MINISTRY OF EDUCATION

Aviation & Aerospace Engineering

TEACHER MANUAL

YEAR 1 - BOOK 1

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

MINISTRY OF EDUCATION

REPUBLIC OF GHANA

Aviation and Aerospace Engineering

Teacher Manual

Year One - Book One

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

AVIATION & AEROSPACE ENGINEERING

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INTRODUCTION

The National Council for Curriculum and Assessment (NaCCA) has developed a new Senior High School (SHS), Senior High Technical School (SHTS) and Science, Technology, Engineering and Mathematics (STEM) Curriculum. It aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, competencies, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, further their education and enter the world of work.

This is the first time that Ghana has developed an SHS Curriculum which focuses on national values, attempting to educate a generation of Ghanaian youth who are proud of our country and can contribute effectively to its development.

This Teacher Manual for Aviation and Aerospace Engineering covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively teach Year One of the new curriculum. It contains this information for the first 13 weeks of Year One, with the remaining 11 weeks contained within Book Two. Teachers are therefore to use this Teacher Manual to develop their weekly Learning Plans as required by Ghana Education Service.

Some of the key features of the new curriculum are set out below.

Learner-Centred Curriculum

The SHS, SHTS, and STEM curriculum places the learner at the center of teaching and learning by building on their existing life experiences, knowledge and understanding. Learners are actively involved in the knowledge-creation process, with the teacher acting as a facilitator. This involves using interactive and practical teaching and learning methods, as well as the learner's environment to make learning exciting and relatable. As an example, the new curriculum focuses on Ghanaian culture, Ghanaian history, and Ghanaian geography so that learners first understand their home and surroundings before extending their knowledge globally.

Promoting Ghanaian Values

Shared Ghanaian values have been integrated into the curriculum to ensure that all young people understand what it means to be a responsible Ghanaian citizen. These values include truth, integrity, diversity, equity, self-directed learning, self-confidence, adaptability and resourcefulness, leadership and responsible citizenship.

Integrating 21st Century Skills and Competencies

The SHS, SHTS, and STEM curriculum integrates 21st Century skills and competencies. These are:

- **Foundational Knowledge:** Literacy, Numeracy, Scientific Literacy, Information Communication and Digital Literacy, Financial Literacy and Entrepreneurship, Cultural Identity, Civic Literacy and Global Citizenship
- **Competencies:** Critical Thinking and Problem Solving, Innovation and Creativity, Collaboration and Communication
- **Character Qualities:** Discipline and Integrity, Self-Directed Learning, Self-Confidence, Adaptability and Resourcefulness, Leadership and Responsible Citizenship

Balanced Approach to Assessment - not just Final External Examinations

The SHS, SHTS, and STEM curriculum promotes a balanced approach to assessment. It encourages varied and differentiated assessments such as project work, practical demonstration, performance

assessment, skills-based assessment, class exercises, portfolios as well as end-of-term examinations and final external assessment examinations. Two levels of assessment are used. These are:

- Internal Assessment (30%) – Comprises formative (portfolios, performance and project work) and summative (end-of-term examinations) which will be recorded in a school-based transcript.
- External Assessment (70%) – Comprehensive summative assessment will be conducted by the West African Examinations Council (WAEC) through the WASSCE. The questions posed by WAEC will test critical thinking, communication and problem solving as well as knowledge, understanding and factual recall.

The split of external and internal assessment will remain at 70/30 as is currently the case. However, there will be far greater transparency and quality assurance of the 30% of marks which are school-based. This will be achieved through the introduction of a school-based transcript, setting out all marks which learners achieve from SHS 1 to SHS 3. This transcript will be presented to universities alongside the WASSCE certificate for tertiary admissions.

An Inclusive and Responsive Curriculum

The SHS, SHTS, and STEM curriculum ensures no learner is left behind, and this is achieved through the following:

- Addressing the needs of all learners, including those requiring additional support or with special needs. The SHS, SHTS, and STEM curriculum includes learners with disabilities by adapting teaching and learning materials into accessible formats through technology and other measures to meet the needs of learners with disabilities.
- Incorporating strategies and measures, such as differentiation and adaptative pedagogies ensuring equitable access to resources and opportunities for all learners.
- Challenging traditional gender, cultural, or social stereotypes and encouraging all learners to achieve their true potential.
- Making provision for the needs of gifted and talented learners in schools.

Social and Emotional Learning

Social and emotional learning skills have also been integrated into the curriculum to help learners to develop and acquire skills, attitudes, and knowledge essential for understanding and managing their emotions, building healthy relationships and making responsible decisions.

Philosophy and vision for each subject

Each subject now has its own philosophy and vision, which sets out why the subject is being taught and how it will contribute to national development. The Philosophy and Vision for Aviation and Aerospace Engineering is:

Philosophy: Every learner can be trained in aviation and aerospace engineering given the right environment and qualified, skilled facilitators/teachers.

Vision: A trained learner grounded in fundamental knowledge and hands-on aviation and aerospace engineering skill sets required to solve the industry's developmental challenges beyond 21st century needs.

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Aviation and Aerospace Engineering Summary

S/N	STRAND	SUB-STRAND	YEAR 1			YEAR 2			YEAR 3		
			CS	LO	LI	CS	LO	LI	CS	LO	LI
	Core Concepts In Aerospace Engineering	Fundamentals of Flight	3	3	6	-	-	-	-	-	-
		Aerodynamics and Propulsion	-	-	-	3	3	7	-	-	-
		Aircraft Structures and Control	-	-	-	-	-	-	3	3	8
	Avionics	Fundamentals of Avionics	2	2	6	-	-	-	-	-	-
		Aircraft Instrumentation	-	-	-	2	2	4	-	-	-
		Communication, Navigation and Surveillance System	-	-	-	-	-	-	3	3	6
	Aviation Industry	The Aviation Profession and Operations	2	2	4	-	-	-	-	-	-
		Aviation Organisations	-	-	-	2	2	4	-	-	-
		Aircraft Maintenance	-	-	-	-	-	-	2	2	4
	Unmanned Aerial Vehicles (UAVS)	UAV Applications	2	2	4	-	-	-	-	-	-
		Safety And Deregulations	-	-	-	1	1	3	-	-	-
		Design And Fabrications Of UAVS	-	-	-	-	-	-	3	3	5
Total			**9**	**9**	**20**	**8**	**8**	**18**	**11**	**11**	**23**

Overall Totals (SHS 1 – 3)

Content Standards	**28**
Learning Outcomes	**28**
Learning Indicators	**61**

SECTION 1: INTRODUCTION TO FLIGHT

Strand: **Core Concepts in Aerospace Engineering**

Sub-Strand: Fundamentals of Flight

Learning Outcome: *Explain the key stages characterising the evolution of flight from its inception to the advent of powered, controlled flight*

Content Standard: Demonstrate knowledge and understanding of the evolution of flight

INTRODUCTION AND SECTION SUMMARY

This section introduces the learner to the basic historical development and pioneers in aviation. It focuses on the contributions of the various pioneers of aviation, the technological challenges they faced, their individual contributions and how those contributions served as stepping stones for other pioneers. It also explains the various aircraft classifications and introduces learners to basic aircraft conceptual design. It compares and contrasts on the similarities and differences of rotary wing and fixed wing aircraft, their various components and functions, as well as the advent of vertical take-off and landing aircraft (VTOL). The learners are also expected to come up with aircraft concepts and support those concepts with sketches. This is covered across the following weeks:

Week 1: The Evolution of Flight

Week 2: The Evolution of Flight

Week 3: Flight Vehicle Nomenclature

Week 4: Flight Vehicle Nomenclature

Summary Of Pedagogical Exemplars

It is expected that teachers make the presentation as relaxed as possible and draw from learners' local experience with flight to the discussions. The major pedagogies emphasised in this section are as follows: collaborative learning, experiential learning, building on what others say, and project-based learning. These are further expounded in the respective lessons.

ASSESSMENT SUMMARY

The Webb's Depth of Knowledge is applied in this section. Teachers are encouraged to consider different learning needs in assessing expected outcomes. Learning tasks are differentiated to accommodate approaching proficient, proficient, and highly proficient learners.

Weeks 1&2: Evolution Of Flight

Learning Indicator(s):

1. *Trace the evolution of flight prior to powered, controlled flight.*
2. *Describe the stages that led to the attainment of powered, controlled flight.*

Theme Or Focal Area: Introduction To The Key Stages Characterising The Evolution Of Flight

Introduction

Humans have always been fascinated by the ability of birds to fly. This has spurred our ingenuity in developing flying machines. Ancient folklore is filled with stories of flying creatures and people. As far back as the fifth century, the Chinese invented the kite. Following this, man's attempts at flight began to hinge on the concept of flying like birds—with wings. First, wings were designed and strapped to the arms, but it took only so much time before the early people realised that we did not possess the muscle power to sustain flight. Thus, the focus shifted to mechanically controlled wings. These designs were known as Ornithopters. In the fifteenth century, Leonardo da Vinci produced about 500 ornithopter sketches, although it is not known whether he built or tested his designs.

The Montgolfier brothers began to explore another paradigm—hot air balloons. On 21st November 1783, a balloon carrying Pilatre de Rozier and Marquis d'Arlandes travelled 5 miles across Paris.

Another approach to balloons was the use of lighter-than-air gases. On 1st December 1783, the French physicist, J. A. C. Charles and Nicolas-Louis Robert flew a hydrogen-filled balloon at a height of 1800 feet for 2 hours and 5 minutes, covering a distance of 36 km.

Most of these early flying machines were at the mercy of the wind; they lacked precise control. It would take further research and development before controlled heavier-than-air flight was achieved.

Figure 1: *Ancient Chinese kite*
(Source: https://medium.com/@rachel_82473/ancient-chinese-kites-chinese-kite-festival-f%C4%93ngzh%C4%93ngff7a03a6b797*)*

Figure 2: *A sketch of an ornithopter.*
(Source: https://www.britannica.com/technology/ornithopter*)*

Figure 3: *The hot-air balloon of the Montgolfier brothers.*
(Source: https://www.britannica.com/biography/Montgolfier-brothers *(accessed: 22/03/2024))*

LEARNING TASK(S):

1. Observe flying animals in their natural environment.
2. Identify and explain features of the observed animals that enable them to fly.
3. Highlight the stages in the development of flight before powered, controlled heavier-than-air flight.

