SPECIAL SUBJECT

AIR WING (NCC)

EDITION 2025

JD/JW CADETS' HAND BOOK
NATIONAL CADET CORPS

National Cadet Corps

Published By: The Director General, National Cadets Corps
Delhi-110030

सत्यमेव जयते

CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, HAVING
solemnly resolved to constitute India into
a sovereign socialist secular democratic republic
and to secure to all its citizens :

JUSTICE,
Social, Economic And Political; LIBERTY
of thought, expression, belief, faith and worship;

EQUALITY
of status and of opportunity; and to promote among them all

FRATERNITY
assuring the dignity of the individual and
the [unity and integrity of the nation];

IN OUR CONSTITUENT ASSEMBLY
this twenty-sixth day of november, 1949, do
HEREBY ADOPT, ENACT AND GIVE TO
OURSELVES THIS CONSTITUTION.

NATIONAL ANTHEM

Jana-Gana-Mana-Adhinayak Jaya He

Bharat-bhagya-vidhata

Punjab-Sindhu-Gujrat-Maratha

Dravid-Utkal-Banga

Vindhya-Himachal-Yamuna-Ganga-

uchchala-jaladhi-taranga

Tava Subha name jage,

tava subha asisa mage, gahe tava jaya-gatha.

Jana-gana-mangala-dayaka

jaya he Bharata-bhagya-vidhata

Jaya he, Jaya he, Jaya he, jaya jaya jaya jaya he.

FOREWORD

It gives me immense pleasure and pride to present the Revised NCC Précis of Common and Special Subjects, 2025 Edition, marking the culmination of a protracted effort mounted for the purpose for more than two years. This achievement has only been made possible through the collective and whole-hearted effort of all stakeholders, comprising the Directorates, the Board of Officers for revision and for printing, & my staff. Your contribution in bringing the project to fruition merits highest appreciation.

The revision was aimed at structuring and updating the syllabus to reflect contemporary thought & realities, as also equip cadets with skills to apply their NCC training in real-life situations. The challenge was to simultaneously keep the language simple for easy comprehension, avoiding too much jargon or pedantry. Endeavour was also to make the presentation interesting and the layout reader-friendly, enabling cadets to engage with each topic meaningfully even through self-study. I extend my sincere appreciation to the entire team for successfully achieving these objectives in their entirety.

This endeavour also aligns the NCC syllabus with tenets of *Vikasit Bharat* for the youth, familiarising NCC cadets with history, geo-strategy, and contemporary technological advances, while remaining rooted in our cultural heritage and ethos. I am sanguine that this vision will be carried forward by present and future generations of cadets, ensuring strong foundations for a robust nation, enabled and ready to achieve greater heights and our rightful place on the global stage.

GOD bless and JAI HIND

Director General,
National Cadet Corps

MASTER INDEX: AIFORCE SPECIALISED SUBJECT (JD/JW)

ARMED FORCES & IAF CAPSULE

CHAPTERWISE INDEX: AFCAP (JD/JW)

CHAPTER AFCAP: ARMED FORCES AND IAF CAPSULE

"I won't die in an accident or die of any disease. I will go down in glory."

- Maj Sudhir Kumar Walia (Ashok Chakra)

TEACHING INSTRUCTIONS

Period	**:**	**04 (Four)**
Type	**:**	**Lecture**
Year	**:**	**1st Year JD/JW**
Conducting Officer	**:**	**ANO**

Training Aids: Class room, OHP, Board, Screen, Pointer, Marker, Book Flagged, or Lesson Plan, File and Aircraft Model

Time Plan

➢ **Introduction**	**:**	**05 Mins**
➢ **Part I**	**:**	**30 Mins**
➢ **Part II**	**:**	**30 Mins**
➢ **Part III**	**:**	**30 Mins**
➢ **Part IV**	**:**	**25 Mins**
➢ **Part V**	**:**	**25 Mins**
➢ **Conclusion and Practice**	**:**	**15 Mins**

INTRODUCTION

1. The military forces of the Republic of India consisting of three uniformed services: the Indian Army, Indian Navy, and Indian Air Force. With strength of over 1.4 million active personnel, it is the world's second-largest military force and has the world's largest volunteer army. The Indian Armed Forces have a rich history. The Indian Armed Forces have been engaged in numerous major military operations, including the Indo-Pakistani wars of 1947, 1965, 1971, the Portuguese-Indian War, the Sino-Indian War, The Kargil War, and many others. The President of India serves as the supreme commander of the Indian Armed Forces. However, actual control lies with the executive headed by the Prime Minister of India. The Ministry of Defence is responsible for the country's defence and security.

PREVIEW

The lecture will be conducted in the following parts:-

- **Part:I: Indian Army**.
- **Part:II: Indian Navy**.
- **Part:III: Indian Air Force**.
- **Part:IV: Badges and Ranks**.
- **Part:V: Honours and Awards**.

LEARNING OBJECTIVES

- **Basic understanding of Indian armed forces their organization and structure**.
- **Badges of ranks**
- **Honors and awards**.
- **Modes of entry in IAF and civil aviation**.
- **Recognizing of Aircrafts**.
- **Information of IAF aircraft inventory**.

PART I: INDIAN ARMY

2. Indian Army is the land-based branch and it is the largest component of the Indian Armed Forces. It is the fourth largest standing Army in the world. The President of India is the Supreme Commander. It is headed by The Chief of Army staff (COAS), who is a four-star General. The Chief of Army Staff is responsible for all the activities of Indian Army. The senior officers who assist him are:-

(a) Vice Chief of Army Staff.
(b) Three Deputy Chiefs of Army Staff.
(c) Principle Staff Officers (PSOs).
(d) Heads of Arms and Services.
(e) Field Army (Commands).

3. The responsibility for national defence rests with the Cabinet. This is discharged through the Ministry of Defence (MoD) which provides the policy framework and wherewithal to the Armed Forces to discharge their responsibilities in the context of the defence of the country. Even though all elements of national defence and national security continuously strive to achieve the assigned roles and tasks the Defence Services play the most vital role in maintaining sovereignty and territorial integrity of our nation from both; external and internal threats. Based on the major wars fought, struggles and the present-day relations with our neighboring countries and strategic allies the Defence forces of our nations have transformed significantly to ensure the compliance to the given mandate. Having read the overview of the current structures of the Indian Armed Forces as discussed in succeeding paragraph the NCC Cadets will be able to appreciate how well these organizations have emerged to meet India's needs of national defence, security, integration and other associated requirements.

4. Even though the responsibility of national defence rests with the Cabinet and is discharged through Ministry of Defence, the President of India is the Supreme Commander of Indian Armed Forces. Like in all other developed and developing countries, the Indian Armed Forces comprises of three main constituents, namely, Indian Army, Indian Navy and Indian Air Force which looks after the multi- dimensional defence needs of the country. Recently the chief of Defence Staff (CDS) was established with intension of enhancing tri-service effectiveness coordination and overall integration of the Indian Armed Forces combat capabilities. CDS is the chief advisor to the Government of India in all matters pertaining to Indian Defence Forces. General Bipin Rawat, PVSM, UYSM, AVSM, YSM, SM, VSM, ADC was appointed as the first CDS on 27 Dec 2019.

5. Throughout this chapter, we will delve into the history, structure, and key functions of each branch of Indian Armed Forces, enabling the Cadet to obtain a basic understanding of these vital national assets.

Soldiers of the Sikh Light Infantry during a Republic Day Parade

6. Army Command Headquarters is commanded by an officer of the rank of 'Lieutenant General', who is known as the Army Commander or General Officer Commanding–in-Chief. The Indian Army is divided into seven Commands who have subordinate formations under them. These are:-

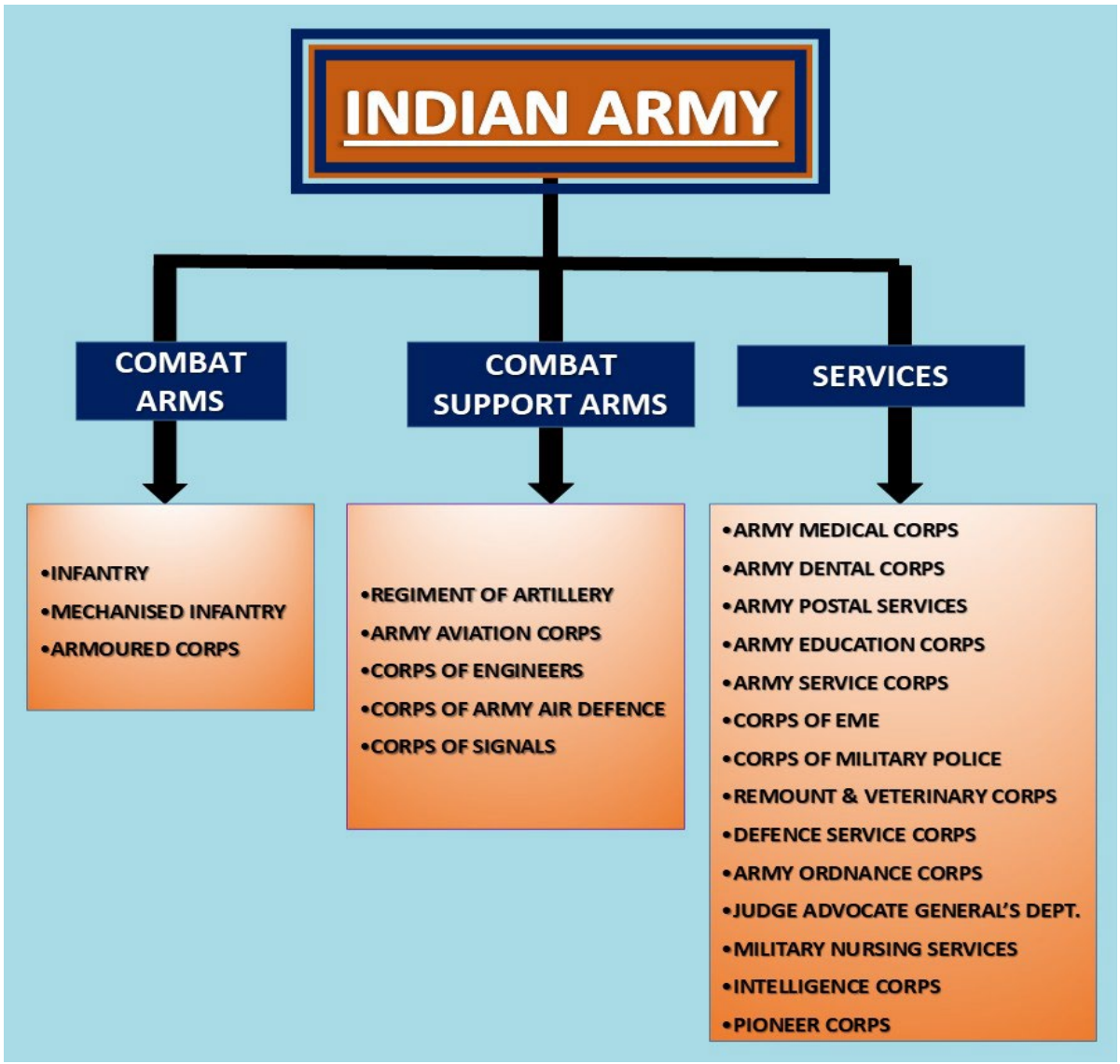
Command Insignia	Command Name	Headquarters
	Central Command	Lucknow
	Eastern Command	Kolkata
	Northern Command	Udhampur
	Southern Command	Pune
	South Western Command	Jaipur
	Western Command	Chandimandir
	Army Training Command	Shimla

7. **Components of Indian Army**. The Indian Army has three main constituents namely the Combat Arms, the Combat Support Arms and the Services which are organized in field formations forming the Brigades, Divisions, Corps and Commands. All three together fight the war as a team as part of the field formations. These three key constituents namely the Combat Arm, Combat Support Arm and Services, which are further divided into sub components have their own unique quality and characteristics.

(a) **Combat Arms**. These are the primary fighting forces of the Army, directly involved in combat operations.

(b) **Supporting Arms**. These support the combat arms by providing essential wherewithal and capabilities vital for war fighting which is not integral to the Combat arms like long range fire power, protection from hostile air craft, mobility and communications in war fighting areas.

(c) **Services**. These units provide logistical and administrative support to the Army, ensuring that combat and supporting arms can function effectively both during war and peace.



8. By manpower wise Indian Army is one of the largest standing armies in the world. The role of the Indian Army is to deny enemy from capturing our land and to capture enemy territory. The army is divided into three components, combat arms, combat support, arms and services. Combat arms are the ones who are in the forefront and in the face of the enemy. Combat Support Arms help the Combat Arms in the battlefield to perform the assigned tasks and provide logistical support.

9. The Indian Army is the fourth largest Army in the world and has a legacy of heroism valor. Also, the motto of Indian Army is "**SERVICE BEFORE SELF**".

PART II: INDIAN NAVY

10. India is covered from three sides with water and have a coastline of approximately over 6000 Km. The sea around India has a great impact/ effect on India's freedom, trade, commerce, and culture. The Indian Navy (Bhartiya Nau Sena) is the naval branch of the Indian Armed Forces. The President of India serves as Supreme Commander of the Indian Navy. The Chief of Naval Staff, usually a four-star officer in the rank of Admiral, commands the navy. The Indian Navy is the eighth largest in the world. The primary objective of the navy is to secure the nation's maritime borders.

11. Our nation has one of the largest peninsulas and has open water on three sides with a coastline of approximately 6000 km. As, it has been historically proven, the seas around our country have an impact/effect on our freedom, trade, commerce and culture The Indian Navy (Bhartiya Nau Sena), the maritime Branch of the Indian Armed Forces is the primary organization which ensures our maritime security. It is also supported by Indian Coast Guard which protects our maritime interests and enforces maritime laws. The Indian Navy today is a multidimensional force that has been organized to safe guard India's maritime territorial integrity and other maritime interests. It plays a crucial role in securing India's vast coastline, protecting maritime trade routes and ensuring the nation's maritime sovereignty. The Navy also engages in humanitarian missions, disaster relief and international peacekeeping efforts. Established in its modern form on January 26, 1950, the Indian Navy has evolved into a formidable blue-water navy capable of operating across the globe.

12. The Indian Navy has a vast strength of personnel and a large operational fleet consisting of aircraft carrier, amphibious transport dock, landing ship tanks, destroyers, frigates, nuclear-powered attack submarine, ballistic missile submarine, conventionally-powered attack submarines, corvettes, mine countermeasure vessels, patrol vessels, fleet tankers and various other auxiliary vessels

13. As of April 2024, the Indian Navy possesses two aircraft carriers, one amphibious transport dock, four tank landing ships, 12 destroyers, 12 frigates, 2 nuclear-powered ballistic

missile submarines, 16 conventionally powered attack submarines, 20 corvettes, eight landing craft utilities, ten large offshore patrol vessels, five fleet tankers as well as various auxiliary vessels and small patrol boats.

14. Indian Navy Air Arm: The air arm is a fighting arm of the Indian Navy which is tasked to provide an aircraft carrier-based strike capability, fleet air defence, maritime reconnaissance, and anti-sub marine warfare. Some prominent fighter air crafts that Indian Navy operates includes MG 29 K and HAWK. It also employs other air crafts including Cheetah, Chetak and SEA KING helicopters. It was raised in 1948 and today has approximately 23 squadrons, 5000 personnel and approximately 300 various types of aircrafts.

SKY KING

MiG 29K

15. Chief of Naval Staff commands Indian Navy. Integrated Headquarters of the Ministry of Defence (Navy) is located in New Delhi. There are three commands of Indian Navy:-

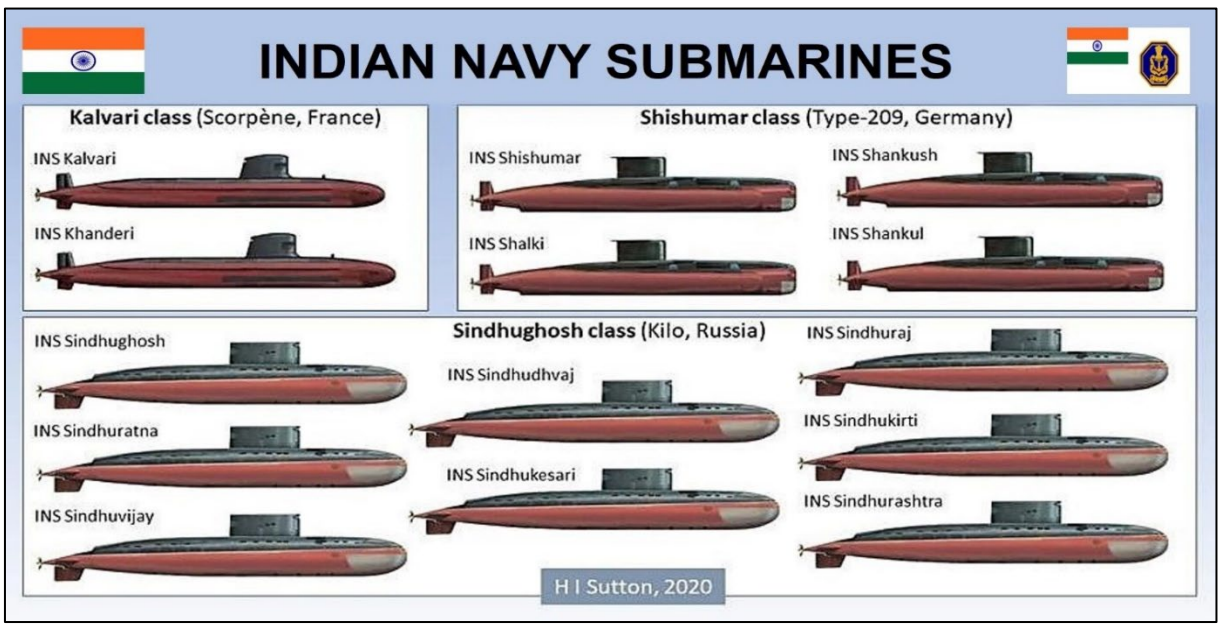
COMMAND	HEADQUARTER
Western Naval Command	Mumbai
Eastern Naval Command	Vishakhapatnam
Southern Naval Command	Kochi

16. Naval Air Stations: The Navy operates several air stations equipped with aircraft for reconnaissance, anti-submarine warfare, and logistics support. Key air stations include INS Hansa in Goa and INS Rajali in Arakkonam.

17. The Indian Navy’s organizational structure ensures it can effectively manage and deploy its resources to protect India’s maritime interests and respond to various challenges and threats.

Types of warships (Indian Navy)

Type of Warship	Description	Examples
Aircraft Carriers	Large ships capable of carrying and launching aircraft.	INS Vikramaditya, INS Vikrant
Destroyers	Versatile warships with anti-air, anti-ship, and anti-submarine capabilities.	INS Kolkata, INS Visakhapatnam, INS Imphal
Frigates	Smaller than destroyers, with multi-role capabilities.	INS Shivalik, INS Nilgiri
Corvettes	Compact warships designed for coastal defense and patrol duties.	INS Kamorta, INS Kiltan
Submarines	Submersible vessels used for stealthy underwater operations.	INS Kalvari, INS Arihant
Patrol Vessels	Smaller craft used for patrolling, search and rescue, and other coastal missions.	INS Saryu, INS Sunayna
Mine Countermeasures Vessels	Designed for mine-clearing operations.	INS Nireekshak, INS Karwar
Landing Platform Docks	Amphibious assault ships for launching troops and equipment ashore.	INS Jalashwa, INS Shardul
Offshore Patrol Vessels	Used for patrolling and surveillance in offshore waters.	INS Vikram, INS Vajra
Research Vessels	Ships dedicated to scientific research and oceanographic studies.	INS Sagardhwani, INS Sindhughosh (research variant)
Training Ships	Used for training purposes and instruction of naval cadets.	INS Tarangini, INS Sudarshini



INTERESTING FACTS

- As of August 2015, the Indian Navy is classified as a Rank 3 navy (Power projection to regions adjacent to its own) on the Todd-Lindberg navy classification system of naval strength.
- The Navy also includes specialized units such as the Marine Commandos (MARCOS) for special operations and the Indian Naval Air Arm for aerial operations.
- Fleet Composition: The Indian Navy's fleet includes aircraft carriers, destroyers, frigates, corvettes, submarines, and various auxiliary vessels. As of 2024, the Navy operates two aircraft carriers, INS Vikramaditya and INS Vikrant, along with a range of other advanced ships and submarines.

PART III: INDIAN AIR FORCE

18. Indian Air Force is the youngest force among the three Armed forces. It is the world's third largest air force in terms of both personnel and aircrafts. Its primary responsibility is to safe guard the Indian airspace and to conduct aerial warfare during a conflict. It came into existence in the year 1932.The secondary purpose of IAF is to assist civil authorities during natural calamities and internal disturbances. The IAF provides close air support to the Indian Army troops in the battle field and also provides strategic and tactical airlift capabilities. IAF also provides strategic air lift or secondary Airlift for the Indian Army. Indian Air Force operates fighter aircrafts, transporter aircrafts, trainer aircrafts, UAV aircrafts, bombers and helicopters. The President of India serves as Supreme Commander of the IAF.

19. Indian Air Force is commanded by the Chief of the Air Staff, usually a four star officer with the rank of Air Chief Marshall. The staff of Air Headquarters consists of three branches:-

(a) Air Staff branch

(b) Administrative branch

(c) Maintenance branch

20. The Air Force is divided in to seven commands which are controlled by Air HQ. These commands are sub-divided in Operational commands and Functional commands. Each Command is placed under the command of an Air Officer Commanding-in-Chief. The Commands of IAF are as follows:-

COMMAND	HEADQUARTER
OPERATIONAL COMMANDS	
Central Air Command (CAC)	Prayagraj, Uttar Pradesh.
Eastern Air Command (EAC)	Shillong, Meghalaya
Southern Air Command (SAC)	Thiruvananthapuram, Kerala.
South Western Air Command (SWAC)	Gandhinagar, Gujarat.
Western Air Command (WAC)	New Delhi.
FUNCTIONAL COMMANDS	
Training Command (TC)	Bengaluru, Karnataka.
Maintenance Command (MC)	Nagpur, Maharashtra.

21. The Indian Air Force (IAF) is the aerial warfare branch of the Indian Armed Forces, tasked with securing Indian airspace and conducting aerial operations during armed conflicts. It was established on October 8, 1932, as the Royal Indian Air Force, which took part in many gallant air actions during World War II. After India gained independence the prefix Royal war removed. On 1st Apr 1954, Air Marshall Subroto Mukherjee, one of the founding members of the Royal Indian Air Force took over as the first Chief of the Air Staff of the Indian Air Force

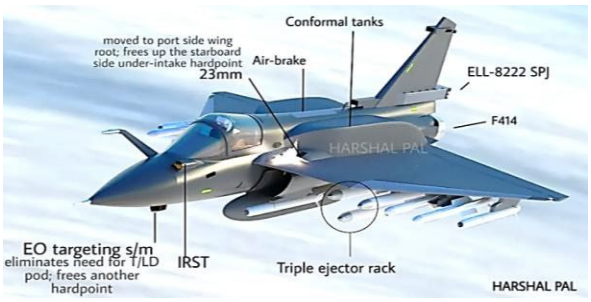
22. The primary mission of the Indian Air Force is to secure Indian air space both during peace and war. The IAF plays the crucial role of conducting aerial warfare during armed conflicts: conducting strategic bombing, destroying enemy air assets, engaging in reconnaissance missions and providing air support to ground and naval forces where and when required. Additionally, the IAF participates in humanitarian missions, disaster relief and international peacekeeping efforts.

23. The IAF is the world's fourth largest air force in terms of both personnel and aircrafts. The Indian Airforce comprises of undermentioned aircraft, helicopters and the associated equipments with which they execute their tasks and responsibilities:-

(a) Fighter Aircrafts
(b) Bombers
(c) Transport aircrafts
(d) Attack Helicopters
(e) Transport Helicopters
(f) Reconnaissance Assets (aircrafts, helicopters and drones)
(g) Missiles
(h) Radars

Boeing C-17 Globemaster III

Rafale M fighter



LCA Mk 1A

Sukhoi SU-30MK

PART IV: BADGES AND RANKS

24. **Indian Army**. Presently, the ranks and hierarchy in the Indian Army (IA) are categorised into three distinct categories given as below:-

(a) **Commissioned Officer**. Indian Army officers are directly commissioned by the President of India and are serve as the leaders of the Indian Army. They are trained at prestigious institutions like the Indian Military Academy (IMA), the Officers Training Academy (OTA) and National Defence Academy (NDA). They go through various entrance exams conducted by UPSC like NDA Exam, CDS Exam followed by SSB interview to get selected. They hold ranks from Lieutenant to General and are responsible for strategic planning, leadership and decision-making at various levels. The rank of a Field Marshal is the highest rank of an officer of the Indian Army. It is an honorary rank and is reserved for significant contributions by an Army officer.

BADGES OF RANK OF OFFICERS OF INDIAN ARMY

(b) **Junior Commissioned Officer (JCO)**. They are equivalent to Group 'B' gazetted officers. They serve as a vital link between the officers and the enlisted soldiers. They are promoted from the ranks of Non-Commissioned Officers (NCOs) and hold ranks such as Subedar Major, Subedar and Naib Subedar. JCOs play a crucial role in maintaining discipline, executing orders and ensuring the smooth functioning of their units. They receive their commission from the President of India.

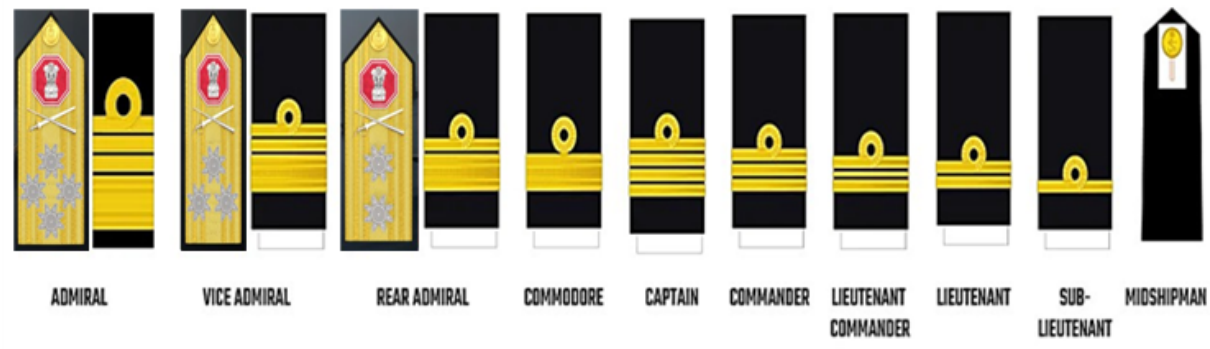
BADGES OF RANK OF JCOs AND NCOs OF INDIAN ARMY

(c) **Non Commissioned Officer (NCO)**. NCOs are the backbone of the Indian Army, responsible for executing orders and maintaining discipline. They are promoted from the ranks of enlisted soldiers and hold ranks like Havildar, Naik and Lance Naik. NCOs are essential for the day-to-day operations and management of their units, ensuring that tasks are carried out efficiently and effectively.

25. **Indian Navy (IN)**. Presently, the IN's rank hierarchy is divided into two broad categories:-

(a) **Commissioned Officers of Indian Navy**. The Indian Navy Officers go through the same selections as mentioned above. From the prestigious rank of Admiral (Chief of Naval Staff) representing the topmost post of naval excellence, to the starting post of Midshipman, each level holds a unique significance in the complex structure of the Indian Navy's structure. The Naval Officers of IN holds ranks for Sub Lieutenant to Admiral and are responsible for strategic planning, leadership and decision making at various levels. The rank of an Admiral of the Fleet, the highest-ranking officer of the Indian Navy with a five-star honorary rank and is reserved for significant contributions by a naval officer.

BADGES OF RANK OF OFFICERS OF INDIAN NAVY



(b) **Sailors of the Indian Navy**. Sailors of the Indian Navy are divided into two categories:-

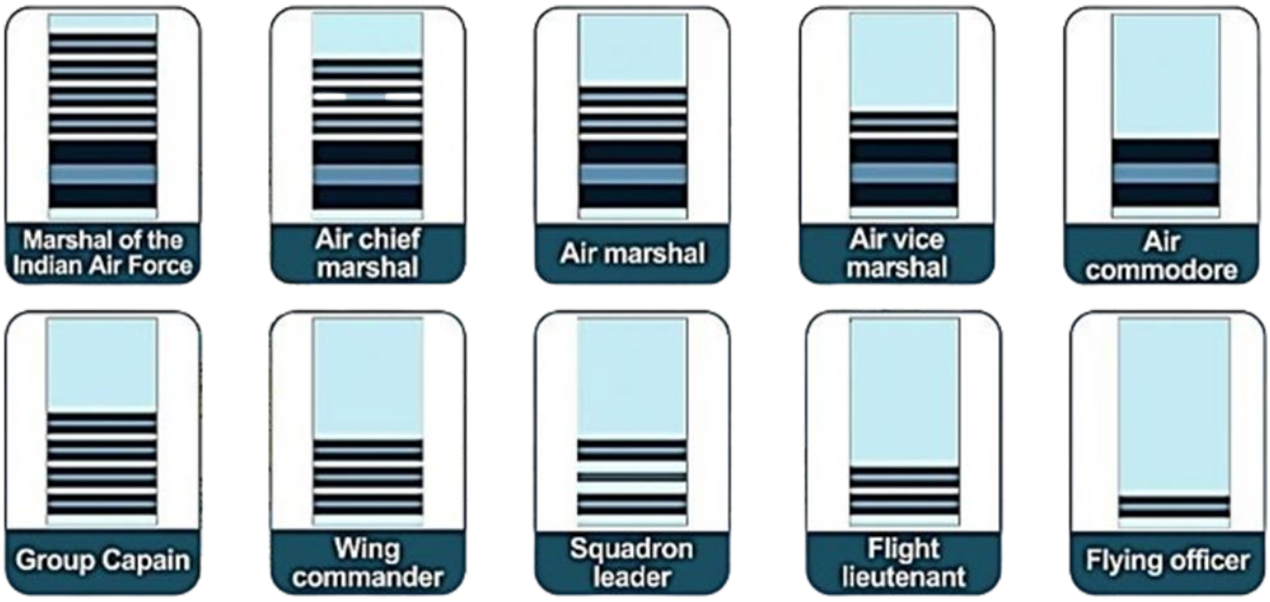
(i) **Senior Sailors**. Petty Officer, Chief Petty Officer, Master Chief Petty Officer (First Class & Second Class).

