

# Lesson Plan

**NEUROHEADWAY**

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Neuroscience Into Education

# Flight Dynamics – External Forces

## Learning Objectives:

- How does an aircraft fly?
- What forces act on an aircraft?
- Where on an aircraft do these forces act?

## Lesson Plan:

| Slide | Topic                                         | Description                                                                                                       | Time |
|-------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------|------|
| 1     | Introduction to Flight Dynamics               | What is flight dynamics?                                                                                          | 2    |
| 2     | Recap                                         | Recap of module 1                                                                                                 | 3    |
| 3     | What defines flight dynamics                  | Definition the two parts of flight dynamics.                                                                      | 3    |
| 4 - 6 | Activity and conclusion                       | Practical example of gravity, drag, thrust and lift forces. How these forces can be controlled to achieve flight. | 15   |
| 7     | Where do these forces on an aircraft act?     | Introduction to centre of force concept. Pictorial representation of where these forces act on an aeroplane.      | 5    |
| 8     | Activity                                      | How to find centre of gravity for a paper aeroplane                                                               | 5    |
| 9     | Centre of forces – Activity and Demonstration | Estimate forces and location of forces for a particular type of movement.                                         | 15   |
| 10    | Summary                                       | Note flight behaviour for different centre of gravity locations.                                                  | 5    |
| 11    | Home assignment                               |                                                                                                                   | 5    |
| 12    | Next Module                                   | Brief overview of what will be covered in the next module                                                         | 2    |

## Slide 1

In the first module we flew our first paper aircraft. However, we did not have very good control on the path the aircraft followed. Notice these acrobatic aircrafts in the picture. They are flying upside down in formation. They have very good control on the direction, speed, angle and height at which they fly. The science on how an aircraft moves in air is called 'flight dynamics'.

In this module, we will learn what affects flight dynamics and how we can control it.

## Slide 2

In the previous module we learnt about the two branches of Aerospace Engineering.

Then we understood how aircrafts fly through activities.

Then we looked at the different career options in aerospace engineering.

## Slide 3

Recall your previous home assignment. We tested flight paths for different design variations. Do you think there is a relationship between flight dynamics and design of the aircraft?

We can understand flight dynamics by looking at two things,

### 1. External forces

These are the forces that act on an aircraft as it moves through air. These are ...

### 2. Control surfaces

This constitutes the design of the aircraft and how it we can manipulate the external forces by using specific design to achieve what we want. Some examples are...

Both external forces and control surfaces are as shown to the left.

The purpose of individual control surfaces will be discussed in the next module.

## Slide 4 – Activity 1: Gravity, Drag and Thrust

### Materials

1. 2 x A4 sheets of paper

Gravity – Take a crumpled ball of paper and ask students to drop it. It goes down because of gravity force.

We can conclude that gravity always acts downwards.

Drag – Take a crumpled ball as well as a plane paper. Drop both of them down at the same time. The plane paper comes slowly as it has more drag than the crumpled paper.

Now take the plane paper and place it on your palm and push upwards, you will feel a resistance when compared to pushing up a crumpled ball.



Thrust – Repeat the experiment with greater force. This force is called thrust.

Thrust forces act in the direction we propel the object in.

For drag force,

We can conclude that drag always acts in direction opposite to motion. It opposes thrust.

Also, drag force increases as the surface area of the object increases.

Conduct a brainstorming session in class. Encourage creativity.

## Slide 5 - Activity 2: Lift Force

### Materials

1. A4 paper

### Procedure

Curve the A4 paper as shown in the figure and place it on a table.

Ask students to blow through the hole.

As the air passes the paper will try to stick to the ground.

# Power point Example

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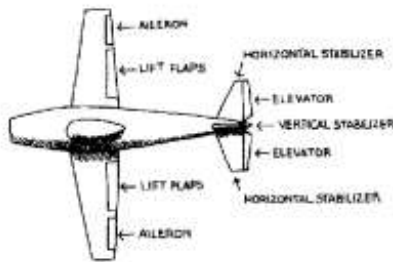
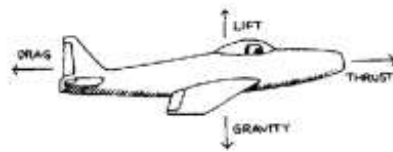


## Recap

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In the previous module we learnt about the two branches of Aerospace Engineering  
Then we understood how aircrafts fly through activities.  
Then we looked at the different career options in aerospace engineering.

In this module we will look at the forces acting on an aircraft in more detail and understand how they interact with each other to control the aircraft's motion.



