Lesson Plan

NEUROHEADWAY

Neuroscience Into Education

What are aircrafts made of?

Learning Objectives:

- What material properties are desirable?
- How can we classify materials?
- What materials are used in aircraft manufacture?
- How do we choose the right material?

Lesson Plan

Slide	Topic	Description	Time
1	What are aircrafts made of?	Introduction to materials used in aircrafts.	2
2	Recap	Recap of module 3	5
3	Fundamental Material Characteristics and examples	Introduce about the 4 material characteristics that define materials through example.	10
4	Desirable characteristics	Summarise 4 desirable material characteristics for aircrafts.	3
5	Material classification	Different groups under which we can classify materials with examples.	3
5	Stiffness of materials	Material stiffness properties for different classes of materials.	5
6	Strength of materials	Material strength properties for different classes of materials.	5
7	Cost of materials	Material cost for different classes of materials.	5
8	Material group examples	Material group examples with their properties.	3
9	Activity	Selection of material class and material.	12
10	Summary	Summary of chapter	5
11	Next Module	Brief overview of what will be covered in the next module	2

Slide 1

Under flight dynamics, we learnt about the importance of weight on an aircraft. The greater the weight, the more lift force we need. This means we need more thrust to generate sufficient lift. This also means the wings must be larger to get higher lift, which increases drag. To increase lift and counter drag, we need more thrust. More thrust means we need larger engines which are heavier.

This cycle keeps going on and on. Hence it is very important that we choose the right material.

So, what are aircrafts made of?

Slide 2

Same as in slide

Slide 3

When we look at materials, there are four important criteria based on which we can evaluate them. They are Strength, Stiffness, Density and Cost.

Teacher may demonstrate the properties with the help of props in class.

Strength – The ability of the material to withstand breaking when a force is applied. Example, a metal scale.

Stiffness – The ability of the material to withstand any deformation. Example, chalk does not deform, it breaks directly. Rubber band has low stiffness as it deforms through stretching.

Density – It defines the materials weight. The higher the density, the more mass it has in a given volume, hence has more weight. Example, steel scale has high density but plastic scale has low density.

Cost – It defines the cost of producing, manufacturing and maintenance cost of the material.

If you look at the figure, you will see a steel rod being bent. Here we can see stiffness and strength properties of the material.

Slide 4

Based on the characteristics we can say that an aircraft material should have the following desirable properties.

It should be lightweight. This can help escape the cycle we saw in slide 1.

It should have high strength. The aircraft experiences very high forces when it flies. The material should be strong enough so that the aircraft does not break.

It should have high stiffness. The aircraft should resist deformation. Otherwise the wings would fold and we will lose lift.

It should be cost effective for viable operations.

Slide 5

We can classify materials into groups based on their internal structure and how they are manufactured. These can be seen as blobs in the chart. Some group examples are…. *The teacher can ask students to give examples from daily life in each group.*

Slide 5

Stiffness of Material groups can be seen from the chart. On one axis we have the density (weight) and on the other axis we have young's modulus which is a number that defines stiffness.

If you take a foam, it deforms easily. Hence it has a low stiffness value. If you a take a ceramic plate that you eat dinner in, it does not deform. Hence it has high stiffness value.

Slide 6

We can see strength of different materials plotted against their respective densities. We can see that foams have low strength. They easily break when we pull them. Metals have very high strengths and are hard to break.

You can see Diamond is marked here as a ceramic and has one of the highest strengths.

Slide 7

We can see strength of materials vs their respective cost per unit volume. Here we can see that metal alloys, especially tungsten alloys are one of the most expensive materials. Non-technical ceramics like concrete on the other hand are inexpensive.

Slide 8

Let us look at some material groups and their respective properties.

Teacher may explain as per table.

Slide 9 - Activity 1: Selection of a suitable material
Procedure

Using the charts select a suitable material for aircraft wings.

Slide 10

Aircrafts can be made of many materials. However, we make a choice based on weight, strength, stiffness and cost.

Metals have high strength and stiffness. However, they are heavy.

Ceramics have high strength and stiffness. However, they can be brittle, expensive and heavy.

Metal alloys have high strength, stiffness, light and inexpensive. They are often used in aircrafts.

Composites have high strength, stiffness and low weight. However, they are expensive. Newer aircrafts are made of composites.