(ii) **Junior Sailors**. Leading Seaman, Sea-I and Sea -II.

BADGES OF RANK OF SAILORS OF INDIAN NAVY

26. **Indian Air Force**. The cadre of the same rank are addressed differently in Navy vis-s- vis the Army. Similarly, the ranks of personnel viz officers, JCOs and NCOs are addressed differently in IAF also. Commissioned Officers lead and manage the forces and they have corresponding ranks in each branch. The Air Force ranks include Marshal of the Indian Air Force (honorary for exceptional contributions), Air Chief Marshal, Air Marshal, Air Vice Marshal, Air Commodore, Group Captain, Wing Commander, Squadron Leader, Flight Lieutenant and Flying Officer. Indian Air Force aircrafts are piloted by officers only.

BADGES OF RANK OF OFFICERS OF INDIAN AIR FORCE



27. The Air Force's JCOs encompass Warrant Officers and Junior Warrant Officers, while NCO/Other Ranks include Sergeants, Corporals, Leading Aircraftsmen and Aircraftsmen.

BADGES OF RANK OF WARRANT OFFICERS AND NCOs OF INDIAN AIR FORCE

28. The NCOs and Airmen are involved in all activities of an air base and give support to various technical and non-technical jobs. While, the JCOs manage and supervise the NCOs and Airmen, the officers on the other hand apart from flying all military aircrafts are involved in strategic planning, management and higher level of technical guidance and navigation.

INTERESTING FACTS

- Till date only IA and IAF Officers have been awarded the honorary rank of Field Marshal or equivalent. These are Field Marshal KM Cariappa and Field Marshal SHFJ Manekshaw from Army and Marshal of the Air Force Arjan Singh from Air Force.
- Since 1950, the designation of Chief Petty Officer was the highest non- commissioned rank in IN's rank hierarchy until December 1968, when the designations of Master Chief Petty Officer I and Master Chief Petty Officer II were introduced.

EQUIVALENT RANKS IN ARMY, NAVY AND AIR FORCE

29. The structured ranks within the Indian Army, Navy and Air Force are an embodiment of the military's order and organization. They represent the dedication and commitment of the personnel who safeguard the country's borders and interests, working together to uphold national security. Understanding equivalent ranks across these branches is crucial for effective communication and cooperation. Let us understand the corresponding ranks in the Indian Army, Navy and Air Force with the help of this table:-

ARMY	NAVY	AIRFORCE
Field Marshal	Admiral of the Fleet	Marshal of the Air Force
General	Admiral	Air Chief Marshal

ARMY	NAVY	AIRFORCE
Lt General	Vice Admiral	Air Marshal
Major General	Rear Admiral	Air Vice Marshal
Brigadier	Commodore	Air Commodore
Colonel	Captain	Group Captain
Lt Colonel	Commander	Wing Commander
Major	Lt Commander	Squadron Leader
Captain	Lieutenant	Flight Lieutenant
Lieutenant	Sub Lieutenant	Flying Officer

JCOs AND NCOs OF INDIAN ARMED FORCES

Army	Navy	Air Force
Sub Major	MCPO I	Master Warrant Officer
Subedar	MCPO II	Warrant Officer
Naib Subedar	Chief Petty Officer	Junior Warrant Officer
Havildar	Petty Officer	Sergeant
Naik	Leading Seaman	Corporal
Lance Naik	Sea I	Leading Aircraftsman
Sepoy	Sea II	Aircraftman

PART V: HONOURS AND AWARDS

30. The Armed forces of India have a glorious history during which they have been awarded with many military decorations, honours and awards. These awards and honours are awarded for extraordinary bravery and courage, as well as for distinguished services during times of war and peace. For the purpose of classification, Indian Armed Forces honours and awards are divided into two categories:

(a) Gallantry Awards

(b) Non-Gallantry Awards / Distinguished Service Awards

31 The seawards are given on occasions of various felicitation ceremonies organized at Rashtrapati Bhawan, New Delhi, on Republic Day and on various occasions. The awards given to Armed Forces, are enumerated below:-

32. **Gallantry Awards in the Face of Enemy (War Time)**.

33. **Gallantry Awards Other than in the Face of Enemy (Peace Time)**.

34. **Non-Gallantry Awards/ Distinguished Service Awards**.

(a) Sarvottam Yudh Seva Medal

(b) Param Vishisht Seva Medal

(c) Uttam Yudh Seva Medal

(d) Ati Vishisht Seva Medal

(e) Yudh Seva Medal

(f) Vishisht Seva Medal

(g) Mention in dispatch

INTERESTING FACTS

- Medals like Sena Medal can be awarded at any time i.e Gallantry award, Non-Gallantry award or Distinguish Service award.
- Commendation card is type of Gallantry award which can be awarded for individual acts of gallantry or distinguished service or devotion to duty performed in operational or non-operational areas.

CONCLUSION

35. The Indian armed forces are the military forces of the republic of India. It consists of the three professional uniformed services: The Indian Army, The Indian Navy, The Indian Air Forces. All three services have distinct Badges of ranks which help in identifying the personnel and their seniority. The President of India is the supreme commander of Indian Armed. Forces. Indian Armed Forces have been engaged in a number of major military operations. Indian armed forces are split into different groups based on their region of operations. The Indian Army is divided into six operational command and one training command each under control of lieutenant General. The Indian Navy operates three commands. Each command is headed by a flag officer commanding-in-chief with the rank of Vice Admiral. The highest wartime gallantry is Param Vir Chakra and peace time is Ashok Chakra.

ASSESSMENT EXERCISE

Multiple-Choice Questions (MCQs)

Q1. Who is the Supreme Commander of the Indian Armed Forces?

(a) Prime Minister
(b) President of India
(c) Chief of Defence Staff
(d) Defence Minister

Q2. Which ministry is responsible for national defence in India?

(a) Ministry of Home Affairs
(b) Ministry of Defence
(c) Ministry of External Affairs
(d) Ministry of Finance

Q3. What is the primary role of the Indian Army?

(a) Maritime security
(b) Aerial warfare
(c) Ensuring national security and unity
(d) Space exploration

Q4. Who was appointed as the first Chief of Defence Staff (CDS) of India?

(a) General Manoj Pande
(b) Air Chief Marshal RKS Bhadauria
(c) General Bipin Rawat
(d) Admiral Karambir Singh

Q5. How many operational commands does the Indian Army have?

(a) 4
(b) 5
(c) 6
(d) 7

Q6. What is the main function of the Army Service Corps (ASC)?

(a) Combat operations
(b) Providing logistics, supply, and transportation
(c) Training personnel
(d) Air defence

Q7. Which of the following is NOT a combat arm of the Indian Army?

(a) Infantry
(b) Armoured Corps
(c) Corps of Signals
(d) Mechanized Infantry

Q8. Where is the headquarters of the Indian Navy located?

(a) Visakhapatnam
(b) Kochi
(c) Mumbai
(d) New Delhi

Q9. What is the name of India's first indigenous aircraft carrier?

(a) INS Vikrant
(b) INS Vishal
(c) INS Arihant
(d) INS Vikramaditya

Q10. Which of the following commands is responsible for training in the Indian Navy?

(a) Western Naval Command
(b) Eastern Naval Command
(c) Southern Naval Command
(d) Central Naval Command

Q11. The Indian Air Force was established in which year?

(a) 1930
(b) 1932
(c) 1947
(d) 1954

Q12. What is the primary role of the Indian Air Force?

(a) Securing Indian airspace
(b) Conducting naval warfare
(c) Managing ground-based logistics
(d) Providing legal support

Q13. Which of the following is a fighter aircraft used by the Indian Air Force?

(a) C-17 Globemaster III
(b) CH-47 Chinhook
(c) MiG-29
(d) Apache AH-64E

Q14. The Indian Armed Forces participate in which of the following international efforts?

(a) UN Peacekeeping missions
(b) Space exploration programs
(c) Foreign elections monitoring
(d) Global financial aid distribution

Q15. Which of the following is a missile system used by the Indian Air Force?

(a) SPYDER
(b) BrahMos
(c) Prithvi
(d) Agni

Short Answer Type Questions

Q1. What are the three main constituents of the Indian Armed Forces?

Q2. Describe the role of the Chief of Defence Staff (CDS) in the Indian Armed Forces.

Q3. What is the primary mission of the Indian Air Force?

Q4. Name the three commands of the Indian Navy and their respective headquarters.

Q5. What is the significance of Services in the Indian Army?

Long Answer Type Questions

Q1. Discuss the historical evolution of the Indian Army from the British Indian Army to its current form.

Q2. Explain the organizational structure and key functions of the Indian Navy.

Q3. Describe the various components and operational capabilities of the Indian Air Force.

Q4. How does the Ministry of Defence (MoD) support the Indian Armed Forces in discharging their responsibilities?

Q5. Analyse the importance Combat Arms and Combat support arms in Indian Army?

INDIAN AIR FORCE

2

CHAPTER-WISE INDEX: INDIAN AIR FORCE (IAF)

CHAPTER IAF: INDIAN AIR FORCE (IAF)

INDIAN AIR FORCE

TOUCH THE SKY WITH GLORY

TEACHING INSTRUCTIONS

Period	**:**	**04 (Four)**
Type	**:**	**Lecture**
Year	**:**	**1st Year JD/JW**
Conducting Officer	**:**	**Permanent Instructor**

Training Aids: Class room, OHP, Board, Screen, Pointer, Marker, Book Flagged, or Lesson Plan, File and Aircraft Model

Time Plan

Part I	**:**	**40 Mins**
Part II	**:**	**40 Mins**
Part III	**:**	**40 Mins**
Part IV	**:**	**30 Mins**
Conclusion and Practice	**:**	**10 Mins**

ORGANISATIONAL CHART – OPERATIONAL COMMAND

AIR OFFICER COMMANDING IN CHIEF (AOC-in-C)		
SASO	SOA	SMSO

PART II: HISTORY OF IAF

3. The Indian Air Force is the youngest among all three military services. It has a bright history even though it is the youngest service. The bravery, valor and achievement of all the personnels of the IAF are integral Part of its proud heritage.

4. The Government passed the IAF bill on 04 April 1932. The Indian Air Force came into existence with the promulgation of the IAF bill on 08 Oct 1932. The governor general-in-council at that time consequently ordered the establishment of Indian Air Force with effect from 08 Oct 1932. The Indian Air Force celebrates its anniversary on 08 Oct every year.

5. In its early years expansion of IAF was rather slow, In Sep 1939 it consisted of only one squadron with a complement of 16 officers and 144 airmen. During World War II the increasing commitment of the RAF in Europe and the impact of Japanese invasion in south-east Asia accelerated the pace of progress.

6. The Indian Air Force today is a modern technology-intensive force distinguished by its commitment towards excellence and professionalism, keeping pace with the demands of contemporary advancement, the IAF continues to modernize in a phased manner and today it stands as a credible air power counted among the fore-most professional services in the world.

7. The primacy of Air Power will be a decisive factor in shaping the outcome of future conflicts. In line with this dictum the IAF has developed into a major ‘Component of National Power’, which can be applied quickly and decisively. The IAF has reoriented itself to a multi-role capability of platforms and equipment, along with muti-skill capability of personnel. The rapid economic growth of the country dictates the need to protect our security interest extending from the Persian Gulf to the Straits of Malacca.

8. Over the years the IAF has grown from a tactical force to one with trans-oceanic reach. The strategic reach emerges from induction of Force Multipliers like Flight Refueling Aircraft (FRA), Remotely Piloted Aircraft (RPA) and credible strategic lift capabilities. There is emphasis on acquiring best of technology.

9. The five operational commands through administrative wings, control over 45 Fixed Wing Squadrons, 20 Helicopters Units and numerous surface to air missile squadrons with unit establishments varying from 12 to 18 aircraft. This represents a total aircraft strength of over 2000 including training and support types, manned by approximately 1,40,000 active personnel.

10. For smooth functioning of an organization it is essential to divide the staff into different branches. Vast organization like Indian Air Force requires various branches to make the organization successful and flawless.

11. Indian Air Force is divided into following branches:-

SER No	Branch Name
01.	Flying Branch
02.	Navigation Branch
03.	Education Branch
04.	Medical Branch
05.	Administration Branch
06.	Logistic Branch
07.	Meteorology Branch
08.	Engineering Branch
09.	Weapon System Branch

PART III: AIRCRAFT RECOGNITION

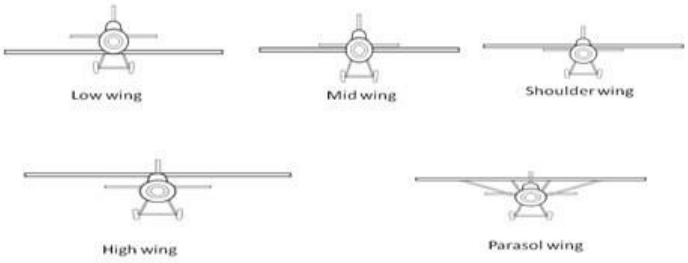
12. Recognizing an aircraft is essential during both in peace and war. Aircraft recognition helps in identifying the different types of aircraft possessed by the enemy and assess the strength of the country and prepare for self-defense. Aircraft recognition helps the MOP (mobile observation post) to identify the Aircraft as friend or foe. It also helps to know the capability of the aircraft by identifying its type.

13. There are various methods used to identify the aircraft:-

(a) Wing position
(b) Shape of canopy
(c) Wing shape
(d) Shape off in sand tailplane
(e) Shape of wingtips
(f) Markings

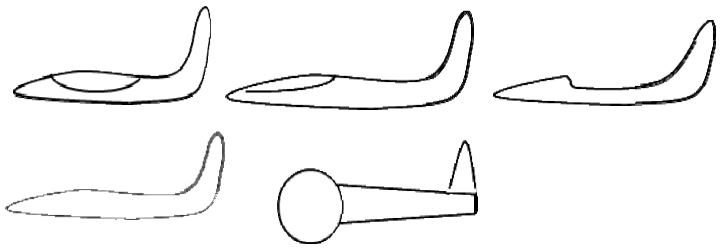
14. Recognition by the Wing Position.

(a) High wing.
(b) Low midwing
(c) Shoulder wing
(d) Low wing
(e) Midwing
(f) Parasolwing



15. Shape of Canopy.

(a) Inline
(b) Submerged
(c) Teardrop
(d) Glasshouse
(e) Bubble



16. Shape of Fin and Tail Plane.

(a) High tail plane
(b) Low mid Tail plane
(c) High mid tail plane
(d) Mid tail plane
(e) Low tail Plane

17. Markings. '**Saffron White Green**'.

PART IV: TYPES OF AIRCRAFT

18. There are different types of aircraft used in Indian armed forces which are designed to undertake specific role. These aircraft are majorly classified into Fighter, Transport, helicopter, Trainer and UAV. Fighter aircrafts are used to establish air superiority over the battlefield. The Transport aircrafts are designed to carry passengers and cargo from one place to another. These transport aircrafts are also used for airlifting victims of natural disasters in India as well as our friendly neighboring countries such as Op. Maitri in Nepal during 2015 Nepal Earth quake. Helicopters have multiple role such as emergency transportation, firefighting, during natural calamities, search and rescue and cargo transportation. Attack helicopters are used to provide close air support and destroy enemy targets on ground. UAVs are used for intelligence, surveillance, target acquisition and reconnaissance.

Fighter Aircrafts

19. **SU-30 MKI**. It Is twin seater twin engine multi role fighter of Russian origin which carries 30mmGSH gun along with 8000 kg armament. It has a capability of carrying a variety of medium-range guided air to air missiles with active or semi-active radar or Infra- red homing close range missiles including nuclear weapons. It has a max speed of 2500km/hr (Mach2.35).

20. **Mirage-2000**. A single seater air defence and multi-role fighter of French origin powered by a single engine can attain max speed of 2495 km / hr (Mach 2.3).It carries two 30 mm integral cannons and two Matra super 530D medium-range and two R-550 Magic II close combat missiles on external stations. This aircraft was used extensively during Kargil war. It was also used in aerial strike in balakot (Pakistan).

21. **MiG-29**. Twin engine, single seater air superiority fighter aircraft of Russian origin capable of attaining a max speed of 2445km per hour (Mach-2.3). It carries a 30 mm cannon along with four R-60 close combat and two R-27R medium range radar guided missiles.

22. **Jaguar**. It is a twin-engine, single seater deep penetration strike aircraft of Anglo-French origin which has a max speed of 1350km / hr (Mach 1.3) It has two 30mm guns and can carry two R-350 Magic missiles.

Transport Aircrafts

23. **C-130J**. A four engine turbo prop transport aircraft of United States (US) origin. This aircraft is capable of performing para drop, heavy drop, casuality evacuation and can also operate from short and semi prepared surfaces. C-130J is the heaviest aircraft to land at DBO a forward high altitude airfield at Indo China border in Aug 2013.

24. **C-17**. A four engine turbo fan transport aircraft of United States (US) origin. A Strategic Lift aircraft is capable of carrying a payload of 40-70 tons upto a distance of 4200-9000km in a single hop. C-17 was used for airlifting Indians who were stuck in Ukraine during Russia-Ukraine war.

25. **IL-76**. IL-76 is a four engine heavy duty/ long haul military transport aircraft of Russian origin with a max speed of 850 km/hr. It has a twin 23mm cannon in tail turret and capacity to carry 225 paratroopers or 40tones freight, wheeled or tracked armoured vehicles. IL-76 along with C-17 was used to airlift over 2000 Indian nationals from Yemen during Operation Rahat in 2015.

26. **AN-32**. Twin engine turbo prop, medium tactical transport aircraft of Russian origin with a crew of four and capacity to carry 39 para troopers or max load of 6.7 tones.

27. **Embraer**. A twin engine turbo fan transport aircraft of Brazilian origin. The main role of employment of this executive Jet Air craft is to convey VVIPs/VIPs to destinations within India and abroad. Air HQ Communication Squadron operates this aircraft and it has maintained a flawless incident/accident free track record till date.

28. **Avro**. Twin engine turbo prop, military transport and freighter of British origin having a capacity of 48 paratroopers or 6 tones freight

29. **Dornier**. Twin engine turboprop, logistic air support staff transport aircraft of German origin capable of carrying 19 passengers or 2057 kg freight.

30. **Boeing 737-200**. It is a twin engine turbofan, VIP passenger aircraft of American origin with total seating capacity of upto 60 passengers. This aircraft is also used in Electronic Warfare Missions.

Helicopters

31. **Mi-35**. Twin engine turboshaft aircraft of Russian origin is an assault and anti armour helicopter capable of carrying 8 men assault squad with four barrel 12.7mm rotary gun in nose and upto 1500 Kg of external ordnance including Scorpion anti- tank missiles. It has a max cruise speed of 310 km/hr.

32. **Mi-17 V5**. The Mi-17V5 is a Russian origin potent helicopter platform, equipped with modern avionics and glass cockpit instrumentation. They are equipped with state-of-art navigational equipment, avionics, weather, radar and are NVG-compatible.

33. **Chetak**. Single engine turboshaft, light utility French helicopter with capacity of 6 passengers or 500kg load.

34. **Cheetah**. Single engine turboshaft, helicopter of French origin which has a capacity to carry 3 passengers or 1000 kg external sling loads. Cheetah is the life line of the Siachen Glacier dropping load and evacuating soldiers from the highest battlefield in the world.

35. **Boeing CH-47 Chinhook**. Boeing CH-47 Chin hook is a tandem-rotor helicopter developed by American rotorcraft company Vertol and now manufactured by Boeing defence, space & security. Chinhook can carry heavy payloads internally and upto 12000 kg externally.

36. **Boeing AH-64 Apache**. The Boeing AH -64 Apache is an American Twin-Turboshaft attack helicopter with tail wheel type landing gear a tandem cockpit for crew of two.

Trainer Aircrafts

37. **Kiran**. Kiran aircraft is indigenously designed by HAL.Is a basic Jet and Armament Trainer. It can carry 2 x 250 kg Bombs or Rocket Pods, 2x 7.62mmguns.

38. **Hawk**. Advanced Jet Trainer, can carry ADEN cannon, in centerline pod, Bombs and Missiles.

39. **Pilatus PC-7**. The Pilatus PC-7 Turbo Trainer is a low-wing tandem- seat training aircraft, manufactured by Pilatus Aircraft of Switzerland. The aircraft is capable of all basic training functions including aerobatics, instrument, tactical and night flying.

Made in India

40. **Light Combat Aircraft (LCA)**. Single seater Multi Role Combat aircraft. It can carry 4000 Kgs (Beyond- Visual-Range missiles, Reconnaissance / Electronic Warfare pods and 23 mm GSH gun. It has a small size which makes it difficult for enemy's radar to spot it. It is capable of take-off and landing from very short runways. An in flight refueling probe has also been attached to this aircraft for to extend its flight time. It is world's smallest lightweight and highly maneuverable combat aircraft with seven hard-points. Developed by aeronautical development agency with contribution from more than 100 government/ private agencies.

41. **Light Combat Helicopter (LCH) Prachand**. The Light Combat Helicopter (LCH) is a multirole combat helicopter developed in India by Hindustan Aeronautics Limited (HAL) for use by the Indian Air Force and the Indian Army. It can carry guns, rockets, missiles and bombs on 04 Hardpoints. It was inducted in Indian Air Force on 03 Oct 2022.

42. **Dhruv**. Dhruv is a utility helicopter developed and manufactured by India's Hindustan Aeronautics Limited (HAL) It can carry Missiles, Rocket Pods, Torpedoes, Depth charges or Anti-ship missiles. It can carry 12 passengers / 04 patients in stretchers with 02 attendant.

CONCLUSION

43. The primary role of the Air Force is to safeguard the nation from any aerial threats and also to provide support to the Army and the Navy. Its secondary role is to provide aid to the civil power in maintaining law and order and in providing relief during natural calamities. The five operational commands through administrative wings control over 45 Fixed Wing Squadrons, 20 Helicopter Units and numerous surface-to-air missile squadrons with unit establishments varying from 12 to 18 aircraft. Visual aircraft recognition is a vital skill for military and defence personnel. Being able to distinguish between various aircraft types helps in identifying potential threats, understanding the capabilities of enemy aircraft, and knowing which aircraft are friendly.

ASSESSMENT EXERCISE

Multiple Choice Questions (MCQs)

Q1. Who is the chief of the Indian Air Force?

(a) Air Chief Marshal
(b) President of India
(c) Chief of Defence Staff
(d) Air Marshal

Q2. Which is Delta wing aircraft?

(a) Hawk
(b) Jaguar
(c) Kiran
(d) Tejas

Q3. Which is high Tail aircraft?

(a) Mig-21
(b) Avro
(c) Sukhoi-30 MKI
(d) IL-76

Q4. Name single engine aircraft?

(a) C-130 J
(b) C-17
(c) Mig-21
(d) Jaguar

Q5. C-295 is _____ aircraft.

(a) Transport
(b) Fighter
(c) Helicopter
(d) RPAS

Q6. Jaguar is _____(mark the correct option) ?

(a) Low level attack aircraft
(b) Cargo aircraft
(c) has turbo prop engine
(d) Single Engine aircraft.

Q7. Which of the following is Trainer Aircraft?

(a) AN-32
(b) Mirage
(c) Avro
(d) PC-7 Pilatus

Q8. Which of the following is VIP Aircraft

(a) Embraer
(b) AN-32
(c) C-130J
(d) Mig-29

Q9. What is the name of Heavy lift transport Aircraft?

(a) Chinhook
(b) Cheetah
(c) Chetak
(d) Mi-35

Q10. Which is the attack helicopter

(a) Mi-8
(b) Mi-17
(c) Chetak
(d) Apache

Short Answers Type Questions

Q1. Write a short note on organization of Indian Air Force.

Q2. Write a short note on history of Indian Air Force.

Q3. Write a short note on Rafale multirole aircraft.

Q4. Write a short note on attack helicopters.

Q5. Write a short note on the branches of Indian Air Force.

Long Answers Type Questions

Q1. Types of aircrafts in IAF inventory.

Q2. Name 5 fighter aircrafts.

Q3. Name any two made in India aircrafts.

Q4. What is the country of origin of AN-32?

Q5. Name any two attack helicopters.

Q6. Country of origin of Apache attack helicopter.

Q7. What are the various methods to identify the aircrafts.

Q8. Country of origin of Rafale.

Q9. Name any 5 transport aircraft.

Q10. Country of origin of embrarer aircraft.

MODERNISATION OF IAF

3

CHAPTER WISE INDEX: MOAF (JD/JW)

CHAPTER MOAF: MODERNIZATION OF IAF

TEACHING INSTRUCTIONS

Period	:	**03 (JD/JW)**
Type	:	**Lecture**
Year	:	**2nd Year JD/JW**
Conducting Officer	:	**Permanent Instructor**

Training Aids: Class room, OHP, Board, Screen, Pointer, Marker, Book Flagged, or Lesson Plan, File and Aircraft Model

Time Plan

➢ **Part I**	:	**60 Mins**
➢ **Part II**	:	**50 Mins**
➢ **Conclusion and Practice**	:	**10 Mins**

INTRODUCTION

1. Use of science and technology in every field always improves the work efficiency, reduces the work load and increases the production rate. A lot of technology improvements have taken place in the field of aviation also. Since the mid-1960s, computer technology has been continuously developed to the point at which aircraft and engine designs are fully automated. In this chapter, we will learn about the list of modern inventions or equipment that has revolutionized the field of aviation. Autopilot, Fly-by-wire, UAVs, Glass cockpit Technology etc. are the gifts of modern technology.

PREVIEW	LEARNING OBJECTIVES
The lecture will be covered in the following parts ➢ **Part I: Latest Trends**. ➢ **Part II: New Acquisitions of IAF**.	➢ **Basic understanding of latest trends in aviation**. ➢ **New acquisitions of IAF in making it a modern aerospace power**. ➢ **Aircraft inventory**.

PART I: LATEST TRENDS IN AVIATION

Autopilot

2. In the early days of aviation, aircraft required continuous attention of a pilot in order to fly safely. As aircraft range increased allowing flight of extended hours, the constant attention led to serious fatigue for the pilot. An autopilot system is designed to perform some of the tasks of the pilot. A single-axis autopilot controls an aircraft in the roll axis only. An aircraft is controlled on pitch and roll axis with the help of two-axis autopilot. A three axis autopilot controls aircraft in all three axis. Computer software is used in modern autopilot to control the aircraft. The software reads the aircraft's current position, and then controls a Flight Control System to guide the aircraft.

Fly By Wire

3. Fly-by-wire (FBW) is a system that replaces the conventional manual flight controls of an aircraft with an electronic interface. The movements of flight controls are converted to electronic signals transmitted through wires (hence the fly-by-wire term), and flight control computers determine how to move the actuators at each control surface to provide the ordered response. The fly-by-wire system also allows automatic signals sent by the aircraft's computers to perform functions without the pilot's input and automatically help stabilize the aircraft

Fly By Optics

4. Fly-by-optics is sometimes used instead of fly-by-wires since it can transfer data at higher speeds because of the use of fibre cables in place of electrical cables.

UAV

5. The UAV stands for Unmanned Aerial Vehicle. UAVs are type of aircraft which are designed in a way that it doesn't require any pilot to be on board. UAVs can be controlled remotely (e.g. flown by a pilot at a ground control station) or can fly autonomously based on pre-programmed flight plans. UAVs are currently used for a number of missions, including reconnaissance and attack roles. They are predominantly deployed for military applications, but also used in a small but growing number of civil applications, such as firefighting and non military security work, such as surveillance of pipelines. UAVs are often preferred for missions that are too 'dull, dirty, or dangerous' for manned aircraft.

Types

6. **Target and Decoy**. Provides ground and aerial target to simulate an enemy aircraft.

7. **Reconnaissance**. Providing battle field intelligence.

8. **Combat**. Providing attack capability for high-risk missions.

9. **Endurance**. Because UAVs are not burdened with the physiological limitations of human pilots, they can be designed for maximized on-station times. The maximum flight duration of unmanned, aerial vehicles varies widely. Internal-combustion-engine aircraft endurance depends strongly on the percentage of fuel burned as a fraction of total weight and so is largely independent of aircraft size.

Air to Air Refueller

10. Air to Air refueling (AAR) is a process where fuel is transferred from one aircraft to another while both are in flight. The aircraft that provides the fuel in called the tanker and the aircraft that receives the fuel is called the receiver. AAR is also known as aerial refueling, In-Flight refueling or tanking. AAR is used is used for Military purposes and is not used in civilian applications. It allows the receiver to stay airborne as

far as the crew can tolerate or until engine factors like engine oil consumption limits it. In IAF, IL-78 is used as tanker for Air to Air Refueling.

