

Unit 24: The Principles of Flight

Unit code:	L/602/5688
QCF Level 3:	BTEC National
Credit value:	2
Guided learning hours:	19

● Aim and purpose

The aim of this unit is for learners to gain understanding of the principles of flight and knowledge of aircraft construction, including how and why aircraft fly and how in-flight stability and control is maintained.

● Unit introduction

All units in this qualification are targeted at airport, airline or handling agent ground staff. Most are directly linked to activities that learners may realistically be expected to undertake in the course of normal duties. This unit takes learners one step further.

The ultimate aim of aviation activities on the ground is to work towards a safe aircraft departure, or to prepare for the efficient arrival of a commercial aircraft. Other units have examined tasks such as load planning, loading, airline operations and customer service which must all run parallel to ensure efficient and timely turnrounds. What happens when the turnround is complete? How does the 300-tonne aircraft manage to lumber into the sky? This unit helps to provide these answers.

This unit is not designed to teach learners how to fly an aircraft, nor is it impossibly technical. It is included to introduce ground staff to the fundamentals of how flight is achieved. Hopefully, the unit will also provide an insight into why seemingly minor breaches of safety rules on the ground can have a serious impact once the aircraft is in the air.

● Learning outcomes

On completion of this unit a learner should:

- 1 Understand how the Four Forces of Flight contribute to controlled flight
- 2 Understand how in-flight stability and control is maintained.

Unit content

1 Understand how the Four Forces of Flight contribute to controlled flight

The Four Forces of Flight:

- causes and effects (lift, mass, thrust, drag)

How the Four Forces of Flight contribute to controlled flight:

- balanced forces
- lift (overcoming mass, aerofoil, wing shape, laminar flow, angle of attack, air density, air temperature)
- mass (not exceeding lift, mass reduction, balance considerations)
- thrust, e.g. engine types, overcome drag
- drag, e.g. form drag, skin friction, drag reduction

2 Understand how in-flight stability and control is maintained

Aircraft parts and functions that contribute to stability and control:

- stability, e.g. wing, horizontal stabiliser, vertical stabiliser
- control, e.g. aileron, elevator, rudder, flap, spoiler/speed brake

Aircraft stability:

- natural stability, e.g. location and shape of fixed surfaces
- load distribution
- mass and balance limitations
- fuel distribution
- autopilot/computer

Aircraft control:

- take-off, e.g. mass and balance calculations, flap setting, full thrust, specific take-off speed
- climb, e.g. drag reduction (retract undercarriage, retract flaps), thrust reduction, specific climb speed/rate
- cruise, e.g. thrust setting, altitude setting
- landing, e.g. controlled descent (speed and rate), reduced thrust setting, drag increase (flap setting, undercarriage deployment, speed brakes), brakes, thrust reversers
- use of control surfaces in all stages of flight, e.g. elevator (climb/descend), aileron (roll), rudder (turn)

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 Identify the Four Forces of flight	M1 Discuss the factors that determine total lift generated by a wing	D1 Analyse the desired and undesired consequences of changing the relationship of the Four Forces of Flight whilst an aircraft is in flight
P2 Explain how the Four Forces contribute to controlled flight		
P3 Describe the component parts of an aircraft and their functions relating to stability and control	M2 Explain the effects of changing the load, in terms of mass and distribution, on aircraft stability and control	
P4 Explain how stability is built into the structural design of modern aircraft [IE]		
P5 Explain how aircraft control is achieved and maintained during take-off, cruise and landing		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Learners working at airports may have the opportunity to observe aircraft and their component parts at close hand. It would be useful for airport-based delivery to include visits onto the ramp where many of the elements discussed in the unit can be seen in practice. For classroom-based learners, this access is unlikely at a major airport, but viewing decks and 'spotting points' still exist at some, so close observation may be possible. Equally, a visit to a small flying club can often be arranged – the aircraft may be smaller, but the principles are largely the same.

It is important that the theory of the Four Forces of Flight is understood before progressing to the application of the principles. It is likely that this will be classroom based, simply to allow graphics, models and diagrams to be used in the tutor-led sessions. The concepts will probably be new to many learners, even those who are currently employed in aviation ground services. Entering The Four Forces of Flight into a search engine produces a great variety of texts and diagrams. It would be preferable to access a UK-based site, as some US sites use different terminology.

