

# [Oten notes engineering studies aeronautical module](https://assignbuster.com/oten-notes-engineering-studies-aeronautical-module/)

[Profession](https://assignbuster.com/essay-subjects/profession/)

This publication is copyright Learning Materials Production, Open Training andEducationNetwork – Distance Education, NSW Department of Education and Training, however it may contain material from other sources which is not owned by Learning Materials Production. Learning Materials Production would like to acknowledge the following people and organisations whose material has been used. Board of Studies, NSW Hawker de Havilland Page Aircraft Company Pty Ltd Bankstown Airport Padstow Aeroskills Centre

All reasonable efforts have been made to obtain copyright permissions. All claims will be settled in good faith. Materials devlopment: Paul Soares, Harry Taylor, Ian Webster Coordination: Jeff Appleby Content edit: John Cook, Josephine Wilms Illustrations: Tom Brown, Barbara Buining DTP: Nick Loutkovsky, Carolina Barbieri Copyright in this material is reserved to the Crown in the right of the State of New South Wales. Reproduction or transmittal in whole, or in part, other than in accordance with provisions of the Copyright Act, is prohibited without the written authority of Learning Materials Production.

## Subject overview

Engineering Studies Preliminary Course Household appliances examines common appliances found in the home. Simple appliances are analysed to identify materials and their applications. Electrical principles, researching methods and techniques to communicate technical information are introduced. The first student engineering report is completed undertaking an investigation of materials used in a household appliance. Landscape products investigates engineering principles by focusing on common products, such as lawnmowers and clothes hoists. The historical development of these types of products demonstrates he effect materials development and technological advancements have on the design of products. Engineering techniques of force analysis are described. Orthogonal drawing methods are explained. An engineering report is completed that analyses lawnmower components. Braking systems uses braking components and systems to describe engineering principles. The historical changes in materials and design are investigated. The relationship between internal structure of iron and steel and the resulting engineering properties of those materials is detailed.

Hydraulic principles are described and examples provided in braking systems. Orthogonal drawing echniques are further developed. An engineering report is completed that requires an analysis of a braking system component. iii Bio-engineering both engineering principles and also the scope of the bio-engineering profession. Careers and current issues in this field are explored. Engineers as managers and ethical issues confronted by the bio engineer are considered. An engineering report is completed that investigates a current bioengineered product and describes the related issues that the bio-engineer would need to consider before, during and after this product development. Irrigation systems is the elective topic for the reliminary modules.

The historical development of irrigation systems is described and the impact of these systems on society discussed. Hydraulic analysis of irrigation systems is explained. The effect on irrigation product range that has occurred with the introduction of is detailed. An engineering report on an irrigation system is completed. iv HSC Engineering Studies modules Civil structures examines engineering principles as they relate to civil structures, such as bridges and buildings. The historical influences of engineering, the impact of engineering innovation, and environmental implications are discussed with eference to bridges.

Mechanical analysis of bridges is used to introduce concepts of truss analysis andstress/strain. Material properties and application are explained with reference to a variety of civil structures. Technicalcommunicationskills described in this module include assembly drawing. The engineering report requires a comparison of two engineering solutions to solve the same engineering situation. Personal and public transport uses bicycles, motor vehicles and trains as examples to explain engineering concepts. The historical development of cars is used to demonstrate the developing material ist available for the engineer. The impact on society of these developments is discussed.

The mechanical analysis of mechanisms involves the effect of friction. Energy and power relationships are explained. Methods of testing materials, and modifying material properties are examined. A series of industrial manufacturing processes is described. Electrical concepts, such as power distribution, are detailed are introduced. The use of freehand technical sketches. Lifting devices investigates the social impact that devices raging from complex cranes to simple car jacks, have had on our society. The mechanical oncepts are explained, including the hydraulic concepts often used in lifting apparatus. The industrial processes used to form metals and the methods used to control physical properties are explained. Electrical requirements for many devices are detailed. The technical rules for sectioned orthogonal drawings are demonstrated. The engineering report is based on a comparison of two lifting devices. v Aeronautical engineering explores the scope of the aeronautical engineering profession. Careeropportunities are considered, as well as ethical issues related to the profession. Technologies unique to this engineering field are described.