AWACS

11. The Indian Air Force has multiple Airborne Warning and Control Systems (AWACS) aircrafts, including Israeli Phalcon AWACS and Netra AEW&C system. AWACS aircrafts are also known as "**Eye in the Sky**".

(a) **Israeli phalcon AWACS**: The IAF operates three Israeli Phalcon AWACS aircrafts that provide 360 degree coverage. The Phelcon AWACS is a product of cooperation between India, Isreal and Russia.

(b) **Netra AEW&C System**: The Netra AEW&C system offers 240 degree coverage. The Netra Mk-1 AWACS played a key role in Balakot operation by providing air situational awareness to IAF fighter pilots.

Glass Cockpit

12. Before 1970's aircraft were not sufficiently demanding torequire advance equipment like electronics flight displays. Also computer technology was not at a level where sufficient light and powerful circuit were available. The increasing complexity of transport aircraft, the advent of digital systems and growing airtraffic congestion around airports began to change that. The average transport aircraft in the mid-1970 had more than one hundred cockpit instrument and

controls and the growing number of cockpit elements were competing for Cockpit space and pilot attention. As a result NASA conducted research on displays that could process the raw aircraft system and flight data into an integrated, easily understood picture of the flight situation, finally culminating in a full glass cockpit system. A glass cockpit is an aircraft cockpit that features electronics instrument displays rather than mechanical gauge. A glass cockpit uses displays driven by flight management system that can be adjusted to displays flight information as needed. This simplifies aircraft operation and navigation and allows pilot to focus only on the most pertinent information.

PART II: NEW ACQUISITIONS OF IAF

Rafale

13. Extremely powerful, superbly agile this is a 5th generation combat aircraft from Dassault Aviation, France.Thanks to its versatility,its adaptability and its ability to meet all air mission requirements, the Rafale is the “poster child” transformational fighter which provides a way forward to air forces confronted to the requirement of doing “more with less” in an ever changing strategic environment. Rafale encompasses largest and most modern range of sensors and multiplies their efficiency with technological breakthrough. It will prove to be a game changer for Indian Air Force in the years to come. It fully complies with the requirement to carry widest range of roles with the smallest number of aircraft.

Chinhook

14. Indian Air Force formally inducted 4 US made Chinhook Heavy Lift Helicopters at Chandigarh. Chinhook is tandem rotor Heavy Lift Helicopter serving19 countries. Chinhook is expected to greatly enhance India’s capabilities across a range of Military Missions. Our country faces a variety of security challenges and we required a vertical airlift capability aircraft for a very diversified terrain. This aircraft was procured with the idea to enhance flexibility of Indian Air Force. This is an all-weather aircraft with state of the art NVG to permit operations in all conditions. This aircraft will redefine high lift capability in wide variety of terrain of India. It is a battle proven machine which has flown mission in war zones from Vietnam to Afghanistan & Iraq. Chinhook is highly maneuverable and especially suited for narrow valleys.

Boeing AH-64 Apache

15. Boeing AH-64 Apache is an American twin turbo shaft attack helicopter with tail-wheel type landing gear and a tandem cockpit with capacity of two pilots. IAF inducted eight AH-64E Apache aircraft on 03 Sep 2019. This aircraft is being used by both Indian Air force as well as by Indian Army. In IAF AH-64 Apache is loaded with a 30 mm M230 chain gun and has four hard points for missiles and rocket pods. It can carry upto 16 missiles at a time. It is also equipped with advanced night vision system and can achieve a maximum speed of 280km/h. This helicopter was used by American Forces in Iraq and Afganistan and played a key role for them by providing close air support, convoy escort and armed reconnaissance.

C295

16. A twin engine turbo prop transport aircraft of Spain origin. It is capable of carrying up to nine ton of payload or as many as 71 troops at a maximum cruise speed of 260 kts and with fuel consumption for a very long endurance of up to 13 hours aloft.

S-400

17. India and Russia signed an inter-governmental agreement for purchase of Russian made S-400 Triumf advanced Air Defence System. India is only the second country after China to receive these state of the art AD system. S-400 is capable of engaging stand off jammer Aircraft, Ballistic & Cruise missiles in a dense electronic warfare environment. It has an extremely accurate target acquisition and engagement radar system integrated to command force. It has operational range of 400 km

and an altitude of up to 185 km. This system is claimed by Russia to be a full proof Air Defence system and is highly respected by NATO.

CONCLUSION

18. The Indian Armed Forces have undergone significant modernization in recent years, with investments in areas such as futuristic soldier systems and missile defence systems.

19. From the raising of Air Force, it has seen various changes and is marching towards the modernization. Since it is the youngest force it has the responsibility of defending the Air territory of our country. It is the eye in the sky and has the nature which is devastating for the enemy of the country.

20. Many factors are involved in making an identification of an aircraft. Some of these are size, viewing angle, visibility, aircraft finish, visual characteristics, colour and external markings. India has a vast inventory of Aircraft. Cadets should be able to recognize and identify the various Fighter/ Transport aircraft and Helicopters.

ASSESSMENT EXERCISE

Multiple-Choice Questions (MCQs)

Q1. The youngest service is the.

(a) Indian Army
(b) Indian Navy
(c) Indian Air Force
(d) None of these

Q2. The Chiefs of the three services are officers wearing.

(a) one star
(b) two stars
(c) three stars
(d) four stars

Q3. Which of the following is not a branch of the IAF?

(a) Logistics
(b) Accounts
(c) Canteen
(d) Administration

Q4. The first aviator in India was.

(a) JRD Tata
(b) SV Sippe
(c) Lt Indra Lal Roy
(d) Prof Venkata Subba Setty

Q5. Which of the following is not the branch of IAF?

(a) Navigation
(b) Operation
(c) Administration
(d) Engineering

Q6. Command HQs in the army is commanded by an officer of the rank of

(a) Gen (b) Lt Gen
(c) Brigadier (d) Colonel

Q7. The Western Naval Command is at

(a) Mumbai (b) Kochi
(c) Delhi (d) Visakhapatnam

Q8. The supreme commander of Indian armed forces is

(a) Defence minister
(b) Vice president
(c) President
(d) Chief of Defence services

Q9. The Gallantry Award Other than in the Face of Enemy is

(a) Mahavir Chakra
(b) Paramveer Chakra
(c) Shaurya Chakra
(d) Veer Chakra

Q10. Our country is covered almost from three sides with water with a coastline of approximately over

(a) 4000 km (b) 5000 km
(c) 8000 km (d) 6000 km

Q11. The Ati Vishisht Seva Medal is an award given for

(a) Gallantry in the face of enemy
(b) Gallantry other than in the face of enemy
(c) Non gallantry Distinguished Service Award.

Q12. Target and decoy role is one of the roles of which of the following?

(a) Fighters (b) UAVs
(c) Transports (d) Helicopters

Q13. The Rafale is considered to be a multirole fighter of the

(a) 3rd generation
(b) 4th generation
(c) 4.5th generation
(d) 5th generation

Q14. The Indian Air Force came into being with the promulgation of the IAF bill on

(a) 04 Apr 1932
(b) 04 Sep 1932
(c) 09 Oct 1932
(d) 08 Oct 1932

Q15. The following is a Gp 'Y' Technical trade.

(a) Electrical Filter
(b) Automobile Technician
(c) Meteorological Assistant
(d) Weapon Fitter
(e)

Fill in the Blanks

Q1. The Indian Armed Forces are headed by the_____.

Q2. Highest gallantry award during peace time is _____.

Q3. Air Force Day is being celebrated on _____

Q4. The head of the Command HQs is called _____ or _____.

Q5. There are _____ Commands in the Army.

Q6. The Air Force is divided into _____ Commands each of which is commanded by an _____of the rank of _____.

Q7. The Hqs of Maintenance Command of the IAF is _____.

Q8. The highest gallantry award in India is the _____and the highest peace time award is the _____.

Q9. _____ aircraft is used for VVIP/VIP movements.

Q10. Dornier is the origin of _____ country.

Short Answers Type Questions

Q1. What are the main tasks of Indian armed forces?

Q2. Write the commands of Indian Air force.

Q3. Mention the Non gallantry/Distinguished service awards.

Q4. How many commands are there in Indian Navy? Write their names.

Q5. Name some fighter and Transport Aircrafts of IAF.

Long Answers Type Questions

Q1. Write down all the commands & their Headquarter of Indian Army.

Q2. Briefly describe the history of IAF?

Q3. What are the methods used to identify the aircraft? Describe.

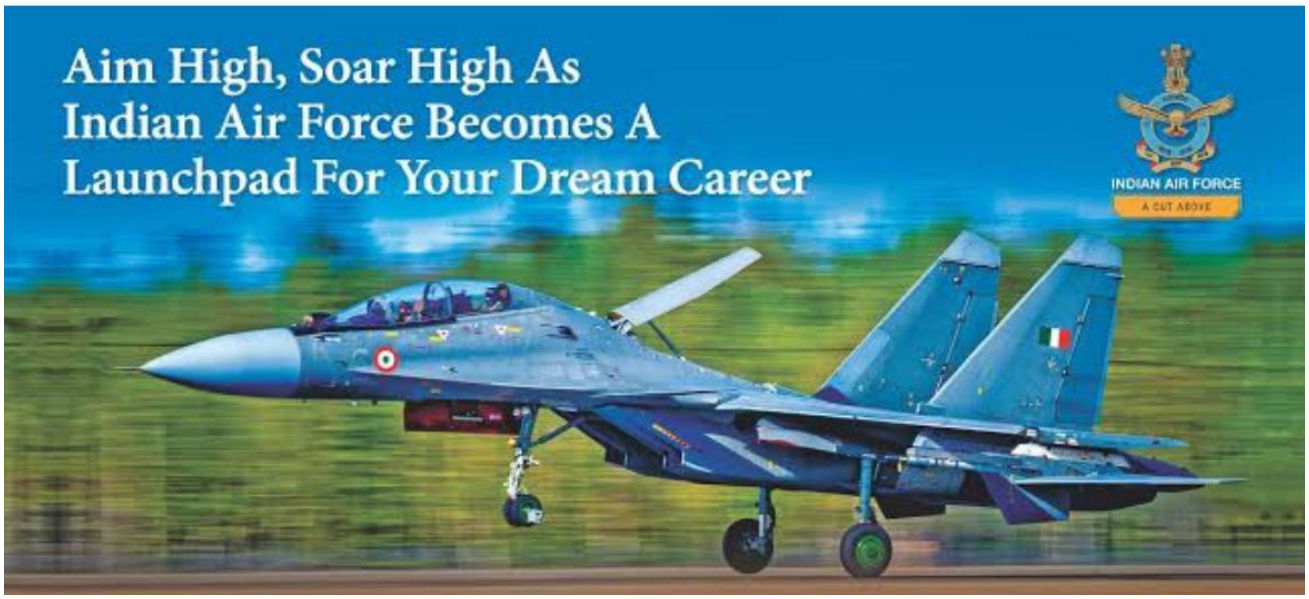
Q4. Write a short note on UAVs.

MODE OF ENTRY IN IAF AND CIVIL AVIATION

4

CHAPTER WISE INDEX: MOE (JD/JW)

CHAPTER MOE: MODES OF ENTRY IN IAF AND CIVIL AVIATION



TEACHING INSTRUCTIONS

Period	**:**	**02 (Two)**
Type	**:**	**Lecture**
Year	**:**	**2nd Year JD/JW**
Conducting Officer	**:**	**Permanent Instructor**

Training Aids: Class room, OHP, Board, Screen, Pointer, Marker, Book Flagged, or Lesson Plan, File and Aircraft Model

Time Plan

- **Part I : 25 Mins**
- **Part II : 25 Mins**
- **Part III : 20 Mins**
- **Conclusion and Practice : 10 Mins**

INTRODUCTION

PREVIEW	LEARNING OBJECTIVES
The lecture will be covered in following parts: ➢ **Part I : Officer Entry**. ➢ **Part II : Agniveer Vayu Entry**. ➢ **Part III: Civil Aviation**.	➢ **Basic understanding of entry as an officer in IAF**. ➢ **Entry as an air warrior**. ➢ **Entry into civil aviation**.

PART I: OFFICER ENTRY

1. **Officer Entry**. An officer is a member of an armed force or uniformed service who holds a position of authority. In order to lead and control, the ability to motivate yourself, inspire others and make tough decisions efficiently is very crucial. Lessons in team work, developing communication skills and confidence, honing strategic and dynamic thinking are grilled into an Officer during their training. The IAF teaches all, not only making men and women of young boys and girls but making them leaders in life. An officer's strength of character and strong moral compass make him/her stand out from the crowd at all times. The various modes of entry into the IAF as an officer are as follows:-

Branch/ Type of Entry	Educational Qualification	Age Limit	Advertise - ment Schedule
Flying Branch			
National Defence Academy (NDA) For Men only	10+2 With Physics, Chemistry & Math	16 1/2 – 19 1/2	Mar/Oct
Combined Defence Service (CDSE) For Men only	Any Grad. With Physics & Math10+2 or BE	19-25	Apr/Sep
Airforce Common Entrance Test (AFCAT) for both men and women	Any Grad. With 60% marks for Flying Branch & four year Grad. Course with 50% marks for Tech and Non-Tech Branches.	20-24 (Flying) 20-26 (Tech & Non-tech branch)	Jun/Dec

Branch/ Type of Entry	Educational Qualification	Age Limit	Advertise - ment Schedule
NCC Special Entry	Any Grad. with Physics & Math at10+2 or BE & NCC Air Wing Sr Div.“C’ Certificate	19-25	Jun/Dec
Short Service Commission	Any Grad. With Physics Math sat 10+2 or BE	20-24	Mar/Sep
Technical Branch: PC For Men/ SCC For Both			
Aeronautical Engineering (Electronics) Aeronautical Engineering (Mechanical)	First class degree in Engineering or GATE score of 70% & above in Electronics /Mechanical / Allied subjects as per advertisement	18-28	Feb/Aug
Ground Duty Branch: PC For Men/ SCC For Both			
Administration	First Class	20-23	Mar/Sep
	Graduate or PG in		
Logistics	Subjects as per	20-25	
Accounts	Advertisement		
Education Meteorology	PG in subjects as per advertisement	20-25	Mar/Sep

PART II: AGNIVEER VAYU ENTRY

2. Followings are the essential requirements for entry in the IAF to become Airman:-

Group	Age on Enrolment Date	Educational Qualification
Group ‘X’ (Technical) Trades	17-21 Years	➢ Passed Intermediate / 10+12 / equivalent examination with mathematics, physics and English with a minimum of 50% marks in aggregate. ➢ Three years Diploma course in engineering (Mechanical/ Instrumentation Technology/ Automobile / computer science/ Instrumentation Technology/ information technology) with at least 50% marks in overall aggregate from a government recognized polytechnic institute.

Group	Age on Enrolment Date	Educational Qualification
Group 'X' (Education Instructor) Trade	20-25 Years	➢ Graduate in Arts, Commerce or Science with B.Ed degree/ two years teaching experience in a Government recognized School/College. Candidate should have scored a minimum of 50% marks in aggregate in Graduation as well as B.Ed.
	20-28 Years	➢ Passed MA English/ MSc in Mathematics, Physics, Computer Science/ MCA with Bed degree/2 Years teaching experience in a Government recognized School/ College.
Group 'Y' Trades (Except Med As stand Musician)	17-21 Years	➢ Passed Intermediate/ 10+2 equivalent with Science, Arts or Commerce subjects or equivalent vocational course with minimum 50% marks in aggregate. Vocational courses should be recognized by Association of Indian Universities.
Group 'Y' (Med Asst) Trade	17-21 Years	➢ Passed Intermediate/ 10+2 /Intermediate/ equivalent exam with Physics, Chemistry Biology and English with a minimum of 50% marks in aggregate.
Group 'Z' (Musician Trade)	17-25 Years	➢ Passed Matriculation / 10th class or equivalent with minimum pass marks from any Government recognized School/ Boards and should be proficient in playing at least one of the following musical instrument Trumpet/ Bass/ Violin/ Saxophone/ Clarinet/ Euphonium/ Jazz-Drum /Piccolo/Bass Trombone/ Key Board/ Guitar/ Sarod/ Viola/Cello/ Contra Bass (String Bass).

PART III: CIVIL AVIATION

3. NCC cadets have several opportunities in civil aviation, especially in roles that emphasize leadership, discipline, and teamwork. Here are some key avenues:-

(a) **Airline Careers**. Cadets can pursue careers with commercial airlines which includes roles such as cabin crew, ground staff, and in operational management.

(b) **Airport Management**. Opportunities in airport operations and management are also available, where cadets can work in various departments such as passenger services, logistics, and security.

(c) **Aviation Safety and Security**. With training in discipline and protocol, NCC cadets can enter roles focused on safety regulations, compliance, and airport security.

(d) **Air Traffic Control**. Although additional training is required, cadets can consider careers as air traffic controllers, managing aircraft movements and ensuring safe operations.

(e) **Flight Operations**. Cadets interested in flying can pursue pilot training programs, often leading to careers as commercial pilots.

(f) **Aviation Engineering**. Those with a technical inclination can explore roles in aircraft maintenance and engineering, requiring relevant educational qualifications.

ASSESSMENT EXERCISE

Multiple-Choice Questions (MCQs)

Q1. The youngest service is the

(a) Indian Army
(b) Indian Navy
(c) Indian Air Force
(d) None of these.

Q2. The Chiefs of the three services are officers wearing.

(a) one star
(b) two stars
(c) three stars
(d) four stars

Q3. Which of the following is not a branch of the IAF?

(a) Logistics
(b) Accounts
(c) Canteen
(d) Administration

Q4. The first aviator in India was.

(a) JRD Tata
(b) SV Sippe
(c) Lt Indra Lal Roy
(d) Prof Venkata Subba Setty

Q5. Which of the following is not the branch of IAF?

(a) Navigation
(b) Operation
(c) Administration
(d) Engineering

Q6. Command HQs in the army is commanded by an officer of the rank of

(a) Gen
(b) Lt Gen
(c) Brigadier
(d) Colonel

Q7. The Western Naval Command is at

(a) Mumbai
(b) Kochi
(c) Delhi
(d) Visakhapatnam

Q8. The supreme commander of Indian armed forces is

(a) Defence minister
(b) Vice president
(c) President
(d) Chief of Defence services

Q9. The Gallantry Award Other than in the Face of Enemy is

(a) Mahavir Chakra
(b) Paramveer Chakra
(c) Shaurya Chakra
(d) Veer Chakra

Q10. Our country is covered almost from three sides with water with a coastline of approximately over

(a) 4000 km
(b) 5000 km
(c) 8000 km
(d) 6000 km

Q11. The Ati Vishisht Seva Medal is an award given for

(a) Gallantry in the face of enemy
(b) Gallantry other than in the face of enemy
(c) Non gallantry
(d) Distinguished Service Award.

Q12. Target and decoy role is one of the roles of which of the following?

(a) Fighters
(b) UAVs
(c) Transports
(d) Helicopters

Q13. The Rafale is considered to be a multirole fighter of the

(a) 3rd generation
(b) 4th generation
(c) 4.5th generation
(d) 5th generation

Q14. The Indian Air Force came into being with the promulgation of the IAF bill on

(a) 04 Apr 1932
(b) 04 Sep 1932
(c) 09 Oct 1932
(d) 08 Oct 1932

Q15. The following is a Gp 'Y' Technical trade.

(a) Electrical Fitter
(b) Automobile Technician
(c) Meteorological Assistant
(d) Weapon Fitter

Fill in the Blanks

Q1. The Indian Armed Forces are headed by the_____.

Q2. Highest gallantry award during peace time is _____.

Q3. Air Force Day is being celebrated on _____

Q4. The head of the Command HQs is called _____ or _____.

Q5. There are _____ Commands in the Army.

Q6. The Air Force is divided into _____ Commands each of which is commanded by an _____of the rank of _____.

Q7. The Hqs of Maintenance Command of the IAF is _____.

Q8. The highest gallantry award in India is the _____and the highest peace time award is the _____.

Q9. _____ aircraft is used for VVIP/VIP movements.

Q10. Dornier is the origin of _____ country.

Short Answers

Q1. What are the main tasks of Indian armed forces?

Q2. Write the commands of Indian Air force.

Q3. Mention the Non gallantry/Distinguished service awards.

Q4. How many commands are there in Indian Navy? Write their names.

Q5. Name some fighter and Transport Aircrafts of IAF.

Long Answers

Q1. Write down all the commands & their Headquarter of Indian Army.

Q2. Briefly describe the history of IAF?

Q3. What are the methods used to identify the aircrafts? Describe.

Q4. Write a short note on UAV.

ELEMENTARY MECHANICS

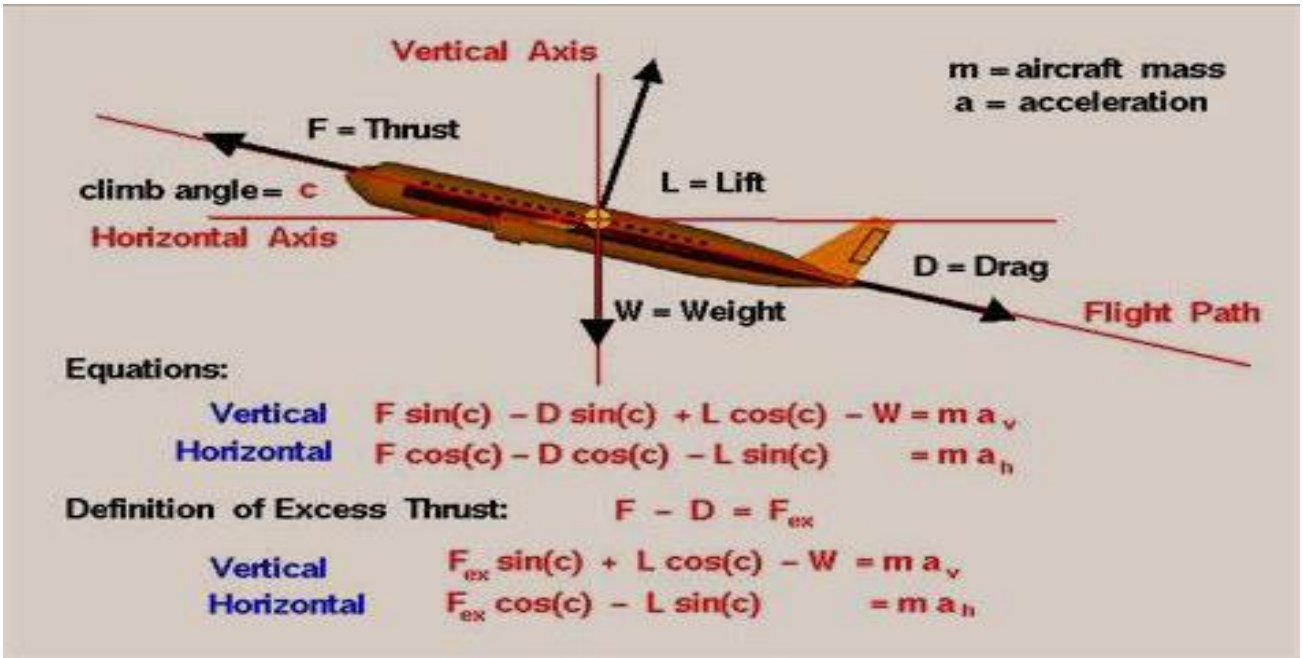
5

CHAPTER WISE INDEX: EM (JD/JW)

CHAPTER EM: ELEMENTARY MECHANICS

"A ship is always safe at the shore, but that is not what it is built for"

-Albert Einstein



TEACHING INSTRUCTIONS

Period	**:**	**02 (Two)**
Type	**:**	**Lecture**
Year	**:**	**1st Year JD/JW**
Conducting Officer	**:**	**Permanent Instructor**

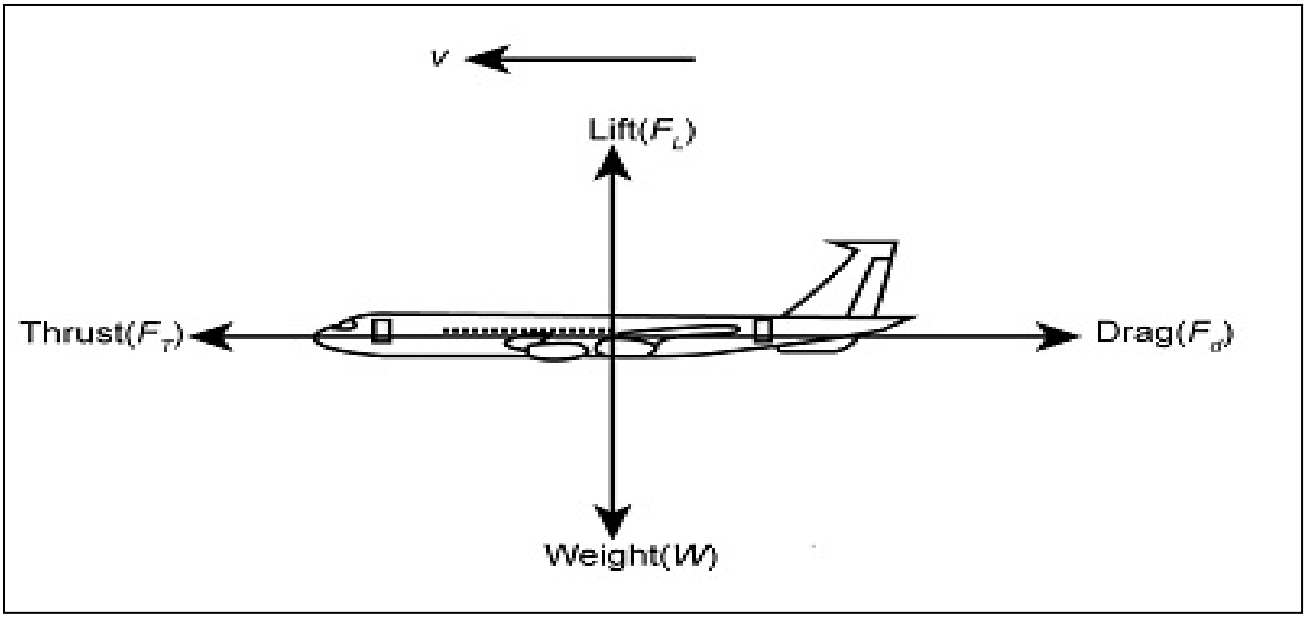
Training Aids : Class room, OHP, Board, Screen, Pointer, Marker, Book Flagged, or Lesson Plan, File and Aircraft Model.

Time Plan

- **Introduction : 05 Mins**
- **Part I : 30 Mins**
- **Part II : 30 Mins**
- **Conclusion and Practice : 15 Mins**

INTRODUCTION

1. It is essential to have a basic knowledge of elementary mechanics to understand the various Principles of Flight, because both the aircraft and the atmosphere in which it flies are Matters and all matter are subjected to the laws of mechanics. Terms like Mass, Density, Motion, Speed, Velocity, Acceleration, Newton's First Law of Motion, Momentum, Force, Pressure, Newton's Third Law of Motion, Weight, Work, Power, Energy, Law of conservation of energy, Moment of a Force, Couple, and Equilibrium.



PREVIEW	LEARNING OBJECTIVES
The class will be conducted in the following parts: ➢ **Part I: Basic definitions** ➢ **Part II: Law of Motion**	➢ **Key definitions related to aviation** ➢ **Laws of motion and their correlation in aviation**

PART I: BASIC DEFINITIONS

2. **Speed**. Speed is the rate of change of position.

3. **Velocity**. Velocity is speed in a particular direction. Velocity is a vector quantity having both magnitude and direction.

4. **Mass**. Unit - Kilogram (kg) - 'The quantity of matter in a body.' The mass of a body is a measure of how difficult it is to start or stop, ("a body", in this context, means a substance. Any substance a gas, a liquid or a solid).

5. **Weight**. The earth exerts a certain force towards its centre on all objects on its surface. This force is called Weight of the body and is equal to the mass of the body multiplied by the acceleration due to gravity 'g'. Unit - Newton (N) - 'The force due to gravity'. (F = m x g).

6. **Displacement**. Displacement is defined as the change in position of an object. It is a vector quantity and has a direction and magnitude. It represented as an arrow that points from the starting position to the final position.

7. **Direction**. Direction is the path or orientation of an object's motion, or the location of something relative to something else.

8. **Acceleration**. Acceleration is the rate of change of velocity. The change may be in magnitude or direction or in both. Thus a body moving along a circular path at constant speed has acceleration .You know that F= ma, so

$$\textbf{Acceleration} = \frac{\textbf{Force}}{\textbf{Mass}}$$

9. **Density**. It is the mass per unit volume.

10. **Work**. Unit - Joule (J) - A force is said to do work on a body when it moves the body in the direction in which the force is acting. The amount of work done on a body is the product of the force applied to the body and the distance moved by that force in the direction in which it is acting. If a force is exerted and no movement takes place, no work has been done.

e.g. (a) **Work = Force x Distance (through which the force is applied)**

11. **Power**. Unit - Watt (W) - Power is simply the rate of doing work, (the time taken to do work)

e.g. (a) $\textbf{Power (W)} = \frac{\textbf{Force (N) x Distance (m)}}{\textbf{Time (s)}}$

12. **Energy**. Unit - Joule (J) - Mass has energy if it has the ability to do work. The amount of energy a body possesses is measured by the amount of work it can do. The unit of energy will therefore be the same as those of work, joules.

13. **Momentum**. Unit - Mass x Velocity (kg-m/s) - 'The quantity of motion possessed by a body'. The tendency of a body to continue in motion after being placed in motion.

