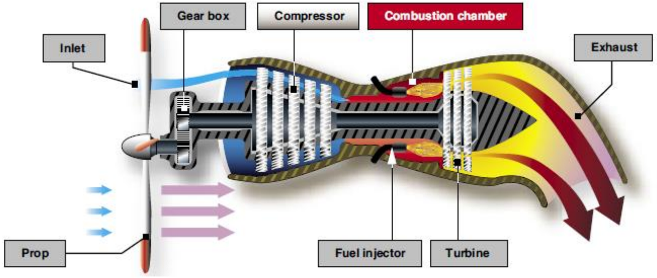
Jet engine turning a propeller

More power per kg than piston

Higher fuel consumption

Better at higher altitude

Higher altitude = lower drag



Propulsion

H1.1 describes the scope of engineering and critically analyses current innovations

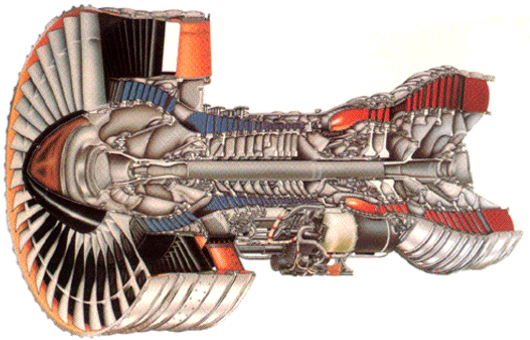
H4.1 investigates the extent of technological change in engineering

- Turbofan

Close to speed of sound

Fan replaces propeller

Higher altitude



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Propulsion

H1.1 describes the scope of engineering and critically analyses current innovations

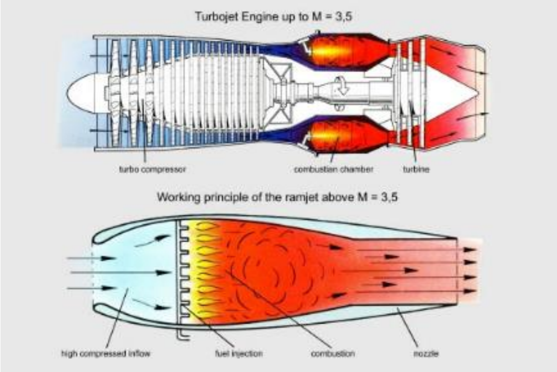
H4.1 investigates the extent of technological change in engineering

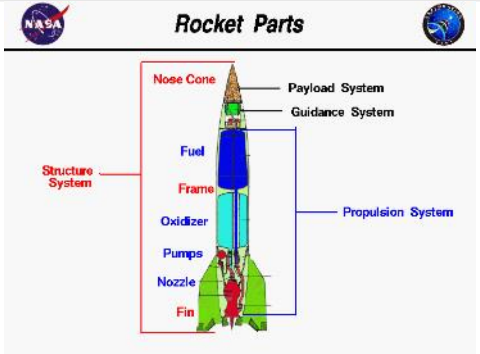
- Ramjet/Scramjet vs Rocket

Rocket carries its oxygen with it, ramjet uses the oxygen from the atmosphere.

See QUT:

http://hypersonics.mechmining.uq.edu.au/





Propulsion

H1.1 describes the scope of engineering and critically analyses current innovations

H4.1 investigates the extent of technological change in engineering

- Electric

Serious progress in R&D.

Commercially available private aircraft already available.

http://www.electraflyer.com/

Electric motors 2x (or better) the power to weight ratio of piston engine. Batteries require development.