Pedagogical Exemplars

1. **Building on what others say:** Brainstorm and build on what others say about humans' attempt to fly like birds, using lighter-than-air- balloons and kites. Organise thoughts using webbing or concept maps. Provide avenues that encourage all learners to fully participate and communicate their findings and views. Teacher should be mindful of the choice of words when providing feedback on learners' responses.
2. **Collaborative learning**: With the aid of a video documentary, textbooks, webpages, or any other relevant sources, work in small mixed-ability groups, to develop posters or PowerPoint presentations on the various phases or stages of flight development. Provide support to learners who may require assistance in developing PowerPoint and poster presentations. Encourage all learners to participate, respect, and tolerate the views of all learners while working in groups or in pairs.

Key Assessment

Assessment Level 1: Name some flying machines that were built prior to powered, controlled flight.

Assessment Level 2: Design a flowchart of the stages of the evolution of flight prior to powered, controlled flight.

Assessment Level 3: Compare the inventions of at least two persons who built flying machines before the advent of powered, controlled flight

Assessment Level 4: Design, build and fly kites and paper aeroplanes.

Week 3: Flight Vehicle Nomenclature

Learning Indicator(s): *Differentiate between the types of aerospace vehicles*

Focal Area Or Theme: The Types Of Aerospace Vehicles And Their Parts

Introduction

Every object on Earth is attracted by its gravitational pull. In order to lift any object and make it airborne, it is necessary to generate a force that opposes Earth's gravity. Scientists have discovered aerofoil, which is capable of generating this force. It operates by creating a difference in air pressure between its upper and lower surfaces. To generate lift, the aerofoil must move through the air at a given speed. The resultant force is an upward push on the aerofoil. Different aircraft achieve this in different ways.

Fixed-Wing Aircraft

In this configuration, the lifting surface (wing) is rigidly attached to the body of the aircraft. The whole aircraft moves through the air in order to generate the pressure difference around the aerofoil. The major parts of a fixed-wing aircraft include the following:

1. Fuselage:
   a. This is the main structure of the aircraft to which the wings, tail, and landing gear are attached. It houses the payload (crew, passengers and cargo). Generally, the fuselage is identified by its cylindrical shape.
2. Wing
   a. This is the main lifting surface of the aircraft. It supports the weight of the aircraft in the air. A vertical section through the wing reveals the aerofoil shape. The wing may be used to store fuel.
   b. Ailerons are attached at the rear of the wings, towards the tips to control the roll of the aircraft.
   c. Flaps are also found at the rear of the wings, closer to the fuselage. They generate more lift at lower speeds for takeoff or landing.
3. Tail/Empennage
   a. The tail comprises the vertical and horizontal stabilisers at the back of the aircraft. They are necessary for its stability.
   b. The rudder is hinged to the vertical stabiliser and is necessary for directional control.
   c. The elevator is hinged to the horizontal stabiliser and is necessary for pitch control.
4. Landing gear
   a. The landing gear supports the aircraft on the ground during taxiing, takeoff, and landing.
   b. Depending on the environment in which the aircraft is used, it could be made of wheels, skis, or floats.
5. Power plant
   a. This provides the energy that moves the aircraft through the air.
   b. It is mostly an internal combustion engine that drives a propeller or pushes backwards a jet of air at high speed.

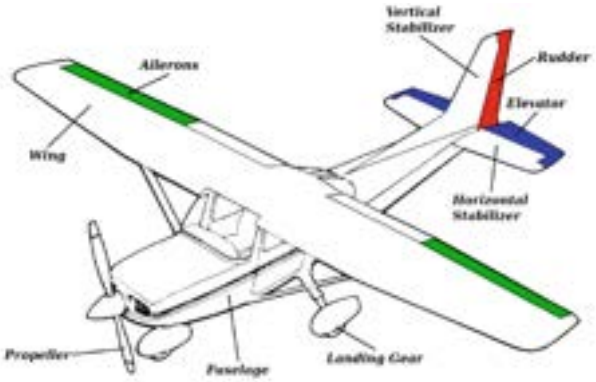

Figure 4: *Parts of a fixed-wing aeroplane*
(Source: https://www.researchgate.net/figure/Sketch-illustrates-the-main-components-of-the-ordinary-aircraft_fig2_344464275 *(accessed: 22/03/2024))*

Rotary-Wing Aircraft

In this configuration, the rotors form the main lifting surface. They are "wings" that rotate at high speed to lift the aircraft vertically into the air. The rotors are attached to a central mast above the aircraft which can be tilted to move the aircraft in the desired direction. Rotorcraft share some features with fixed-wing aircraft. For example, the fuselage, power plant, and landing gear. Features peculiar to rotary-wing aircraft include:

1. Main rotors
    a. The main rotors are made up of two or more blades attached to a central mast. As they spin, they cause the fuselage to spin in the opposite direction. Certain configurations have more than one rotor to counter this torque; others use a tail rotor.
2. Tail rotor
    a. The tail rotor is attached to a tail boom. It produces a counterforce that prevents the aircraft from spinning. The boom houses the element that transmits power from the main engine to the tail rotors.

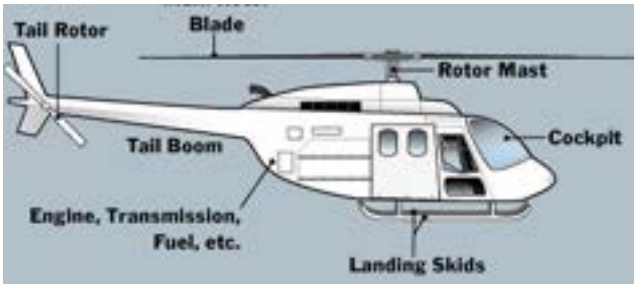

Figure 5: *Parts of a helicopter*
(Source: https://science.howstuffworks.com/transport/flight/modern/helicopter3.htm *(accessed 22/03/2024)*

Figure 6: *Tandem-rotor helicopter*
(Source: : https://www.indiatoday.in/india/story/chinook-helicopter-iaf-air-force-chopper-india-feature-1485864-2019-03-25 *(accessed 22/03/2024))*

Spacecraft

This refers to vehicles that operate outside of the Earth's atmosphere. They include launch vehicles, satellites, and deep space probes. Because there is no air in space, spacecrafts have to carry their own oxidisers in addition to fuel. The payload carried by the spacecraft depends largely on its mission.

Common applications of spacecrafts include communications, Earth observation, meteorology, navigation, space colonisation, planetary exploration, and transportation of humans and cargo.

A typical spacecraft may have the following elements:

1. Instruments for conducting science experiments
2. Structures that hold all of the equipment
3. Mechanisms that allow some parts to point independently of the main spacecraft
4. Telecommunications for sending and receiving data
5. Propulsion for correcting the spacecraft's flight path
6. Guidance, navigation, and control systems
7. Thermal systems for maintaining proper temperatures
8. Electrical power, usually derived from solar panels

Figure 7: *A spacecraft*
(Source: https://www.theguardian.com/lifeandstyle/2021/feb/07/readers-reply-how-do-spacecraft-manoeuvre-in-the-vacuum-of-space *(accessed 22/03/2024)*

Figure 8: *Parts of a rocket*
(Source: https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/rocket-parts/ *(accessed 22/03/2024)*

Learning Tasks

1. *List the features of selected aerospace vehicles*
2. *Explain the features of selected aerospace vehicles*
3. *Compare and contrast the features of different aerospace vehicles*

Pedagogical Exemplars

Collaborative Learning: Assign learners to small task groups for them to research and make PowerPoint or poster presentations on the differences between aircraft and spacecraft. Let them work in mixed-ability groups and encourage respect of views and tolerance among all group members. Teacher should make provision for adequate resources to ensure all learners are able to undertake meaningful research and make presentation.

Talk-for-Learning: Initiate a class discussion on flight vehicle nomenclature. Use appropriate aircraft models, pictures and audio-visual contents to demonstrate the importance of aircraft and spacecraft parts to facilitate learners' understanding. Teacher should steer discussion using these focal points:

a. Requirement for flight: Generation of lift

b. Broad classes of aircraft: Fixed-wing and rotary wing.

c. Major parts of a helicopter and a fixed-wing aircraft.

d. Major differences between rotary and fixed-wing aircrafts.

e. Types and components of space vehicles.

Note: To ensure equal participation, do not avoid learners having difficulty sharing ideas with the whole class; use strategies such as randomly selecting group members to ensure equal participation. Also provide further explanations to learners who may struggle with the concepts or task and challenge learners who give correct responses with leading questions.

Key Assessments

Assessment Level 1:

a. Identify the different parts of the following flight vehicles:
   i. Rotary-wing
   ii. Fixed–wing
   iii. Spacecraft

b. State the functions of the parts of these flight vehicles:
   i. Rotary-wing
   ii. Fixed–wing
   iii. Spacecraft

Assessment Level 2: Explain the functions of the parts of:

a. Rotary-wing aircraft

b. Fixed-wing aircraft

c. Space vehicle

Assessment Level 3: Make a PowerPoint presentation on the difference between an aircraft and a spacecraft

Week 4: Flight Vehicle Nomenclature

Learning Indicator(s): *Make freehand sketches of current and future aerospace vehicles and label their parts.*

Theme Or Focal Area: Sketching Of Various Current And Future Aerospace Vehicles

Learning Tasks

1. Assign learners in mixed-gender and ability groups to develop sketches of various aerospace vehicles. Teacher ensures that learners' outputs in the various groups do not receive unpleasant comments from their peers. The aerospace vehicles to be sketched are:
   a. Current fixed-wing aircraft (Group 1)
   b. Future fixed-wing aircraft (Group 2)
   c. Current rotorcraft (Group 3)
   d. Future rotorcraft (Group 4)
   e. Current spacecraft (Group 5)
   f. Future spacecraft (Group 6)
2. Initiate group discussions on the sketches learners have made. Discussions should be focused on the features of current aerospace vehicles that enable them to fly and the ideas informing the features of future aerospace vehicles. Learners are guided to engage in discussions on the various sketches, tolerating each other's views and opinions.

Pedagogical Exemplars

Collaborative learning: In small, mixed- ability groups, assign each group to specific aerospace vehicles for them to make freehand sketches. Learners should pay attention to details and show commitment to the assigned task and tolerate one another's viewpoints. Ask learners who have completed their sketches early to help their colleagues, using polite and appropriate language.