14. **Basic of physics and its importance in aviation**. Few basic terms of physics and their importance is described below:

(a) **Force**. Which causes or tends to cause a change in motion of a body. Unit - Newton (N) -'A push or a pull'.

$$F = ma$$

(b) **Pressure**. Pressure is force per unit area.

(c) **Law of Conservation of Energy**. The sum total of all energy in the universe remains constant.

(d) **Momentum of a Force**. Moment of a force is the turning effect of the force about a point and is measured as the product of the force and the perpendicular distance between the point and the line of action o the force.

(e) **Couple**. A couple consists of two equal and opposite and parallel forces not acting through the same point. The moment of a couple is equal to the force multiplied by the perpendicular distance between the two lines of action.

(f) **Equilibrium**. A body is said to be in equilibrium when

(i) Algebraic sum of all the forces acting on the body is zero.

(ii) Clockwise moment is equal to the anticlockwise moment about any point.

(g) **Centre of Gravity (CG)**. The point through which the weight of an aircraft acts.

(i) An aircraft in flight is said to rotate around its CG.

(ii) The CG of an aircraft must remain within certain forward and aft limits, for reasons of both stability and control.

(h) **Kinetic Energy**. Unit - Joule (J) - 'The energy possessed by mass because of its motion'. 'A mass that is moving can do work in coming to rest'.

$$KE = {}^{1}/_{2}\, m\, V^{2} \text{ joules}$$

PART II: LAWS OF MOTION

DID YOU KNOW?

- Laws of motions are used to design and build all types of machines including the ones used in vehicles and planes.

15. **Inertia**. A property of matter by which it remains at the state of rest or uniform motion in the same straight line unless acted upon by some external force.

16. **Newton's First Law of Motion**. A body will continue to be in state of rest or of uniform motion in a straight line unless acted upon by an external force. This property of all bodies is called inertia and a body in such a state is said to be in Equilibrium. This Law is also known as **Law of Inertia**.

17. **Newton's Second Law of Motion**. The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction of the application of the said force.

18. **Newton's Third Law of Motion**. To every action, there is an equal and opposite reaction.

19. **Practical applications of laws of motion**. Newton's laws of motion can be observed in everyday life such as swimming, seat belts, car accidents, acceleration, and many more.

20. **Correlation of laws of Motion in aviation**. All the three laws of motion are applicable to aviation and it explains how airplanes fly and is described as follows:

(a) **Newton's First Law of Motion**. An airplane maintains a steady flight at cruising altitude and speed until any external forces of surrounding does not make it to change its altitude or speed.

(b) **Newton's Second Law of Motion**. An airplane gets affected by surrounding winds and follows its direction. By various control surfaces of airplane it is being maneuvered and thus lift overcomes gravity to move.

(c) **Newton's Third Law of Motion**. To lift the airplane, its wing has been designed to deflect air downward, which creates an upward force called lift and thus action-reaction law being applied.

DID YOU KNOW?

- Physics is considered a basic science because it involves the study of the interaction of matter and energy. It deals with explanations of natural phenomena such as the motion of objects in the universe or the behavior of subatomic particles.

CONCLUSION

21. A flying object is a mechanical body in a three dimensional space. The knowledge of above definitions is necessary for effective understanding of Principle of Flight.

22. Study of correlation of Laws of motion in aviation results in better understating of various aspects of flying aircraft.

23. Basic definition of various terms i.e. Mass, Density, Motion, Speed, Velocity, Acceleration, Newton's First Law of Motion, Momentum, Force, Pressure, Newton's Third Law of Motion, Weight, Work, Power, Energy, Law of conservation of energy, Moment of a Force, Couple, and Equilibrium is to be understood by cadets.

24. Laws of motion, their application and correlation in aviation has been explained briefly and same needs to be understood by cadets.

ASSESSMENT EXERCISE

Multiple-Choice Questions (MCQs)

Q1. Which of the following is the definition of density?

(a) Mass per unit volume
(b) Force per unit area
(c) Mass multiplied by velocity
(d) Rate of doing work

Q2. According to Newton's First Law of Motion, a body will remain in its state of rest or uniform motion unless

(a) It gains speed
(b) It is acted upon by an external force
(c) It has zero velocity
(d) It reaches its equilibrium point

Q3. What is the unit of force?

(a) Kilogram (kg)
(b) Newton (N)
(c) Joule (J)
(d) Watt (W)

Q4. What is the formula for work done on a body?

(a) Work = Mass × Velocity
(b) Work = Force × Distance
(c) Work = Force ÷ Time
(d) Work = Mass × Acceleration

Q5. Velocity is speed in …….. direction.

(a) Each
(b) All
(c) Particular
(d) Both

Q6. Weight is the force of gravity acting on an object and this force pulls object towards…….

(a) Sky
(b) Earth
(c) Opposite direction
(d) Nowhere

Q7. What is the unit of Power?

(a) Watt (W)
(b) Newton (N)
(c) Joule (J)
(d) Kg

Q8. Acceleration is equal to ……

(a) Force/ Weight (b) Force/ Mass

(c) Force/ Time (d) Force/ Distance

Q9. Unit of kinetic energy is…..

(a) Watt (W) (b) Newton (N)

(c) Joule (J) (d) Kg

Q10. Newton's first law of motion also known as ……

(a) Inertia (b) Action-reaction

(c) Momentum (d) None

Q11. Newton's second law of motion also known as ……

(a) Inertia (b) Action-reaction

(c) Quantitative law of motion (d) None

Q12. Newton's third law of motion also known as ……

(a) Inertia (b) Action-reaction

(c) Quantitative law of motion (d) None

Q13. Law of conservation of energy is total sum of all energy in the universe remains……..

(a) Constant (b) Changing

(c) Both (a) and (b) are correct (d) None

Q14. Newton's second law of motion also known as ……

(a) Inertia (b) Action-reaction

(c) Quantitative law of motion (d) None

Q15. An aircraft in flight is said to rotate around it's ……

(a) Weight (b) Centre of Gravity (CG)

(c) Both (a) and (b) are correct (d) None

Short Answers Type Questions

Q1. What is the difference between speed and velocity?

Q2. Explain Newton's Third Law of Motion with an example.

Q3. Define kinetic energy and provide its formula.

Q4. Explain practical applications of laws of motion.

Q5. Establish correlation of laws of motion in aviation.

Long Answers Type Questions

Q6. What do you mean by Inertia and how it relates to Newton's first law of motion?

Q7. What is equilibrium and how force play a vital role for it?

Q8. Define work and also provide its formula with unit.

Q9. Define power and also provide its formula with unit.

Q10. Define acceleration and also provide its formula with unit.

BASICS OF AEROFOIL

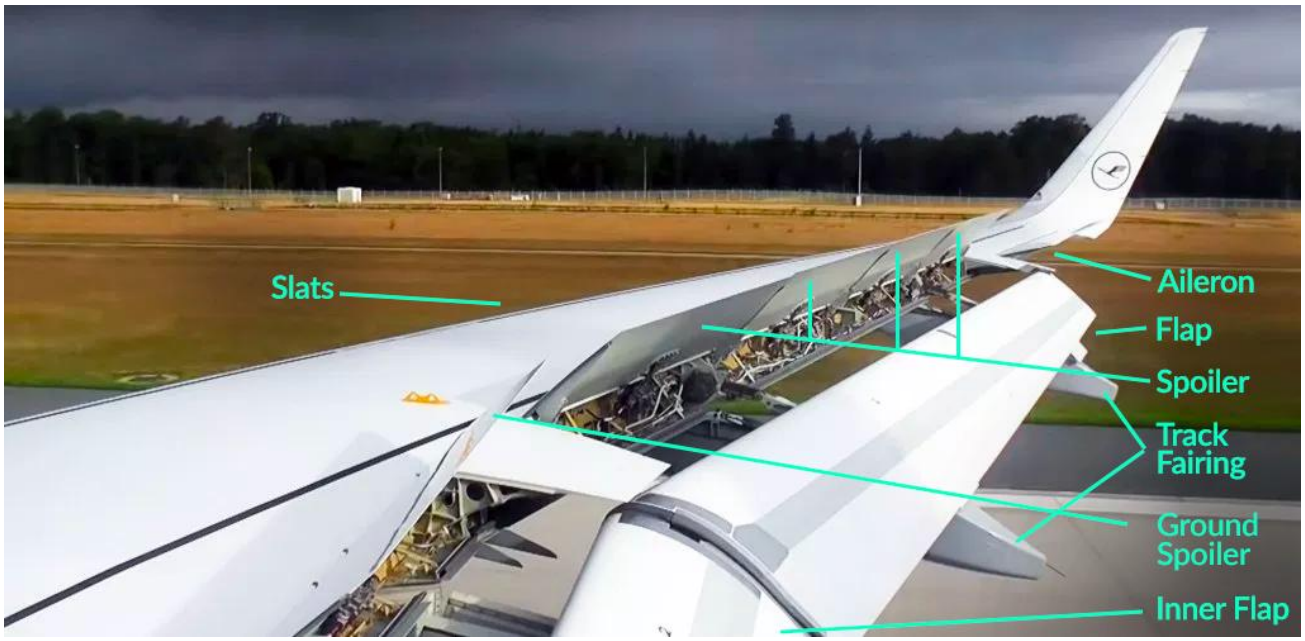
6

CHAPTER WISE INDEX: BOA (JD/JW)

CHAPTER BOA: BASIC OF AEROFOIL

"The Wright Brothers created the single greatest cultural force since the invention of writing. The airplane became the first World Wide Web, bringing people, languages, ideas, and values together."

– Bill Gates



TEACHING INSTRUCTIONS

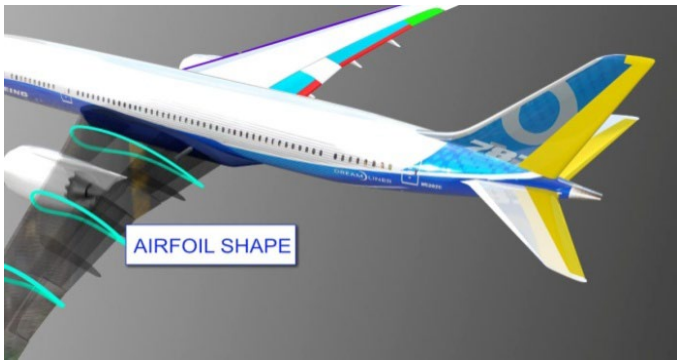
Period	**:**	**03 (Three)**
Type	**:**	**Lecture**
Year	**:**	**1st Year JD/JW**
Conducting Officer	**:**	**Permanent Instructor**

Training Aids: Class room, OHP, Board, Screen, Pointer, Marker, Book Flagged, or Lesson Plan, File and Aircraft Model

Time Plan

➢ **Introduction**	**:**	**05 Mins**
➢ **Part I**	**:**	**40 Mins**
➢ **Part II**	**:**	**30 Mins**
➢ **Part III**	**:**	**30 Mins**
➢ **Conclusion and Practice**	**:**	**15 Mins**

INTRODUCTION



1. Aerofoil is the shape of a wing or blade (of a propeller, rotor or turbine) or sail as seen in cross-section. An aerofoil-shaped body moved through a fluid produces an aerodynamic force. The component of this force perpendicular to the direction of motion is called lift. The component parallel to the direction of motion is called drag. Subsonic flight aerofoils have a characteristic shape with a rounded leading edge, followed by a sharp trailing edge, often with asymmetric camber. Foils of similar function designed with water as the working fluid are called hydrofoils.

PREVIEW	LEARNING OBJECTIVES
The class will be conducted in the following parts: ➢ **Part I: Aerofoil**. ➢ **Part II: Types of Aerofoil**. ➢ **Part III: Introduction to Lift & Drag**.	➢ **Aerofoils and its type with usage** ➢ **Reason behind occurrence of lift & drag in aviation**

PART I: AEROFOIL

2. A fixed-wing aircraft's wings, horizontal, and vertical stabilizers are built with aerofoil-shaped cross sections, as are helicopter rotor blades. Aerofoils are also found in propellers, fans, compressors and turbines. Any object with an angle of attack in a moving fluid, such as a flat plate will generate an aerodynamic force (called lift) perpendicular to the flow. Aerofoils are more efficient lifting shapes, able to generate more lift (up to a point), and to generate lift with less drag.

3. An aerofoil with a positive camber produces lift at zero angle of attack. With increased angle of attack, lift increases in a roughly linear relation, called the slope of the lift curve. At about 18 degrees this aerofoil stalls, and lift falls off quickly beyond that. The drop in lift can be explained by the action of the upper-surface boundary layer, which separates and greatly thickens over the upper surface at and past the stall angle. The thickened boundary layer's displacement thickness changes the aerofoil's effective shape, in particular it reduces its effective camber, which modifies the overall flow field so as to reduce the circulation and the lift. The thicker boundary layer also causes a large increase in pressure drag, so that the overall drag increases sharply near and past the stall point.

4. Movable high-lift devices, flaps and sometimes slats, are fitted to aerofoils on almost every aircraft. A trailing edge flap acts similarly to an aileron; however, it, as opposed to an aileron, can be retracted partially into the wing if not used.

DID YOU KNOW

- Daniel Bernoulli was an 18th-century Swiss mathematician and physicist known for his contribution to fluid dynamics, which explains how a fluid's pressure and velocity are related. This principle is vital for understanding how air moves around airplane wings. It is crucial for understanding the principle of flight.

PART II: TYPES OF AEROFOIL

5. Aerofoil design is a major facet of aerodynamics. Various aerofoils serve different flight regimes. Asymmetric aerofoils can generate lift at zero angle of attack, while a symmetric aerofoil may better suit frequent inverted flight as in an aerobatic airplane. In the region of the ailerons and near a wingtip a symmetric aerofoil can be used to increase the range of angles of attack to avoid spin-stall. Thus a large range of angles can be used without boundary layer separation. Subsonic aerofoils have a round leading edge, which is naturally insensitive to the angle of attack. The cross section is not strictly circular, however: the radius of curvature is increased before the wing achieves maximum thickness to minimize the chance of boundary layer separation. This elongates the wing and moves the point of maximum thickness back from the leading edge.

6. **High Lift**. Aerofoils are designed to produce high lift-to-drag ratios, which are essential for high speed cruises. They are often equipped with flap systems to increase and reduce landing speeds. Some factors that contribute to high lift are Angle of attack, Thickness, Area, Leading edge and Dorsal fin.

7. **Medium Lift**. Lift on an aerofoil is the result of a pressure difference between the top and bottom surfaces of the aerofoil and is affected by its shape, angle of attack and fluid flow.

8. **High Speed**. Aerofoils can help aircraft fly at high speeds by displacing air, using supercritical aerofoils and designing supersonic aerofoils.

INTERESTING FACTS

- Sir, George Cayley invented the aerofoil.
- Aerofoil are also used in the design of rotor blades and wind turbines.
- Supersonic aerofoils are much more angular in shape and can have a very sharp leading edge, which is very sensitive to angle of attack. A supercritical aerofoil has its maximum thickness close to the leading edge to have a lot of length to slowly shock the supersonic flow back to subsonic speeds. Generally such transonic aerofoils and also the supersonic aerofoils have a low camber to reduce drag divergence. Modern aircraft wings may have different aerofoil sections along the wing span, each one optimized for the conditions in each section of the wing.

PART III: INTRODUCTION TO LIFT & DRAG

9. **Definition**. Lift and Drag is defined as follows:

(a) **Lift**. Lift is a positive force caused by the difference in air pressure under and above a wing. The higher air pressure beneath a wing creates lift, and is affected by the shape of the wing. Changing a wing's angle of attack affects the speed of the air flowing over the wing and the amount of lift that the wing creates.

(b) **Drag**. Drag is the resistance of the air to anything moving through it. Different wing shapes greatly affect drag. Air divides smoothly around a wing's rounded leading edge, and flows neatly off its tapered trailing edge. This is called streamlining.

10. **Aerodynamics affecting Lift & Drag**. When an object generates lift, it also creates induced drag. At low speeds, an aircraft needs to generate lift with a higher angle of attack, which results in more induced drag. Aerodynamic lift and drag are forces that affect an object's movement through the air. Airplanes use flaps to change the curvature of their wings and increase lift. Flaps also increase drag, which helps slow plane down. Ailerons are flaps near the back of each wing that control lift and drag to make plane roll.

DID YOU KNOW?

- A thin layer of contamination on aircraft surface can increase drag, which can make the aircraft less efficient and increase fuel consumption. Ice is particularly dangerous because it can change the wing's shape and increase the plane's weight.

CONCLUSION

11. An aerofoil-shaped body moved through a fluid produces an aerodynamic force. The component of this force perpendicular to the direction of motion is called lift.

12. There are different types of aerofoil such as symmetric, asymmetric, supersonic, and supercritical.

13. Aerodynamic lift and drag are forces that affect an object's movement through the air.

14. Aerofoils create lift by forcing air to travel further over the top of the wing than the bottom, which creates lower air pressure and an upward force on the wing.

15. Aerofoils also create drag, which acts in the same direction as the airstream.

16. At low speeds, an aircraft needs to generate lift with a higher angle of attack, which results in more induced drag.

17. Flaps also increase drag, which helps slow plane down. Ailerons are flaps near the back of each wing that control lift and drag to make plane roll.

ASSESSMENT EXERCISE

Multiple-Choice Questions (MCQs)

Q1. Who has invented the aerofoil?

(a) Sir George Cayley (b) Isaac Newton
(c) Albert Einstein (d) Thomas Addison

Q2. Following are the types of aerofoil.

(a) Symmetric (b) Asymmetric
(c) None of the above (d) Both (a) and (b) are correct

Q3. A thin layer of contamination on aircraft surface can increase drag.

(a) True (b) False

Q4. Aerofoils create lift and can also create drag as well?

(a) True (b) False

Q5. At low speeds, an aircraft needs to generate ……. with a …… angle of attack, which results in more induced drag?

(a) Lift, Higher (b) Drag, Lower
(c) Both (a) and (b) is correct (d) None of the above

Q6. Flaps also increase ……, which helps slow plane down?

(a) Drag (b) Lift
(c) None of the above (d) (a) & (b) both are correct

Q7. Ailerons are flaps near the back of each wing that control …… and …….. to make plane roll?

(a) Lift, Drag (b) Weight, Thrust
(c) None of the above (d) (a) & (b) both are correct

Q8. Aerofoils can help aircraft fly at high speeds by displacing air, using supercritical aerofoils and designing supersonic aerofoils?

(a) True (b) False

Q9 ……. aerofoils are much more angular in shape and can have a very sharp leading edge, which is very sensitive to angle of attack?

(a) Supersonic (b) Subsonic
(c) Supercritical (d) Transonic

Q10. When an object generates lift, it also creates ……

(a) Induced drag (b) Thrust
(c) High lift (d) None

Q11. Aerofoils also creates drag and it acts on …… direction as the airstream.

(a) Same (b) Opposite
(c) Upward (d) Downward

Q12. An aerofoil-shaped body moved through a fluid produces an aerodynamic force. The component of this force..... to the direction of motion is called lift.

(a) Perpendicular (b) Opposite
(c) Upward (d) Downward

Q13. Changing a wing's …… affects the speed of the air flowing over the wing and the amount of lift that the wing creates.

(a) Color (b) Angle of attack
(c) None of the above (d) (a) & (b) both are correct

Q14. Airplanes use flaps to change the curvature of their wings and increase lift.

(a) True (b) False

Q15. Flaps also increase drag, which helps slow plane down.

(a) True (b) False

Short Answers Type Questions

Q1. What is difference between chord line and camber line?

Q2. What do you understand by symmetrical aerofoil?

Q3. What is the purpose of high speed aerofoil?

Q4. What is mean camber line?

Q5. Helicopter blades are aerofoil explain how?

Long Answer Type Questions

Q1. What is an aerofoil and its application in aviation?

Q2. Types of aerofoil and explain them briefly?

Q3. Define lift & drag and their role in aviation?

Q4. Briefly explain aerodynamics affecting lift & drag?

Q5. How aerofoil provides high lift, medium lift, and high speed?

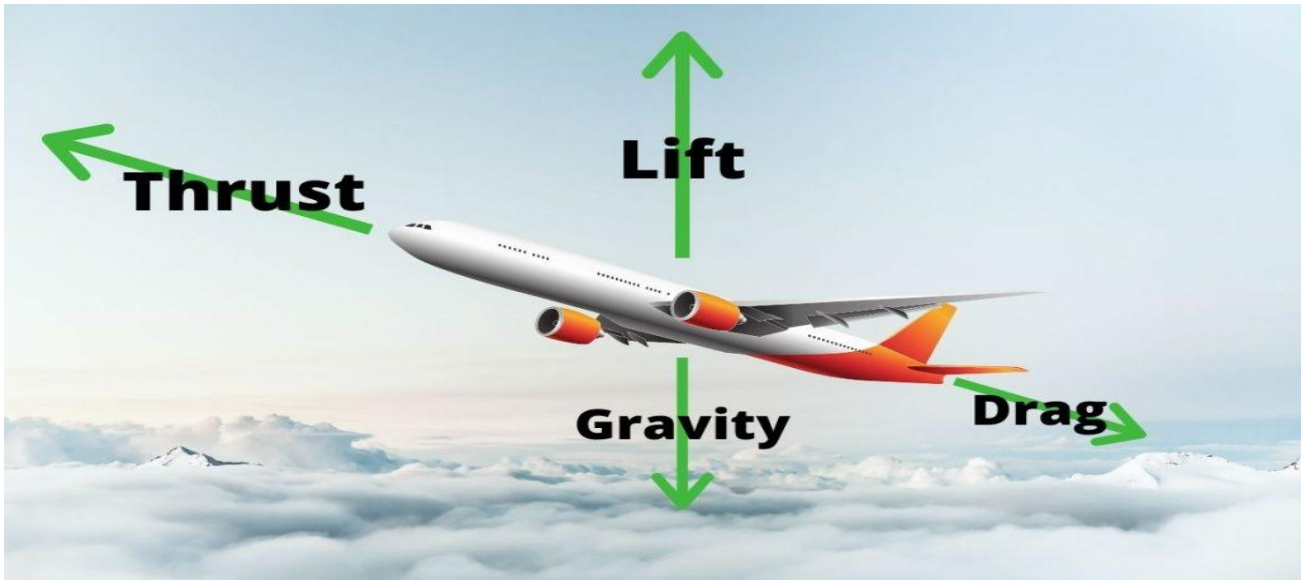
FORCES ON AIRCRAFT

7

CHAPTER WISE INDEX: FOA (JD/JW)

CHAPTER FOA: FORCES ON AIRCRAFT

"It is possible to fly without motors, but not without knowledge and skill"
- Wilbur Wright



TEACHING INSTRUCTIONS

Period: 04 (Four)

Type	**:**	**Lecture**
Year	**:**	**1st Year JD/JW**
Conducting Officer	**:**	**Permanent Instructor**

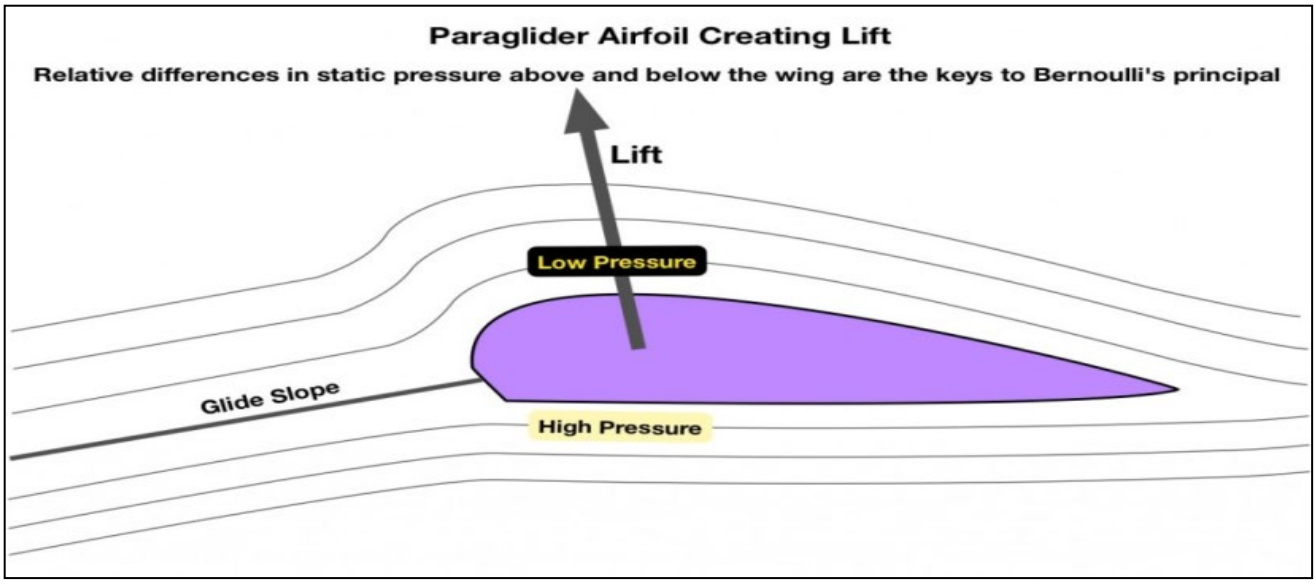
Training Aids: Class room, OHP, Board, Screen, Pointer, Marker, Book Flagged, or Lesson Plan, File and Aircraft Model

Time Plan

- **Introduction : 05 Mins**
- **Part I : 15 Mins**
- **Part II : 30 Mins**
- **Part III : 15 Mins**
- **Conclusion and Practice : 15 Mins**
- **Explain in simple terms forces on the aircraft & high lift devices practically on the microlite : 40 Mins**

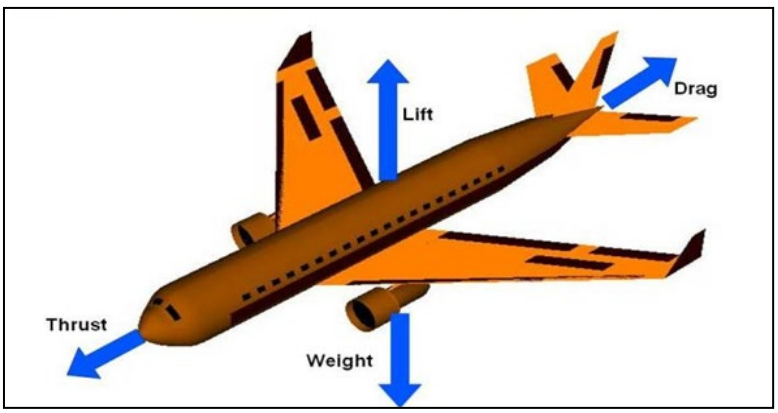
INTRODUCTION

1. An Aircraft is considered to be in straight and level flight when it is flying at a constant altitude and speed, maintaining lateral level and direction. Force acting on aircraft at any given movement is Lift, Drag, Thrust and Weight.



PREVIEW	LEARNING OBJECTIVES
The class will be conducted on following parts: ➢ **Part I: Forces acting on aircraft.** ➢ **Part II: How Lift & Drag Occurs.** ➢ **Part III: High Lift Devices.** ➢ **Part IV: Stall.**	➢ **Various forces acting on aircraft.** ➢ **High lift devices i.e. flaps & slats.** ➢ **Stall and its effect.**

PART I: FORCES ACTING ON AIRCRAFT



Four Forces on an Airplane

2. **Lift**. is a positive force caused by the difference in air pressure under and above a wing. The higher air pressure beneath a wing creates lift, and is affected by the shape of the wing. Changing a wing's angle of attack affects the speed of the air flowing over the wing and the amount of lift that the wing creates.

3. **Weight**. is the force that causes objects to fall downwards. In flight, the force of weight is countered by the forces of lift and thrust.

4. **Thrust**. is the force that propels an object forward. An engine spinning a propeller or a jet engine expelling hot air out the tailpipe are examples of thrust. In bats, thrust is created by muscles making the wings flap.

5. **Drag**. is the resistance of the air to anything moving through it. Different wing shapes greatly affect drag. Air divides smoothly around a wing's rounded leading edge, and flows neatly off its tapered trailing edge, this is called streamlining.

DID YOU KNOW?

- Bernoulli's principle explains how an airplane can stay in the air and it's fascinating to think that the simple act of air moving over the curved surface of a wing can create enough lift to keep an airplane airborne.

PART II : UNDERSTANDING LIFT

6. **Bernoulli's Principle**. Bernoulli's principle is based on the principle of the conservation of energy. It states that the total sum of the pressure energy, kinetic energy and potential energy of the fluid flow is constant. It also implies that for an in viscid & incompressible flow, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. ***We can therefore safely conclude that in a steady, incompressible flow, an increase in the fluid's velocity leads to a decrease in its static pressure***.

Over the wing.

(a) **Faster airflow above → lower pressure**

(b) **Slower airflow below → higher pressure**

(c) The **pressure differential** results in a **net upward force—Lift**.

7. **Venturi Effect**. A short piece of narrow tube between wider sections is called a venturi. In the narrow section the air speeds up, causing the static pressure to decrease. The **Venturi effect** describes how a fluid's **velocity increases,** and **pressure decreases** when it flows through a **narrowed (constricted) section** of a tube or passage.

<u>How?</u> Based on the Principle of Continuity an incompressible **fluid flow (a valid assumption at subsonic speeds), mass flow rate must remain constant along a streamline**.