Mechanical analysis includes aeronautical flight principles and fluid mechanics. Materials and material processes concentrate on their application to aeronautics. The corrosion process is explained and preventative techniques listed. Communicating technical information using both freehand and computer-aided drawing is required. The engineering report is based on the aeronautical profession, current projects and issues. Telecommunications engineering examines the history and impact on society of this field. Ethical issues and current technologies are described. The materials section concentrates on specialised esting, copper and its alloys, semiconductors and fibre optics. Electronic systems such as analogue and digital are explained and an overview of a variety of other technologies in this field is presented. Analysis, related to telecommunication products, is used to reinforce mechanical concepts. Communicating technical information using both freehand and computer-aided drawing is required. The engineering report is based on the telecommunication profession, current projects and issues. Figure 0. 1 Modules vi Module overview Aeronautical engineering is the first focus engineering module in the HSC course.

The scope of the aeronautical engineering profession is investigated. Career opportunities are considered, as well as ethical issues related to the profession. Technologies unique to this engineering field are described. The mechanical analysis topics include aeronautical flight principles and fluid mechanics. Materials, and material processes concentrate on those most associated with the aeronautical engineer. The corrosion process is explained and preventative techniques listed. Communicating technical information using both freehand and computer aided drawing are required. The engineering report is based on the aeronautical rofession, current projects and issues. Module components Each module contains three components, the preliminary pages, the teaching/learning section and additional resources.

Module outcomes At the end of this module, you should be working towards being able to: • describe the scope of engineering and critically analyse current innovations (H1. 1) differentiate between properties of materials and justify the selection of materials, components and processes in engineering (H1. 2) analyse and synthesise engineering applications in specific fields and report on the importance of these to society (H2. 2)  se appropriate written, oral and presentation skills in the preparation of detailed engineering reports (H3. 2)  investigate the extent of technological change in engineering (H4. 1) appreciate social, environmental and cultural implications of technological change in engineering and apply them to the analysis of specific problems (H4. 3)  select and use appropriate management and planning skills related to engineering (H5. 2)  demonstrate skills in analysis, synthesis and experimentation related to engineering (H6. 2) Extract from Stage 6 Engineering Studies Syllabus, © Board of Studies, NSW, 1999.

Refer to for original and current documents. ix Indicative time The Preliminary course is 120 hours (indicative time) and the HSC course is 120 hours (indicative time). The following table shows the approximate amount of time you should spend on this module. Preliminary modules Percentage of time Approximate number of hours Household appliances 20% 24 hr Landscape products 20% 24 hr Braking systems 20% 24 hr Bio-engineering 20% 24 hr Elective: Irrigation systems 20% 24 hr HSC modules Percentage of time Approximate number of hours Civil structures 20% 24 hr Personal and public transport 20% 24 hr Lifting devices 0% 24 hr Aeronautical engineering 20% 24 hr Telecommunications engineering 20% 24 hr There are five parts in Aeronautical engineering.

Each part will require about four to five hours of work. You should aim to complete the module within 20 to 25 hours. x Resource requirements During this module you will need to access a range of resources including: • technical drawing equipment – drawing board, tee square, set squares (30? , 60? , 45? ), protractor, pencils (0. 5 mm mechanical pencil with B lead), eraser, pair of compasses, pair of dividers • calculator • rule • thumb tack or pin • small sheet of thin cardboard pair of scissors • cotton reel. xi xii Icons As you work through this module you will see symbols known as icons. The purpose of these icons is to gain your attention and to indicate particular types of tasks you need to complete in this module. The list below shows the icons and outlines the types of tasks for Stage 6 Engineering studies. Computer This icon indicates tasks such as researching using an electronic database or calculating using a spreadsheet.

Danger This icon indicates tasks which may present a danger and to proceed with care. Discuss This icon indicates tasks such as discussing a point or ebating an issue. Examine This icon indicates tasks such as reading an article or watching a video. Hands on This icon indicates tasks such as collecting data or conducting experiments. Respond This icon indicates the need to write a response or draw an object. Think This icon indicates tasks such as reflecting on your experience or picturing yourself in a situation. xiii Return This icon indicates exercises for you to return to yourteacherwhen you have completed the part. (OTEN OLP students will need to refer to their Learner's Guide for instructions on which exercises to return). xiv Glossary