Key Assessment

Assessment Level 1:

1. List the features of a fixed-wing aircraft
2. List the features of a spacecraft.

Assessment Level 2:

a. Explain the main differences between a fixed-wing and a rotorcraft.

b. Make a sketch of two future aerospace vehicles and propose differences between current and future aerospace vehicles.

Section Review

Flight has been an interesting field for humanity. The section introduces learners to the history of its development, the mastery of birds in this area and the attempts made by early pioneers. The learners also have been introduced to preliminary conceptual thinking and practical design of flying models. This section positions learners on a path to basic aeronautical thought.

The pedagogies employed will help learners acquire critical thinking skills, collaboration, communication, creativity, research and analytical skills.

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SECTION 2: SAFETY IN THE AEROSPACE LABORATORY

Strand: **Core Concepts in Aerospace Engineering**

Sub-Strand: Fundamentals of Flight

Learning Outcomes: *Discuss recommended practices in the Aerospace laboratory*

Content Standard: Show understanding of safety regulations in the Aerospace laboratory.

INTRODUCTION AND SECTION SUMMARY

This section explains the implications of safety practice in an aerospace engineering laboratory to learners. The various tools, equipment, emergency procedures and laboratory ethics are expounded to help learners avoid unnecessary accidents or incidents in the laboratory during practical sessions. This section also considers certain case studies of laboratory accidents, how these accidents can be dealt with and how they could have been prevented altogether. The teacher must therefore make conscious efforts to help learners appreciate practical safety practices in the laboratory, avoid improper laboratory practices and adhere to laid-down safety precautions. Only week 5 (Safety in the Laboratory) is covered in this section.

SUMMARY OF PEDAGOGIES

Teacher should ensure that safety precautions and regulations, as well as their importance, are firmly ingrained in learners' activities. The main pedagogies highlighted in this section to achieve this aim are building on what others say, talk-for-learning and experiential learning. These pedagogies are further explained in the coming week.

ASSESSMENT SUMMARY

This section uses Webb's depth of knowledge as the assessment model. The learning tasks are differentiated so as to accommodate the learning needs of all learners.

Week 5: Safety In The Laboratory

Learning Indicator(s): *Discuss the advantages of adhering to safety precautions in the laboratory*

Theme Or Focal Area: Safety Practices And Recommendations In The Aerospace Laboratory

Introduction to safety

Aerospace Engineering, like several other science disciplines, has a laboratory component. Several principles explained during a teaching session would only be fully grasped when demonstrated under controlled conditions. In order to ensure safety and decorum in the laboratory, it is customary to define regulations that must be adhered to.

Safety regulations in the laboratory

1. The laboratory is a safety environment, and "horseplay" is discouraged.
2. Learners are not allowed at any time to work alone in the laboratory.
3. Always wear the prescribed personal protective equipment, i.e., hearing protection, goggles, dust masks, gloves, helmet etc.
4. Contact lenses should not be worn in the laboratory in situations where vapours or fumes are present.
5. Learners must know the location of emergency equipment including fire extinguishers, first-aid kit, alarm bells, etc. in the laboratory.
6. All learners must be familiar with emergency response procedures.
7. All electrical devices must be grounded before they are turned on. Worn or frayed extension cords or those with broken connections or exposed wiring must not be used.
8. Learners must always adhere to laid-down equipment operating procedures.
9. All laboratory aisles and exits must remain clear and unblocked.
10. Learners are prohibited from sniffing, breathing, or inhaling any gas or vapour used or produced in any experiment.
11. All containers must be labelled as to the content, composition, and appropriate hazard warning: flammable, explosive, toxic, etc.
12. Learners must read, and ensure to abide by the instructions on all warning signs in the laboratory.
13. All liquid and solid waste must be segregated for disposal.
14. Eating, drinking, use of any tobacco products, gum chewing or application of makeup is strictly prohibited in the laboratories, shops, and storage areas.
15. All injuries, accidents, and "near misses" must be reported to the laboratory technician immediately
16. No tools, supplies, or any other items may be tossed from one person to another, or carried out of the laboratory.
17. Compressed gas cylinders must be secured at all times. Proper safety procedures must be followed when moving compressed gas cylinders. Cylinders not in use must be capped.
18. Learners are never to play with compressed gas hoses or lines or point their discharges at any person, neither should they use adapters nor try to modify any gas regulator or connection.

19. There will be no open flames or heating elements used when volatile chemicals are exposed to the air.
20. Flammable chemicals will be exposed to the air only under a properly ventilated hood or in an area, which is adequately ventilated.
21. Personal items brought into the laboratory must be limited to those things necessary for the experiment and safe operation of the equipment in the laboratory.

Figure 9: *Personal protective equipment*
(Source: https://safetyculture.com/topics/ppe-safety/ *(accessed 22/03/2024))*

Learning Tasks

1. Familiarise with safety regulations in the laboratory and compare with safety regulations at home
2. Familiarise with safety measures observed in the aerospace engineering laboratory
3. Demonstrate the use of personal protective equipment in the laboratory.

Pedagogical Exemplars

Building on what others say: Initiate a question-and-answer session by asking learners to add to a list of rules and regulations on safety at home. Make room for divergent responses from learners, whether oral, written or graphical. Give support to learners who may need it.

Talk-for-learning: Learners relate safety rules at home to those in the aerospace laboratory through a class discussion. Encourage all learners to participate freely and tolerate each other's views. Use additional resources like pictures, sign posts and videos to help facilitate the discussion. Learners may struggle to articulate their thoughts or express themselves clearly during discussions. Therefore, provide clear instructions on effective communication skills, such as active listening, paraphrasing, and using evidence to support their views. Model effective communication and provide constructive feedback to help students improve their verbal and non-verbal communication skills.

Experiential learning: Learners visit the Aerospace laboratory where learners interact with technician/assistants; they are introduced to items in the laboratory, as well as the do's and don'ts. In the absence of a lab, documentaries/videos should be used. Provide additional support to learners who might need it, and use leading questions to clarify the responses of learners. Learners should observe, take notes and present their observations in class.

Key Assessments

Assessment Level 1:

1. List at least three safety regulations in the laboratory.
2. Make posters of at least four safety signs in the aerospace laboratory.

Assessment Level 2:

1. Explain the rationale behind the use of at least three Personal Protective Equipment (PPE) in the laboratory.
2. Explain the rationale behind three safety regulations in the laboratory.

Section Review

This section helps learners appreciate the importance of adhering to safety practices in the laboratory. Learners are encouraged to always maintain alertness during procedures to ensure minimal to zero incidents in the laboratory. Safety is discussed as a collective responsibility of all learners. Activities that learners undertake further enhances their communication, collaboration and anticipatory skills.

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SECTION 3: AVIONICS

Strand: **Avionics**

Sub-Strand: Fundamentals of avionics

Learning Outcome: *Use analogies in nature to describe avionics systems*

Learning Indicator: *Demonstrate knowledge of various classes of avionic systems*

INTRODUCTION AND SECTION SUMMARY

This section explores the various ways by which aircrafts use electronics and associated systems to communicate, navigate and survey their operational environment. Numerous systems that have been developed for aircraft operation have been addressed. A general discussion of basic electronics is given in the beginning week to prepare learners for in-depth consideration of standard aircraft equipment. Teachers must give special attention to the operation of electro-magnetic waves and how these have been applied to develop various aircraft systems. The necessary media must be carefully selected to help learners appreciate the operation of aircraft avionic systems.

The following weeks are covered in this section:

Week 6: Basic Electronic Principles & Components

Week 7: Basic Electronic Principles & Components

Week 8: Avionics Communication Systems

Week 9: Avionics Navigation Systems

Week 10: Avionics Surveillance Systems

SUMMARY OF PEDAGOGIES

This section introduces the learners to major aircraft avionics systems. The teacher first introduces learners to basic electronics components and principles as a foundation to understand aircraft avionics system. Experiential learning and talk-for-learning are the major pedagogies used in this section.

ASSESSMENT SUMMARY

Webb's depth of knowledge assessment model is used in this section. Teacher should ensure learning tasks and assessment are differentiated to accommodate the learning needs of all learners.

Weeks 6 And 7: Basic Electronics

Learning Indicator(s):

1. *Identify basic electronics components.*
2. *Discuss the functions of basic electronics components.*
3. *Discuss how Ohm's law affects the flow of current in an electronic circuit.*

Theme Or Focal Area: Introduction To The Basic Principles And Circuit Components Of Electronics

Introduction To Electronics

Electronics is the study of the flow and controls of electrons through conductors, semiconductors and vacuum. Electronics is the foundation of most modern digital systems.

Figure 10: *Electronic components mounted on a printed circuit board.*
Source: https://morepcb.com/high-voltage-pcb/ (accessed: 22/03/2024)

Materials in electronics

There are three major groups of materials that are used in electronics. They are conductors, semiconductors and insulators.

Conductors:

These are materials that allow current to freely flow through them. Examples are metals, graphite and water with dissolved minerals like salt. Conductors, like copper wires, are used to connect components in an electric circuit.

Figure 11: *strands of copper used as electrical conductors*
Source: https://harborenergysolutions.com/which-is-better-stranded-or-solid-wire-and-why/ *(accessed: 22/03/2024)*

Figure 12: *Graphite used in pencils is a conductive material.*
Source: https://www.quora.com/Why-is-graphite-used-in-the-manufacturing-of-pencils *(accessed: 22/03/2024)*

Figure 13: *Copper cables with various colours of PVC plastic insulation.*
Source: https://www.istockphoto.com/photos/copper-cable *(accessed: 22/03/2024)*

Figure 14: *Fibreglass material used in electrical insulation.*
Source: https://www.amazon.com/Nansheng-Fiberglass-Yards%EF%BC%8CFiberglass-Chopped-Material/dp/B08ML9B3C4 *(accessed: 22/03/2024)*

Insulators: These materials do not allow current to flow through them. Examples are plastics, glass, rubber, ceramics, fibreglass and dry wood. Due to their ability to prevent current from flowing through them, they are used to protect people from the dangers of electrical appliances and cables. They are also used to prevent contact between conductors in a circuit.

Semiconductors: These materials have their conductivity between conductors and insulators. They can be doped (the addition of impurities, i.e. other materials) to alter their conductivity. Examples are Silicon, Germanium and Arsenic. Semiconductors are used in diodes, transistors and integrated circuits. They form the basic materials for modern computer processors.