The continuity equation states $\rho AV=constant$

Where:

- ρ = Air density (kg/m³)
- A = Cross-sectional area (m²)
- V = Air velocity (m/s)

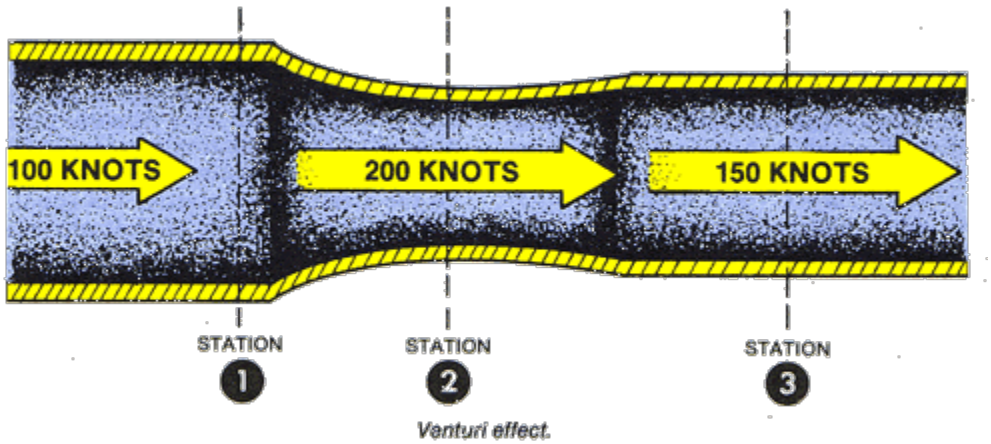
What this means

- If air flows into a **narrower space** (smaller A), and ρ remains constant then as area decreases, **velocity must increase** to keep the flow rate constant.
- $A\downarrow \Rightarrow V\uparrow$

At low flight speeds, air experiences relatively small changes in pressure and negligible changes in density. This airflow is termed **incompressible** since the air may undergo changes in pressure without apparent changes in density. Such airflow is similar to the flow of water, hydraulic fluid, or any other incompressible fluid. This suggests that between any two points in the tube, the **velocity varies inversely with the area**. **Venturi effect** is the name used to describe this phenomenon. Fluid flow speeds up through the restricted area of a venturi in direct proportion to the reduction in area. The **Venturi effect** states that when air flows through a narrower passage, it **speeds up**, and its **pressure drops**.

Think of squeezing a garden hose—the water comes out faster and thinner.

The Figure below suggests what happens to the speed of the flow through the tube discussed.



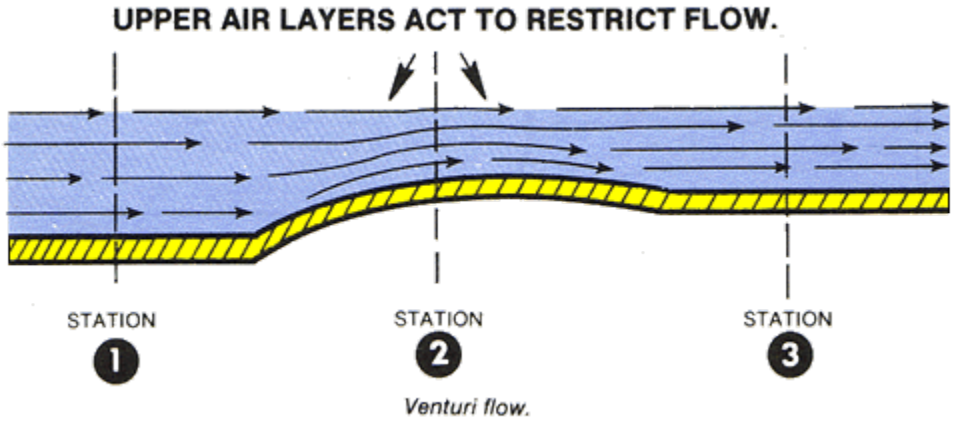
Venturi effect.

8. Also note that the **total energy** in a given closed system does not change, but the **form of the energy may be altered**. The **pressure of the flowing air** may be compared to energy in that the **total pressure of flowing air** will always remain constant unless energy is added to or taken from the flow. In the previous examples, there is **no addition or subtraction of energy**; therefore, the **total pressure will remain constant**.

9. **Fluid flow pressure** is made up of two components — **static pressure** and **dynamic pressure**. **Static Pressure** is that measured by an aneroid barometer placed in the flow but

not moving with the flow. **Dynamic Pressure** is that component of total pressure due to the **motion of the air**. It is difficult to measure directly, but a **Pitot-static tube** measures it indirectly. The **sum of these two pressures** is known as the **total pressure**.

10. **Static pressure decreases as the velocity increases**. This is what happens to air passing over the curved top of an aircraft's aerofoil. Consider only the bottom half of a **Venturi tube** in the figure below. Notice how the shape of the restricted area at **Station 2** resembles the top surface of an aerofoil. Even when the top half of the Venturi tube is taken away, the air still accelerates over the curved shape of the bottom half. This happens because the **air layers restrict the flow**, just as the top half of the Venturi tube did. As a result, **acceleration causes decreased static pressure above the curved shape of the tube**. A **pressure differential force** is generated by the local variation of **static and dynamic pressures** on the curved surface.



Venturi flow.

11. **Application to a Wing (Aerofoil)**.

(a) The **top of a wing** is **curved**, causing the airflow path to become **narrow**, just like a Venturi tube:

- Air **speeds up** over the curved top surface → $V_{top}\uparrow$
- Static pressure drops over the top → $P_{top}\downarrow$

(b) The bottom of the aerofoil (wing) is less curved (lower camber) as compared to the top.

- Bottom surface has **slower airflow**, **higher pressure** relative to top of the aerofoil
- → $P_{bottom} > P_{top}$

(c) This pressure difference creates **net upward force** = **Lift**.

12. **<u>Equation of Lift</u>**

The **lift force** produced by a wing or aerofoil is given by the

Lift Equation:Lift = $\frac{1}{2}\rho V^2 S C_L$

Symbol	**Term**	**Unit**	**Description**
L	Lift	Newton (N)	Vertical component of Total Reaction

Symbol	Term	Unit	Description
ρ	Air Density	Kg/m^3	
V	True Airspeed	m/s	
S	Wing surface area	m^2	
C_L	Coefficient of lift	Dimensionless	Depends mainly on aerofoil shape, surface condition & AoA

Detailed explanation of each term.

(a) **Air Density (ρ)**.

- Higher air density → **more lift** (since more air molecules interact with the wing).
- Affected by:
  - **Altitude** (higher altitude → thinner air → lower density)
  - **Temperature** (hot air is less dense)
  - **Humidity** (more moisture → less dense air)

    ➢ **Lift decreases at high altitude or in hot/humid conditions**.

(b) **True Airspeed (V)**

- Lift is **proportional to the square of the velocity**.
- Doubling the airspeed **quadruples** the lift.
- High speed → more air flows over the wings per second → greater pressure difference → **more lift**.

(c) **Wing Surface Area (S)**

- Larger wing area → more surface to generate lift.
- Aircraft with high wing loading (small wing area relative to weight) need **more speed** to generate required lift.

(d) **Coefficient of Lift (C_L)**

- Depends on:
  - **Angle of Attack (AoA)** (higher AoA → higher C_L - up to critical AoA)
  - **Wing shape (aerofoil)** – cambered surfaces have higher base C_L
  - **Flap settings** – deploying flaps increases C_L

- There is a **maximum** C_L just before the point when the aircraft stalls (where airflow separates and lift drops suddenly).

Summary: How Each Term Affects Lift

Variable	Value	Effect on Lift
ρ (air density)	Increases	Lift increases
V(airspeed)	Increases	Lift increases significantly (squared effect)
S (wing area)	Increases	Lift increases
C_L(lift coefficient)	Increases (via AoA or lift augmentation device)	Lift increases—up to stall point**(critical AoA)**

PART III: HIGH LIFT DEVICES

13. Slats and Flaps are the two high lift devices as described below:

Slats. The chord of the slat is typically only a few percent of the wing chord. The slats may extend over the outer third of the wing, or they may cover the entire leading edge. Slat does not give the air in the slot high velocity (it actually reduces its velocity) and also it cannot be called high- energy air since all the air outside the actual boundary layers has the same total heat. The actual effects of the slat are aerodynamic surfaces on the leading edge of the wings of fixed-wing aircraft which, when deployed, allow the wing to operate at a higher angle of attack. A higher coefficient of lift is produced as a result of angle of attack and speed, so by deploying slats an aircraft can fly at slower speeds, or take off and land in shorter distances. They are usually used while landing or performing maneuvers which take the aircraft close to the stall, but are usually retracted in normal flight to minimize drag.

14. Slats are of three types as described below:

(a) **Automatic**. The slat lies flush with the wing leading edge until reduced aerodynamic forces allow it to extend by way of aerodynamics when needed. Sometimes referred to as Handley-Page slats.

(b) **Fixed**. The slat is permanently extended. This is sometimes used on specialist low-speed aircraft (these are referred to as slots) or when simplicity takes precedence over speed.

(c) **Powered**. The slat extension can be controlled by the pilot. This is commonly used on airliners.

15. **Flaps**. Slat are hinged surfaces mounted on the trailing edges of the wings of a fixed-wing aircraft to reduce the speed at which an aircraft can be safely flown and to increase the angle of descent for landing. They shorten takeoff and landing distances. Flaps do this by lowering the stall speed and increasing the drag.

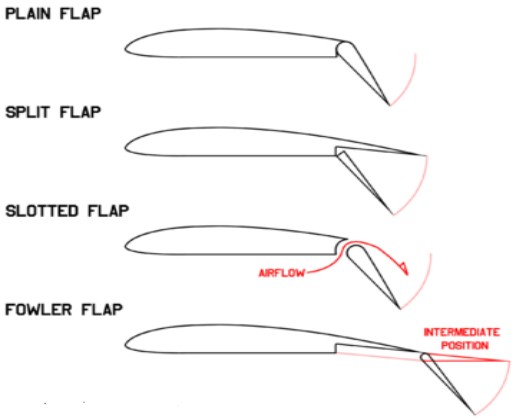
16. Flaps are of four types as described below:

(a) **Plain flap**. The rear portion of aerofoil rotate downwards on a simple hinge mounted at the front of the flap. Due to the greater efficiency of other flap types, the plain flap is normally only used where simplicity is required. A modern variation on the plain flap exploits the ability of composites to be designed to be rigid in one direction, while flexible in another. When such a material forms the skin of the wing, its camber can be altered by the geometry of the internal supporting structure, allowing such a surface to be used either as a flap or as an aileron.

(b) **Split flap**. The rear portion of the lower surface of the aerofoil hinges downwards from the leading edge of the flap, while the upper surface stays immobile. Like the plain flap, this can cause large changes in longitudinal trim, pitching the nose either down or up, and tends to produce more drag than lift. At full deflection, a split flaps acts much like a spoiler, producing lots of drag and little or no lift.

(c) **Slotted flap**. A gap between the flap and the wing forces high pressure air from below the wing over the flap helping the airflow remains attached to the flap, increasing lift compared to a split flap. Additionally, lift across the entire chord of the primary aerofoil is greatly increased as the velocity of air leaving its trailing edge is raised, from the typical non-flap 80% of free stream, to that of the higher-speed, lower-pressure air flowing around the leading edge of the slotted flap. Any flap that allows air to pass between the wing and the flap is considered a slotted flap.

(d) **Fowler flap**. Split flap that slides backwards flat, before hinging downwards, thereby increasing first chord, and then camber. The flap may form part of the upper surface of the wing, like a plain flap, or it may not, like a split flap but it must slide rearward before lowering. It may provide some slot effect but this is not a defining feature of the type.



17. The general airplane lift equation is $L = \frac{1}{2}\rho V^2 S C_L$

Where:

- ***L*** is the amount of *Lift* produced,
- ***ρ*** is the air density,
- ***V*** is the indicated airspeed of the airplane or the *Velocity* of the airplane, relative to the air
- ***S*** is the *Surface area* of the wing and
- C_L is the *lift coefficient* which is determined by the camber of the aerofoil used, the chord of the wing and the angle at which the wing meets the air (or angle of attack).

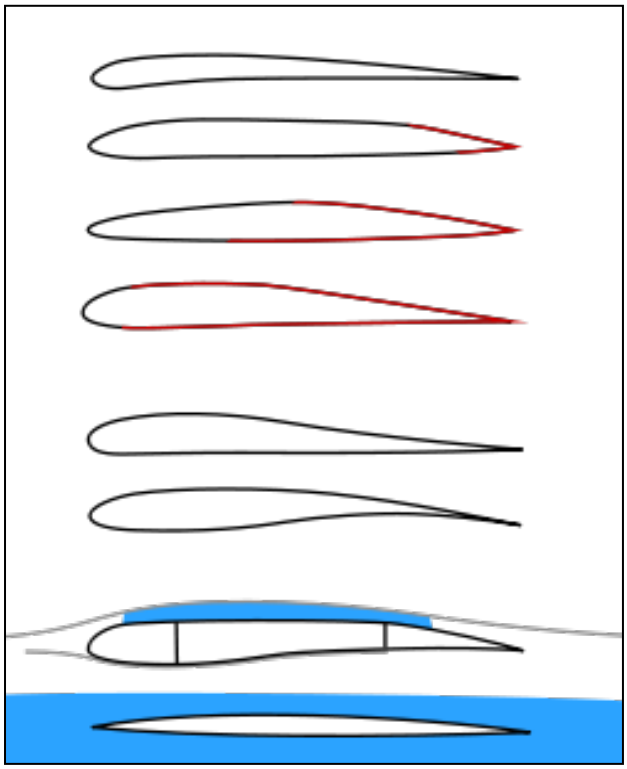
Here, it can be seen that increasing the area (S) and lift coefficient (C_L) allow a similar amount of lift to be generated at a lower airspeed (V).

18. Extending the flaps also increases the drag coefficient of the aircraft. Therefore, for any given weight and airspeed, flaps increase the drag force. Flaps increase the drag coefficient of an aircraft because of higher induced drag caused by the distorted spanwise lift distribution on the wing with flaps extended. Some flaps increase the planform area of the wing and, for any given speed, this also increases the parasitic drag component of total drag.

INTERESTING FACTS

- The lifting force pushes the wings up, which lifts the plane in the air and keeps it there.
- As long as the wings produce lift, the plane will continue to fly.

PART IV: STALL



- Laminar flow aerofoil for a RC park flyer
- Laminar flow aerofoil for a RC pylon racer
- Laminar flow aerofoil for a manned propeller aircraft
- Laminar flow at a jet airliner aerofoil
- Stable aerofoil used for flying wings
- Aft loaded aerofoil allowing for a large main spar and late stall
- Transonic supercritical aerofoil
- Supersonic leading edge aerofoil

Colors:

Black = laminar flow, red = turbulent flow, grey = subsonic stream, blue = supersonic flow volume

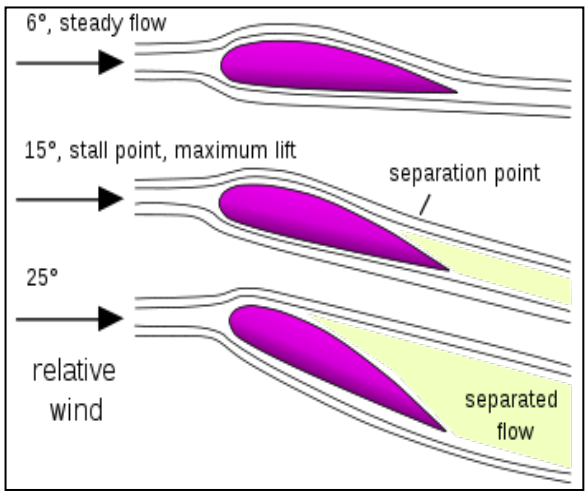
19. **Laminar flow**. It is a system that maintains a uniform speed and direction of airflow in a given space. It's often used in clean environments, such as laboratories and healthcare facilities, to keep the air clean and free of contaminants.

20. **Turbulent flow**. When air moves in a chaotic, random, and unpredictable way then the flow is known as turbulent. It occurs when something disrupts the smooth, horizontal flow of air, causing it to move in different directions and at different speeds.

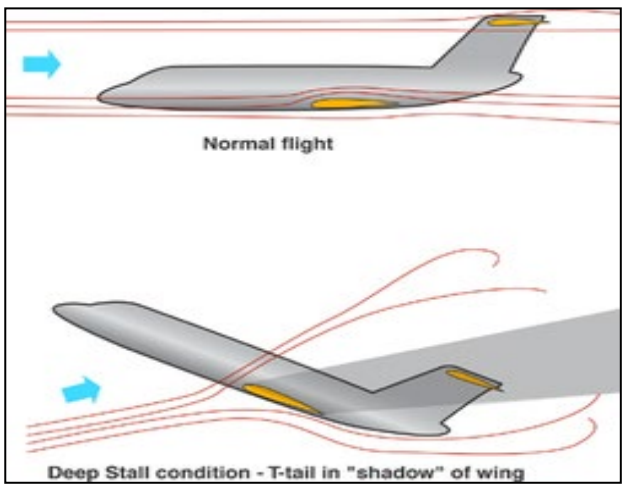
21. **Breakdown of flow on aerofoil**. The flow over an aerofoil breaks down in a number of ways, including laminar to turbulent flow where the Reynolds number is high which increases drag, Flow separation when pressure gradient is too high and boundary layer separation which can degrade aerodynamic performance.

22. **Stall**. A Stall is a reduction in the lift coefficient generated by a foil as angle of attack increases. This occurs when the critical angle of attack of the foil is exceeded. The critical angle of attack is typically about 15 degrees, but it may vary significantly depending on the fluid and aerofoil. Stalls in fixed-wing flight are often experienced as a sudden reduction in lift as the pilot increases angle of attack and exceeds the critical angle of attack (which may be due to slowing down below stall speed in level flight). A stall does not mean that the engine(s) have stopped working, or that the aircraft has stopped moving — the effect is the same even in an unpowered glider aircraft.

23. **A Stall**. A Stall is a condition in aerodynamics and aviation wherein the angle of attack increases beyond a certain point such that the lift begins to decrease. The angle at which this occurs is called the critical angle of attack. This critical angle is dependent upon the profile of the wing, its platform, its aspect ratio, and other factors, but is typically in the range of 8 to 20 degrees relative to the incoming wind for most subsonic aerofoils. The critical angle of attack is the angle of attack on the lift coefficient versus angle-of-attack curve at which the maximum lift coefficient occurs.



24. Separation begins to occur at small angles of attack while attached flow over the wing is still dominant. As angle of attack increases, the separated regions on the top of the wing increase in size and hinder the wing's ability to create lift. At the critical angle of attack, separated flow is so dominant that further increases in angle of attack produce less lift and vastly more drag.



25. **Stall & its effects**. During a stall, a plane may experience buffeting or a change in its attitude. Most planes are designed to stall gradually, with features that warn the pilot and allow time to react. For example, if there's no buffet before the stall, the plane may have a warning system like a stick shaker that vibrates the controls. The "buffet margin" refers to the maximum amount of g-force that can be safely applied before buffeting occurs (Buffeting is the turbulent shaking or vibration of an aircraft caused by airflow disruptions, often indicating an impending stall). In steady, level flight, a plane can only reach the critical angle of attack at low speeds. Trying to increase the angle at higher speeds can cause a high-speed stall or make the plane climb.

26. **Stalling Speed**. Stalling speed is the minimum speed at which an airplane can maintain level flight. It is the speed below which the plane can no longer generate enough lift

to support its weight. In level, unaccelerated flight, as the airplane's speed decreases, it must increase its angle of attack (the angle between the wing and the airflow) to maintain lift. When the angle of attack reaches the critical limit, the plane will stall. This is called the "stall speed," and it varies with the plane's weight, altitude, and configuration (such as flaps). While stalls are determined by angle of attack, airspeed is often used as a practical indicator of approaching a stall.

CONCLUSION

27. To enable an aircraft to fly, the engine and propeller are designed to produce thrust to overcome drag, and the wings are designed to produce lift to overcome gravity.

28. Aircraft are also designed to be as smooth as possible to reduce surface friction drag.

29. Bernoulli’s principle and venture effect has been described briefly for better understanding of cadets and their application in aviation.

30. Extending the flaps also increases the drag coefficient of the aircraft. Therefore, for any given weight and airspeed, flaps increase the drag force.

31. A stall is a condition in aerodynamics and aviation wherein the angle of attack increases beyond a certain point such that the lift begins to decrease. The angle at which this occurs is called the critical angle of attack.

32. The stall speed will vary depending on the airplane's weight, altitude, and configuration (flap setting, etc.)

33. The Venturi effect is a specific examples of Bernoulli’s principle which states that an increase in fluid velocity results in a decrease in static pressure.

34. The relationship between the velocity and pressure exerted by a moving liquid is described by the Bernoulli's principle: as the velocity of a fluid increases, the pressure exerted by that fluid decreases. Similarly, Airplanes get a part of their lift by taking advantage of Bernoulli's principle.

35. Race cars employ Bernoulli's principle to keep their rear wheels on the ground while travelling at high speeds.

36. The stall is a breakdown of the smooth airflow over the wing into a turbulent one, resulting in a decrease in lift. The lift will no longer fully support the aeroplane’s weight, and the aeroplane sinks.

ASSESSMENT EXERCISE

Multiple-Choice Questions (MCQs).

Q1. According to the Venturi effect, what happens to the fluid flow when it passes through a restricted area in a tube?

(a) The velocity decreases, and the pressure increases
(b) The velocity increases, and the pressure decreases
(c) Both velocity and pressure increase
(d) Both velocity and pressure decrease

Q2. What is the primary component of aerodynamic force that acts perpendicular to the direction of motion?

(a) Drag (b) Lift
(c) Thrust (d) Weight

Q3. At what angle of attack does an aerofoil typically stall?

(a) 10 degrees (b) 15 degrees
(c) 30 degrees (d) 24 degrees

Q4. Which of the following forces opposes the forward motion of an aircraft?

(a) Lift (b) Drag
(c) Thrust (d) Weight

Q5. What is the primary function of flaps on an aircraft?

(a) Increase the aircraft's speed
(b) Increase lift and reduce the stall speed
(c) Reduce drag and increase speed
(d) Maintain level flight at high speeds

Q6. Which of the following describes how slats function on an aircraft?

(a) They decrease the aircraft’s weight during landing
(b) They allow the wing to operate at a higher angle of attack without stalling
(c) They reduce thrust during level flight
(d) They improve the aircraft’s fuel efficiency

Q7. Which force acts parallel and opposite to the direction of flight?

(a) Lift (b) Thrust
(c) Drag (d) Weight

Q8. At what angle of attack does a stall typically occur for most subsonic aerofoils?

(a) 0 to 5 degrees (b) 5 to 10 degrees
(c) 15 to 20 degrees (d) 25 to 30 degrees

Q9. What happens to lift as the angle of attack increases beyond the critical angle?

(a) Lift increases (b) Lift remains constant
(c) Lift decreases and drag increases (d) Both lift and drag decrease

Short Answer Type Questions

Q1. How do flags help an aircraft during landing?

Q2. What is critical angle of attack and what occurs when it is exceeded?

Q3. Why is thrust essential for an aircraft flight?

Q4. Describe four forces acting on an aircraft in straight and level flight.

Long Answer Type Questions

Q5. Explain Bernoulli's principle and how it relates to the Venturi effect.

Q6. What are the main differences between subsonic and supersonic aerofoils in terms of their design and functions?

Q7. How does increasing the area of the wing(s) affect lift, according to the lift equation?

Q8. What is the purpose of streamlining in an aircraft's design?

AIRMANSHIP

8

CHAPTER WISE INDEX: AM (JD/JW)

CHAPTER AM: AIRMANSHIP (JD/JW)

"Fly-Fight-Win"

TEACHING INSTRUCTIONS

Period	**:**	**Six (1st year)** **Seven (2nd year)**
Type	**:**	**Lecture and Practical**
Year	**:**	**1st/2nd year JD/JW**
Conducting Officer	**:**	**ANO/CTO**

Training Aids: Class room, Computer, OHP Marker, Screen, Pointer, Presentation and practical learning during Airfield visit

Time Plan

- **Introduction : 10 Mins**
- **Part I : 20 Mins**
- **Part II : 20 Mins**
- **Part III : 30 Mins**
- **Part IV : 30 Mins**
- **Part V : 30 Mins**
- **Conclusion and Practice : 20 Mins**
- **Visit to the Airfield & ATC : 360 Mins**

INTRODUCTION

1. The chapter on Airmanship introduces cadets to the operational and structural aspects of an airfield, with emphasis on its layout, terminologies, and safety procedures. Through this chapter, cadets gain insights into airfield operations, markings, lighting systems, and the roles of various services like Air Traffic Control (ATC), rescue, and radar systems. This theoretical knowledge, combined with practical exposure during airfield visits, equips cadets to understand the complexities of aviation ground operations and procedures.

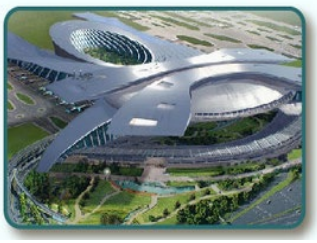
INTERESTING FACTS

Oldest Airport

Juhu Airport or the Juhu Aerodrome is the oldest surviving airport in the country. It was founded in *1928* and the first commercial flight landed here in *1932*.

Newest Airport

Noida International Airport in Jewar, Uttar Pradesh is the newest international airport in India and is expected to begin its functions from *2024*.



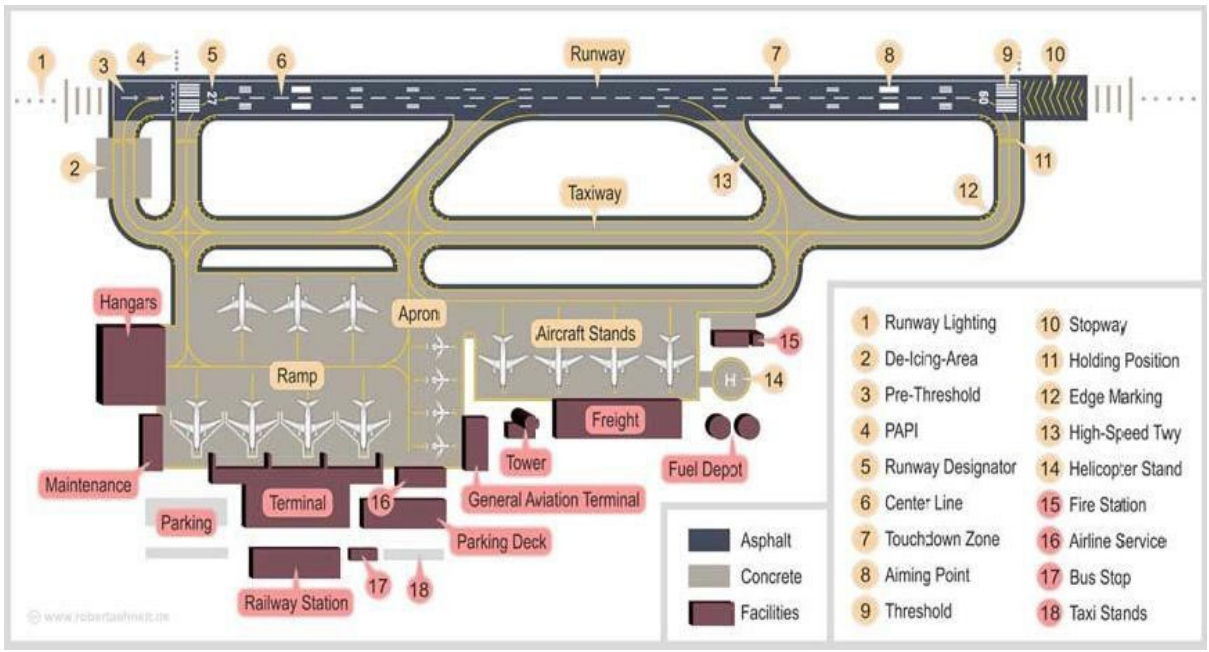
PREVIEW	LEARNING OBJECTIVES
The lecture will be covered in the following parts:- ➢ **Part I: Visit to Airfield and Airfield Layout.** ➢ **Part II: Aerodrome Markings and Lighting Systems.** ➢ **Part III: Basic Terminologies and Definitions.** ➢ **Part IV: Function of Air Traffic Control (ATC) and Rescue Services.** ➢ **Part V: Radar Services in Airfield Area.**	**At the end of this lesson, cadets will be able to:-** ➢ **Understand the Layout of an Airfield** ➢ **Understand various Markings and Lighting Systems on the taxi tracks and runway.** ➢ **Understand key terminologies related to Aerodrome and Aviation.** ➢ **Understand the Functions of Air Traffic Control (ATC)** ➢ **Understand the Importance of Rescue and Fire Services at an aerodrome.** ➢ **Understand different types of Radar and their usage at an aerodrome.**

PART I: VISIT TO AIRFIELD AND AIRFIELD LAYOUT

1. **Visit to Airfield**. Before commencing flying, the cadets visit to ATC and Meteorology Section should be planned. At the ATC the cadets are to be shown the Airfield Layout and RT procedures. The basics of meteorology need to be explained at the Met Section for better understanding and assimilation.

AIRFIELD LAYOUT

2. Following are the areas laid down at the airfields to facilitate safe and expeditious conduct of aircraft operations



3. **Movement Areas**. Movement areas are that part of an airfield intended for the surface movement of the aircraft. These are paved areas and include runways, taxiways, dispersal areas, aprons etc.

4. **Runways**. Runways are paved surfaces intended for take-off and landing of ac. The number and orientation of runways at an airfield will depend upon the volume of traffic, runway occupancy time and climatological data on surface winds.

5. **Taxiways**. These are paved surfaces provided for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another.