Structure and Materials

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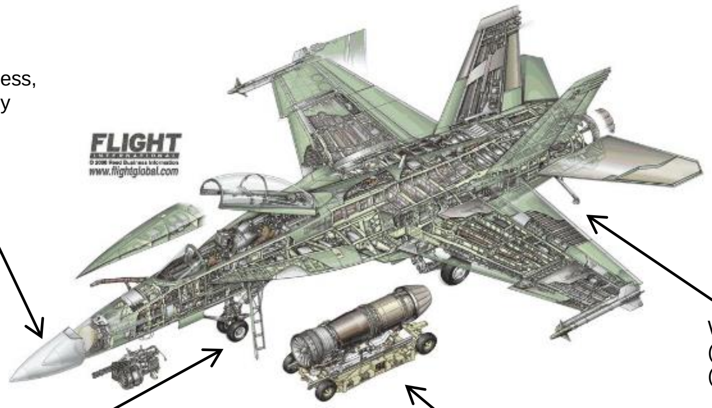
- Three important properties:
  - Strength
  - Stiffness
  - Toughness

Match the material to the job.

Structure and Materials

H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

- Materials are matched to the job required of them – Strength, Stiffness, Toughness, Thermal Resistance.



Radome – Toughness,
Radar transparency
(E-glass, Nomex)

Undercarriage –
Toughness
(Forged 4340 Steel)

Engines – Thermal
Fatigue
(Titanium, Nickel Alloys,
Stainless Steels)

Wing structure – Stiffness
(maintain shape) –
(Composites, Aluminium)

Materials - Metals

H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

- Aluminium Alloys – 2024-T3, 7075-T6
- Steel – ANSI 4130, 4340
- Titanium
- Monel (Nickel Alloys)

- Same strength in all directions.
- Can trade of toughness with strength using heat treatment – difficult to have both.

Materials - Metals

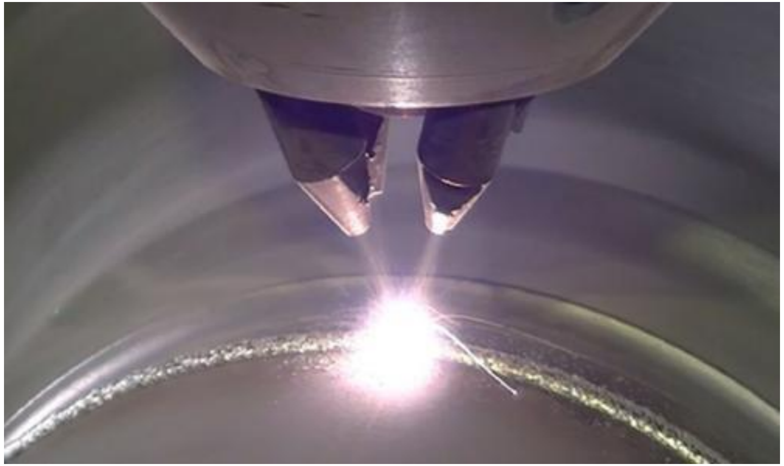
H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

- Machined

Materials - Metals

H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

- 3D Laser Sintering (future)
- Monash University
- https://youtu.be/nCcK-XSuaHs



Repair, Fracture and Failure Analysis

H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

- Starts with NDT results;
- Involves applying knowledge to determine cause and the fix;
- Large proportion of work in Australia;
- Not included in syllabus?

Materials - Composites

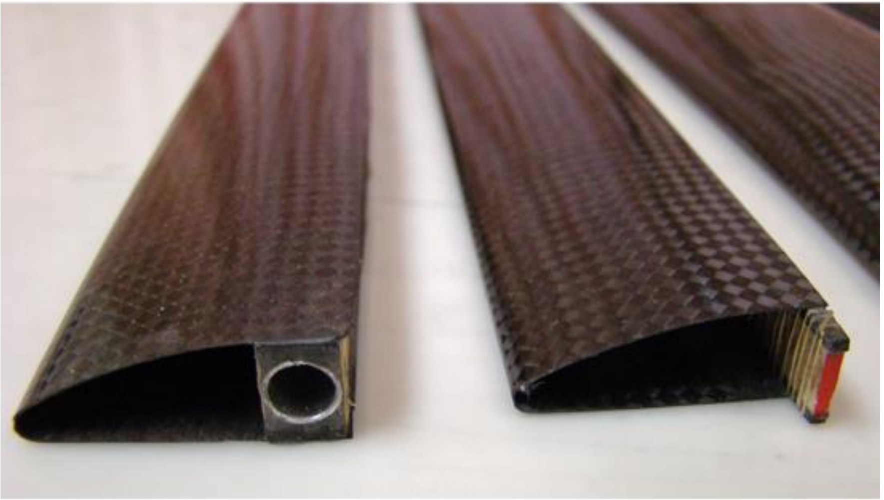
H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