As you work through the module you will encounter a range of terms that have specific meanings. The first time a term occurs in the text it will appear in bold. The list below explains the terms you will encounter in this module. aerofoil any surface such as a wing, aileron, or stabiliser, designed to help in lifting or controlling an aircraft aileron special purpose hinged flap on the rear edge of a wing designed to control sideways balance autogyro early form of helicopter with a propeller and freely rotating horizontal vanes biplane aeroplane with two sets of wings, one above the other cambered arched or curved upwards in the middle oncurrent passing through the same point, foe example, a number of forces are concurrent if an extension of the lines representing their directions all cross at the same point cowling removable cover on aircraft engine drag the force, due to the relative airflow, exerted on an aeroplane and tending to reduce its forward motion elevator a hinged, horizontal surface on an aeroplane, generally located at the tail end of the fuselage and used to control the forward/backward tilt empirical data information from experience or experiment, not from any scientific or theoretical deduction fatigue the condition of having experienced many cycles or epeated applications of stress that is lower than would normally be required to causefailure, but can cause failure under these conditions flap hinged or sliding section on the rear edge of a wing designed to control lift xv fuselage gyro gyroscopic device for keeping an object, such as a rocket, in stable controlled flight ICBM missile designed to deliver a warhead from one continent to another interplanetary between planets, from planet to planet Mach 5

A speed that is five times the speed of sound at the particular altitude (the speed of sound at sea level is approximately 380 meters per second or 1370 kmph) oment a force that tends to cause rotation because the object is fixed in position at one point or because the force is not applied at the centre of gravity monoplane aeroplane with one set of wings nacelle outer casing of an aeroplane’s engine orbit path of one body around another body under the influence of gravity payload weight being carried pitch angle that a propeller or rotor blade makes with the air passing over it pressurisation increasing the air pressure in an aircraft cabin as altitude increases and the air pressure outside is too low for breathing radar radio distance and ranging – an instrument to allow light when there is no visibility retrofit to incorporate new parts and changes into old models riveting a method for joining solid sheet materials to a firm support rotors the rotating blades on a helicopter that act as propeller and wing rudder broad flat wooden or metal piece hinged to the rear of an aeroplane for steering satellite a body revolving in some fixed path around another body shot xvi body of aeroplane Consists of small pellets; in shot-peening these are ‘ fired’ onto a surface spar a stout pole such as those used for masts or booms etc on a boat.

Also the main member of the wing frame in an aeroplane stall hen an aircraft loses lift, usually due to loss of relative air speed, and is in danger of falling streamlined made to a shape calculated to cause the least resistance to motion supercharger a device to force air into an aeroplane engine with pressure to overcome the reduction in atmospheric pressure at high altitudes and so maintain engine power as the aircraft climbs triplane an aeroplane with three sets of wings arranged one above the other wind tunnel a box or tube designed to drive a moving stream of air around an object or a scaled model of the object within it to determine the behaviour of the object in an airstream aw the motion of an aircraft about it's vertical axis xvii xviii

Directive terms The list below explains key words you will encounter in assessment tasks and examination questions. account account for: state reasons for, report on; give an account of: narrate a series of events or transactions analyse identify components and the relationship between them, draw out and relate implications apply use, utilise, employ in a particular situation appreciate make a judgement about the value of assess make a judgement of value, quality, outcomes, results or size calculate ascertain/determine from given facts, figures or information larify make clear or plain classify arrange or include in classes/categories compare show how things are similar or different construct make, build, put together items or arguments contrast show how things are different or opposite critically (analyse/evaluate) add a degree or level of accuracy, depth, knowledge and understanding, logic, questioning, reflection and quality to (analysis/evaluation) deduce draw conclusions define state meaning and identify essential qualities demonstrate show by example xix describe provide characteristics and features discuss identify issues and provide points for and/or against distinguish ecognise or note/indicate as being distinct or different from; to note differences between evaluate make a judgement based on criteria; determine the value of examine inquire into explain relate cause and effect; make the relationships between things evident; provide why and/or how extract choose relevant and/or appropriate details extrapolate infer from what is known identify recognise and name interpret draw meaning from investigate plan, inquire into and draw conclusions about justify support an argument or conclusion outline sketch in general terms; indicate the main features of predict suggest what may happen based on available nformation propose put forward (for example a point of view, idea, argument, suggestion) for consideration or action recall present remembered ideas, facts or experiences recommend provide reasons in favour recount retell a series of events summarise express, concisely, the relevant details synthesise putting together various elements to make a whole Extract from The New Higher School Certificate Assessment Support Document, © Board of Studies, NSW, 1999. Refer to for original and current documents. xx Aeronautical engineering Part 1: Aeronautical engineering – scope of the profession & engineering report