PART II: AERODROME MARKINGS AND LIGHTING

6. **Aerodrome Markings**. This consist of signs on surface of movement areas to convey aeronautical information. Aerodrome ground markings shall consist of the following:

(a) Runway markings.

(b) Taxiway markings.

(c) Unserviceability markings.

7. **Runway Markings**. Runway markings shall consist of:

(a) **Runway Designation Markings**. Runway designation markings shall consist of a two-digit number and on parallel runways shall be supplemented by a letter. The two- digit number shall be the whole number nearest to one tenth of magnetic azimuth of centre line measured clockwise from magnetic North when viewed from direction of approach.

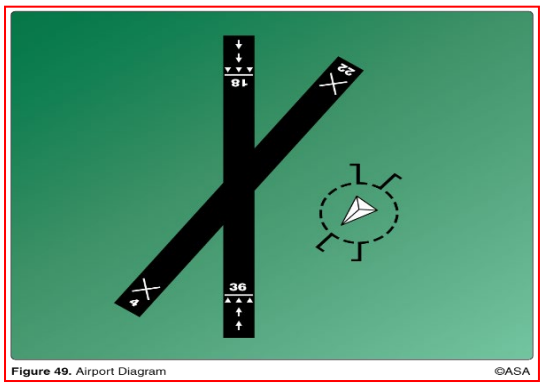
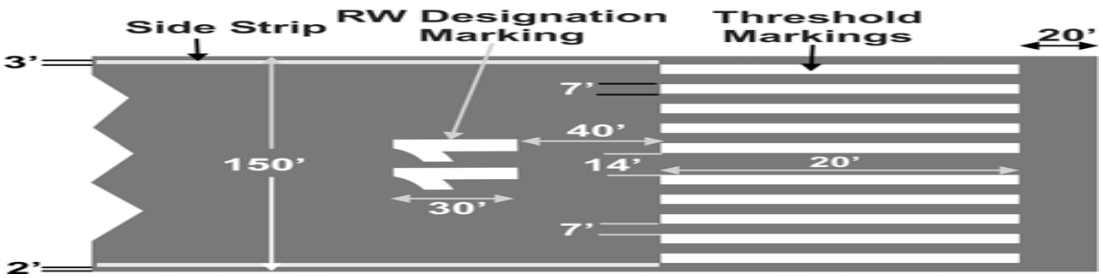


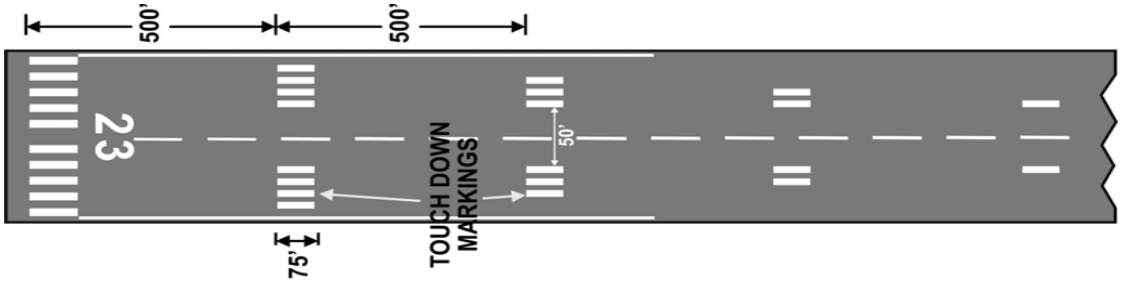
Figure 49. Airport Diagram

(b) **Runway Centre Line Markings**. Runway centre line markings shall consist of a series of broken longitudinal lines along the runway centre line and extending along the whole length of the runway.

(c) **Runway Threshold Markings**. The markings shall consist of a series of longitudinal strips of uniform dimensions symmetrically placed on both sides of runway centre line and extending laterally to 1.5 m (5 ft) from the edge of runway.



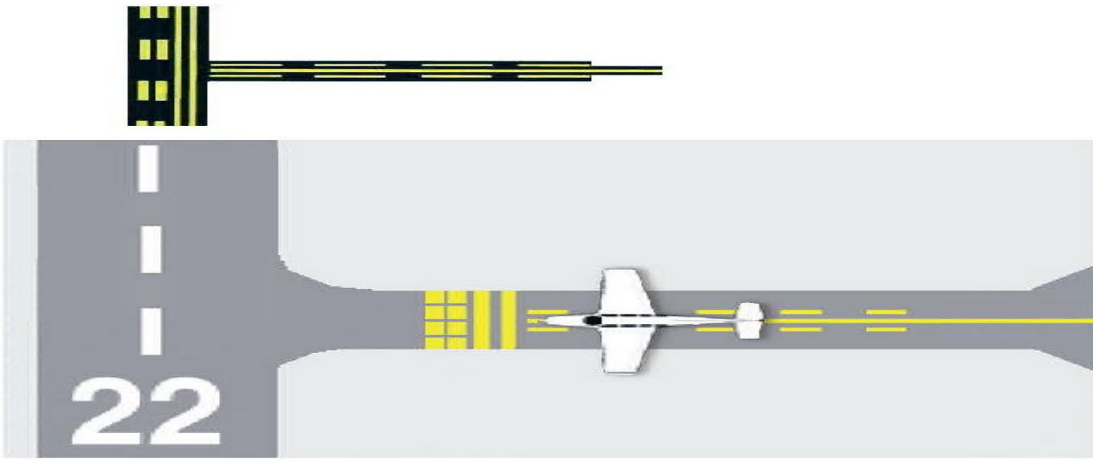
(d) **Runway Touch Down Zone Markings**. Touch down zone markings shall be located over the first 600 m (2000 ft) of instrument runways at longitudinal spacing of 150 m (500 ft). These markings shall be provided with distance coding.



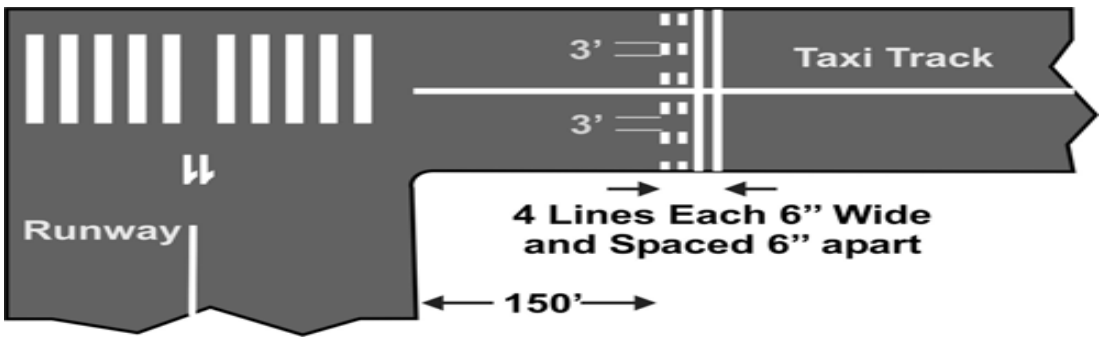
(e) **Runway Side Strip Markings**. Side strip markings shall be provided on all paved runways. These markings shall consist of two lines extending the whole length of the runway parallel to and equidistant from runway centre line.

8. **Taxiway Markings**. These markings shall consist of:

(a) **Taxiway Centre Line Markings**. These markings shall be single unbroken lines 0.15 m (6") wide along the centre line of taxiway.



(b) **Runway Holding Position Markings**. These markings shall consist of four lines of 0.15 m (6") width each with spacing of 0.15 m (6").

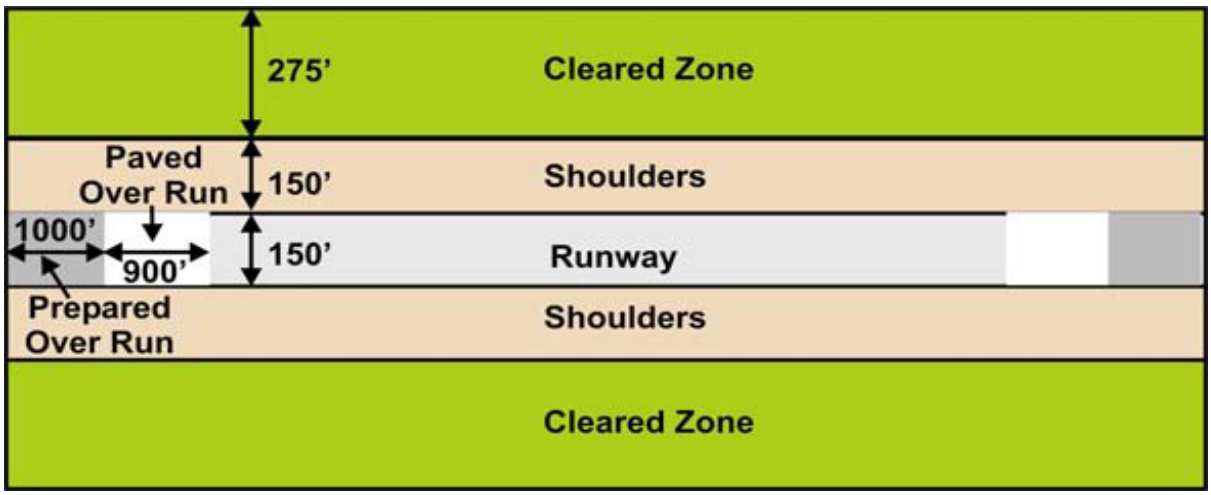


(c) **Unserviceability Markings**. Unserviceability markings shall be displayed on those parts of movement area, which are unfit for landing, take-off or surface movement of aircraft. Unserviceability markings shall be in the form of a cross as given.

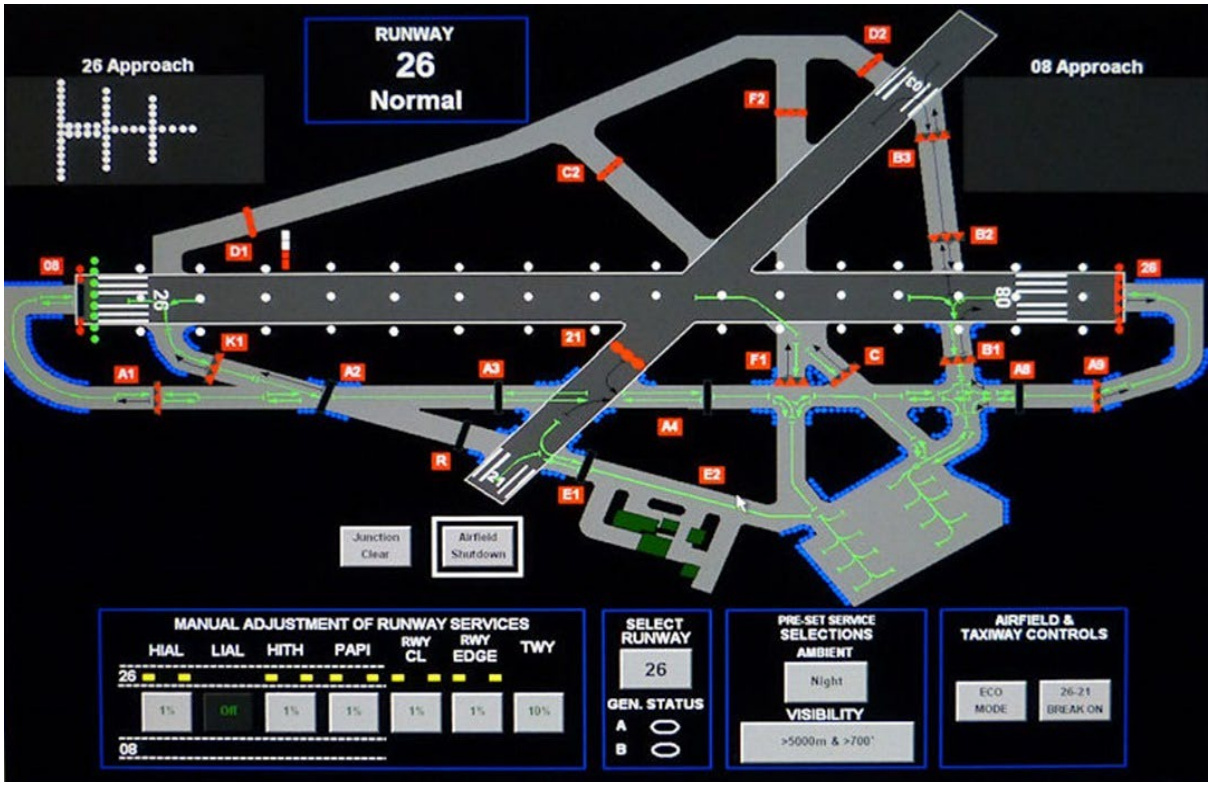
9. **Shoulders**. These are areas immediately adjacent to the edges of the runway, taxiways, overruns and SGAs prepared for accidental or emergency use in the event of an aircraft running off the paved surface.

10. **Cleared Zones**. These are those areas of the flight strip adjacent to the shoulders, which for safety of aircraft operations, should be levelled and be free of obstructions as far as possible.

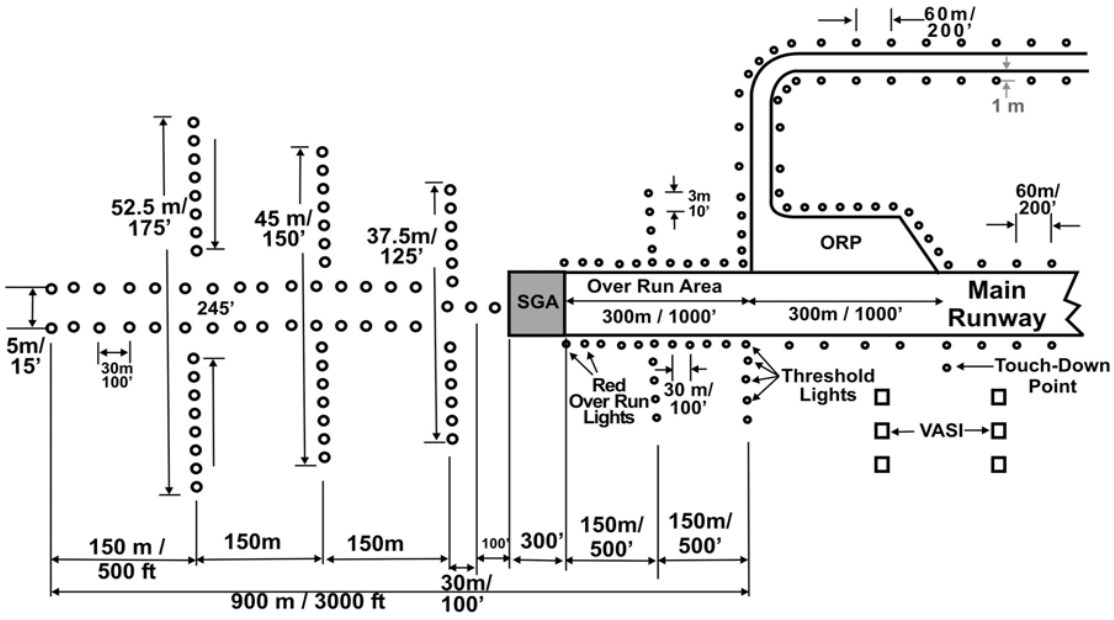
11. **Over-Run Areas**. A defined rectangular area on ground at the end of runway in the direction of take-off prepared as a suitable area in which an aircraft can be stopped in case of abandoned take off, or during a landing emergency.



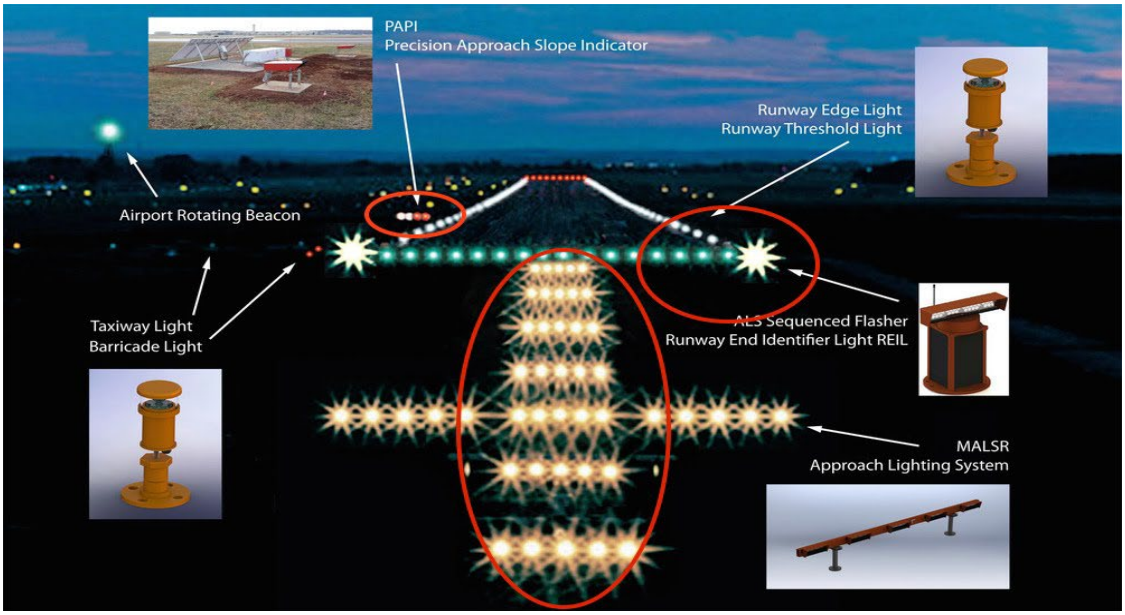
12. **Aerodrome Lighting**. There are several types of approach and airfield lighting in use in the service. All permanent installations are normally on the mains electricity supply but also have some alternative arrangements for use in the event of power failure. Aerodrome lighting is considered under two headings.



(a) **Approach Lighting**. This is to assist the pilots to make an approach for landing in poor visibility or at night.

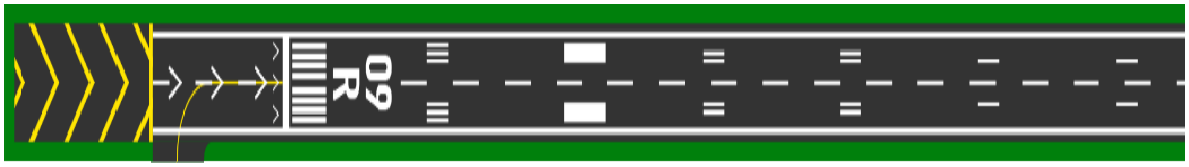


(b) **Airfield Lighting**. Modern installation consists of raised high intensity white lights along each side of the runway, beamed towards the landing aircraft. At the beginning of runway, called the threshold, is a bar of green lights going across the full width of the runway.



PART III: BASIC TERMINOLOGIES AND DEFINITIONS

13. **Aerodrome**. Defined area on land or water including any buildings, installations and equipment intended to be used either wholly or in part for the arrival, departure and movement of aircraft.



14. **Aerodrome Reference Point (ARP)**. It is a designated geographical location of an aerodrome, normally taken as the geometrical centre of Runway

15. **Air Report**. It is a report passed during the course of a flight in conformity with requirements for position, operational, or meteorological reporting in the AIREP or POMAR (Position, Operation Meteorology Air Report) forms.

16. **Air Route**. The navigable airspace between two points, identified to the extent necessary for the application of flight rules.

17. **Air Traffic Control**. It is a service provided by ground-based air traffic controllers who direct aircraft on the ground and through a given controlled airspace and can provide advisory services to aircraft in non-controlled airspace.

18. **Alerting Service**. A service provided to notify appropriate organizations regarding ac in need of search and rescue aid, and assist such organizations as required.

19. **Alternate Aerodrome**. An aerodrome specified in the flight plan to which a flight may proceed when it becomes inadvisable to land at planned aerodrome.

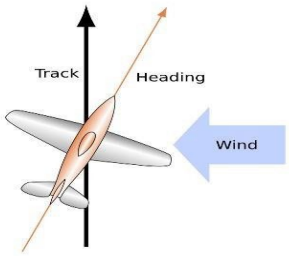
20. **Altitude**. The vertical distance of a level, a point or object considered as a point measured from mean sea level (MSL).

21. **Distress Message**. Emergency message to be used when an aircraft is threatened by serious or imminent danger and the crew is in need of immediate assistance.

22. **Elevation**. The vertical position of a point or a level, above, on or affixed to the surface of the earth, measured from mean sea level.

23. **Estimated Time of Arrival (ETA)**. For IFR flights, the time at which it is estimated that the ac will arrive over a designed point, defined by reference to navigation aids, from which it is intended that an instrument approach procedure will be commenced, or, if no navigational aid is associated with the aerodrome, the time at which the ac will arrive overhead. For VFR flights, it is the time at which it is estimated that the ac will arrive over the aerodrome.

24. **Heading**. The direction in which the longitudinal axis of an aircraft is pointed usually expressed in degrees from North (magnetic).



25. **Height**. The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

26. **Load Classification Number (LCN)**. The bearing strength of a pavement or runway is defined by a number. This is associated with an indication of the characteristics and type of construction of the pavement

27. **Prohibited Area**. Airspace of defined dimensions, above the land areas of territorial waters of a State, within which the flight of aircraft is prohibited.

28. **QFE**. Aerodrome pressure corrected for temperature. When set on the altimeter on the ground, the Altimeter should read zero.

29. **QNH**. Aerodrome pressure corrected for temperature and adjusted to Mean Sea Level, using the ICAO formula. When set on the altimeter on the ground, the altimeter should read aerodrome elevation

30. **Restricted Area**. An airspace of defined dimensions, above the land areas or territorial waters of a State, within which the flight of aircraft is restricted in accordance with specified conditions.

31. **Transition Altitude (TA)**. The altitude in the vicinity of an aerodrome at or below which the Vertical position of an aircraft is controlled by reference to altitudes above mean sea level or height above the aerodrome depending on whether QNH or QFE is set on the altimeter.

32. **Transition Layer**. The airspace between the transition altitude and the transition level. The depth of the layer will normally be insignificant, and will in any case never exceed 1500 ft.

33. **Transition Level**. The lowest flight level above the transition altitude. It will vary in accordance with the relationship between the QNE and the standard pressure datum.

34. **Visibility**. The ability, as determined by atmospheric conditions and expressed in units of distance, to see and identify prominent lighted objects by night.

PART IV: FUCTIONS OF ATC AND RESCUE SERVICES

35. An organisation established to provide:-

(a) Air traffic control within a control area.

(b) Flight information service within a flight information region.

(c) Alerting service for search and rescue within its flight information region.

36. Air Traffic Control Services are provided by licensed Air Traffic Controllers. It is a service provided for the purpose of:

(a) Preventing collisions between aircraft in the air.

(b) Prevent collisions on the manoeuvring area between a/c and obstructions

(c) Expediting and maintaining an orderly flow of traffic.

(d) Provide information and support for pilots.

Function of Rescue Services

37. The rescue and fire services at an airport in India are responsible for a number of functions including:

(a) **Emergency response**. The rescue and fire services are responsible for responding to emergencies at the airport, including aircraft accidents and incidents.

(b) **Fire protection**. The rescue and fire services are responsible for maintaining fire protection at the airport, including in the terminal building and other vital installations.

(c) **Egress Routes**. The rescue and fire services are responsible for creating and maintaining egress routes for occupants in the event of an emergency.

(d) **Rescue**. The rescue and fire services are responsible for rescuing occupants who are unable to escape without assistance.

(e) **Airport Emergency Plan**. The rescue and fire services are responsible for managing the airport emergency plan, which coordinates the efforts of mutual aid agencies.

PART V: RADAR SERVICES IN AIRFIELD AREA

38. Basic Radar Services in an Airfield:

(a) Primary Functions:

(i) Surveillance: Monitor aircraft movement and weather conditions.

(ii) Separation: Prevent collisions of aircraft.

(iii) Guidance: Provide navigational assistance.

(b) Radar Services:

(i) **Surface Movement Radar (SMR)**. To provide Surface movement control of all aircraft and vehicles.

(ii) **Airport Surveillance Radar (ASR)**. This radar system detects and displays the location of aircraft in the airspace around an airport within designated airspace usually upto 60 Nautical miles and below 25000 feet.

(iii) **Terminal Radar**. This radar guide aircraft as they approach and depart from an airport within designated coverage area and vertical limits.

(iv) **Precision Approach Radar (PAR)**. Precisely guides aircraft in 3D during approach and landing. This is extremely useful in bad weather wherein visibility is low and precision approach navigation facilities such as Instrument Landing system (ILS) is not available at an airport.

DID YOU KNOW ?

- Aircraft can be landed, stopped and taxi in zero visibility also, provided the aircraft is suitably equipped, pilot is trained and cleared for such operations and the airfield has appropriate class of precision approach and instrument landing system available. (Cat-III C).
- ALG stands for advanced landing ground. Nyoma ALG in eastern Ladakh is India's highest advanced landing ground located at an altitude of around 13,700 Ft.

CONCLUSION

39. The understanding of various aspects of Airmanship helps develop a better situational awareness and readiness to conduct safe operations. The purpose of this subject is as follows:

(a) **Visit to Airfield**. The visit to the airfield provides cadets with practical exposure to the layout, operations, and procedures involved in aviation. By observing the Air Traffic Control (ATC) and meteorology sections, cadets develop a real-world understanding of flight operations, RT procedures, and meteorological reports.

(b) **Airfield Layout**. Understanding the airfield layout, including runways, taxiways, dispersal areas, aprons and differentiate between aircraft manoeuvring areas and normal areas. Enables cadets to identify the key components that ensure smooth and safe movement of aircraft. This knowledge emphasizes the importance of proper design and maintenance of movement areas for efficient airfield operations.

(c) **Aerodrome Markings and Lighting Systems**. The study of aerodrome markings, such as runway designations, centerlines, and threshold markings, highlights their role in providing visual guidance to pilots. Similarly, aerodrome lighting systems, including approach and airfield lighting, assist pilots in landing and taxiing, especially during low visibility or night operations.

(d) **Basic Terminologies and Definitions**. The introduction of aviation-specific terminologies, such as **QNH, QFE, altitude, elevation, and transition levels**, familiarizes cadets with global aviation standards. This ensures accurate communication and understanding of operational protocols.

(e) **Air Traffic Control (ATC) and Its Functions**. Air Traffic Control plays a critical role in preventing collisions, expediting traffic flow, and providing essential information to pilots. By understanding ATC operations and the use of radar systems like **SMR, ASR, and PAR**, cadets appreciate the importance of communication, monitoring, and navigation in ensuring aviation safety.

(f) **Rescue and Fire Services**. The study of rescue and fire services highlights their vital role in emergency response, fire protection, and passenger safety. Their preparedness ensures quick and effective action during aircraft accidents or incidents, reinforcing the safety culture in aviation.

(g) **Radar Services in Airfield Area**. Radar systems, such as **Surface Movement Radar (SMR), Airport Surveillance Radar (ASR), and Precision Approach Radar (PAR)**, are essential for aircraft monitoring, separation, and navigation. These services ensure the safe movement of aircraft on the ground and during landing or departure, especially under poor weather conditions.

(h) Understand various terminologies and definitions related to an airfield layout.

(i) The Runway designation markings consist of two-digit number indicating the magnetic directions of the Runway central line, measured clockwise from the magnetic north.

(j) Understand other markings to differentiate between the meanings they convey.

(k) Understanding that the vacant areas around the main runway are for safety of aircraft which while experiencing emergencies which may lead aircraft to lose directional control.

(l) The approved kind of lighting is extremely important for operations in low visibility.

(m) ATC is the organisation that has vital role in operations of aircraft from an airfield.

(n) Fire and rescue services are for quick response to save lives in case of emergencies faced by an aircraft and its occupants.

(o) Radar has come a long way in the form of a sensor, that can be applied for identifying, controlling and guiding various airborne elements at an airport. They are primarily classified based on their functions and services.

ASSESSMENT EXERCISE

Multiple Choice Questions

Q1. What is the primary purpose of a runway at an airfield?

(a) Aircraft parking
(b) Take-off and landing of aircraft
(c) Aircraft maintenance
(d) Passenger boarding

Q2. What do runway designation markings consist of?

(a) A series of longitudinal strips
(b) A bar of green lights
(c) A two-digit number and, for parallel runways shall be supplemented by a letter
(d) A cross indicating unserviceability

Q3. Unserviceable areas shall be marked as_____ on an airfield?

(a) A two-digit number
(b) Longitudinal strips
(c) Cross markings
(d) Green lights

Q4. What is the purpose of taxiways?

(a) To provide aircraft maintenance
(b) To link one part of the aerodrome to another
(c) To assist during poor visibility
(d) To mark unserviceable areas

Q5. Which of the following is NOT a component of runway markings?

(a) Runway designation markings
(b) Runway side strip markings
(c) Runway threshold markings
(d) Runway clearance zone markings

Q6. What type of lighting helps pilots approach for landing in poor visibility?

(a) Approach lighting
(b) Aerodrome lighting
(c) Airfield lighting
(d) None of the above

Q7. What is the definition of "altitude"?

(a) Vertical distance measured from mean sea level
(b) Horizontal distance between two points
(c) Elevation of a point above the earth's surface
(d) Height of an aircraft from the runway

Q8. What does QNH refer to?

(a) Aerodrome pressure corrected for temperature
(b) Aerodrome pressure corrected to mean sea level
(c) Unserviceable area markings
(d) The altitude of an aircraft in flight

Q9. What is the function of precision approach radar (PAR)?

(a) To monitor weather conditions
(b) To provide guidance for surface movement
(c) To guide aircraft during approach and landing
(d) To provide airport lighting

Q10. What does the acronym ATC stand for?