- Composite = combination of 2 materials
- Fibre + Plastic
- Fibre takes the load, only in the direction of the fibre
- Plastic ‘glues’ the layers of fibre together, sharing the load

Materials - Composites

H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

- Carbon Fibre
- Aramid Fibre (‘Kevlar’)
- E-glass
- Nomex/honeycomb
- Foams



Materials – Composites - Application

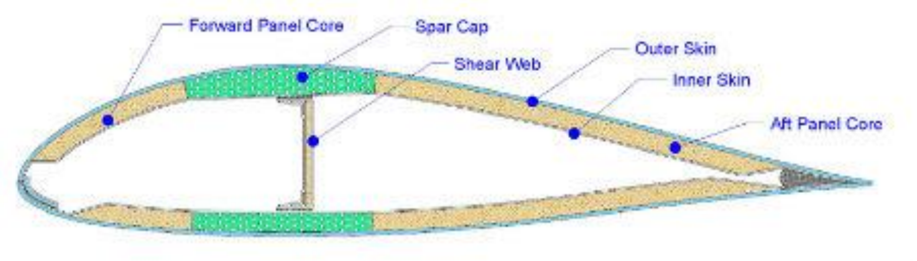
H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

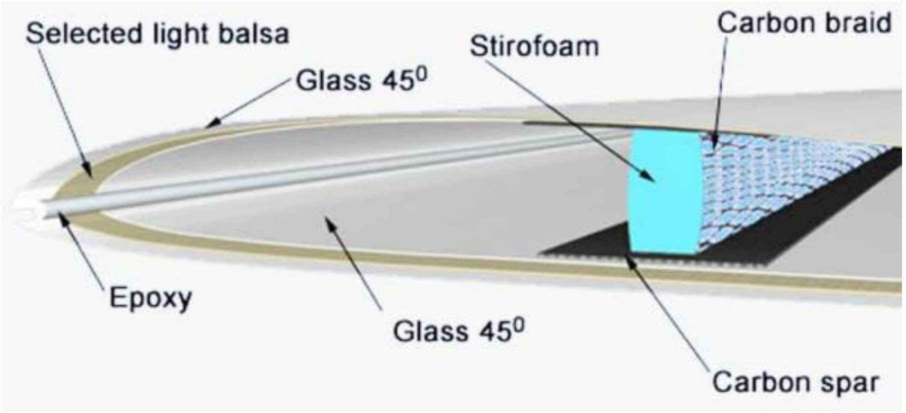
- Wing Spars
  - Composites advantage is to put the strength of the fibre in the same direction as the load.
  - Wing spars are beams. The most common load is bending, with all the load being taken by the top and bottom “Spar Cap”.
  - Video – making gliders.

Materials – Composites - Application

H1.2 differentiates between the properties and structure of materials and justifies the selection of materials in engineering applications