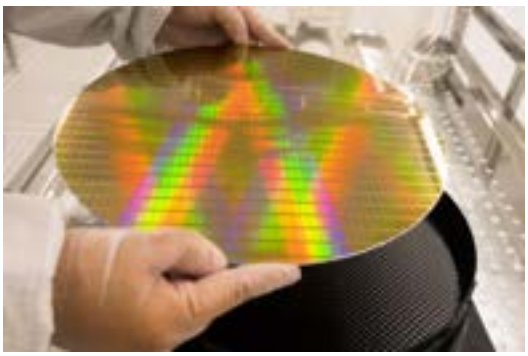

Figure 15: *A silicon wafer used to make integrated circuits*
Source: https://www.gep.com/blog/mind/outlook-for-the-global-semiconductor-silicon-wafer-industry (accessed: 22/03/2024)

Important terms in electronics

Current: It is the flow of electric charge through a conductor or semiconductor. The SI unit of current is ampere (A). The instrument for measuring current is the Ammeter.

Voltage: It is the potential difference between two points in a circuit. Voltage is measured in volts (V). It is the potential difference that pushes the electrons through a conductor to create current. Voltage is measured with an instrument called the voltmeter.

Resistance: It is the opposition to the flow of current through a material. Resistance is measured in Ohms (Ω). An ohmmeter is used to measure resistance.

Circuit: A circuit is an interconnection of electronic components. A circuit may be **open** or **closed**.

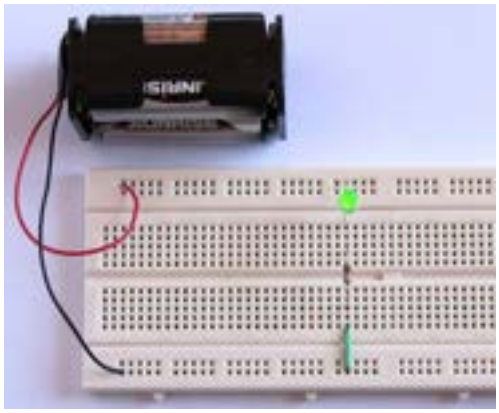

Figure 16: *A simple LED bulb circuit on a breadboard*
Source: https://startingelectronics.org/beginners/start-electronics-now/tut1-breadboard-circuits/?showall=&start=2#google_vignette *(accessed: 22/03/2024)*

Open circuit is a circuit that has a break between components such that current is unable to flow through them.

Closed circuit is a circuit that has no break in its network and current is able to flow through circuit components.

Ohm's law

Ohm's law is perhaps the single most important law in the study of electronics. Ohm's law states that the current (I) passing through conductor is directly proportional to the potential difference across it. Ohm's law is one of the most important laws that govern the field of electronics. It is a fundamental

tool to the study of electronics and understanding the behaviour of electronics components. It is mathematically expressed as

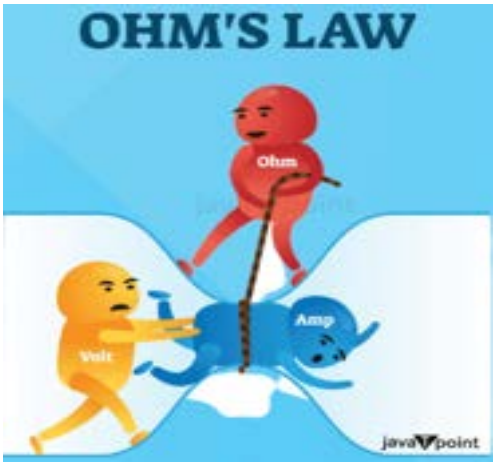

Figure 17: *Voltage pushes the current through the conductor while the resistance "resist" the flow of current through the conductor.*

Source: https://www.dreamstime.com/illustration/ohm-law.html (accessed: 22/03/2024)

Basic electronics components, their functions and circuit symbols

Resistors: This component is used to limit the flow of current through components in an electric circuit. This is usually done to protect components that are current sensitive to avoid excess current going through them. They usually come in cylindrical shapes with bands of colours around them to indicate their resistance in Ohms.

Figure 18: *A resistor (Source: NaCCA, 2024)*

Capacitors: A capacitor is a two-terminal circuit component used in electronic circuits to store energy in the form of an electric field. The capacitance is usually indicated in Farads (F). Two common types of capacitors are electrolytic capacitors and ceramic capacitors. Electrolytic capacitors are polarised, which means that one terminal is designed to be connected toward the positive terminal of a voltage source and the other terminal is designed to be connected to the negative terminal of the voltage source.

Connecting electrolytic capacitors in a reversed polarity may damage it. Electrolytic capacitors are used in direct current (DC) applications where the current flows in only one direction (from the positive terminal of the voltage source to the negative terminal) and does not change direction as does happen in alternating current (AC). Ceramic capacitors on the other hand are not polarised and the terminals can be reversed without causing changes to the circuit or damage to the capacitor. Ceramic capacitors can be used in both DC and AC.

Figure 19: *A ceramic capacitor*
(Source: NaCCA, 2024)

Figure 20: *An electrolytic capacitor*
(Source: NaCCA, 2024)

Inductors: An inductor is a two-terminal circuit component used in circuits to store energy in the form of a magnetic field. The inductance units are Henrys (H). An inductor is basically a coiled wire. When current passes through it, a magnetic field is created around it. It may be used to electrically isolate parts of a circuit (as in a transformer) or to detect sudden changes in current.

Figure 21: various types of inductors *(Source: field work, 2024)*

Diodes: Diodes are two-terminal semiconductor circuit components that allow current to flow through them in only one direction. A prominent application of diodes is in rectifier circuits (circuits that convert AC voltages to DC voltages) like in phone chargers.

Figure 22: *A diode (Source: NaCCA, 2024)*

Light Emitting Diodes (LEDs): These are diodes that give off light when current passes through them. They come in different sizes and colours. They usually serve as visual indicators in a circuit. For example, one may integrate a light emitting diode to a circuit to give an indication if there is power in the circuit. LEDs, just like typical diodes, allow current to pass through in only one direction. Only then will they light.

Figure 23: *A green light emitting diode (LED) (Source: NACCA, 2024)*

Transistors: These are three-terminal semiconductor devices. Transistors form the building blocks of most modern digital systems. They serve as amplifiers and switches in electronics systems. They can be combined to create logic circuits which can then be used to build more complex systems like microprocessors and processors of computers.

Figure 24: *A transistor (Source: NaCCA, 2024)*

Integrated Circuits: An integrated circuit is a small device consisting of several electronic components like transistors, resistors and capacitors etched on a single small piece of semiconductor wafer, usually silicon. They are used in several electronic devices like computers, phones and calculators. Integrated circuits allowed the miniaturisation of computers since processors and other system components can be made much smaller. They are mounted on circuits using two main methods. There is the Through-Hole-Technology (THT) and Surface-Mount Technology (SMT).

Figure 25: *THT integrated circuit*

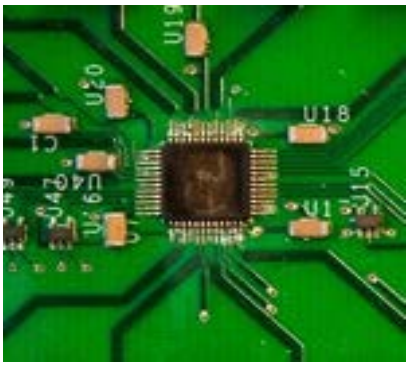

Figure 26: *SMT integrated circuit*

Microcontrollers: A microcontroller is a small computer on a single integrated circuit programmed to control a specific task. It usually has input and output ports through which it receives and sends signals to communicate with other components in an electronic circuit. Modern microcontrollers can be purchased off-the-shelf and programmed on a personal computer (PC) to control sensors and other devices. Microcontrollers find themselves in most modern systems like washing machines, automatic teller machines and fight controller boards for UAVs.

Figure 27: *Raspberry Pi Pico*
(Source: NaCCA, 2024)

Figure 28: *Arduino nano*
(Source: NaCCA, 2024)

Learning Tasks

1. List and identify basic electronic components.
2. Outline the functions of basic electronic components in a circuit.
3. Demonstrate understanding of Ohm's law and its applications in circuits
4. Demonstrate ability to solder electronic components unto a printed circuit board.

Pedagogical Exemplars

Talk-for-learning: Learners are guided to identify various electronic components, discuss their functions and their applications in circuits. Encourage all learners to participate during the exchange of ideas on functions of the electronic components. Teacher should remind learners to use appropriate language during the discussion. Control the class discussion to avoid a few learners dominating the discussions and encourage learners who may not be vocal to contribute to the discussion through writing.

Experiential Learning: Learners are exposed to an array of electronic components and supported in identifying them. Guide all learners to make conscious efforts at identifying and explaining the functions of the electronic functions. Learners should be guided in using basic components on a breadboard to demonstrate Ohm's law. Teacher should be intentional in supporting all learners to achieve moderate competence in soldering. Maintain an active presence and provide support to learners as needed while ensuring that health and safety protocols are adhered to before, during and after the practical work.

Key Assessment

Assessment Level 1: Identify basic electronics components.

Assessment Level 2: Explain the functions of the various electronic components used in avionics.

Assessment Level 3: Using basic electronics components, demonstrate how Ohm's law applies to the flow of current in a circuit.

Week 8: Avionics Communication Systems

Learning Indicator(s): *Discuss the various communication systems on aerospace vehicles.*

Theme Or Focal Area: Introducing Communication System In Avionics

Avionics

Avionics refers to systems on aerospace vehicles, which rely on electronics for their operation. This includes navigation systems, communication systems, surveillance systems and instrumentation.

Communication

Communication refers to the exchange of information between two or more parties. Traditional communication systems include: sign language, talking drums, musical instruments, smoke signals, etc.

Avionics Communication Systems

In aviation, communication may occur between the aircraft and air traffic controllers, between two or more aircraft, within the aircraft or between the aircraft and airline operations control. Different technologies are used to accomplish this. They include High frequency (HF) communication, Very High Frequency (VHF) communication, Satellite communications (SATCOM).

Very High Frequency (VHF) communications

VHF radio signals range from 30 – 300 MHz, but the range used in aviation is 118 – 137 MHz. It is used for air traffic control, approach and departure information, meteorological information, ground handling of aircraft, communications to airline operations control and the Aircraft Communications Addressing and Reporting System (ACARS). It is used for communication over distances reaching up to about 160 km. It supports both voice and data communications.