Aeronautical engineering – scope and engineering report

## Arial Arial bold Introduction

The purpose of this part is to introduce you to the scope and nature of the aeronautical engineering profession. What will you learn? You will learn about: • the nature and scope of the aeronautical engineering profession • current projects and innovationshealthand safety issues • training for the profession • career prospects • unique technologies in the profession • legal and ethical implications • engineers as managers • relations with the community. You will learn to: • define the responsibilities of the aeronautical engineer • describe the nature of work done in this profession • examine projects and innovations from within the aeronautical profession • analyse the training and career prospects within aeronautical engineering. Extract from Stage 6 Engineering Studies Syllabus, © Board of Studies, NSW, 1999. Refer to for original and current documents.

## Aeronautical engineering

Scope of aeronautical engineering Today, you would pay little attention to the sound of an over-flying aircraft, that is, if you noticed it at all. Yet less than ninety years ago everyone around you would have looked skyward and wondered in awe at the sight. The aircraft of 90 years ago was not the sophisticated unit that you may see in the sky today. They were a combination of timber, wire, fabric and a crude engine or two, flown on a ‘ wing and a prayer’. The designers of these aircraft were not aeronautical engineers as such. More often than not they were scientists or enthusiastic amateurs.

The little knowledge they did possess was the collected result of a variety of experiments with kites and models conducted during the late 1800s and early 1900s. Often the over enthusiastic and over confident experimenters piloted their less than airworthy designs to an early grave. Could this have been a form of natural selection? Many early workers used the empirical data collected from these many failures and a few successes to develop the first working aircraft. This was not always done with reference to pure theory and equations. Basically the cambered wing at a suitable angle of attack appeared to give good lift.

Consequently many aircraft experimenters chose to concentrate on the cambered wing and other ideas that ‘ seemed to be a good idea at the time’. However, scientists such as Dr Lancaster had developed and confirmed mathematical theories for phenomena such as lift generation and induced drag well before the Wright Brothers first flew an aircraft. Today’s aeronautical engineers still use models. The test pilot still has to be the first person to pilot the aircraft. However, the Concord and the FA 18 Hornet, could not be designed without extensive reference to aeronautical theory and use of sophisticated calculation.

The test pilot will have already flown many hours in a flight simulator which emulates the predicted in-flight characteristics of the new aircraft. This then is the domain of the aeronautical engineer. Part 1: Aeronautical engineering – scope and engineering report 3 Arial Arial bold List the general areas of knowledge that you think a team of aeronautical engineers would need to possess to design and build a complete aircraft. Did you answer? aerodynamics  electrical and electronic systems  materialstechnologyhydraulics  fuel engines and propulsion systems • structural mechanics  drawing and drafting skills. Before venturing further into the day to day complexities of being an aeronautical engineer you should take a step back to consider the aircraft as an engineered system. Aerodynamics An aircraft is not just a wing with a powerful jet engine strapped to it. Moreover it is the product of a combined effort by hundreds of individual designers and engineers working toward a common goal.

As aircraft grow more sophisticated no one person can fully understand every detail that goes into an aircraft’s design. An aircraft before all other considerations is an aerodynamic entity. It is held aloft by the lift forces generated by the camber and angle of attack of the wing. It is restrained by drag forces created by form and shape of the aircraft and induced through the process of generating lift. The everpresent pull of gravity will eventually pull all aircraft back to earth. The movement of air around an aircraft is a complex thing to understand and at times it is difficult to predict.

Aerodynamic theory helps predict the movement of air and the amount of lift generated but it is only a starting point. 4 Aeronautical engineering Aerodynamics is a major concern of aeronautical engineers but there are other equally important aspects to the profession. Reel tricky You will need:

a thumb tack or pin from the sewing cabinet

a small sheet of thin cardboard

a drawing compass and a pair of scissors.

a cotton reel from the same place that you found the pin. Carry out the following steps: 1 draw an 80 mm diameter circle on the cardboard, then cut out the circle using the scissors 2 ush the thumb tack or pin through the center of the cardboard disc so that the pointy end goes through as far as it can go 3 pick up the cotton reel, place the pointy end of the tack or pin into the hole on the bottom side of the cotton reel and hold the disk in place with your finger 4 blow through the top of the cotton reel and let go of the disk while you are still blowing. Blow Cotton reel Pin Cardboard disk Figure 1. 1 The disk on the cotton reel trick Part 1: Aeronautical engineering – scope and engineering report 5 Arial Arial bold The disk should have remained in position until you stopped blowing.