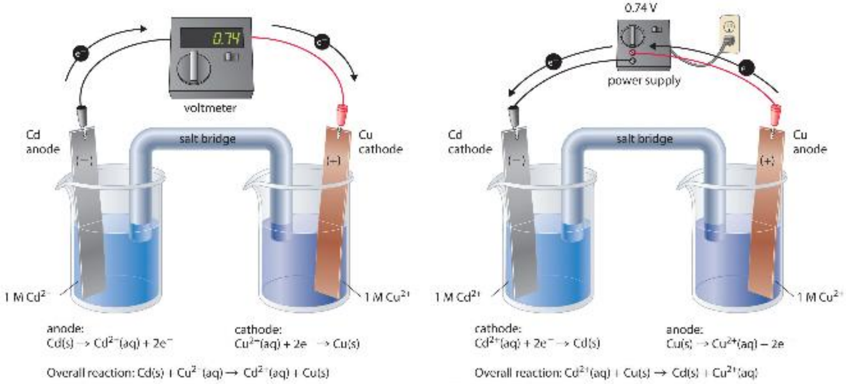
- Wing Spar





Corrosion

- Generally a metal (eg Aluminium) in contact with an electrolyte (eg saltwater);
- Chemically same as a battery – its an electron process;
- Two dissimilar metals with an electrolyte;



(a) Galvanic cell **(b) Electrolytic cell**

Corrosion - Protection

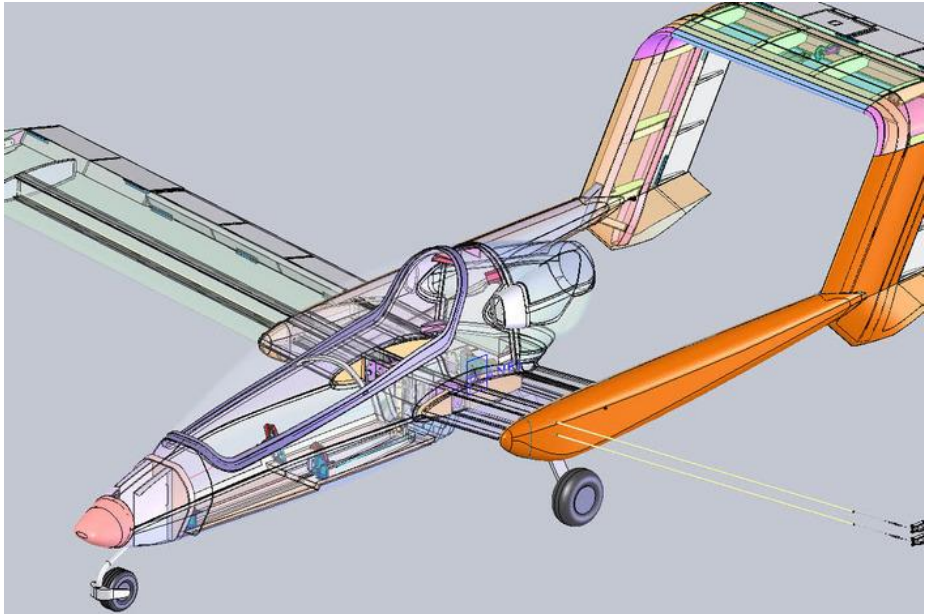
Corrosion - Protection

- Use special paint to prevent electrolyte contacting metal.

Design Communication

H3.3 develops and uses specialised techniques in the application of graphics as a communication tool

- Majority of industry using 3D CAD software;



Critical Items not in Curriculum

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- **Avionics** - Airborne software, electronic control systems, navigation computers. Unmanned aircraft are the ultimate flying computers;
- **Space Engineering** – a new space race is on;
- **Simulation** – Computational Fluid Dynamics and Structural Finite Element Analysis (combined as ‘Multiphysics simulation’)
- **Important because this is where the growth and opportunities are.**

Airborne Electronics

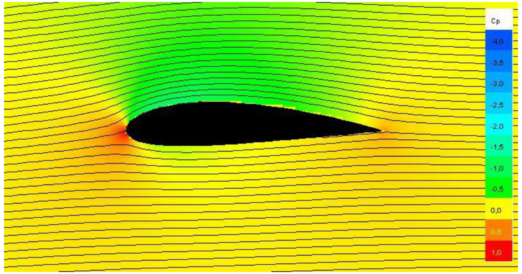
- Control systems – control the aircraft.
- Data fusion – taking information from many sensors, combining it, summarising it and presenting it for human decisions.
- Unmanned Aerial Vehicles – more than 150 certified operators now in Australia.