High frequency (HF) communications

This occurs over the frequency range; 3 MHz to 30 MHz. It is used for long distance communication (500 to 2500 km) between aircraft and the ground. Different frequencies are used depending on the time of the day. A typical daytime frequency is 8 MHz, falling to about 3 MHz at night. HF communication effectively fills in the gap in VHF coverage. It supports both data and voice communications.

Satellite Communications (SATCOM)

SATCOM voice and data services facilitate aircraft to ground communication in locations and in situations where conventional HF and VHF radio communication is not possible. It is being used for airline operation control and air traffic control. SATCOM is also being increasingly used as a means of connecting to ground-based networks, allowing crew and passengers to make calls to conventional telephone equipment on the ground or provide Internet access.

Flight-deck audio systems

These allow for communication between the flight deck, crew and passengers.

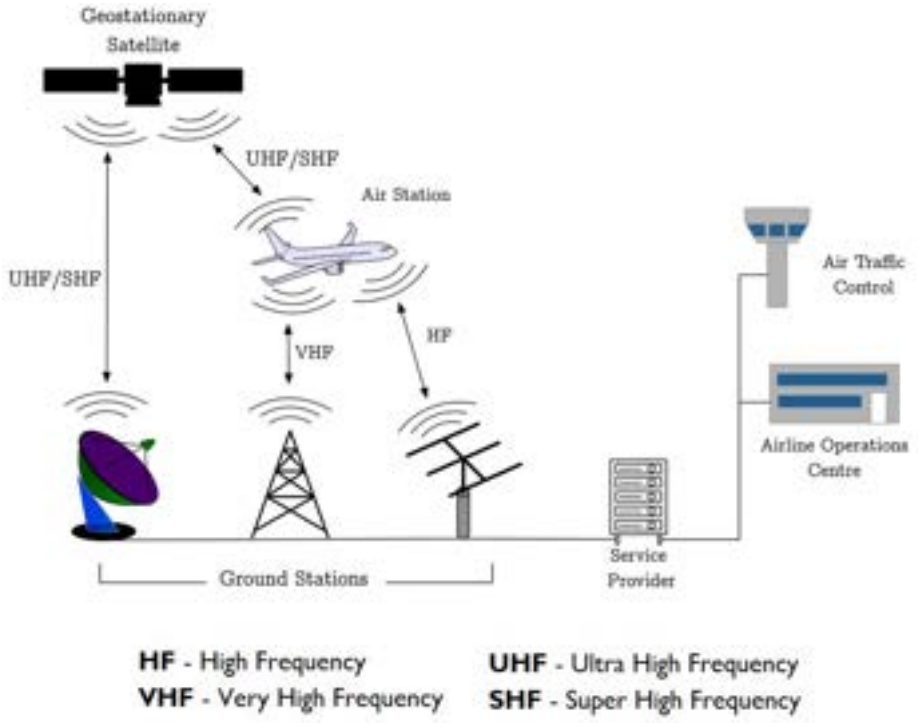

Figure 29: *Aircraft communication technologies*
(Source: https://www.researchgate.net/figure/Representation-of-the-ACARS-sub-systems_fig1_317040201 (accessed: 22/03/2024))

Learning Tasks

1. List the different aircraft communication systems.
2. Describe each of the aircraft communication systems.
3. Describe the purposes and circumstances where each of the aircraft communication systems is used.
4. Explain how basic electronic principles are applied in each system.

Pedagogical Exemplars

Talk-for-learning: Using audio-visual resources, lead learners to identify and explain the concept of operation of the various aviation communication systems. With the use of appropriate questions, learners take turns to talk about how the systems work. Encourage as many learners as possible to share their views freely and with respect for one another's views. In mixed-ability grouping, guide learners to explain the technicalities employed by the aviation communication devices. Place special emphasis on the electronic principles on which each system operates. Provide opportunities for learners to share their experiences with the use of traditional communication modes, and encourage learners to share their ideas with each other to promote collaborative learning about how these systems have evolved with time.

Key Assessment

Assessment Level 1: List the four aircraft communication systems.

Assessment Level 2:

1. Describe at least two of the aircraft communication systems.

2. Explain the principle which is employed in a selected aircraft communication system.

Assessment Level 3:

1. Compare and contrast the different electronic principles for at least two of the aircraft communication systems
2. Explain the purposes and describe the circumstances where each of the aircraft communication systems is used.

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Week 9: Avionics Navigation Systems

Learning indicator(s): *List the systems used on aerospace vehicles for navigation and explain their working principles.*

Theme / Focal Area: Navigation

Navigation refers to the determination of the position, velocity and orientation of a moving vehicle with respect to a known reference. A unique position is identified by specifying its longitude, latitude and altitude. There are basically two paradigms of navigation: position fixing and dead reckoning.

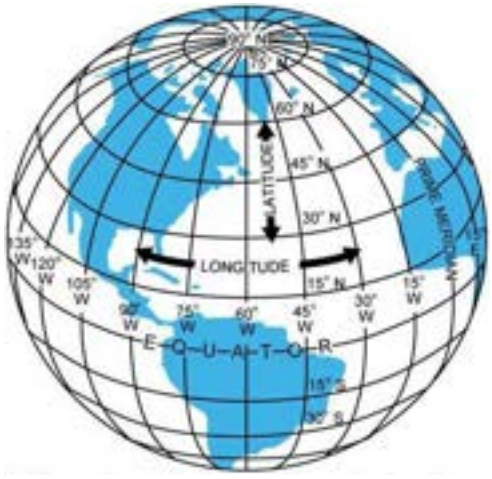

Figure 30: *Latitudes and longitudes.*
Source: https://socratic.org/earth-science/earth-s-surface/location-longitude-and-latitude (accessed: 22/03/2024)

Position Fixing

Position fixing involves determining the position of the vehicle using external references. When travelling short distances over land, natural terrestrial features such as rivers, valleys, hills, can be used as direct observation. Celestial navigation was used effectively in the early days of long-distance aircraft navigation. For navigation using radio signals, the intersection of signals from two or more navigation aids can be used to fix a position; the distance and bearing from a single navigation aid may also be used; as well as distance from any two navigation aids. The radio navigation systems include: Distance measuring equipment (DME), VHF Omnidirectional Range (VOR), Automatic Direction Finder (ADF). Satellite navigation systems also include: the American Global Positioning System (GPS), Russian GLONASS, Chinese BeiDou and European Galileo.

VHF Omnidirectional Range (VOR)

VOR is a short/medium-range navigation system operating in the 108 – 117.95 MHz range of frequencies. It provides the bearing to-or-from a radio navigation aid on the ground. Each VOR navigation aid is identified by a unique three-letter code on navigation charts. In order to use this system, aircraft must be fitted with the appropriate antennas, receivers, control panels and displays.

Distance Measuring Equipment (DME)

DME is a short/medium range navigation system that enables the crew to determine the distance to a navigation aid. The aircraft transmits to the ground station and measures the time it takes to receive a response. Transmission occurs at frequencies ranging between 1025 and 1150 MHz; Receiving is in

the range 962 to 1215 MHz. The aircraft must have the appropriate antenna, interrogator, and display installed in order to use the system.

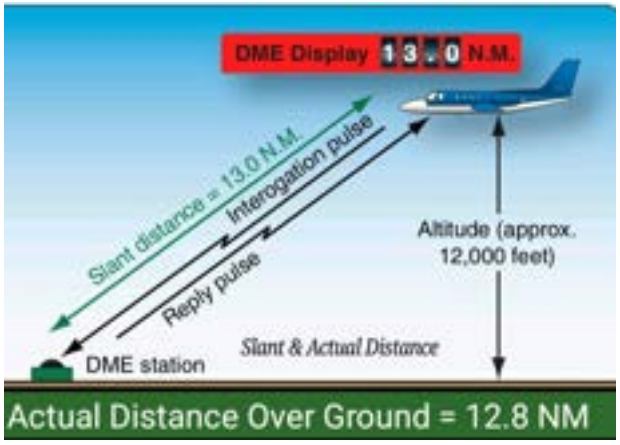

Figure 31: *Distance measuring equipment operation.*
Source: https://www.linkedin.com/pulse/distance-measuring-equipment-dme-pramod-prabhakaran/ (accessed 22/03/2024)

Automatic Direction Finder (ADF)

ADF is a short/medium range (200 nautical miles) navigation system providing directional information. It operates within the frequency range 190 – 1750 kHz. It provides the relative bearing from the aircraft to a suitable station.

Global Navigation Satellite Systems (GNSS)

It refers to a navigation system based on satellites. There are several operating systems: GPS, GLONASS, Galileo, Beidou, IRNSS. Knowing the position of the satellite, and measuring the time delay between when the signal was transmitted (from the satellite) and received (at the ground station) provides a means of calculating the range between the satellite and the aircraft. Range measurements from at least four satellites are required in order to determine a unique three-dimensional position.

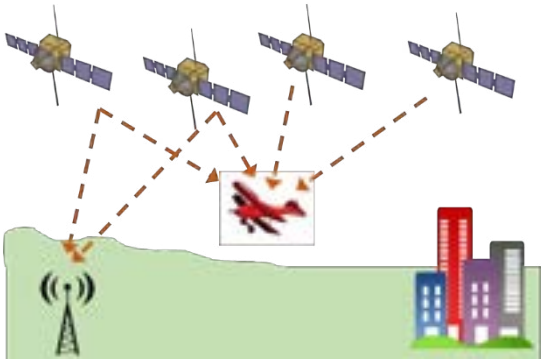

Figure 32: *GNSS navigation uses ranging signals from four or more satellites to determine the unique position of the aircraft.*
Source: https://tc.canada.ca/en/aviation/publications/aviation-safety-letter/issue-4-2019/presence-satellites-general-aviation *(accessed: 22/03/2024)*

Dead Reckoning

Dead reckoning refers to estimating position by extrapolating from a known position and then keeping note of the direction, speed and elapsed time. Dead reckoning systems include: Doppler navigation systems and Inertial navigation systems.

Inertial navigation systems

Inertial navigation systems are autonomous; they require no external inputs or references from ground stations for their operation. Inertial navigation is ideally suited to long distance navigation over oceans and undeveloped areas.

Accelerometers and gyroscopes are used as the primary sensors.

Doppler navigation system

Doppler navigation uses the change in frequency of reflections from radio waves (Doppler effect) to determine aircraft speed and direction.

Learning Tasks

1. Identify an application of navigation in everyday life.
2. Describe different aircraft navigation systems.
3. Demonstrate different navigation systems using graphical representations.