Slide 11

Next topic – Aircraft Structural Design

Power point Example

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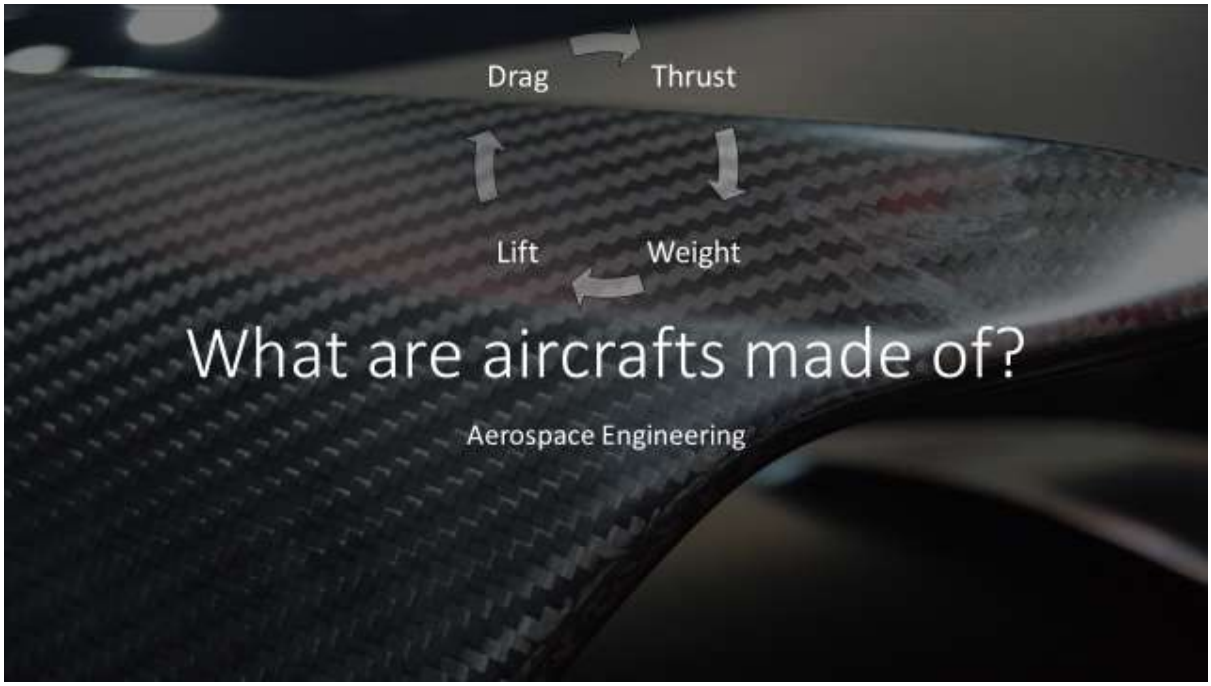


What are aircrafts made of?

Aerospace Engineering

Recap

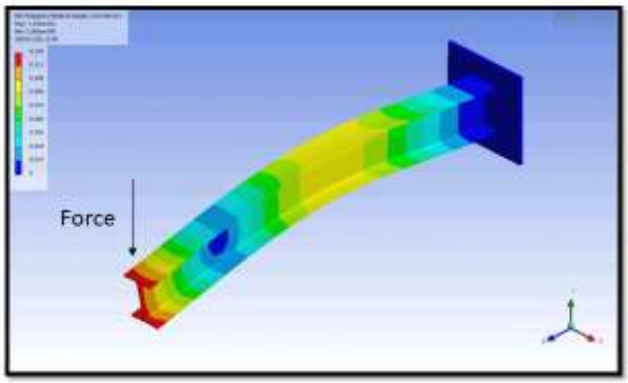
Recall home assignment in module 2. Paper clips were added to the aircraft to increase the weight of the aircraft.

We noticed that as the weight increased, the flight became more stable. However, as the weight increased, the distance travelled also decreased.

In the following modules we will look at different types of materials and how we can characterize them. We also look at material charecteristics that are desirable to have.

Aircraft Structures
Fundamental charecteristics

- Strength
- Stiffness
- Density
- Cost



Strength – Structure is strong enough to withstand breaking

Stiffness – Structure is stiff enough to withstand deformation

Weight – Structure is light enough to attain flight

Cost – Structure is cost efficient for commercial viability

We need a material that satisfies criteria suitable for aircraft design.

