Aircraft Design Course

Washburn
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Abstract: This course is designed to fill a need for an in depth understanding of how and why an airplane flies. The content includes the physics of aerodynamics, factors affecting flight, airplane stability and control, aircraft performance, high speed flight, Ground effect, modern design concepts and aerodynamic static and dynamic testing. Students will step back in time to embrace the developments throughout history from a time before the Wright Brothers to a time we only dream of; future flight. This course will also emphasize the application of physics principles to the area of flight with regard to aircraft st ability and performance and the interrelation of these same principles to the fundamentals of aeronautical engineering.
Dates: -

Enduring Understandings

Many of the important milestones in aviation development have been attained by unconventional aircraft and perhaps the majority of pioneering "stick and string" airplanes built at the very dawn of heavier-than-air flying fit into some form of design category. But certain design conventions has to be observed. Often a good place to start when looking at aircraft designs is amongst records of those least remembered. Because, a small number of these never got past the marketing stage.

It would be a mistake, however, to assume that all aircraft designed were assigned to the trash bin or made it to the market place, many were built as "one-offs" or in tiny numbers for research alone. This could not be further from the truth. Amongst these aircraft many proved to be highly successful in their assigned tasks and helped take aviation knowledge to new levels of excellence, for example: the Bell X-I, the first aircraft to break the sound barrier. This little rocket powered airplane, air dropped from a larger plane was intended for research and had no production counterpart whatsoever. Yet, so great its achievement that it carved a place in history of the world and the endeavors of man.

As young aircraft designers and engineers there are no correct answers. "You must think outside the box"!

Standards

ID Standards Benchmarks

After successfully completing this course, the student will be able to:
1. Demonstrate an understanding of the science of aerodynamics.
2. Explore, analyze and discuss the relationship between the components of lift, weight, thrust and drag. To discover why these are such an issue with aircraft design and flight.
3. Demonstrate a knowledge of aircraft performance parameters and the factors that influence them.
4. Demonstrate knowledge of aircraft stability and control parameters and the factors that influence them.
5. Demonstrate knowledge of the many factors that impede high speed flight.
6. Demonstrate knowledge of the variety of design concepts and how these concepts have evolved over time.
7. Understand the various aircraft construction techniques and materials employed to build aircraft over the years and into the future.
8. Be knowledgeable about famous designers of aircraft.
9. Will understand what educational requirements are needed to pursue a career in this line of work.
10. Will have developed sound sketching skills and "Blueprint" interpretation skills.
11. Will have produced a "One-Off" design, test in the University of Minnesota's Aeronautical Engineering Department's wind tunnel. The student will document all the data and produce a full report on his/her findings.

Essential Questions

1. What were the influential issues that spurred the Wright Brothers not to give up on their endeavor to invent a successful heavier-than-air controllable airplane?

2. What were some of the landmark developments in aviation prior to WWI?

3. What were some of the experimental developments that aviation scientists had to overcome?

4. Which of the above developments remain today?

5. What would it be like to live the life of a "Test Pilot"?

6. Will aeronautical engineers ever achieve the perfect design?

7. What evolutionary trends have taken place with materials development?

8. How has the airplane changed over the years? Why?

9. When did chemistry enter the world of aircraft design?

10. What role does the psychologist play in the design of aircraft?

11. How has the development of "Fly-by-wire allow the technical advances to take place in advanced airplane design? Why was this a giant leap forward?

12. Will the pilot become redundant? When? What needs to be achieved for this to happen?

13. What are the mediums that aircraft are constructed from? Why are there differences? Are any better than the other?

14. Flight took place for the first time over 100 years ago, look to the future and to the aeronautical engineer. What designs of airplanes will your grand children take for granted? What will these airplanes look like?

Concepts

Designing Aircraft:

The conceptual design phase is the most important part of the design process. It consists of:
Make a wish list of what you want the airplane to do. (These are preliminary specifications).
Size, lifting and control surfaces.
Select and design airfoils. Many projects such as; the variable wing geometry, high speed aircraft, the Lancair and Stallion, the jump start gyroplane, the Acro I, have required special airfoils.

Make a three view drawing of aircraft.

Make an inboard profile layout showing location of all major components.

Perform a weight, balance and stability check and rearrange components to meet requirements.

Calculate performance.

Make an isometric drawing to show what the design looks like.

Final airplane specifications.

Once the conceptual design has been completed by the student, discussions can begin on what the student sees regarding the structural design. This includes:

The structural design by carving from balsa wood to produce a mock-up.

Decide and design the undercarriage, fixed or retractable.