Pedagogical Exemplars

Talk-for-learning: Learners share their views on everyday activities that require navigation. Use audio-visuals to explain the principles of navigation behind the flight of a colony (swarm) of bats. Learners' watch/observe and share their observations with the class. Learners compare their observations of the navigation of a colony of bats with different aircraft navigation systems. Teacher should create opportunity for all learners to participate in the discussions.

Key Assessment

Assessment Level 1:

1. Define navigation.
2. Outline at least 3 everyday activities that make use of navigation.

Assessment Level 2:

1. Explain the forms of navigation systems used in aerospace vehicles.
2. Explain the working principles of different aircraft navigation systems.

Assessment Level 3:

1. Explain the circumstances when at least two different navigation systems would be used.
2. Compare and contrast the differences between the different navigation systems explained in (3a) above.

References

1. Collinson, R.P., 2012. Introduction to avionics (Vol. 11). Springer Science & Business Media
2. Tooley, M. and Wyatt, D., 2017. Aircraft communications and navigation systems. Routledge

Week 10 – Avionics Surveillance Systems

Learning indicator(s): *Discuss the systems used for surveillance on aerospace vehicles.*

Theme Or Focal Area: Introduction To The Various Aerospace Surveillance Systems

Surveillance Systems On Aircraft

Surveillance systems refer to the equipment that makes it possible to determine the position of an aircraft in range and bearing. There are four main technologies that enable this.

They include:

- Primary surveillance radar (PSR)
- Secondary surveillance radar (SSR)
- Traffic Alert and Collision Avoidance System (TCAS)
- Automatic Dependent Surveillance Broadcast (ADS-B)

Primary Surveillance Radar

PSR is a surveillance radar system, which uses reflected radio signals. An antenna rotating at speeds of 5–12 rpm emits a pulse of radio wave. Upon reaching an aircraft, the wave is reflected and some of the energy is returned to the antenna. Primary Surveillance Radar provides range and bearing of the targets found in respect of the antenna position. Range is determined by the time difference of the emitted and received pulse, while the bearing is obtained from the antenna angular position. PSR does not require any equipment on board the aircraft in order to function. It requires that the antenna transmit at a high power so that a reflection is received.

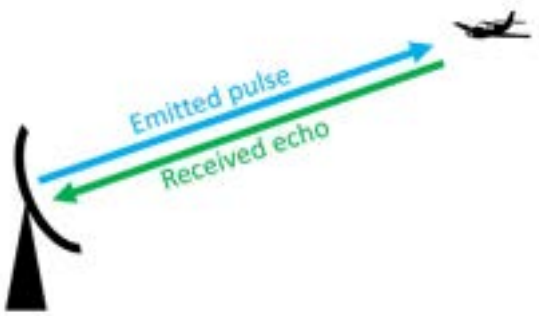

Figure 33: *Primary surveillance radar operation.*
Source: https://skybrary.aero/articles/primary-surveillance-radar-psr *(accessed: 22/03/2024)*

Secondary Surveillance Radar

SSR is a surveillance radar system that requires a transponder on-board the aircraft to determine its position. A radar antenna on the ground rotates (usually at 5-12 rpm) and transmits a pulse (at 1030 MHz), which is received by the on-board equipment (transponder). The transponder sends back a reply containing information such as the aircraft identification and altitude (reply is at 1090 MHz). When the reply is received, aircraft position (range and bearing) is determined, range is calculated by knowing the time difference between the interrogation and the reply, while azimuth is taken from the antenna position.

Figure 34: *Secondary surveillance radar operation.*
Source: https://skybrary.aero/articles/secondary-surveillance-radar-ssr *(accessed: 22/03/2024)*

Figure 35: *PSR/SSR antenna.*
Source: https://www.radartutorial.eu/19.kartei/03.atc/karte017.en.html *(accessed: 22/03/2024)*

Traffic Alert And Collision Avoidance System

TCAS is an aircraft collision avoidance system designed to reduce the incidence of mid-air collisions. It monitors the airspace about an aircraft for other aircraft equipped with TCAS, and warns about the presence of traffic, which may present a threat of mid-air collision. Each TCAS aircraft interrogates all other aircraft in a determined range about their position via the 1030 MHz radio frequency. All other aircraft reply to interrogations via the 1090 MHz channel. The interrogation-and-response cycle occurs several times per second. The TCAS system builds a 3D map of aircraft in the airspace, incorporating their range, altitude and bearing. Current range and altitude are extrapolated to determine their future values, and whether a risk of collision exists. After identifying potential collisions, TCAS automatically negotiates a mutual avoidance manoeuvre; this involves modification of altitude and rate of climb or descent. The avoidance manoeuvres are communicated to flight crew by synthesised voiced instructions.

Automatic Dependent Surveillance-Broadcast

ADS-B is a means by which aircraft, aerodrome vehicles and other objects can automatically receive data such as identification and position as appropriate in a broadcast, which is made via a data link. It is a surveillance technique that relies on aircraft or airport vehicles broadcasting their identity, position and other information desired from on-board systems such as GPS. ADS-B is automatic because no

external stimulus is required. It is also dependent as it relies on data from on-board systems. ADS-B signals can be captured for surveillance purposes on ground or on board other aircraft to facilitate airborne traffic situation awareness, spacing and separation.

Aircraft equipment includes:

- A transponder with "ADS-B out" capability
- A receiver which has "ADS-B in" capability
- A processing system (traffic computer)
- Cockpit display of traffic information

Data transmitted by aircraft or airport vehicles are received by the ADS-B ground stations. In most cases, output of ADS-B ground stations is sent to Surveillance Data processing and distribution systems, where they are fused with inputs from other surveillance sensors, e.g., Radar, to create an accurate traffic situation picture.

Learning Tasks

1. Identify the forms of surveillance systems used in aerospace vehicles.
2. Examine the principles of operation of the different surveillance technologies.
3. Brainstorm the advantages and disadvantages of satellite communication with HF and VHF communication.
4. Analysis of an air crash caused due to a failure of surveillance systems and prescribe measures to prevent future recurrence, e.g. Air Florida Flight 90 (1982)

Pedagogical Exemplars

Talk-for-learning: Teacher introduces learners to the concept of surveillance and the various surveillance systems on aerospace vehicles through class discussion. In mixed-ability/gender groupings, the teacher leads learners to identify and discuss everyday activities that apply the concept of surveillance. Learners, in mixed-groups, discuss and analyse an air crash due to failure of an on-board surveillance system. Encourage learners to accommodate divergent views and express theirs in a polite manner.

Group Work/Collaborative Learning: Learners in mixed-groups brainstorm the advantages and disadvantages of satellite communication with HF and VHF communication. Offer additional resources such as visual aids, to learners who may have difficulties understanding the concept to reinforce understanding the principles of aircraft communication systems. Also, encourage learners to engage in collaborative discussions, allowing for peer teaching and learning to promote deeper understanding of where they can share insights and perspectives on the various methods of aircraft communication, allowing opportunities for peer teaching and learning, and promoting a deeper understanding of aircraft communication systems.

Problem-Based Learning: Learners in mixed-groups are presented with a case study of an air crash caused due to a failure of surveillance systems e.g. Air Florida Flight 90 (1982). Through analysis of the case and all the evidence learners are expected to prescribe measures to prevent future recurrence. Allow learners with difficulties contributing vocally in class to contribute through writing while ensuring that a few learners do not dominate the discussions.

Key Assessment

Assessment Level 1

Mention at least two forms of surveillance systems used in aerospace vehicles.

Assessment Level 2

Explain the principles of operation of the various aircraft surveillance technologies.

Assessment Level 3

Analyse an air crash incident and make recommendations to prevent future recurrence.

References

1. I. Moir, A. Seabridge, M. Jukes, Civil Avionics Systems, 2nd Edition. West Sussex: Wiley, 2013
2. C. R. Spitzer, U. Ferrel, T. Ferrel (Eds), Digital Avionics Handbook, 3rd Edition. Boca Raton: Taylor and Francis, 2015

Section Review

This section introduced learners to the basic principles in electronics and has helped learners be better prepared to understand how aircraft electrical systems work. The various laws and components that go into basic electronic circuits have also been explained to help learners appreciate their role in aircraft avionics.

SECTION 4: AVIATION INDUSTRY

Strand: **Aviation Industry**

Sub-Strand: The Aviation Profession and Operations

Learning Outcome: *Describe the learning pathways that lead to the various aviation professions*

Content Standard: Demonstrate knowledge of various career paths in the aviation industry.

INTRODUCTION AND SECTION SUMMARY

This section introduces learners to the numerous professions in the aviation industry and how they each work to support the safety operation of air travel. The people and processes involved in ensuring air safety are outlined, as well as the coordination between them. The section also explains the learning pathways through which individuals may use to qualify to work in the various aviation fields. The following weeks are covered in this section:

Week 11: Aviation Careers /Roles/ Academic Pathways

Week 12: Aviation Careers /Roles/ Academic Pathways

Week 13: Coordination in Aviation

SUMMARY OF PEDAGOGICAL EXEMPLARS

Learners will be introduced to their possible future careers in aviation in this section. Teachers are therefore encouraged to use clear presentation methods to help learners grasp the requirements of individuals prospecting to work in aviation. The main pedagogies enshrined here are talk-for-learning, collaborative learning, building-on-what-others-say and project-based learning.

ASSESSMENT SUMMARY

This section employs the lower levels of Webb's depth-of-knowledge, Levels 1, 2, and 3, to guide learners measure their appreciation for a certain careers in aviation.

Week 11 And 12: Careers In Aviation

Learning indicator(s): Describe the various career paths in the aviation industry.

Theme Or Focal Area: Introduction To Aviation Careers, Their Roles And Learning Pathways

Introduction to aviation professions

The aviation industry refers not just to occupations directly involved with the aircraft but also to all the professions that make it possible for air travel to remain pleasant, safe and secure. This week and the next are devoted to describing some of these careers.

Pilot

Pilots are responsible for actually flying aircraft. Their job is very challenging, as they have to fly in varying weather conditions into many unfamiliar airports. It is required that they have good concentration and the ability to make sound decisions under pressure. Pilots may fly for an airline, where they are in charge of "large" aircraft carrying several people. Other commercial pilots fly missions like banner towing, real estate surveying and power line inspections. Then, there are the private pilots who fly for recreation or personal transport. Test pilots fly new/prototype aircraft to test their performance. Theirs is an interesting endeavour as they push the plane to the limits of its design strength and performance capabilities.