Once the Four Forces of Flight are understood, learners can discuss how these factors, when balanced, contribute to a safe, stable flight. This should be extended to include the possible consequences of one or more of the forces of flight being unbalanced (either intentionally or unintentionally).

Learners can demonstrate their knowledge of aircraft by describing key parts that contribute to stability and control. Firstly, the fixed surfaces that create the natural stability of the aircraft (wings, horizontal and vertical stabilisers), then the moving surfaces that enable the aircraft to be controlled (ailerons, elevators, rudders, flaps).

Natural stability is a design feature of modern aircraft. Learners can look at several aircraft types and comment on the similar appearance that many share. Frequently, the only differences are between T-tail and conventional tail or high-wing and low-wing. These comparisons can be continued to explain how the requirement for stability can be assured for all types.

For learning outcome 2, the theory is applied. A narrative explaining how the surfaces providing stability and control use the Four Forces throughout flight from take-off to landing will enable learners to appreciate the simple principles used.

Having established the factors behind stable flight, learners should then continue to discover how loading (passengers, baggage, cargo and fuel) can impact on the controllability of aircraft, both in terms of total mass and its distribution.

Throughout delivery the use of models, diagrams and video clips to support the input is essential. Ideally, at least one airside visit which enables learners to see the control surfaces first-hand should be arranged.

Although it will not be assessed, it would be good practice to use this unit to emphasise the importance of following turnaround regulations carefully to ensure flight safety. In particular:

- reporting of any damage to the aircraft skin, or engines – even the smallest impact could have serious consequences due to a reduction in lift or thrust, or potential decompression
- securing of loads within the aircraft – any shift in loads could adversely affect the balance of the aircraft and render it difficult to control.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way of planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to the unit. Using models, diagrams, video clips, explain what is meant by the Four Forces of Flight and their universal application to heavier-than-air flight.
Class discussion – explore how the Four Forces of Flight contribute to controlled flight. Using models and graphics, learners could suggest how balanced forces are maintained.
Tutor-led or visiting qualified pilot – explain the factors that combine to determine the amount of lift generated by a wing. Learners must understand that a change in any one of these will alter the total lift. It is particularly useful to emphasise that some factors (e.g. air temperature) will vary from day to day for the same aircraft.
Preparation for assignment Assignment 1: Four Forces of Flight (P1, P2, M1) Feedback on assignment
Tutor-led discussion. Learners may already be familiar with many of the names of significant aircraft parts. Using diagrams and models, all those in the unit content should be identified and their function described. At this point the difference between stability and control should be clarified (i.e. control relates to the ability to change direction, stability is the tendency to resist change).
Tutor-led discussion – learners should explore how flight stability is integral in aircraft design (i.e. there is a natural tendency for the aircraft to fly in a stable manner). Reference to items in the unit content should be made.
Tutor-led discussion following a visit to an aircraft – learners should be made aware of the methods of maintaining control during the various stages of flight. This will include periods of low-speed flight (e.g. take-off, landing) where the generation of lift is critical and control surfaces are less effective, and high-speed flight (e.g. cruise) where drag reduction is paramount and control surfaces are extremely effective. Research for this can be combined with P5.
Tutor-led discussion following a visit to an aircraft – investigate the changed relationships of the Four Forces of Flight and the differences in controllability at low and high speed. The use of flaps and slats and the requirement for larger control inputs at low speed should be explained along with the effect of drag flap during landing.
Class discussion – how total payload mass (passengers, baggage, cargo) plus fuel mass can change the relationship of the Four Forces of Flight. Discussion should continue to examine how load distribution can make the difference between a safe, controllable aircraft and one that is unsafe and uncontrollable.
Building on knowledge gained so far, the group could continue the discussion to predict the results of changing the relationship of the Four Forces of Flight (either intentionally or unintentionally). This would include answering the questions: How might the imbalance occur? What would be the result? If it was unintentional, how could balance be restored? In what circumstances would an imbalance be intentional?
Preparation for assignment Assignment 2: Stability and Control (P3, P4, P5, M2, D1) Feedback on assignment

Assessment

This unit can be assessed through a learner presentation or as a written report. In either case, it is expected that learners will make extensive use of diagrams and illustrations to support their descriptions and explanations. Video clips and model aircraft can also be used to help clarify points.

P1 – P2 – M1

To achieve P1, learners must clearly identify the causes and effects of the Four Forces of Flight as experienced by a modern aircraft.

To achieve P2, learners must explain how the Four Forces of Flight are balanced to contribute to controlled flight. This should include the methods used and the reasons why maintaining this balance is important.