Design the fuselage, pressurized or non-pressurized.

Discuss loads and stress analysis.

Discuss how finite element analysis for composites, metallic structures, buckling, liner/nonlinear static analysis, shock analysis, random vibration.

Discuss the science behind flutter analysis.

Discuss the design of lightning strike protection.

Discuss icing protection system designs.

Discuss propeller designs.

Discuss materials testing at ambient and elevated temperature.

Discuss the role of "Test Pilot" and "Proto Stage" of development.

Skills

The skills students will gain from this course are as follows:

1. The student will be able to apply and use the "Design Process" model.
2. The student will be able to set up, operate and evaluate findings from wind tunnel testing.
3. The student will be able to communicate in a technical way.
4. The student will develop teaming skills.
5. The student will understand cross-curriculum processes.
6. The student will develop good sketching skills.
7. The student will develop good workshop safety skills.
8. The student will develop good research skills.
9. The student will demonstrate skills in research evaluation.
10. The student will demonstrate an understanding of career options and who employs aeronautical design engineers.

Summative Assessment

Title:

Research and Analysis and Assessment Instruments

Description:

The students will engage in the development of research papers, building models to conduct tests in wind tunnels and convey their findings to the class.

There will be three major assignments over the course of one semester:

A research assignment focusing on a famous airplane designer.

The second assignment will be designing an airfoil section and testing the airfoil section in a wind tunnel. The results will be collected and presented to the class.

The third assignment will be to construct a scale balsa model of a unusual airplane (taken from internet research). This model upon completion, will be tested in the wind tunnel at the University of Minnesota.

Formative Instruction/Assessments

The content of this course is based on a 16 week semester program. All the topics are sequential and will follow a pattern that will lead the student smoothly from one unit of work to the next.

Week 1. Study Skills, Research skills, note taking, assignment testing skills. The passion

necessary to be in this industry.

Unit 1. What is Aerodynamics?
A brief look at the birth of aviation and the frustrations of "getting it right". Aerostatics, Heavier-than-air flight. The science behind aerodynamics.

Unit 2. What is lift? How is this generated?
The physics of the all important "lift". Pressure distribution and pitching moments. The stall. Airfoil development and designation. Wing lift and span effects. Span-wise lift and stall sequences. Lift coefficient and lift quantity. Lift from a momentum change consideration. Flaps and other devices for controlling lift.

Unit 3. Drag; and all those things that hang off an airplane.
Parasite drag. Skin friction and boundary layers. Wakes and pressure drag. Drag coefficient. Induced drag. Total drag. Equivalent flat plate area. Special types of parasite drag. Ground effect.

Unit 4. Performance.
Level flight performance. Jet engines. Reciprocating engines. Superchargers. Propellers.

Unit 5. Why are there different types of Power Plants?
In-line. Radial. Vee. Horizontal opposed. Twin engines, Pusher and tractor. Turboprop. Turbojet and turbofan. First major assignment- A report on a historical aircraft designer.

Unit 6. Stability and Control.
The meaning of stability. Airplane axes. Longitudinal stability. Dynamic stability. Center of gravity effects. Controls in the airplane. Directional stability. Lateral stability.

Unit 7. Cockpit design.
The psychology behind different designs. Why are instruments designed the way they are. what colors work better for the pilot. comfort and functionality.

Unit 8. Aircraft Design the practical application.
Design specifications. Airworthiness requirements, Design phases. Initial conception. Fuselage designs. Wing designs. Power Plant selections. Landing gear configurations. Tail designs.

Unit 9. Aerodynamic testing.
History of wind tunnels. Wind tunnel designs. Types of wind tunnel tests. High-speed wind tunnels. Flight testing. Field trip to the U of M. (Dept of Aeronautical Engineering.)

Unit 10. Modern design concepts.
Design evolution. Canards. Flying wing. Effective aspect ratio devices. Swept wings. Modern airfoil design. Second major assignment- Airfoil design and wind tunnel testing.

Unit 11. Practical applications. (Lab work).

Workshop safety. Tools, equipment and their safe use. Wood construction. Metal construction. Composite materials. The design of an airplane with a maximum wingspan of 18 inches and a maximum length of 18 inches. This model will be tested in a wind tunnel at the U of M.

Unit 12. Career Investigation.

Differentiation

Student with language difficulties will be catered for by providing them with either a "reader" or "writer"

Ethnic diverse populations will not be effected by this program.

Academic Language

Students will engage in using aviation jargon. They will use new technical words to supplement their language skills.

Resources

Additions