Roles

1. Create a flight plan, considering aircraft performance, altitude and weather conditions.
2. Check the aircraft before every flight (engines, radars, navigation systems, etc.).
3. Ensure cargo weight doesn't exceed aircraft limits.
4. Communicate with air traffic control to ensure safe takeoff and landing.
5. Ensure the aircraft has adequate fuel supplies.
6. Monitor cockpit instruments like altimeters and speed indicators and report any malfunctions.
7. Check the airplane's position, weather conditions and air traffic regularly during the flight and determine change of path when needed.
8. Work closely with flight attendants to ensure all passengers follow safety rules while on board.
9. Fill out reports about the flight and the status of the aircraft after landing.
10. Test pilots work hand-in-hand with flight test engineers to investigate the performance characteristics of new/retrofitted aircraft.

Requirements

Airline pilots often require a college degree in aeronautical engineering or a related discipline. Following this, they must obtain a pilot's license by undertaking flight instruction at a certificated flying school. The training consists of a number of hours of ground school instruction where students learn the principles of flight, aerial navigation, weather factors, and flight regulations; and flying lessons, usually conducted in dual-controlled aircraft. The first step is usually to earn a private pilot's license after taking written and flight examinations, and passing a third-class medical examination. The private pilot can then undertake advanced instruction, learn to fly on instruments (fly blind) and earn a commercial pilot's license upon acquiring additional hours of flight experience. With further

study and experience, the pilot eventually earns the air transport rating to qualify as an airline pilot. Some universities offer flight training with credit toward a degree. Learners who follow this path graduate with a pilot's license plus a degree. Another route is obtaining pilot training in the armed forces. This entails no expense to the learner other than a service obligation for a number of years after training. Military pilots are usually in high demand in the civil space.

Figure 36: *A pilot.*
Source: https://magazine.fabafriq.com/meet-the-female-pilot-changing-the-aviation-sector-in-africa/ *(accessed: 22/03/2024)*

Aerospace Engineer

Aerospace engineers are people who have knowledge in the design of both aircraft and spacecraft—they combine the expertise of aeronautical and astronautical engineers. They study the science that underlies the behaviour of vehicles within and outside of the earth's atmosphere and develop cutting-edge technologies that aim to improve the efficiency, safety and security of air and space travel. Aerospace engineers are also involved in the design of high-speed ballistics including rockets and missiles that often find application in defence systems.

Roles

1. Develop leading-edge technologies and integrate them into aerospace vehicle systems used for transportation, communications, exploration, and defence applications
2. Involved in the design and manufacturing of aircraft, spacecraft, propulsion systems, satellites, and missiles.
3. Supervise the assembly of airframes and the installation of engines, instruments and other equipment.
4. Measure and improve the performance of aircraft, components and systems.
5. Collate information, interpret data and publish the results of specific projects in technical report form.
6. Communicate technical and regulatory advice to clients, teams, suppliers and other professionals within the aerospace industry.

Requirements

An entry-level job in aerospace engineering usually requires a bachelor's degree, which is usually obtained at a four-year higher education institution with classes in aerodynamics, flight dynamics and control, aircraft structures, and propulsion. Some positions require a master's degree to facilitate progression in the organisation. For learners who would like to be involved with the research and development of new technologies and systems, a doctorate degree may also be required.

Aircraft Maintenance Engineer

An aircraft maintenance engineer performs functions similar to those of automobile technicians, except that they work on aircraft and aircraft parts. Due to the level of safety required of air transport, the role of the maintenance engineer cannot be overemphasised. They work using manuals developed by aerospace engineers to troubleshoot and repair/replace aircraft parts. Aircraft maintenance engineers specialise in one of two areas: the aircraft structure and propulsion system or the electrical/ electronic systems.

Roles

1. Perform preventive maintenance, inspections, adjustments, servicing, and repairs on airborne equipment.
2. Research, evaluate, and recommend improvements to manufacturing processes, equipment, and procedures.
3. Troubleshoot aircraft systems, components, and assemblies.
4. Maintain aircraft logs, records, and records management.
5. Manage the maintenance and repair budget.

Requirements

While a high school diploma is not required to become an apprentice aircraft mechanic, employers give preference to applicants who are high school or vocational school graduates. Relevant subjects to pursue while in high school include Mathematics, Physics, Computer Science, chemistry, English, and Aerospace education courses. These subjects help the maintenance engineer understand the physical principles involved in the operation of the aircraft and its systems. It is also necessary that the aircraft maintenance engineer acquires relevant formal qualifications and to complete a technical training program, which will include written and practical exams to obtain a license as an avionics or airframe and power plant technician. The aircraft maintenance engineer is expected to continue their education, even after hiring, in order to keep abreast of the continuing technical advancements in aircraft and associated systems.

Figure 37: *Aircraft maintenance engineer*
*Source: (*https://www.flightglobal.com/flight-international/interview-engineering-a-great-start-to-an-aviation-career/131934.article*)*

Air Cargo Handler

The air cargo handler works for an airline or air freight company. They are responsible for ensuring that passenger luggage is loaded onto the right aircraft and in an efficient, safe and secure manner. They also handle unloading of baggage. Most of their work is done outdoors in all kinds of weather, and they are usually required to wear a uniform.

Roles

1. Direct ground crew in the loading, unloading and securing of aircraft cargo or baggage.
2. Determine the quantity and orientation of cargo, compute aircraft centre of gravity, and sign the load plan or manifest.
3. Load and unload aircraft, perform preflight and post-flight aircraft checks, and compute weight and balance.
4. Calculate load weights for different aircraft compartments, using charts and computers.
5. Operate a variety of equipment, including trucks, forklifts, conveyors and baggage tugs.
6. Accompany aircraft as a member of the flight crew to monitor and handle cargo in flight.

Requirements

Air cargo handler positions are typically entry-level jobs that require little or no prior training; training is usually done on the job. They must be high school graduates. Usually though, the airlines like to see some post-secondary education in either an academic or vocational field. A qualification in cargo management or training in shipping offers the learner an advantage.

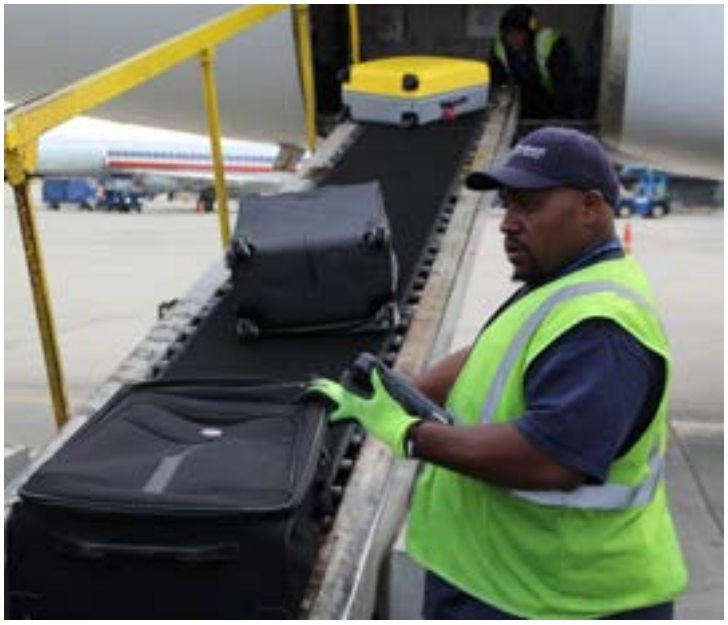

Figure 38: *An air cargo handler at work.*
Source https://www.prospectair.com/rampcabin-services/ *(accessed: 22/03/2024)*

Air Traffic Controller

The air traffic controller plays a major role in flight safety. They direct air traffic so it flows smoothly and efficiently. They monitor aircraft movements and provide directions/instructions to pilots and other crewmembers. Air traffic controllers may be responsible for monitoring the airspace close to airports, for flights en route, and for controlling ground traffic at the airport.

Roles

1. Inform pilots of any runway closures, bad weather or other critical information.
2. Direct pilots through the entire takeoff and landing process.
3. Alert the airport response team whenever there is an aircraft emergency.

4. Give departing flight control to other traffic control centres and receive control of any arriving flight.
5. Assist in searches for missing aircraft.
6. Compile and analyse data and reports to develop more effective flight plans and prevent delays.

Requirements

A four-year college degree in an aviation-related discipline is usually required for this position. Candidates study airspace, weather, how to read charts, flight regulations, clearances and other similar topics. Beyond this, it is required that air traffic controllers be certified after taking a knowledge test and practical exam. Skills needed for this role include: good communication, attention to detail, and strong concentration.

Figure 39: *Air traffic controllers.*
Source: https://www.airport-suppliers.com/product/mobile-atc-tower/nucleo-mobile-atc-3/ *(accessed: 22/03/2024)*

Flight Dispatcher

A flight dispatcher is an important player in the operation of an airline. They are responsible for coordinating all flights administered by the airline. Flight dispatchers liaise with the pilots and ground staff, ensuring that all essential services required for safe flight are provided. They are responsible for signing off the aircraft for flight, together with the pilot, and keep all personnel concerned with the flight informed about its status.

Roles

1. Monitor aircraft arrivals and departures and amending turnaround schedules if there are delays.
2. Liaise with ground crew and ensuring that tasks, such as cleaning, refueling and loading, are completed on time.
3. Calculating how much fuel is required for the weight of the aircraft and distance of the journey.
4. Prepare flight paperwork for the crew, such as printing of flight plans, passenger lists and weather reports.
5. Check that all passengers and luggage is loaded and decide, along with the pilot, when to close the departure gate.
6. Authorise, together with the pilot, dispatch of the aircraft, and complete all reports and logs according to company regulations.

Requirements

In order to become a flight dispatcher, a high school diploma or equivalent is required. A college degree with a major in air transportation or meteorology is advantageous. Experience is equally important. The flight dispatcher must be familiar with navigation facilities over airline routes and at airports as well as with the takeoff, cruising, and landing characteristics of all aircraft operated by the airline.

Passenger Service Agent

Passenger service agents act as customer service representatives for airline passengers in the airport. They act as ground hosts and are highly visible and helpful to the public, assisting passengers to pass through the airport from the ticket counter to boarding. They are mostly found at ticket counters, gate and baggage areas of the airline they serve. They answer questions and offer a wide range of information concerning the airline, flights and other airport related topics. They also tend to passengers requiring special assistance.