Air moving over the disk had velocity and therefore a dynamic pressure component. Benoulli’s predictions on total pressure would indicate that the static pressure above the disk in the moving air would therefore be lower than the pressure below the disk in still air, therefore the disk experiences ‘ lift’. (The disk is pushed upwards by the higher pressure beneath it. ) 6 Aeronautical engineering Propulsion systems An aircraft requires a propulsion system to provide thrust (or in the case of a glider, a launching system to get it into the air in the first place).

An engineer will have to decide the best combination of engine and thrust device to attach to an aircraft. Identify engine types and thrust devices that are used on new or old aircraft. Some of the engine types and thrust devices you may have identified include; internal combustion engine, jet engine, turbine, radial, propeller, fan, rotor and rocket.

You will hear more of propulsion systems in the mechanics and hydraulics part of this module. Stress-n-Strain Aeronautical engineers who design superbly aerodynamic aircraft that crash and burn because the wings fall off will not lead a successful career. The aeronautical engineer has to calculate and consider the forces present in all components of the aircraft. They then have to predict whether the material that the components are manufactured from will sustain that load without failure. This prediction must be for the full service life of the aircraft.

If a component is predicted to fail within the service life of the aircraft, the engineer will mandate when that component must be periodically replaced. The piston engines in light aircraft usually have a minor service after 100 hours operating time and a major service every 1000 hours operating time. A major service will involve a full strip-down of the engine. Many components, for example pistons, must be replaced whether or not they appear to be in serviceable condition. Other components will be subjected to testing. Part 1: Aeronautical engineering – scope and engineering report 7 Arial Arial bold

Materials Linked to considerations of structural forces are the consideration and selection of appropriate materials. An aeronautical engineer will need to have a good knowledge of the manufacturing and service properties of the materials used on aircraft. An aircraft operates in a harshenvironment. During any flight an aircraft is subjected to constant vibration, to stresses due to turbulence, to cyclic pressurisation and depressurisation of the cabin, to moisture and to wide fluctuations of temperature. The temperature on the ground may be 36? C while at 38 000 feet it may be –60°C.

Materials selected must first be readily formed in the shapes required and must secondly be suited to the service conditions. Predict or identify any materials based problems that might occur due to the harsh environment that the aircraft is subject to.  brittleness at low temperature • fatigue due to repeated cycles of stress crack propagation under high stresses, vibration, temperature changes • corrosion due to continuous exposure to the elements • failure under impact • loss of strength at high temperature. Avionics and electrical Modern aircraft depend on many electronic systems to safely complete their flights. The flight deck instruments, navigation systems, the actuation of aerodynamic surfaces, the landing and autopilot systems are now controlled by electronics and micro-processor systems. The design and implementation of avionics is the realm of another engineer, the electrical or electronic engineer.

The aeronautical engineer must however be aware of the impact of these systems when designing an aircraft. 8 Aeronautical engineering Control systems and hydraulics The control surfaces of aircraft; elevators, ailerons, rudders and flaps need to move in response to pilot inputs on the control column and rudder pedals. In light aircraft this is achieved using wires and rods. In large commercial jets this is done with hydraulic systems connected to electronic or hydraulic controllers. Cowl Cockpit/cabin Spinner Prop Wing tip Aileron Flaps Fuselage Tailplane Elevator Trim tab Fin and rudder Figure 1. Main parts on an aeroplane If you have access to the Internet visit this Sydney University web site is an excellent source for additional aeronautics information (accessed 30. 10. 01). Part 1: Aeronautical engineering – scope and engineering report 9 Arial Arial bold Unique technologies in aeronautical engineering Many of the technologies found in the aeronautical engineering profession are not unique in the sense that they are solely found and used in this discipline. The technologies used by the aeronautics industry are also found in industries that deal with similar problems and issues.