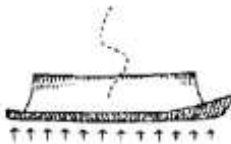
## What do we need to understand 'Flight Dynamics'

### External Forces

- Lift
- Drag
- Thrust
- Gravity

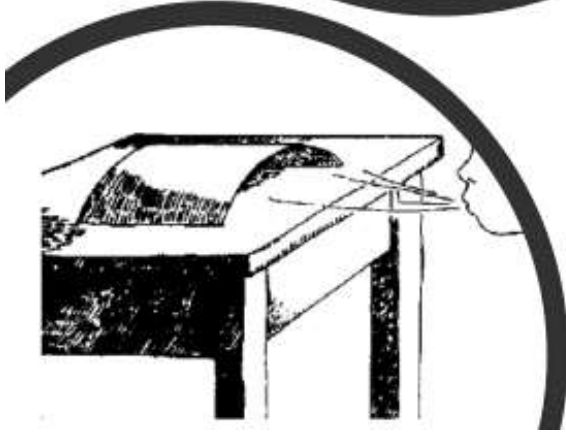
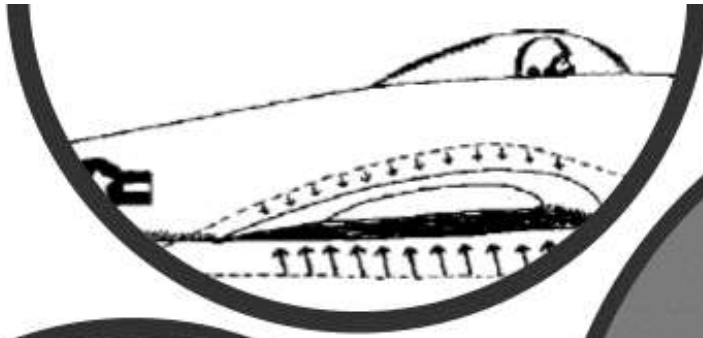
### Control Surfaces

- Flap
- Aileron
- Stabilizer
- Elevator
- Rudder



## Activity 1

Gravity, Drag and Thrust



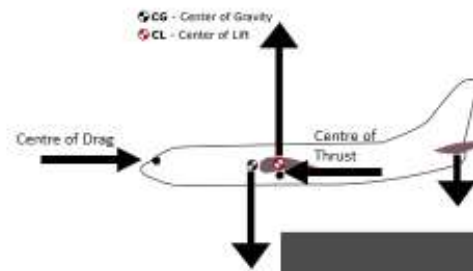
## Activity 2 Understanding Lift

By controlling these four  
forces, we can move the  
aircraft

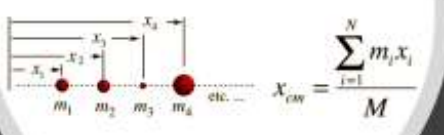
## At what point do these forces act?

We need to understand the following concepts,

- Centre of Gravity
- Centre of Lift
- Centre of Thrust
- Centre of Drag



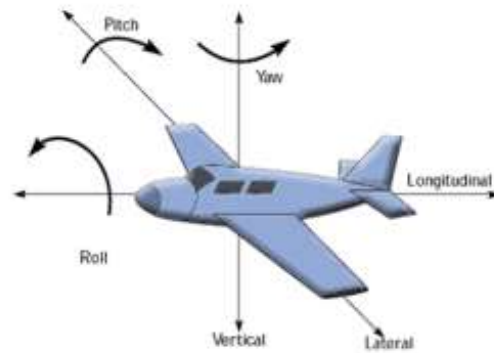
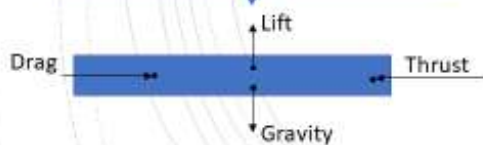



$$X_{cg} = \frac{\sum_{i=1}^N m_i x_i}{M}$$

### Activity 3

Centre of gravity

## Centre of forces



The location of centre of gravity, lift, thrust and drag on the aircraft determines if the aircraft

In pairs, sketch the centres of the four forces on a dummy plane, such that the aircraft shows the above behaviour.

Example, for longitudinal motion

- Thrust and Drag are in same line. Thrust > Drag.
- Lift and Gravity are in same line. Gravity = Lift.

## Summary

Flight dynamics can be understood by studying the external forces and shape of the aircraft.

There are four principal external forces that act on an aircraft. Gravity, Lift, Drag and Thrust.

Location where these forces act can be imagined by finding respective centre of forces.

The aircraft maneuvers based on the location and magnitude of centre of forces.