(a) Aerodrome Traffic Control
(b) Air Traffic Control
(c) Aircraft Tracking Command
(d) Aviation Terminal Control

Q11. _____ are the areas immediately adjacent to the edges of runway?

(a) Shoulders
(b) Cleared Zones
(c) Over-Run Areas
(d) Both b & c

Q12. What is the main purpose of aerodrome shoulders?

(a) For aircraft parking
(b) Emergency use during accidental off-paved surface movement
(c) As a lighting area
(d) As a cleared zone for maintenance

Q13. Which radar system detects aircraft location in airspace up to 60 nautical miles?

(a) Precision Approach Radar (b) Terminal Radar
(c) Airport Surveillance Radar (d) Surface Movement Radar

Q14. Which of the following are Radar services?

(a) Surface Movement Radar (SMR)
(b) Airport Surveillance Radar (ASR)
(c) Precision Approach Radar (PAR)
(d) All the above

Q15. What is the function of the air traffic control service?

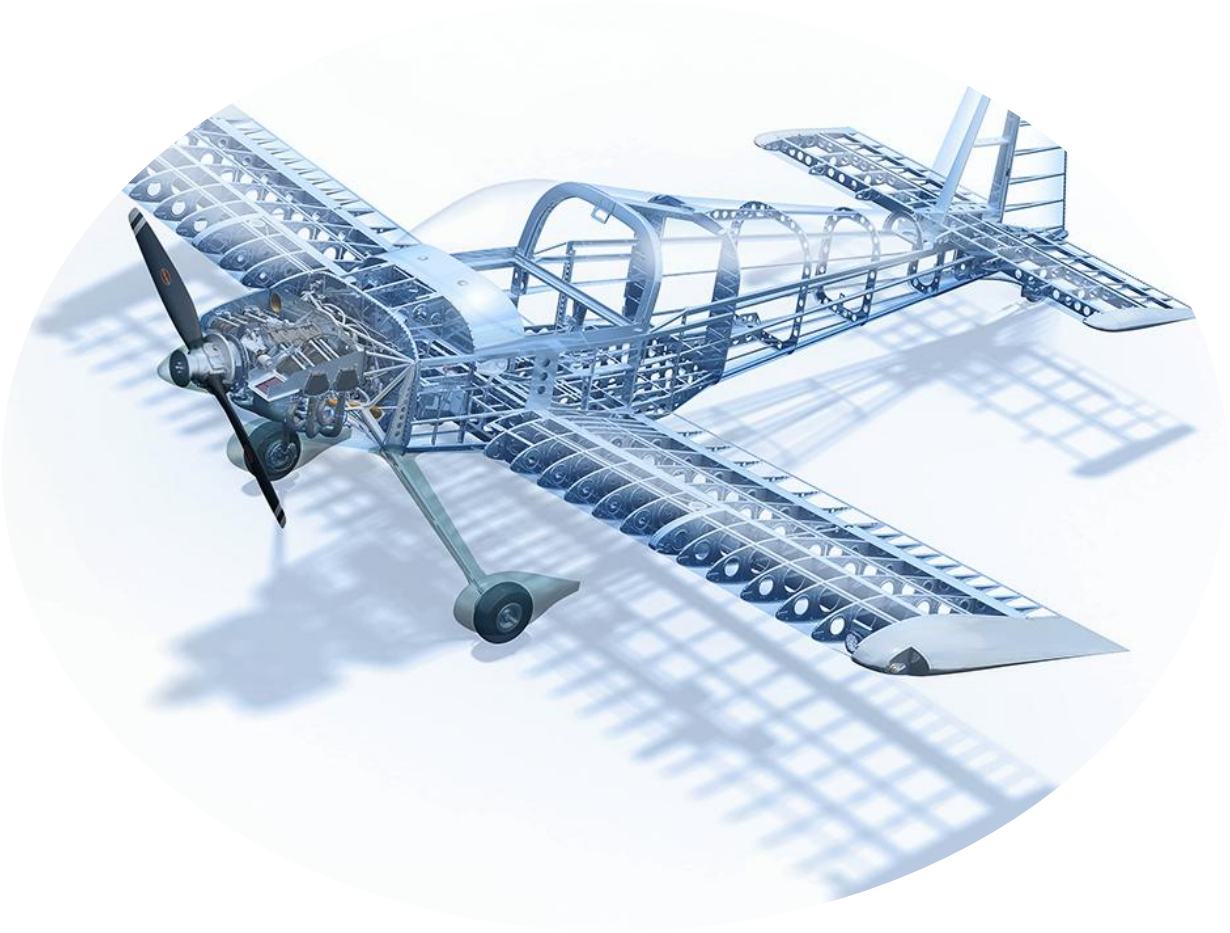
(a) Maintenance of aircraft
(b) Preventing collisions and maintaining orderly flow of air traffic
(c) Operation of runway lighting
(d) Management of airport facilities

Short Answer Type Questions

Q1. Write short note how aero models are powered.
Q2. Name categories of drone
Q3. What are the parts of drone
Q4. Explain drone construction process
Q5. Name 3 sensor or payload of drone.

Long Answer Type Questions

Q1. Write a note materials used in aero model.
Q2. What are the types of aeromodel.
Q3. Describe construction of control line.
Q4. Describe construction of RC model.
Q5. Explain how models are tested in air.



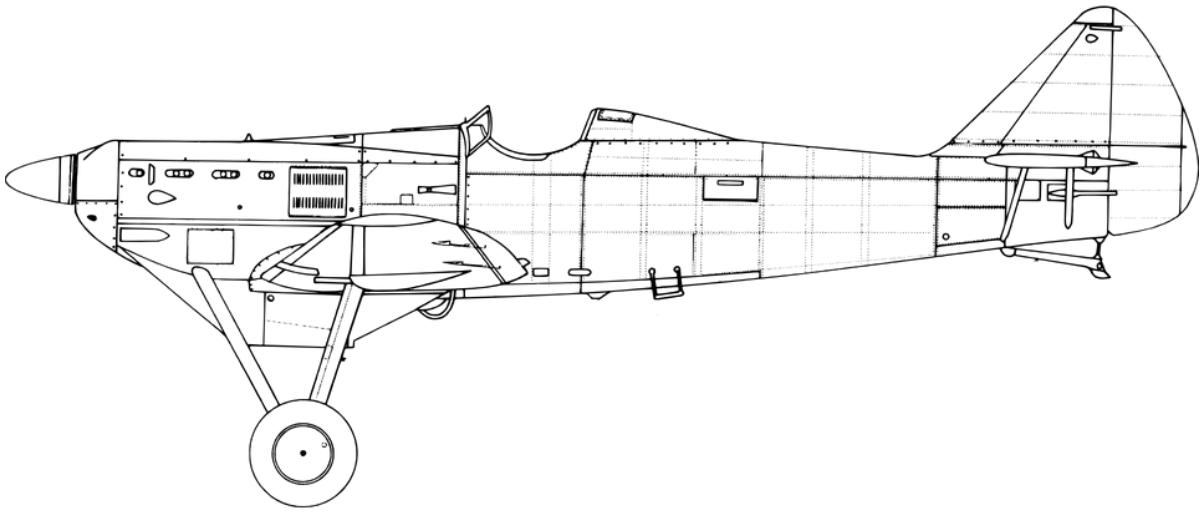
AIRFRAME

"Once you have tasted flight, you will forever walk the earth with your eyes turned skyward"

9

CHAPTER WISE INDEX: AF (JD/JW)

CHAPTER AF: AIRCRAFT PARTS AND CONTROLS



TEACHING INSTRUCTIONS

Period	**:**	**Three (03).120 Minutes**
Type	**:**	**Lecture and Practical**
Year	**:**	**2nd Year JD/JW**
Conducting Officer	**:**	**Permanent Instructor**

Training Aids : Class Room, PPT, White board and markers, PC with internet. OHP, Hand book and visit to hangar for demonstrated class on microlight.

Time Plan

- **Introduction : 05 Mins**
- **Basic definitions : 10 Mins**
- **Aircraft Parts : 10 Mins**
- **Aircraft Controls : 15 Mins**
- **Main Control Surfaces : 15 Mins**
- **Landing Gear : 05 Mins**
- **Demonstrated learning on microlight : 60 Mins**

INTRODUCTION

The airframe of a fixed-wing aircraft is generally considered to consist of five principal units, the fuselage, wings, stabilizers, flight control surfaces, and landing gear. Similarly helicopter airframes consist of the fuselage, main rotor, tail rotor (on helicopters with a single main rotor), and related gearbox, and the landing gear.

INTERESTING FACTS

- **Loss of control has been the cause of many air disasters. Aeroflot Flight 8641. Metal fatigue in the jackscrew of the horizontal stabilizer caused the component to fail while the plane was enroute from Leningrad to Kyiv, Ukraine, on 28 June 1982. The crew lost control of the plane, and at 10:50 crashed just south of the city of Mazyr in Belarus, killing all on board.**

PREVIEW

The lecture will be conducted in the following parts:

- **Part I : Definition.**
- **Part II: Aircraft Parts.**
- **Part III: Aircraft Controls.**
- **Part IV: Main Control Surfaces.**
- **Part V: Landing Gear.**

LEARNING OBJECTIVES

- **Basic definitions.**
- **Understanding the airframe structure.**
- **Understanding the control surfaces.**
- **Landing gear system.**
- **Demonstrated learning on microlight.**

PART I: DEFINITIONS

1. **Aeroplane**. A mechanically driven heavier than air aircraft (fixed wing) supported by dynamic reactions of the air upon its wings.

2. **Aerofoil**. A surface designed to produce lift when driven through the air.

3. **Aileron**. A horizontal control surface usually hinged to rear spar of main plane near wing tip for the purpose of lateral (roll) control (Fig 1-1).

4. **Aircraft**. Any weight carrying device designed to be supported by the air, either buoyant or dynamic.

5. **Airframe**. An aircraft without its engine/engines.

6. **Air Brake**. Any device primarily used to increase the air drag of an aircraft at will.

7. **Angle of Attack**. The angle which the chord line makes with the relative airflow.

8. **Camber**. The curvature of a surface of an aerofoil.

9. **Cantilever**. A spar or beam fixed rigidly at one end only.

10. **Centre of Gravity**. That point at which the total weight is considered to act, irrespective of the position of the body concerned.

11. **Centre of Pressure**. The point, usually on the chord line, through which the total reaction may be considered to act.

12. **Centre Section**. The portion of the fuselage or hull forming a continuous structure with the mainplane.

13. **Chord**. The distance between the leading and trailing edge of an aerofoil measured along the chord line.

14. **Cockpit**. The portion of a fuselage designed to accommodate pilot and crew.

15. **Control**. The intentional manoeuvring of the aircraft into any desired position.

16. **Control Column**. The lever (or the pillar supporting hand wheel) by which the elevator and aileron controls are operated.

17. **Control Surface**. A surface movable in flight, whose primary function is to govern the motion of aircraft in pitch, roll or yaw.

18. **Longerons**. The principle longitudinal members of the fuselage which run from front to rear and is usually supported at various points along its length by other structural members.

19. **Longitudinal Axis**. An imaginary line running fore and aft through the centre of gravity.

20. **Lateral Axis**. An imaginary line through aircraft's centre of gravity considered to be parallel to line joining the wing tips.

21. **Incidence Angle**. The angle which the chord line makes with the horizontal.

22. **Fuselage**. The main structure or body of most types of the aircraft to which wings, tail plane, fin, rudder and other surfaces are attached.

23. **Frames**. Transverse structural members of the fuselage supporting the longerons.

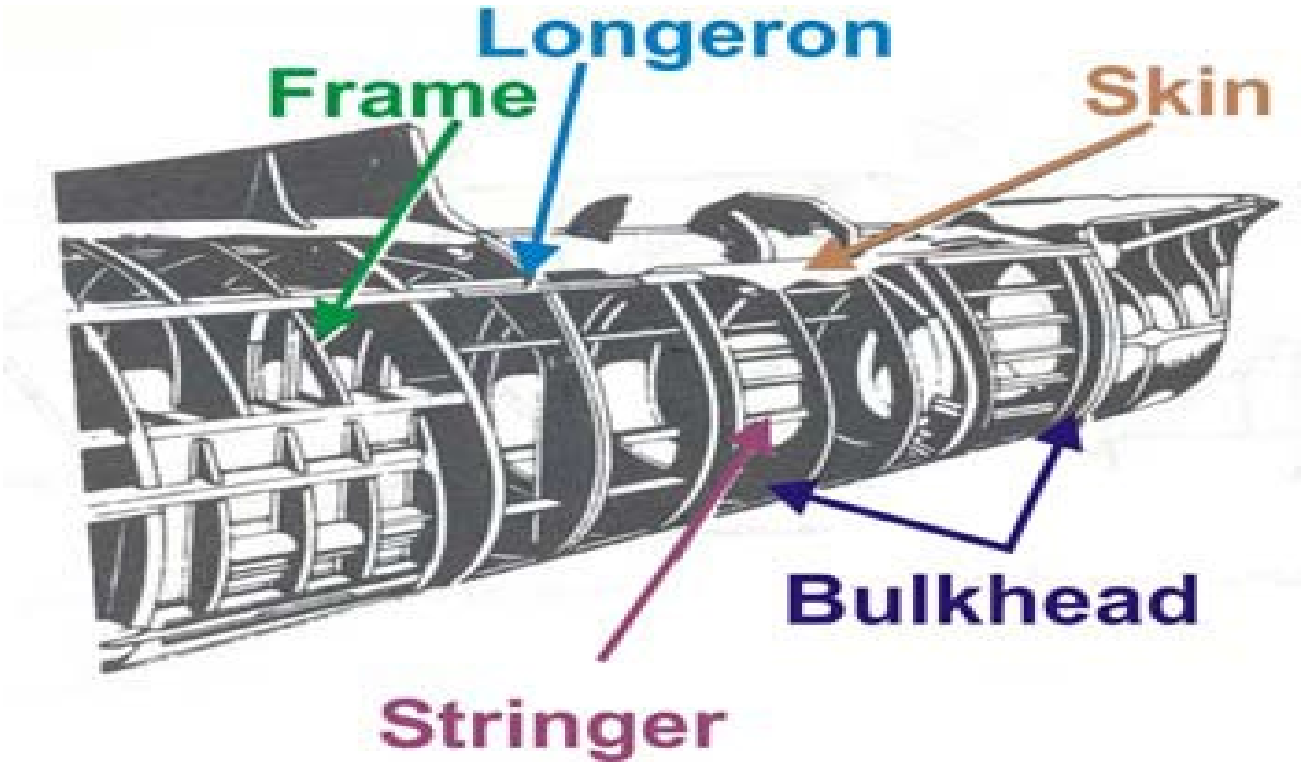
24. **Fairing**. Additions to any structure to reduce its drag.

25. **Glider**. A non-power driven heavier than air aircraft.

PART II: AIRCRAFT PARTS

Introduction

26. The airframe components are constructed of a wide variety of materials and are joined by rivets, bolts, screws, and welding or adhesives. The aircraft components are composed of various parts called structural members (i.e., stringers, longerons, ribs, bulkheads, etc.).



Cut Out of a Fuselage

27. Aircraft structural members are designed to carry a load or to resist stress. A single member of the structure may be subjected to a combination of stresses. In most cases the structural members are designed to carry end loads rather than side loads that is, to be subjected to tension or compression rather than bending. Strength may be the principal requirement in certain structures, while others need entirely different qualities. For example,

cowling, fairing, and similar parts usually are not required to carry the stresses imposed by flight or the landing loads. However, these parts must have such properties as neat appearance and streamlined shapes.

Fuselage

28. The fuselage is the main structure or body of the aircraft. It provides space for cargo, controls, accessories, passengers and other equipment. In single engine aircraft, it also houses the power plant. In multi-engine aircraft the engines may either be in the fuselage, attached to the fuselage, or suspended from the wing structure. There are three general types of fuselage construction: the truss type, monocoque type and the semi-monocoque type.

Basic Design

29. The basic design of fuselage should satisfy the following:-

(a) Smooth skin of the required aerodynamic form.
(b) Sufficient strength to withstand aerodynamic loads, landing loads and handling loads.
(c) Sufficient stiffness to retain its correct shape under all loads.
(d) Mounting points for engine, armament, fuel tanks and equipment.
(e) Protection of aircrew and passengers from ambient conditions.
(f) Sufficient break down points for easy dismantling for transportation and port- holes accessible for inspection and servicing.
(g) Design itself should be economical and easy for production and repairs.

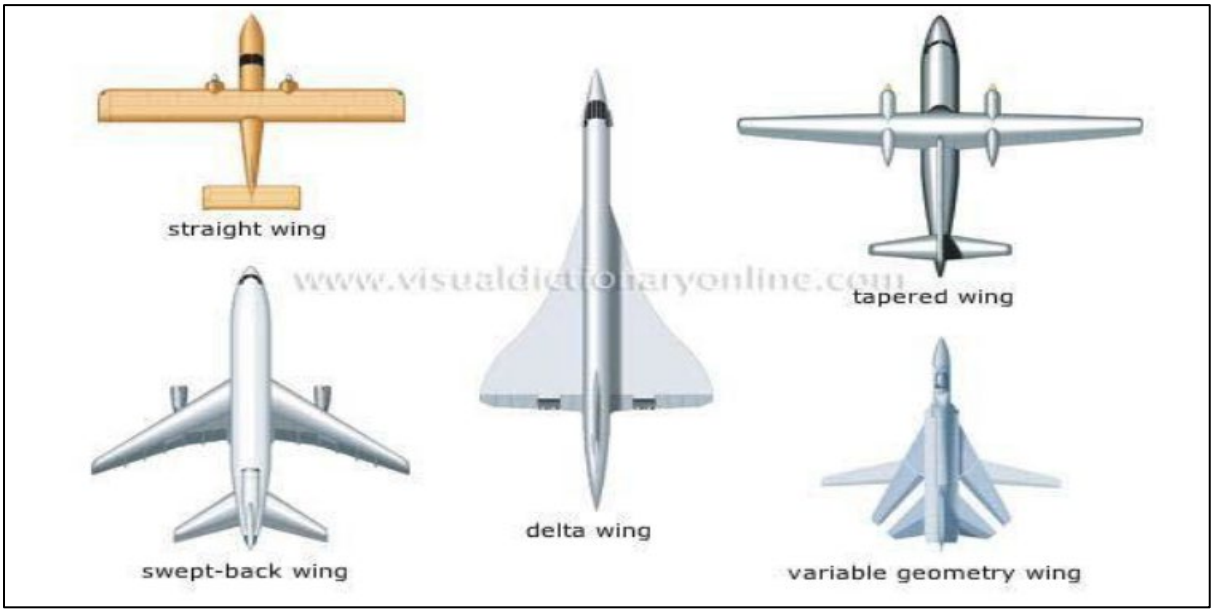
Materials Used

30. Early aircraft were constructed of wood frames covered in fabric. As monoplanes became popular, metal frames improved the strength, which eventually led to all-metal aircraft with metal covering all surfaces. Some modern aircraft are constructed with composite materials for major control surfaces, wings or the entire fuselage such as the Boeing 787. Hence the various types of materials used are wood, metals and composites

Wing Structure

31. The wings of an aircraft are surfaces which are designed to produce lift when moved rapidly through the air. The particular design for any given aircraft depends on a number of factors, such as size, weight, use of the aircraft, desired speed in flight & at landing, and desired rate of climb.

Different Types of Wings



32. There are various types of wings as shown in figure. They are as follows straight wing, swept back wing, delta wing, tapered wing and variable geometry wing.

DID YOU KNOW?

- The Antonov An-225 is the largest aircraft ever built, with a maximum take off weight of 640 tons. It was designed in Ukraine and first flew in 1988. The An-225 was used to transport the Soviet space shuttle Buran and other oversized cargo. However, the only An-225 was destroyed during the Russian invasion of Ukraine in 2022.

PART III: AIRCRAFT CONTROLS

33. A conventional wing aircraft flight control system consists of flight control surfaces, the respective cockpit controls, connecting linkages, and the necessary operating mechanisms to control an aircraft's direction in flight. Aircraft engine controls are also considered as flight controls as they change speed. Generally basic aircraft control can be classified as follows Primary controls and Secondary controls.

34. The basic aircraft controls are classified in to following:

(a) **Primary Controls**. The primary aircraft controls are as follows:

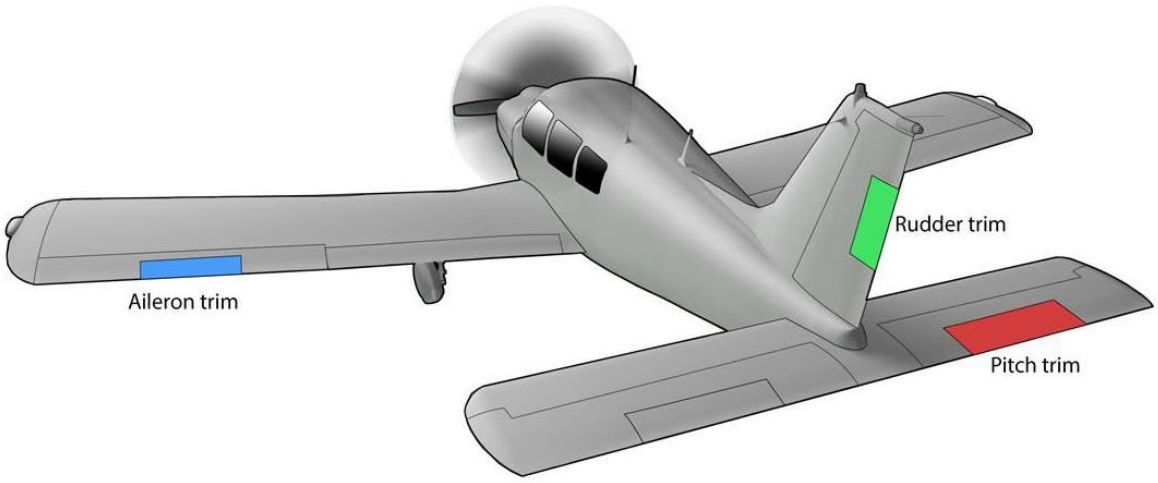
(i) A control yoke (also known as a control column), centre stick, or side-stick governs the aircraft's roll and pitch by moving the ailerons when turned or deflected left and right, and moves the elevators when moved backwards or forwards.

(ii) Rudder pedals control yaw by moving the rudder; for instance, pressing the left foot forward will move the rudder left.

(iii) Throttle controls regulate engine speed or thrust for powered aircraft.

(b) **Secondary Controls**. The secondary controls are trim tab, flaps, air brakes, spoiler, leading edge slats and variable-sweep wing.

(i) Trim tabs are small control surfaces connected to the trailing edge of a larger control surface on an aircraft. They are used to control the trim of the controls, i.e., to counteract aerodynamic forces and stabilize the aircraft in a desired attitude without the need for the operator to constantly apply a control force.



(ii) Air brakes and spoilers: Air brakes, or speed brakes, are a type of flight control surface used on an aircraft to increase drag. Spoilers are designed to increase drag while making little change to lift.

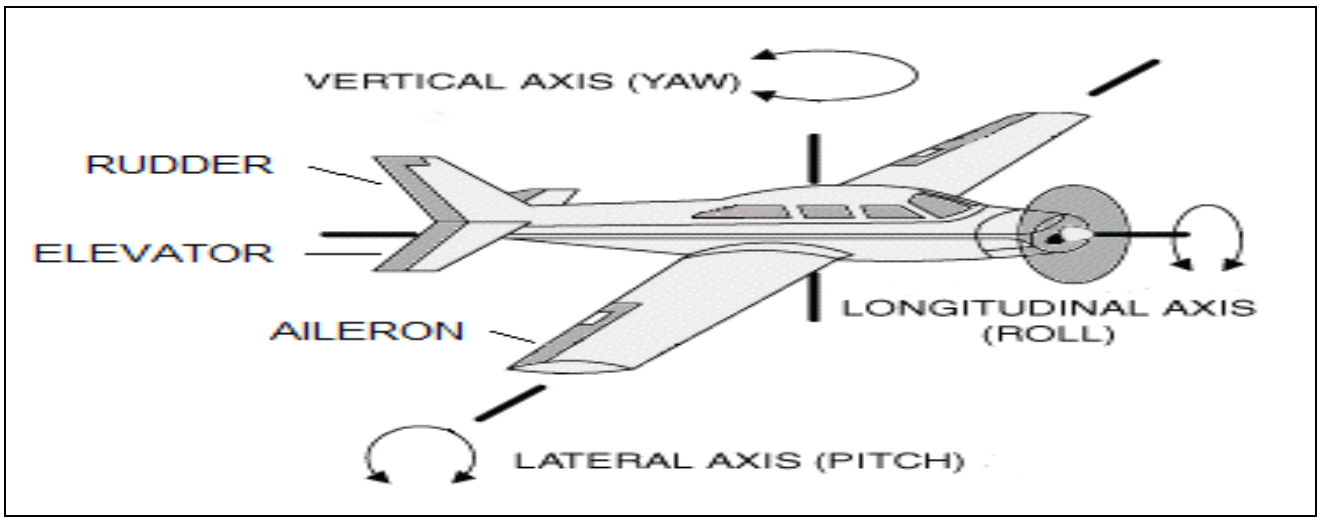
(iii) Slats: Slats are aerodynamic surfaces on the leading edge of the wings of fixed-wing aircraft which, when deployed, allow the wing to operate at a higher angle of attack. A higher coefficient of lift is produced as a result of angle of attack and speed, so by deploying slats an aircraft can fly at slower speeds or take off and land in shorter distances. They are usually used while landing or performing manoeuvres that take the aircraft close to a stall, but are typically retracted in normal flight to minimize drag.

(iv) **Variable - Sweep Wing**. A variable-sweep wing, also known as "swing wing", is an aeroplane wing that may be swept back and then returned to its original position during flight. It allows the aircraft's planform to be modified in flight, and is therefore an example of a variable-geometry aircraft.

(v) **Flaps**. Flaps are hinged surfaces mounted on the trailing edges of the wings of a fixed- wing aircraft to reduce the speed at which an aircraft can be safely flown and to increase the angle of descent for landing. They shorten take-off and landing distances. Flaps do this by lowering the stall speed and increasing the drag.

PART IV: MAIN CONTROL SURFACES

35. The main control surfaces are Aileron, Elevator and Rudders and are attached to the airframe on hinges or tracks so that they may move and thereby deflect the air stream passing over them.



Main Controls

Ailerons

36. Ailerons are mounted on the trailing edge of each wing near the wingtips and move in opposite directions. When the pilot moves the stick left, or turns the wheel counter-clockwise, the left aileron goes up and the right aileron goes down. A raised aileron reduces lift on that wing and a lowered one increases lift, so moving the stick left causes the left wing to drop and the right wing to rise. This causes the aircraft to roll to the left and begin to turn to the left.

Elevators

37. An elevator is mounted on the trailing edge of the horizontal stabilizer on each side of the fin in the tail, as shown in the figure above. They move up and down together. When the pilot pulls the stick backward, the elevators go up. Pushing the stick forward causes the

elevators to go down. Raised elevators push down on the tail and cause the nose to pitch up. This makes the wings fly at a higher angle of attack, which generates more lift and more drag.

Rudder

38. The rudder is a fundamental control surface, typically controlled by pedals rather than at the stick. It is the primary means of controlling yaw-the rotation of an airplane about its vertical axis. On an aircraft, the rudder is a directional control surface. The rudder is usually attached to the fin (or vertical stabilizer) which allows the pilot to control yaw about the vertical axis, i.e. change the horizontal direction in which the nose is pointing. The rudder's direction in aircraft has been manipulated with the movement of a pair of foot pedals by the pilot.

PART V: LANDING GEAR

39. The functions of a landing gear are to support an aircraft during ground manoeuvres, dampen vibration, and absorb landing shocks; when required, it also performs the functions of steering and braking. These objectives are achieved by many different designs, depending on the type of aircraft to which the landing gear is fitted and the degree of sophistication required. A landing gear usually takes the form of two or more main undercarriage units in the wings or fuselage, and an auxiliary undercarriage unit at the nose or tail which carries only a small proportion of the total load and is used for steering purposes.

Landing Gears

40. With slow, light aircraft, and some larger aircraft on which simplicity is of prime importance, a fixed (non-retractable) landing gear is often fitted; the reduced performance caused by the drag of the landing gear during flight is offset by the simplicity, reduced maintenance and low initial cost. With higher performance aircraft, drag becomes progressively more important, and the landing gear is retracted into the wings or fuselage during flight; there are however, penalties of increased weight, greater complication and additional maintenance.

CONCLUSION

41. Airframe materials must be strong, lightweight, and reliable to support the weight of the aircraft and the additional loads it experiences during flight and landing. They must also be able to withstand extreme temperatures, moisture, and ultraviolet radiation. When an aircraft is flying, the wings and fuselage experience stresses from acceleration and deceleration. These stresses include tension, compression, shear, bending, and torsion. The

landing gear absorbs the forces from take-offs and landings. Airframes must be designed to meet airworthiness requirements.

42. An airframe is the mechanical structure of an aircraft, excluding the power plant and instrumentation. The main components of an airframe are the wings, fuselage, tail assembly, and landing gear. The wings are considered the most important component because they provide lift to keep the aircraft airborne.

43. Primary controls and secondary controls are the most essential control systems for all types of aircraft.

44. The functions of flight control systems such as ailerons, elevators, elevons, flaps and flaperons are the most important to the understanding of aircraft controls.

45. The functions of a landing gear are to support an aircraft during ground manoeuvres, dampen vibration, and absorb landing shocks.