For instance, if you were to design a high technology, 18 foot racing skiff, you would need to consider and use many of the technologies available in the aeronautics industry, excluding perhaps the requirement for the vessel to fly. Can you identify any technologies that you believe overlap between aeronautics and boat-building industries? Consider the major areas of emphasis in this course; history, materials, mechanics and communication. List the technologies that you believe overlap between the aircraft industry and the construction of high tech boats

* materials – such as graphite and kevlar and aluminium alloys
* computerised design and drawing systems
* wind tunnel testing of airframes and sails
* computerised calculation systems.

Aircraft design Aircraft design is primarily concerned with flight and how to achieve this condition safely and efficiently. Basically an aircraft must be aerodynamically sound – have lots of lift and minimal drag.

The aircraft must also be as light as possible to maximize its payload and to allow it to get off the ground in the first place. The materials must be suited to the operating conditions and the environment and remain in good condition for the expected service life of the aircraft. 10 Aeronautical engineering The aircraft must also be structurally sound. The stresses in the components must not exceed the component's safe working limits. Nothing ruins a pilot’s day more than having the wings fold up in a tight turn! Finally, aircraft components are often sourced from manufacturers from all over the world.

To ensure that it all goes together when all the parts arrive, very accurate and detailed drawings are required by each component manufacturer. These have to be drawn to internationally accepted standards. So, you ask, what has all this got to do with weekend sailors and flimsy boats? Skiff design A sailing skiff, aside from any other considerations, must use wind and air to drive it. A close inspection of a sail in operation will reveal that the sail is in fact a curved aerofoil not a flat sheet of sailcloth. You would notice this particularly on the sail of a windsurfer.

The sail develops lift just as does the wing of an aircraft. The hull of the skiff moves through a fluid that you refer to as water. A badly designed hull generates a large amount of drag that slows the skiff down. The skipper usually comments loudly about this situation as better-designed skiffs race past on their way to the finish line. Many designers of modern racing skiffs use sophisticated fluid dynamics software to assist in designing both hull and sails. Similarly, these same designers are concerned with the two competing virtues of low weight and structural strength.

In Auckland, in 1995, the America’s cup challenger ‘ One Australia’ broke into two reasonably large but none-the-less rapidly sinking pieces. This was a perfect example of poor strength to weight analysis. Put simply, the structural forces imposed on the hull exceeded the strength of the hull material. The designer sacrificed strength to obtain a lighter hull and paid the price. The strength and modulus of light weight materials such as marine and aircraft grade aluminium, carbon fibre composites and Kevlar are compared to complex mechanical analyses of the hull, spar and sail design. Again software solutions exist and are utilized.

The skiff’s final drawings and component shapes may be drawn by hand. Often the drawings are produced using common, off the shelf CAD programs or perhaps specialist lofting software designed for the marine industry. Part 1: Aeronautical engineering – scope and engineering report 11 Arial Arial bold As you can see, the technologies in two seemingly unrelated industries are similar in nature and do overlap. However, the aeronautical engineering profession is distinct in some very significant ways: The scale of operations and the shear complexity of the calculations involved in aeronautical engineering are infinitely greater.

The aircraft industry uses and often develops leading edge technology. Leading edge technology is usually very expensive. Industries such as the manufacturers of small boats tend to acquire this technology when it is more established and the cost of the new technology is more affordable. More about aeronautical engineering technologies You will now learn more about some of the leading edge technologies associated with the aircraft industry. The technologies tend to fall into two broad areas; those technologies used to design the aircraft, and those technologies associated with the materials manufacturing aspects of aircraft.

Aircraft design technologies Throughout this course you have been involved in calculating forces, reactions, moments and stress in two dimensions and only on flat or uniform surfaces. At times you may have considered the calculations a little difficult. Consider then the degree of difficulty that would be involved if you now had to calculate forces and moments in three dimensions, on curved surfaces with loads that fluctuated and using calculus that Extension 2 (4 Unit)mathematicsdoes not cover. Does this conjure up an image in your mind?

Now imagine applying similarly difficult calculations to more than a thousand points across a single wing. Are you now thinking that this is getting a little difficult? A modern jet aircraft may contain over a million individual components and someone has to draw each and every one of them. Again, just to make things difficult virtually every component is curved in some special and very critical way. Imagine the most difficult drawing that you have done so far in this course, then multiply the degree of difficulty by ten. Then repeat the drawing several thousand times. Starting to get the picture yet!