To achieve M1, learners must discuss the factors that determine total lift in a wing. This must include factors that are controllable (for example aerofoil shape) and those which are not (for example air density).

P3 – P4 – P5 – M2 – D1

To achieve P3, learners must describe the parts of the aircraft that provide both stability and control. All items in the unit content must be included.

To achieve P4, learners must explain how stability is designed into modern aircraft, covering the items listed in the unit content.

To achieve P5, learners must explain how control is maintained throughout all stages of flight (take-off, cruise, descent and landing).

To achieve M2, learners must explain the effects of changing the load (total mass and its distribution) on an aircraft in terms of controllability and stability.

To achieve D1, learners must analyse the intentional and unintentional consequences of changing the relationship of the Four Forces of Flight. This should include examples for all four forces stating why the flight profile might change and how this could either present a problem or be a desired effect.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Assignment 1: Four Forces of Flight	Working for an airline or handling agent, produce a chapter to be included in an induction guide for new ramp staff.	Introductory guide for new ramp staff, booklet, presentation, posters
P3, P4, P5, M2, D1	Assignment 2: Stability and Control	Writing for a specialist interest journal, produce an article explaining how stability and control is managed.	Report

Links to other BTEC units

This unit forms part of the BTEC aviation sector suite. This unit has particular links with the following unit titles in the aviation suite.

Level 2	Level 3	Level 4
n/a	Unit 25: Aircraft Take-off and Landing Performance	n/a

Essential resources

Learners must have access to library and research facilities, including current trade publications. For demonstration purposes, learners should have access to an aircraft model with control surfaces and video clips of aircraft in flight.

Employer engagement and vocational contexts

Industry visits and visits from guest speakers from the industry are recommended. Learners should have access to accurate and up-to-date industry case studies.

Indicative reading for learners

Oxford Aviation Training – *Principles of Flight* (OAT Media, 2007) ISBN 978-0955517747

Pooleys – *Air Pilots Manual Vol 4* (Air Pilot Publishing, 1999) BTT040 APM 4

Taylor R – *Understanding Flying* (Thomasson-Grant Publishers, 1992) ISBN 978-1565660021

Journal

Pilot (monthly) – Archant Specialist

Websites

<http://pilotsweb.com/principle.htm>

Pilots' Web – online aviation journal – the principles of flight

www.southendflyingclub.co.uk/lecture/principles.htm

Southend Flying Club – the principles of flight

www.youtube.com/watch?v=5ltjFEei3AI&feature=related

YouTube clip (good video animation, but US terminology used)

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	planning and conducting research into the structural design of modern aircraft and how stability is built in.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	investigating the Four Forces of Flight
Team workers	working in groups to identify and describe the key parts of aircraft that contribute to stability and control
Self-managers	managing the workload of the unit assessment.

● Functional Skills — Level 2

Skill	When learners are ...
ICT — Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using a variety of systems to explain how the Four Forces of Flight contribute to controlled flight
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	planning and carrying out research using appropriate search criteria
Manage information storage to enable efficient retrieval	organising work into folders to enable retrieval and development
Follow and understand the need for safety and security practices	logging in to a variety of systems securely and visiting trusted websites
Troubleshoot	as required.
ICT — Find and select information	
Select and use a variety of sources of information independently for a complex task	investigating how stability is built in to the structural design of modern aircraft
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	using appropriate search criteria in order to research modern aircraft design.
ICT — Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records 	entering and developing images, diagrams and text to explain how the Four Forces of Flight contribute to stability in flight
Bring together information to suit content and purpose	collating notes and research findings to explain how the forces of flight contribute to stability in flight
Present information in ways that are fit for purpose and audience	presenting information clearly and accurately to a range of aviation personnel
Evaluate the selection and use of ICT tools and facilities used to present information	selecting the most appropriate ICT tools to produce presentations and reports throughout the unit.

Skill	When learners are ...
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	exploring the Four Forces of Flight and how they contribute to controlled flight and how control is maintained during take-off, cruise and landing.
Identify the situation or problem and the mathematical methods needed to tackle it	
Select and apply a range of skills to find solutions	
Use appropriate checking procedures and evaluate their effectiveness at each stage	
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	
Draw conclusions and provide mathematical justifications	
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	working in groups to label aircraft parts and discuss the forces of flight
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading and comparing text about different aircraft designs
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing an article to communicate how stability and control is managed.