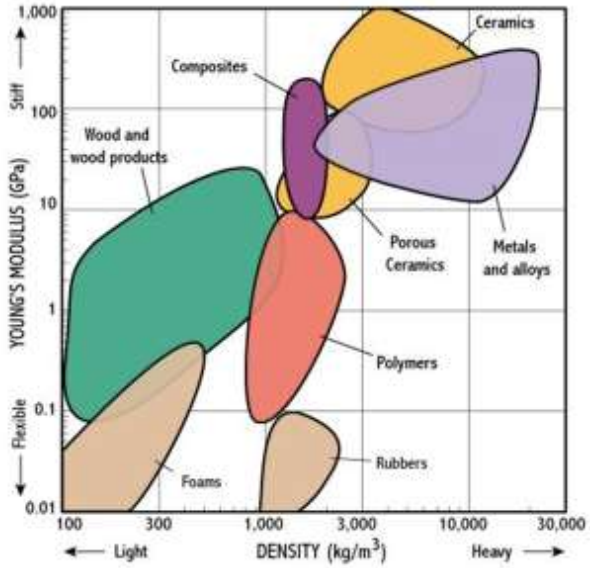
Lightweight

High Strength

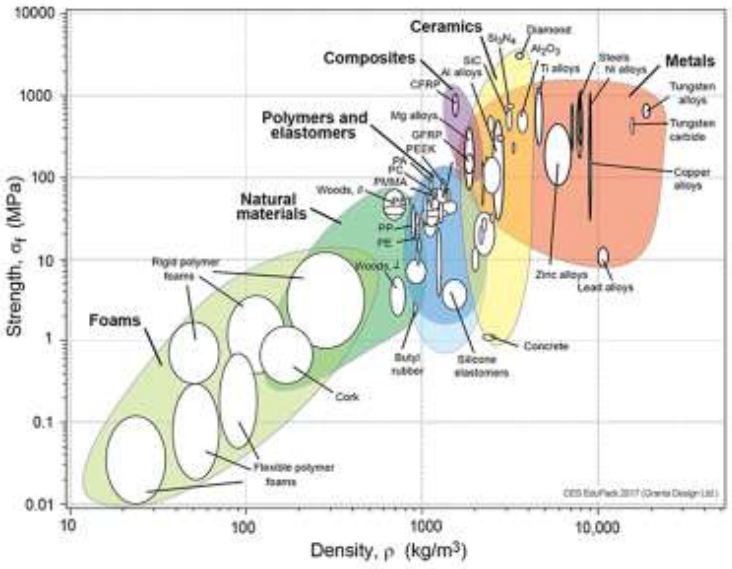
High Stiffness

Cost effective

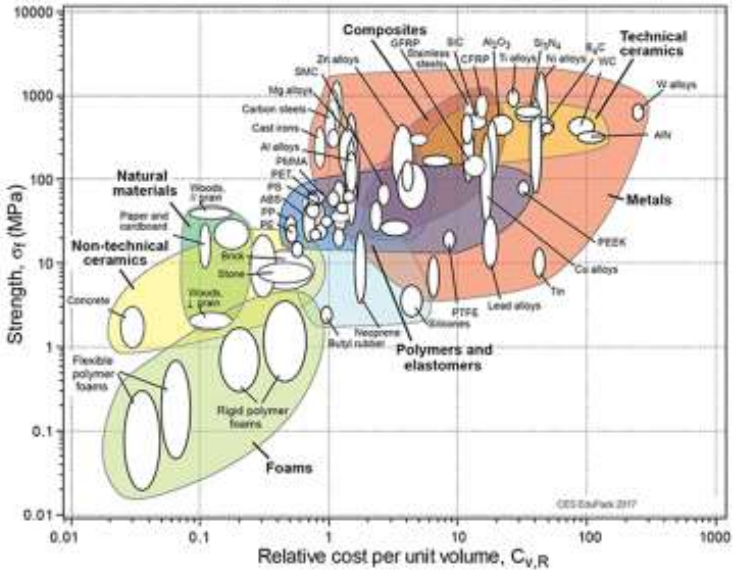
Stiffness of different materials



Material strength vs weight



Material strength vs cost



Examples of ideal materials

Material Group	Charecteristic of example
Metals (Eg, Titanium)	Very high strength, heavy
Ceramics (Eg, Diamond)	Very high stiffness, heavy, expensive
Foams (Eg, Polyurethane)	Very light, low stiffness and strength
Composites (Eg, Carbon fiber –epoxy)	Very high cost, very high strength, very high stiffness, Very light
Aluminium	Low cost, low weight, moderate strength, moderate stiffness