Space Race 2.0

- Spaceflight has transitioned from a domain of governments to a domain of companies;
- Space Engineering is available at Australian Universities – students are designing and deploying satellites;
- http://www.spacex.com/
- http://www.virgingalactic.com/
- https://www.blueorigin.com/

Simulation in Design

- Computational Fluid Dynamics (video) – Aerodynamics;
- Finite Element Analysis – Structural;
- Multiphysics – simulating aerodynamics, thermal and structural simultaneously eg aerodynamics bends the wings up, which changes the flow which changes the structure etc.



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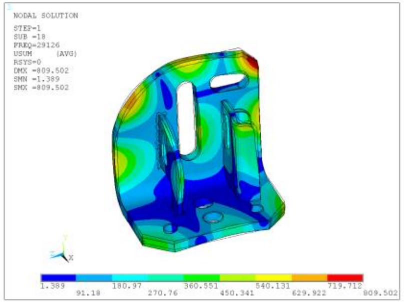

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Summary

- Engineers Australia is your link with the Engineering Profession / Industry
- These Presentations and forums can provide important networking opportunities with other teaching professionals
- Engineers Australia can assist in providing exciting ways of presenting concepts with real world examples and applications.
- We encourage a link of support with exam assessors
- We emphasise that pathways to engineering exist for all students- Professional, Technical, Trade, VET

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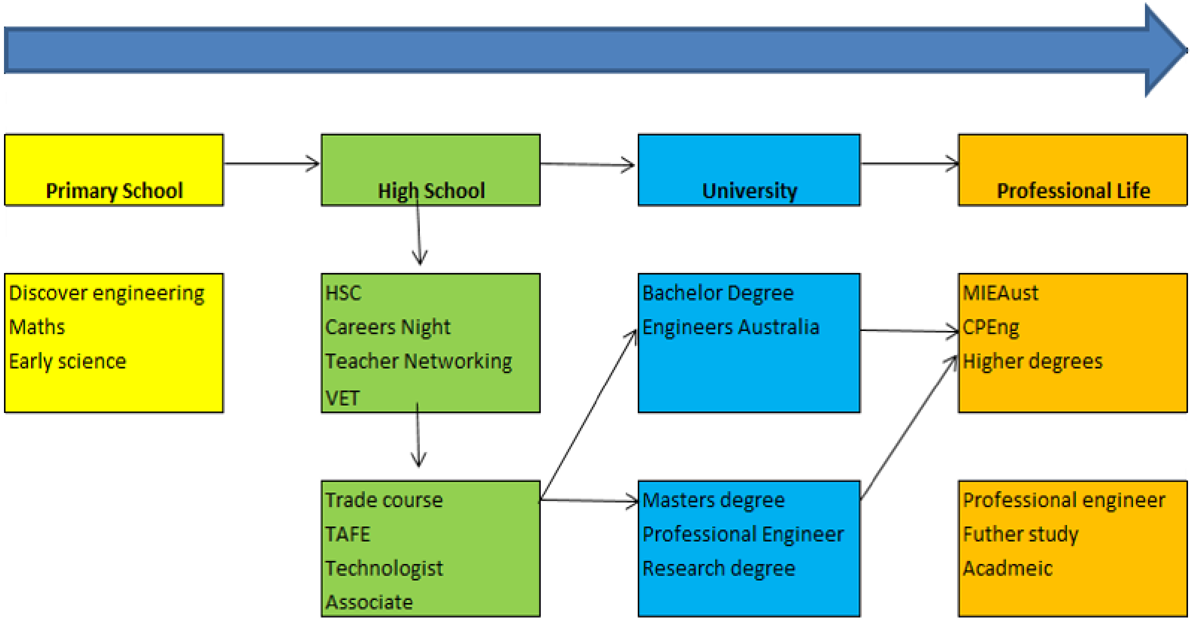
Pathways to Engineering



Engineers Australia is the trusted voice of the profession. We are the global home for engineering professionals renowned as leaders in shaping a sustainable world.

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