Aeronautical engineering List some systems and products that exist to reduce the difficulty and complexity of designing modern jet aircraft. r? One of the most significant is computerised design and calculation software. Others include ‘ off the shelf’ systems for navigation, communication and cockpit management. The bad news

All aeronautical engineers have to learn and understand how to do these difficult calculations. They have to use their brain, some mathematics and a calculator. Aspiring aeronautical engineers soon encounter the complexities of computational analysis (difficult mathematics). They will see a lot more calculation before their aeronautical engineering course finally ends. The good news There are software tools available to assist the engineer in the design process. To use these software tools effectively and correctly the engineer must first understand the underlying mathematics and theory on which these programs are based.

That is, you must be able to understand and do the mathematics before using the program. You will now examine four common categories of aircraft design software:

* structural analysis software
* modeling software
* aerodynamic calculation software
* CAD software.

Part 1: Aeronautical engineering – scope and engineering report 13 Arial Arial bold Structural analysis software The structural analysis of an aircraft is a complex problem. There are not many straight lines involved, virtually every component is curved, even the ones that look straight are usually curved. The loading is not uniform, it varies from point to point.

In other words, the loads and stresses will vary infinitely across the components being analysed. An infinite number of equations could take quite some time. The solution is really quite straight-forward. If an engineer intends to examine the forces, stresses and moments in an aircraft wing, the wing can be mathematically broken up into a large number of sections referred to as elements. The conditions in each element are then examined. The results from each element are combined together to produce a distribution of forces, stresses and moments across the wing. The number of elements considered in this procedure is finite.

There is an upper limit to the number of elements to be analysed. This mathematical process is called ‘ finite element analysis’. The industry abbreviates this to FEA. Finite element analysis is a very powerful tool but is very slow when done by hand. A very popular finite element software (FEA) package in the aircraft industry is called NASTRAN. This package falls into the category of a computer aided engineering software (CAE) tool. NASTRAN is a high end software tool for critical engineering applications. It is capable of stress, vibration, heat transfer, acoustic and aeroelastic analysis. If you have access to the Internet visit .

Select the appropriate option from the software section of the directory to find out more about NASTRAN (accessed 06. 11. 01). Modeling software The production and testing of physical working models is a costly and time consuming activity. An activity that is closely related to finite element analysis is ‘ finite element modeling’. In the aeronautical engineering industry ‘ finite element modeling’ is abbreviated to FEM. Using finite element modeling software, an engineer can construct models using computer aided design (CAD) parts, submit the models for simulation and observe the behavior of the model under simulation.

The results can be used to modify and improve the product designs to yield better performance and to better resist loads. A high end finite element modeling program that is commonly used in the aeronautical engineering industry is PATRAN. This product is 14 Aeronautical engineering produced by MSC, the same company that produces the analysis package NASTRAN. Figure 1. 3 was produced by the Page Aircraft Company Pty Ltd using the finite element modeling package PATRAN. This company is associated with the University of NSW and is currently developing a light aircraft that it hopes to put into full commercial production.

A PATRAN generated image of an aircraft under development © Reproduced with the permission of the Page Aircraft Company Pty Ltd Aerodynamic calculation and modeling software Aerodynamics is concerned primarily with the flow of air and the interaction of that air with objects that it encounters. Aeronautical engineers are usually concerned with the interaction of an aircraft’s outer surfaces with the air through which the aircraft moves. 'CFD' calculations can help to predict the lift and drag levels for a particular airframe as well as stall and other performance characteristics.

Air is considered to be a fluid and the mathematical processes involved in predicting the behaviour of the air is called computational fluid Part 1: Aeronautical engineering – scope and engineering report 15 Arial Arial bold dynamics or CFD for short. The mathematics involved is complex but again there is software available which can carry out these calculations. Outline a practical way in which an aeronautical engineer could visualize the flow of air around an aircraft without using software. The flow of air around an aircraft can be observed using a wind tunnel where wind is pushed over a model with smoke streams passing over it. An industry standard software package commonly used by aeronautical engineers is VSAERO. This package allows an engineer to input the surface geometry of an aircraft. The surface geometry is simply the outside shape of the aircraft.