ASSESSMENT EXERCISE

Q1. What is the primary function of an aircraft's fuselage?

(a) To provide lift
(b) To reduce drag
(c) To support aircraft components and cargo
(d) To control flight

Q2. Which aircraft structural component provides additional lift during take off and landing?

(a) Ailerons
(b) Elevators
(c) Flaps
(d) Rudder

Q3. Which aircraft structural component controls roll?

(a) Ailerons
(b) Elevators
(c) Rudder
(d) Flaps

Q4. What is the purpose of an aircraft's rib?

(a) To provide structural support to the wing
(b) To control airflow over the wing
(c) To reduce wing vibration
(d) To increase lift

Q5. Which wing shape provides improved roll control?

(a) Tapered
(b) Rectangular
(c) Swept-back
(d) Delta

Q6. A surface designed to produce lift when driven through the air.

(a) Trim tab
(b) Aerofoil
(c) Wing Tip
(d) Propeller

Q7. A horizontal control surface usually hinged to rear spar of main plane near wing tip for the purpose of lateral (roll).

(a) Trim Tab (b) Rudder
(c) Aileron (d) Elevator

Q8. The curvature of a surface of an aerofoil.

(a) Wing
(b) Camber
(c) Aileron
(d) Parachute

Q9. The principle longitudinal members of the fuselage which run from front to rear.

(a) Longeron
(b) Spar
(c) Frame
(d) Fairing

Q10. Parts usually that are not required to carry the stresses imposed by flight or the landing loads.

(a) Tail Plane
(b) Wing Spar
(c) Tyre
(d) Fairing and cowling

Q11. In single engine aircraft, also houses the power plant.

(a) Wing
(b) Fuselage
(c) Cockpit
(d) Cargo Compartment

Q12. Boeing 787 Dreamliner wing is constructed mainly with

(a) Wood
(b) Metal
(c) Composite
(d) Glass

Q13. Transverse structural members of the fuselage supporting the longerons.

(a) Longeron
(b) Spar
(c) Frame
(d) Fairing

Q14. A non-power driven heavier than air aircraft.

(a) Balloon
(b) Glider
(c) Para Motor
(d) Aerostat

Q15. Change of direction is achieved by

(a) Roll
(b) Pitch
(c) Yaw
(d) Yaw, Pitch and Roll

Q16. What is the primary function of the landing gear?

(a) To provide propulsion
(b) To control direction
(c) To absorb shock
(d) To support aircraft during landing

Short Answer Questions

Q1. What is the function of an aircraft's fuselage?

Q2. What materials are commonly used in aircraft structures?

Q3. Write a short note on various wing types?

Q4. Describe the purpose of landing gear.

Long Answer Questions

Q1. What are the basic design features of a fuselage?

Q2. Explain the function of the flight control system.

Q3. Describe various types of secondary flying controls?

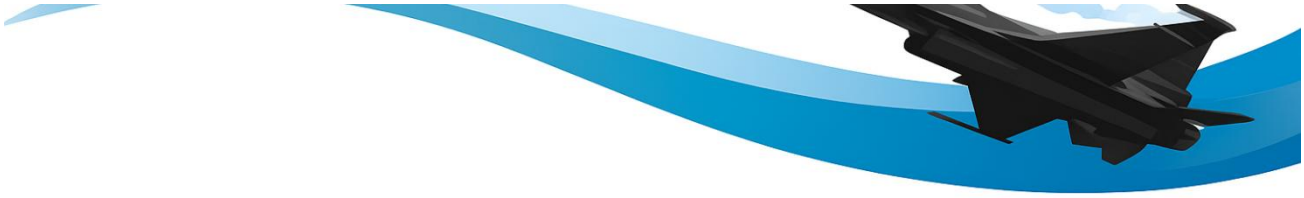
Q4. With the help of a diagram explain the primary control surfaces.

AEROMODELLING

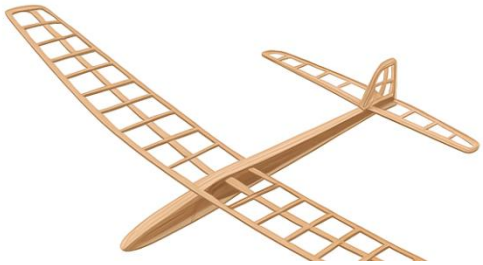
10

CHAPTER WISE INDEX: AE (JD/JW)

CHAPTER AE: AEROMODELLING



AEROMODELLING



TEACHING INSTRUCTIONS

Type : Lecture and Practical
Year : 2nd Year JD/JW
Conducting Officer : AMI/CO

Training Aids: Class room, Computer, OHP Marker, Screen, Pointer, Presentation and practical learning during conduct of Aeromodelling.

Time Plan

- **Introduction : 10 Mins**
- **Part I : 20 Mins**
- **Part II : 20 Mins**
- **Part III : 20 Mins**
- **Conclusion and Practice : 10 Mins**

After 2 periods of theoretical class, 7 periods of practical class at aeromodelling workshop will be Conducted. The cadets will be demonstrated the flying of aero models.

INTRODUCTION

1. Aeromodelling is one of the finest & costly hobbies, which is very popular worldwide among people of various age groups. It has often been the starting point of many pilot/ aero-nautical careers. The aim of including aeromodelling in the NCC curriculum is to enhance the interest among NCC cadets. If taken on the right lines, it can be extremely thrilling for all, as by constructing the models by one's own hands, will make understanding of various principles of flight and problems of construction etc., very easy, apart from providing great personal satisfaction to the aero modeller.

2. There are quite a number of variants of aero models, which are classified according to the role and utility of the particular type, the main types are described in the following parts.

3. International competitions for different aeromodelling events are organized at various levels across the world. In India the apex body for aeromodelling is known as 'All India Aeromodellers Association' which conducts 'all India' competitions in various events. Gradually, aeromodelling is becoming increasingly popular all over the country specially amongst the NCC Airwing cadets.

PREVIEW

The lecture will be covered in following parts:

- **Part I: History of Aeromodelling**.
- **Part II: Types of Aeromodels**.
- **Part III: Flying /Building of Aeromodels**.

LEARNING OBJECTIVES

What is aeromodelling and its history

- **Types of aeromodels and material used in building**.
- **Flying procedure of an aeromodel**.

PART I: HISTORY OF AEROMODELLING

4. 'Aeromodelling' is a costly hobby. The material and equipment are expensive, and can only be procured conveniently by people forming various clubs and associations. As a result, there have come up hundreds of such clubs all over the world, where like-minded people get together and have access to approved materials and equipment in sufficient quantity. International competitions for different aeromodelling events,

have now become a regular feature. In India the apex body for aeromodelling is known as 'All India Aeromodellers Association' which conducts 'all India' competitions in various events. Gradually, aeromodelling is becoming increasingly popular all over the country specially amongst the NCC Airwing cadets.

5. It can thus be seen that "aeromodelling" provides an earnest approach to the understanding of an otherwise highly technical subject, i.e. "aerodynamics". The 'air minded' aeromodeller of today is the potential aircraft designer of to-morrow. Although, aeromodelling is a technical hobby and is usually cluttered up with complicated calculations and formulae, it need not necessarily discourage the beginners and the non-technical persons, as they can still derive immense plea- sure and satisfaction from this hobby.

6. The history of aeromodelling goes back much further than the history of real aircraft. The successful experiments, however, started in the nineteenth century. Dr. Thomas Young was the first person to discover the ‘lifting’ property of a cambered surface in comparison to the flat surface. Sir George Caley built a helicopter model, based on a design of Leonardo-da-Vinci, in 1796. Another great name amongst the pioneers of aeromodelling is of Alphones Penand, who invented models fitted with tail surfaces and wings with dihedral angles. This gave substantial stability of flight to aero models, which till this time had lasted for very short duration. After this, came the era of miniature petrol-driven engines. In 1878, Professor Langley builds a petrol driven model called ‘Aerodrome No.5’. This revolutionalised the concept of aeromodelling, as there was now an ideal power plant small enough for the requirement, available to the enthusiasts. Hundreds of varieties of petrol models were subsequently built. Later, these gave ways to more powerful diesel engines, which are in use even today.

Materials used in Aeromodelling

7. Aeromodelling requires a variety of materials. Selection of correct material and proper use of the same is important factor of Aeromodelling. The following are the main substances from which the Aero models can be made:

(a)	Balsa Wood	(b)	Spruce	(c)	Japanica Wood fast
(d)	Plywood	(e)	Cement	(f)	Setting Epoxy
(g)	Cyanoarcylate Glue (Cyano)	(h)	Putty	(j)	Metal Paste
(k)	Dope	(l)	Paint	(m)	Sand Paper
(n)	Fiber glass	(o)	Carbon Fibre	(p)	Silver foil
(q)	Monokote & etc				

8. **Wood**. Types of wood used in construction of aeromodels is as follows-

(a) **Balsa**. This wood is very light and can be easily worked for almost every purpose in aeromodelling. Balsa, however, is a short-grained wood and should not be used for highly stressed parts of the model. It is also prone to absorb moisture and rubber lubricants. Balsa was found in the forests of South America from where it has since spread all over the world. There are many varieties of Balsa, the best of the type is known as medium hard Balsa, which gives the best combination of

strength and lightness. Balsa wood is available in a variety of sections and thickness of sheets.

(b) **Spruce**. Next to Balsa wood comes silver spruce, which is light as well as strong. It has been used extensively in manufacturing full sized aircraft and heavier type of models. It is mainly used for fuselage, longerons, bracing struts and wing spars.

(c) **Birch**. It is stronger than silver spruce but also heavier. It is used where extreme strength is required i.e. heavy power models.

(d) **Bass Wood**. It is mainly used as a Balsa substitute. Its working properties are similar to Balsa except that it is much stronger. Basswood blocks are found ideal for making propellers and wings of solid models.

(e) **Cane and Bamboo**. They are ideally suited for tail and rudder frames as they are strong, light and flexible Under car - ridges are generally made of bamboo.

(f) **Plywood**. Plywood sheets are used for paneling work, formers and wing tips. Plywood is a very strong material.

(g) **Pine**. White wood and Mahogany: Propeller blades are sometimes made of these types of wood.

9. **Fabric and Tissue**. Tissue paper sheets are used to cover the model aircraft after construction. They are available in various weights and colours. For heavier and power-driven models, silk fabric (Chinese or Japanese) and-bamboo paper are all needed, being strong. Synthetic silk is not useful since it dissolves out by the action of dope.

10. **Dope**. Doping is used for the following purposes:

(a) For air-proofing of surface.

(b) For tightening the surface skin by plasticising effect.

(c) For making the model hardy and less vulnerable to weather conditions.

Dope is a liquid which has celluloid and thinner as basic mate- rials. It is available in a variety of colours. Several thin (diluted) sprays are preferable to one or two heavy coats. These applications should be allowed to dry naturally for best effects. Extremely light models are not doped, but sprayed with water and left to dry.

11. **Adhesives**. These comprise of glues and cements of various types and are used for joining various parts of model aircraft.

12. **Wire**. Common piano wire is used for under-carriages of aero models. Wing tips, propeller shafts, rudder frames, all are generally fixed with hooks etc. made out of such wires and springs.

13. **Rubber**. Rubber bands are used for making various types of rubber- models. They are also used for keeping various a/c parts attached in their respective positions.

Rubber bands should be stored in air tight containers with french chalk powder, and should be lubricated before use. There is also a variety of other materials which is used in aeromodelling i.e. metal tubing made of brass and aluminium, cello-phane, small nails, celluloid etc.

14. **Basic tools**. Majorly using tools used in aeromodelling are listed below:

(a) Screw driver

(b) Hand drill

(c) Sand paper and pins

(d) Pliers

(e) Knives with different blades

(f) Different kinds of saw

(g) Files

(h) Soldering irons

(i) RC set (Transmitter and receiver, servos)

15. After selection of good materials and required tools, one has to handle these tools carefully. Mishandling of tools may cause serious injuries to the Aeromodellers/ builders.

PART II: TYPES OF AEROMODELS

16. **Introduction**. There are quite a number of variants of aero models, which are classified according to the role and utility of the particular type, the main types are described in the following pages.

17. **Static models**. These are the miniature replicas of the original, full sized aircraft types and attract the best skills of the model maker. The scope of this particular type is boundless and depends upon the ideas of the individual concerned. It requires only an elementary knowledge of carpentry and involves fitting together of the various parts as well as finishing and painting of the models.

18. **Gliders**.

(a) **Chuck Gliders**. These are solid balsa models which have to be hand-catapulted. These are available in kit forms and are precut to the required sizes. They just have to be cemented together. Chuck gliders are further classified as:

(i) Hand launched

(ii) Catapult Launched

(b) **Towline Glider**. These models have a far superior performance as compared to the chuck glider. They are quite robust and professional looking, and have stable flight characteristics. There are normally 3 components to the model when completely built up i.e. wing, fuselage and tailplane. It is therefore convenient to carry them to the flying grounds and assemble them with rubber bands. The standard methods of launching them it either from the shoulder or by a towline.

(c) **Sail plain**. These are advanced type of gliders. These beautiful models are intended for contest flying. Their building method is same as earlier models. They are however a little complicated in structure. The launching methods is same as previous. In a strong wind, the model will climb on the line without even pulling on the towline.

19. **Rubber Models**. These models get their power to fly from rubber strips. One end of the strip is attached to the fuselage as an anchorage and the other end is tied to the propeller hook. The propeller is now wound a number of given turns and when the models is launched the rubber unwinds itself, spurning the propeller and propelling the model forward.

20. **Power Models**. The power models have a long history. The main types are listed below.

(a) **Free Flight Model**. These required large, open fields to perform. They are usually hand- launched although some modellers often prefer an ROG (Rise off ground). These models are divided into 2 categories i.e (i) sport and (ii) contest. The SPORT type possesses a reasonable degree of stability, whereas the CONTEST type has exceptional flying characteristics.

(b) **Control Line Model**. This type is CONTROLLED from the ground by its PILOT. Two wires are attached to the model and terminate at a CENTRAL HANDLE which is held by the PILOT. These wires control the up and down movement of the elevator or flap of the model. By pulling the handle up, the elevators or flaps of the model move up, resulting in the model climbing. Similarly, by moving the handle down or forward, the elevator of the model moves down, resulting in the closest a person can get to physically controlling a model. Control a model. Control models can be further divided into 4 main categories.

(i) Trainer Model

(ii) Stunt Mode

(iii) Speed Model

(iv) Team Racer

(b) **Radio Controlled Models**. This type of model is fitted with radio receiver sets which, through a set of actuators operate the control surfaces of the model. The radio receiver receives the signals from the control box which is operated by the PILOT. The control box is nothing, but a transmitter with various channels for operating the respective controls including throttle. This way, the model can be operated without physical contact.

DID YOU KNOW?

- It is a popular pastime that requires both technical skills and creativity to create miniature replicas of real-life planes and helicopters.
- Aeromodelling can be a great way to learn about aviation and engineering.
- Another important aspect of aeromodelling is propulsion. The engines or motors that power model airplanes must be carefully chosen and configured to provide the right amount of power and thrust for the size and weight of the aircraft. This involves knowledge of mechanics and physics, including the principles of torque, power, and energy.

21. **Jetex Models**. These models illustrate the operation of the jet aircraft. They get their power from jetex power units which can be fixed on to the model by a simple clip. It does not produce any torque, like a propeller driven aircraft and the thrust is almost straight and constant, the trimming of this type is quite simple also.

22. **Engines for Aeromodels**. There are four different types of miniature engines used in aeromodels. Although their basic features are similar, they differ in the manner of their operation. These are listed below:

(a) Spark Ignition

(b) Diesel

(c) Glow-plug

(d) Jet

23. **Fuel**. Following are the two most commonly used fuel mixture:

(a) Diesel oil Ether Lubricating oil

(b) Mobile oil SAE-40 Paraffin Ether

PART III: FLYING /BUILDING OF AEROMODELS

Construction of Static Models

24. These are the miniature replicas of original aircrafts, full sized aircraft types and attract the best skill of the model maker. The scope of this particular type is boundless and depends upon the ideas of the individual concerned. It requires only an elementary knowledge of carpentry and involves fitting together of various parts as well as finishing and painting of the models.

25. Constructions plans are provided normally with all model kits. These should be studied thoroughly. Then follow the shaping of various parts using sandpaper and sand blocks as shown in the blue print. After which the whole plan is fixed on the drawing board. Then the individual parts are placed on the blue print and make sure it is proper as per the blue print. Parts are then assembled together as per the dimensions provided in the blue print. Dope is applied with brush but only in thin coats two to three times. Sand the excess dope using a fine emery paper.

26. **Painting**. Apply a coat of surfacer using a brush or spray gun and make sure it has covered all the wooden area. After the surfacer is dried up check for dents and apply putty or metal paste to cover the dents. After it dries up using a wet emery paper, sand the model to get a clean surface till it is suitable for painting. Etch rivet marking as shown in the blue print. Spray a thin layer of base coat and paint the model as per the required colour

scheme. Add details, undercarriage, wheels, drop tanks etc. & apply lacquer or polish if required.

Construction of Control Line Models

27. Each and every part of a model aero plane is important as it would not function in the absence of even one component. Construction plans are provided normally with all model kits. These should be studied thoroughly. Then follows the actual construction of various parts. The power units are, also available in readymade forms, and are required to be installed as they are, as per the power/weight combination prescribed by the manufactures.

28. First, the whole plan is fixed on to the drawing board. Then the individual parts are fixed on it with the help of pins parts are then glued together with cement. After drying, the various components are assembled together with correct alignment. Sand papers of various grades are used for smoothening out of edges and curves. Patience and meticulous operation is needed at this point. Assemble the bell crank assembly with the lead outs carefully. Model is then covered with sliver foil, monokote or tissue paper. Dope may be applied with brush, in thin coats two to three times.

29. Before engine installation, ensure that the engine compartment is properly treated with paint work. While installing the engine, extreme care is needed to be taken to ensure that the thrust line of the propeller is in line with the fuselage. Out of line thrust will result in the model going hay wire and crashing. Engines are mounted either by projection made of hard wood beams or on screws against the plywood.

30. Install the Radio-control servos as per the requirement to make sure the control rods should move freely without causing any disturbance to the other control rods. Wrap the receiver and the battery pack in foam and place it in the model in such a way that the CG of the model is correct as per the marking shown in the plan by the manufacturer of the kit. Then assemble the wing using a pairs of rubber bands or nylon screws.

INTERESTING FACTS

- The first recorded Aeromodellers were the Wright Brothers and L.H. Hargrave.
- Aeromodelling is highly educational as it combines hands-on learning with scientific and engineering principles, making it an engaging way for students to understand complex concepts.
- Aeromodelling has real-world applications in fields such as aerospace engineering, aviation, drone technology, and even remote sensing.

Flying The Models

31. The necessity of choosing a large field for flying the aero models is obvious. However, trees and wooded areas are the greatest hazards for the aeromodeller. Trees cause air pockets and down-draughts and often 'suck' the model into their branches.

32. **Flying Sequence**. The flying sequence can be arranged as:

(a) Gliding test

(b) Trail flight

(c) Launching

(d) Trouble Shooting

33. **Gliding test**. First check the model for correction of alignment. The wing and tail must be checked from the front and rear for setting and must not be warped or out of plane. Testing is carried out during mid-day when there is little or no wind. The model is held on the point of balance i.e. approximately 1/3rd back from leading edge of the wing, and is gently launched into wind slightly nose down attitude. If the model is set properly and trimmed correctly, it will glide forward gracefully and will land on wheels. Use plasticine or lead weight at the nose and tail for balance as required.

34. **Trial Flight**. Power flight is not advisable till the gliding test is carried out successfully. For trial flight, a small amount of fuel is put into the fuel tank and the engine started by rotating the propeller. And the model launched gently the model should fly short distance and land perfectly.

35. **Launching**. A good launching is the result of proper coordination between the aero modeller and his helper. The checks which are listed in the gliding test should be followed meticulously in order to achieve best results. Any short cuts or slip-shod procedures would only result in frustration to the aero modeller.

36. **Trouble Shooting**.

(a) During Gliding Test

(i) If the glide angle is too steep, it may be due to the model being under-elevated. The remedy is to move the mainplanes forward along the fuselage.

(ii) If the model ascends first or glides in a series of sweeps, it may due to over-elevation i.e. the center of pressure is situated too much ahead of the e.g. This may also induce stalling. In the case, the mainplanes are moved back along the fuselage. In this case, the tail plain should also be checked for high angle of incidence and corrected if so required.

(b) During power flight

(i) If the model files steeply to the ground (even after correcting for under elevation), it indicates that engine is under-powered and should be changed.

(ii) If the nose goes up, a small packing of bales under the tail-plane leading edge should correct it. If the model nose-dives, the bales packing should be reduced.

(iii) If the model persistently turns to one side it may be due to torque effect. This should be corrected by adjustment of rudder fin, However, if the torque is excessive, the engine should be shifted to one side by giving packing of bales at the side of the engine compartment. The shift should be such that the propeller shaft should point to the opposite direction to which the aircraft tends to turn. When the correction is complete the packing should be made permanent.

(iv) If the model side-slips, it indicates inadequate dihedral angle of the main planes which should be increased.

(v) If the model wallow – it indicates excessive dihedral angle which should be corrected accordingly.

37. It is advisable to keep a log of corrections made for future reference and easier understanding of model flying.

38. **General Safety Code**. The following is the general safety code:

(a) I will not fly my model aircraft in competition or in the presence of spectators until it has been proven to be airworthy by having been previously successfully flight tested.

(b) I will not fly my model higher than approximately 400 feet within 3 miles of an airport without notifying the airport operator. I will give right of way to, and avoid flying in the proximity of full scale aircraft. Where necessary an observer shall beutilized to supervise flying to avoid having models fly in the proximity of full-scale aircraft.

(c) I will abide by the safety rules for the flying site I use, and I will not willfully and deliberately fly my models in a careless, reckless, and/or dangerous manner.

39. **Radio Control Safety Code**. The following is the radio control safety code:

(a) I will have completed a successful radio equipment ground range check before the first flight of a new or repaired model.

(b) I will not fly my model aircraft in the presence of spectators until I become a qualified flyer, unless assisted by an experienced helper.

(c) I will perform my initial turn after take off away from the pit, spectator, and parking areas, and I will not thereafter perform manoeuvers, flights of any sort, or landing approaches over a pit, spectator, or parking area.

CONCLUSION

40. The ‘aero-modelling provides an earnest approach to understanding of an otherwise highly technical subject, i.e ‘aerodynamics. This ‘air-minded’ aero modeller of today is the potential aircraft designer of tomorrow. Although, aero-modelling is a technical hobby and is usually cluttered up with complicated calculations and formulae, it need not necessarily discourage the beginners and the non- technical persons, as they can still derive immense pleasure and satisfaction from this hobby. Gradually, aeromodelling is becoming increasingly popular all over the country especially amongst the NCC Airwing cadets as it aligns with STEM (Science, Technology, Engineering, and Mathematics) education by integrating multiple disciplines, promoting experiential learning, and inspiring students to pursue careers in these fields.

41. Aeromodelling is one of the finest & costly hobbies, which is very popular worldwide among people of various age groups.

42. In India the apex body for aeromodelling is known as 'All India Aeromodellers Association'.

43. Types of wood used in construction of aeromodels are balsa, spruce, birch, bass, cane, bamboo, plywood and pine.

44. Types of Aeromodels are static, gliders, rubber models, power models and jetex models.

45. Flying of Aeromodels involves gliding test, trail flight, launching and trouble shooting.

ASSESSMENT EXERCISE

Multiple Choice Question

Q1. Aeromodelling provides an earnest approach to the understanding of highly technical subject called.

(a) aerodynamics
(b) Thermodynamics
(c) Optics
(d) Electricity

Q2. In Inia the apex body for aeromodelling is known as.

(a) All Asia Aeromodellers Association
(b) International Aeromodellers Association
(c) All India Aeromodellers Association
(d) Indian Aeromodellers Association

Q3. _____ wood is very light and can be easily worked for almost every purpose in aeromodelling.

(a) Balsa
(b) Teak
(c) Pine
(d) Willow

Q4. _____are found ideal for making propellers and wings of solid models.

(a) Basswood blocks
(b) Balsa Blocks
(c) Spruce Blocks
(d) Birch Blocks

Q5. The successful experiments of aeromodelling started in the which century

(a) 18th
(b) 21st
(c) 19th
(d) 20^{th}

Q6. Who was the first person to discover the ‘lifting’ property of a cambered surface in comparison to the flat surfac.

(a) Dr. Thomas Young
(b) Dr. Thomas Edison
(c) Dr. Heisenberg
(d) Dr. Rutherford

Q7. In 1878, Professor Langley builds a petrol driven model called.

(a) Aerodrome No.5
(b) Aerodrome No.6
(c) Aerodrome No.7
(d) Aerodrome No.4

Q8. _____ is used for air-proofing of surface and tightening the surface skin by plasticising effect.

(a) Fabrication
(b) Resizing
(c) Filing
(d) Doping

Q9. _____ are the miniature replicas of the original, full sized aircraft types.
(a) Rubber Models
(b) Chuck Gliders
(c) Catapult Gliders
(d) Static Models

Q10. Control models can be further divided into _____ main categories.

(a) 3
(b) 4
(c) 5
(d) 6

Q11. Which type of model is fitted with radio receiver sets which, through a set of actuators operate the control surfaces of the model.

(a) Static Models
(b) Radio Controlled Models
(c) Gliders
(d) Jetex Models

Q12. Which among these is not a type of miniature engines used in aeromodels

(a) Spark Ignition
(b) Diesel
(c) Glow-plug
(d) Petrol

Q13. The flying sequence can be arranged as:

(a) Trail flight- Gliding test- Launching- Trouble Shooting
(b) Gliding test- Launching- Trail flight- Trouble Shooting
(c) Trouble Shooting- Gliding test- Trail flight- Launching
(d) Gliding test- Trail flight- Launching- Trouble Shooting

Q14. A good launching is the result of proper coordination between _____ & _____

(a) Aero Modeller and Aircraft
(b) Aero Modeller and His Helper
(c) Aircraft and Engine
(d) Remote and Receiver

Q15. If the model files steeply to the ground (even after correcting for under elevation), it indicates that engine is _____ and should be changed.

(a) Under powered
(b) Over powered
(c) Heavy
(d) Light

Q16. If the model persistently turns to one side it may be due to _____ effect

(a) Energy
(b) Banking
(c) torque
(d) Power Variation

Q17. Generally aeromodel is not flown higher than _____ within 3 miles of an airport without notifying the airport operator

(a) 400 Feet
(b) 500 Feet
(c) 600 Feet
(d) 700 Feet

Q18. Which among these is not a component of fuel mixtures

(a) Mobile oil SAE-40
(b) Paraffin
(c) Ether
(d) Petrol

Q19. The 'air minded' aeromodeller of today is the potential _____ designer of to-morrow

(a) Aircraft
(b) Runway
(c) Ship
(d) Weapon

Q20. Which among these is not among the 3 components to the Towline Glider model when completely built up.

(a) Wing
(b) Fuselage
(c) Propeller
(d) Tailplane

Short Answer Type Questions

Q1. Materials used in Aeromodelling?

Q2. Name basic tools used in aeromodelling?

Q3. Name types of Aeromodels?

Q4. Name different types of miniature engines used in Aeromodels?

Q5. Name commonly used fuel mixture?

Long Answer Type Questions

Q1. Write a note on Radio Controlled Models?

Q2. Write a note on Control Line Models?

Q3. Write a note on Gliders, briefly describing each?

Q4. Write a note on the Balsa wood?

Q5. Write a note on the dope and its purpose?

ANSWER KEY

ANSWERS KEY

Q No	AFCAP	IAF	MOAF	MOE	EM	BOA	FOA	AM	AF	AE
1.	(b)	(a)	(c)	(c)	(a)	(a)	(b)	(b)	(c)	(a)
2.	(b)	(d)	(d)	(d)	(b)	(d)	(b)	(c)	(c)	(c)
3.	(c)	(d)	(c)	(c)	(b)	(a)	(b)	(c)	(a)	(a)
4.	(c)	(c)	(a)	(a)	(b)	(a)	(b)	(b)	(a)	(b)
5.	(d)	(a)	(b)	(b)	(c)	(a)	(b)	(d)	(b)	(c)
6.	(b)	(a)	(b)	(b)	(b)	(a)	(b)	(a)	(b)	(a)
7.	(c)	(d)	(a)	(a)	(a)	(a)	(c)	(a)	(c)	(a)
8.	(d)	(a)	(c)	(c)	(b)	(a)	(c)	(b)	(b)	(d)
9.	(a)	(a)	(c)	(c)	(c)	(c)	(c)	(c)	(a)	(d)
10.	(c)	(d)	(d)	(c)	(c)	(a)		(a)	(d)	(b)
11.	(b)		(c)	(d)	(a)	(a)		(a)	(b)	(b)
12.	(a)		(b)	(a)	(b)	(c)		(b)	(c)	(c)
13.	(c)		(d)	(d)	(a)	(b)		(c)	(b)	(d)
14.	(a)		(d)	(a)	(a)	(a)		(d)	(b)	(b)
15.	(a)		(c)	(c)	(b)	(a)		(b)	(d)	(a)
16.										(b)
17.										(b)
18.										(b)
19.										(a)
20.										(c)

ANSWER KEY FILL IN THE BLANKS (MOE)

1. President
2. Ashok chakra
3. 08 Oct
4. AoC-in-C or C-in-C
5. 7
6. 7, AoC-in-C, Air Marshall
7. Nagpur
8. Param Veer chakra, Ashok Chakra
9. Embraer
10. Germany

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