Roles

1. Providing information to passengers about flight times, gate changes, delays, and other pertinent information.
2. Processing boarding passes, checking identification documents, and directing passengers to security checkpoints.
3. Coordinating with other ground staff to arrange for transportation and hotel accommodations for passengers who need assistance.
4. Assisting with wheelchair boarding procedures and helping passengers with disabilities board or disembark from aircraft.
5. Handling customer complaints, helping resolve disputes, and referring problem cases to supervisors for further attention.
6. Greeting passengers at airports and providing information about flight schedules, delays, or cancellations.
7. Performing safety checks of aircraft before boarding begins to ensure that emergency exits are not blocked and that life vests are available if needed.

Requirements

In order to become a passenger service agent for an airline, a high school diploma is often required. High school classes in reading and reasoning skills enable one to be successful in this position. An associated degree in subjects like communication or hospitality might give one an advantage in the hiring process. Learning a foreign language might be advantageous as well, as passenger service agents work with people from around the world. It is also necessary to develop customer service skills, perhaps, through internships, part-time work or other entry-level positions in other institutions.

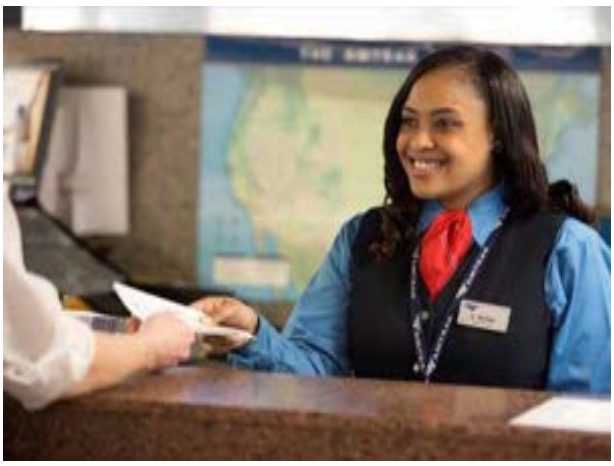

Figure 40: *Airline passenger service agent.*
Source: https://keralacabrental.com/services.html *(accessed: 22/03/2024)*

Airport Security Personnel

Airport security personnel are involved with security procedures at the airport. They are found throughout the airport and are responsible for identifying and neutralising security risks at the airport. An airport security manger devises security strategy, monitors security and safety procedures and coordinates with other security personnel to ensure the security of travellers and staff at the airport.

Roles

1. Screen passengers and luggages.
2. Ask security questions of passengers.
3. Direct passengers through security equipment.
4. Report suspicious activity to appropriate authorities.
5. Ensure a safe and respectful environment at all times.
6. Comply with safety measures.
7. Work with passengers to ensure that their needs, as well as security regulations, are met.

Requirements

Airport security personnel usually require a high school diploma or its equivalent. Previous airport security experience and having taken courses pertaining to criminal justice, law enforcement or security greatly improves employability and earning potential. After joining an airline security role, most employees receive field training and gain knowledge of the protocols and processes involved in airport security while engaging with them on the job. Airport security personnel undergo strict background checks and receive designation-specific training before starting work officially.

Figure 41: *Airport security personnel.*
Source: https://securityguardcompanysingapore.blogspot.com/2021/03/which-security-company-is-best-to-work.html *(accessed: 22/03/2024)*

Airport Manager

The airport manager runs the airport. They perform classic managerial duties, such as coordinating different teams, delegating work, hiring employees, writing reports and devising business strategies. They supervise other staff, ensuring that the airport complies with all regulations. The airport manager also helps to implement new strategies and secure contracts with airlines, retailers, security companies and others involved in day-to-day airport operations.

Roles

1. Manage personnel and operational activities of airport facility to ensure that all rules and regulations are followed.
2. Ensure that all airport staff follow aviation and security rules.
3. Provide training to airport staff in safety and emergency procedures.
4. Ensure customer complaints are handled and resolved in accurately and timely manner.
5. Manage recruitment, training, workload assignment, performance review, appraisals and promotions for airport staff.
6. Assist in preparing annual budget for airport operations and monitor and manage all expenses within the approved budget.
7. Develop and implement safety policies and practices for employees.
8. Ensure airport facilities and equipment are in good working order.

Requirements

In order to become an airport manager, a bachelor's degree from an accredited university with major course work in business, airport or aviation management or a closely related field is usually required. It is necessary that the airport manager be knowledgeable in aviation regulations. This position may also be assumed by workers who have had experience working as airport operations agents.

Airline Flight Attendant

The flight attendant is perhaps the most visible employee to passengers on an aircraft. They tend to a wide variety of needs and requests, offering personalised service to passengers for the duration of the flight. They spend most of their time in the passenger cabin and are responsible for the safety and comfort of passengers. Flight attendants are required to remain pleasant and provide quality service to passengers at all times.

Roles

1. Provide information, guidance, and assistance for the safety and comfort of passengers on board the aircraft.
2. Conduct safety checks before flight.
3. Greet customers, check their tickets and accompany them to their seats.
4. Prepare and serve drinks and food to passengers.
5. Present emergency equipment and give instructions on their use.
6. Monitor and secure the cabin regularly.
7. Provide special help to passengers with special needs (e.g., children, disabled persons, elders etc.).

Requirements

In order to work as a flight attendant, an applicant must hold a high school diploma or its equivalent, although many airlines prefer a college degree. Flight attendants are usually required to complete a training program organised by the airline. Other post-secondary institutions also offer training for flight attendants. Advanced degrees are often helpful when pursuing a management or supervisory position.

Figure 42: *Flight attendants.*
Source: https://www.pinterest.jp/pin/464011567835269124/ *(accessed: 22/03/2024)*

Learning Tasks:

1. Develop flash cards with the name of an aviation profession on one side and its roles on the other side.
2. Examine the qualifications required to work in the various aviation professions.

Pedagogical Exemplars

Talk-for-learning: With the aid of audio-visuals, introduce the various aviation professions to learners. Invite a resource person/ aviation professional from the aviation industry for both weeks to have a seminar with students on the roles they play in their respective professions. Resource person should also share with learners the learning pathways that led to his/her career. Prompt resource person to be mindful of choice of words in order not to reinforce existing stereotypes and biases associated with professions in the aviation industry (especially those associated with gender and social status). Control the class discussion to avoid a few learners dominating the discussions and encourage learners who may not be vocal to contribute to the discussion through writing.

Building on what others say: With the aid of audio-visuals, learners in mixed-ability groups are led to discuss the roles of the various aviation professionals. The learning pathways leading to the various aviation professions should be discussed and emphasis should be placed on breaking stereotypes in aviation professions especially those associated with gender and social status. Teacher should endeavour to have all learners to actively participate in the discussions.

Key Assessment

Assessment Level 1

1. List at least three aviation professions and describe the roles they play in the aviation industry.
2. Identify any qualifications common to at least two aviation professions.

Assessment Level 2

1. Select an aviation profession you would like to work in and give reasons for the choice.
2. Develop a chart that traces the educational progression from high school through to professional institutions in the aviation industry.

Assessment Level 3

1. Create a career path for an aviation profession you would like to work in showing the qualifications required, the different roles that you may hold as you progress in this profession, and the length of experience expected at each stage.
2. Create a career path for another aviation profession in a different role from (3a).

References

1. International Civil Aviation Organization (I.C.A.O) Annexes

Week 13 – Coordination In Aviation

Theme / Focal Area

Previous weeks have explored the many aviation professions, focusing on the roles they play and requirements learners will have to meet to take up these careers. This week seeks to present the interrelationship between the different roles: how they work together to achieve smooth air travel.

- We begin with the aerospace engineer. They are probably at the root of the whole chain. They continually research into new and safer technologies for the aviation industry and bring their knowledge to fruition when they design and build aircraft and aerospace systems. Like any other profession, in order to thrive, there must be a customer. The aerospace engineer's customers are the airlines. They may be looked at as the true employer of the aerospace engineer. The airlines provide the funds that support the aerospace engineer in his/her research when they sign up for new designs and products. The airlines go on to purchase the end products of the aerospace engineer's work.
- Aircraft maintenance engineers continue the aerospace engineer's work in the field. They inspect the aircraft and make sure it is fit for flight. They service all the working parts especially faulty or overdue components to ensure the prolonged life of the aircraft.
- With the aircraft in hand, the airlines need a place to operate. Airports are normally constructed and operated by the state. At the helm of affairs is the airport manager. They receive the airlines' business and allocate resources necessary for their operation at the facility.
- Flight dispatchers liaise with airline management, airport staff and pilots to plan flight schedules.
- Passengers book flights with their favourite airline. With the current advancement in technology, most people do this online with the help of customer service representatives at the airline. They arrive at the airport and are received by airline passenger service agents. Passenger service agents assist passengers to check in, and receive their baggage. Luggage is passed on to cargo handlers who process them for loading onto the aircraft.
- Airport security personnel process passengers as they move from the airline counters towards the boarding gates. They check to make sure that passengers are not in possession of any items that might present a security risk to other travellers. They monitor passenger behaviour and coordinate with the security services to identify and isolate potentially harmful individuals.
- Passenger service agents interact with passengers one more time when they call out boarding schedules at the gate. Passengers make their way to the aircraft and are received by flight attendants who direct them to their seats and assist them with stowing their carry-on luggage. They ensure that all passengers are seated and safely strapped in, then secure the doors and prepare for flight. They make presentations about safety measures on board the aircraft in the event of emergency, and serve food and drinks as the flight progresses towards its destination.
- Pilots take charge of the flight and control the aircraft from taxi, to take-off, cruising and landing at the destination airport. They maintain constant communication with air traffic controllers for instructions to ensure the safety of theirs and other aircraft in the same airspace.

Learning Task

Demonstrate the interrelationship between the different aviation professions

Pedagogical Exemplars

Collaborative learning; Project-based learning: Teacher forms mixed-ability groups of learners to perform a play to demonstrate the interrelationship among the different aviation professions for ensuring smooth, safe and secure air travel.

Key Assessment

Assessment Level 2

- Develop a flowchart showing the interrelationship between the aviation professions.
- Learners perform a play portraying the interrelationship between the aviation professions for safe air travel.

References

1. International Civil Aviation Organization (I.C.A.O) Annexes
2. Internet sources

Section Review

This Section has explained in the detail what goes on in the various aviation professions in ensuring smooth air travel. Also stressed was the interdependencies existing between all aviation professions in carrying out their day-to-day activities.