The engineer can also input reference conditions such as velocity of the air, angle of attack of the wing and yaw. The package will then calculate and display the predicted behaviour of the air around the aircraft. If you have access to the Internet visit . Under products there is a graphic showing an image of the C-130, the Hercules transport aircraft used by the Australian military at present. Take a close look at what is happening to the wingtips (accessed 30. 10. 01). If you have access to the Internet visit to view a photograph of a real C-130 activating anti missile flares (accessed 30. 10. 1).

Computer aided design The last type of software package that you need to learn about are the computer aided design (CAD) drawing packages. You’re probably familiar with one of the CAD packages available for use on personal computers. These include Autocad Light, Autosketch and TurboCAD. These packages vary in power and are fine for standard drawing applications such as architecture and medium scale manufacturing. The aeronautics industry uses specialist CAD packages which fit the industry’s need to produce drawings of complex surface shapes and 16 Aeronautical engineering curved components.

They also use state of the art, multiple processor workstations with large screen monitors for speed and ease of viewing. The large monitors reduce eye-strain and allow more of each drawing to be displayed. CAD software packages currently used by many aeronautical engineering companies include CATIA and CADDS 5. The CATIA package is promoted as CAD/CAM/CAE package. CATIA can be used solely for drawing and designing. However, it can also be used for CAM (computer aided manufacturing) and CAE applications. If you have Internet access visit to find out more about CATIA (accessed 30. 10. 1). Figure 1. 4 Image produced by the Page Aircraft Company Pty Ltd using CATIA software. The aircraft shown is currently under development © Reproduced with the permission of the Page Aircraft Company Pty Ltd Wind tunnels To this point all the development tools have been based on computer software. In the aerodynamic calculation and modeling section you were asked to suggest a method of assessing the aerodynamic behaviour of an aircraft without using computers. Many successful aircraft have been developed without the aid of modern computers. In fact the computer models are not perfect.

The information provided by computer analysis is usually valid but does not exactly predict the behaviour of a real aircraft. Part 1: Aeronautical engineering – scope and engineering report 17 Arial Arial bold Why do you think this is so?  Computer output is based on computational methods that have been programmed into the computer.

These computational methods are based on theoretical analyses of conditions. Variables are input to reflect real situations and conditions as much as possible but can never predict the precise conditions that exist. Input into a computer is based on precise or perfect data, the behaviour of materials, fluids and the like is not necessarily perfect. The output from a computer program is based purely on the input. Another method of assessing an aircraft design is to construct a very accurate scale model then subject the model to wind tunnel testing.

Wind tunnel testing does not exactly predict the behaviour of a real, fullsize aircraft flying in open air. However, when scale effect corrections are applied valid data can be obtained. Model boats on ponds do not behave like real ships, the forces and accelerations are all out of proportion. They bounce around like corks. Similarly model aircraft in wind tunnels do not behave like real aircraft. There are several reasons for this. It is difficult to make accurate models. The sides of the wind tunnel constrain the air-flow. Most seriously, the model is flown in full size air not ‘ model size’ air.

This is known as the scale effect. Larger size models in larger size wind tunnels give the most meaningful data. The most sophisticated wind tunnels actually compress the air at up to 25 atmospheres to correct for scale effect. Most aircraft design is based on both CFD and wind tunnel analysis. This is because neither system gives perfect results. The following photograph shows a model under test in a wind tunnel at the University of NSW. 18 Aeronautical engineering Figure 1. 5 A model aircraft being tested in a wind tunnel © Reproduced with the permission of the Page Aircraft Company Pty Ltd Manufacturing technologies and systems unique to the aeronautics industry Aeronautical engineers also deal with materials and manufacturing processes that are highly specialized in their nature and could be considered unique.

The materials used for aircraft manufacture need to possess very special manufacturing and service properties. List five properties which you believe are important for materials used in aircraft manufacture and construction. Give your reasons for each choice. Property Reason why it is important Part 1: Aeronautical engineering – scope and engineering report 19 Arial Arial bold Did you answer?

Property Reason why it is important Low fatigue aircraft vibration can cause fatigue failures High strength to weight lower the overall weight Corrosion resistance resist harsh operating conditions Ductility (before forming) Provide for forming of complex shapes Elasticity allow the aircraft to flex Later, in the materials section of this module you will investigate the materials commonly used in the aircraft manufacturing industry. This section is more concerned with the technologies used when dealing with these materials. Advanced composite materials Two commonly used materials are aluminium and carbon fibre