SCHEME :K

Name :_____________________________
Roll No.:_________ Year : 20 ___ 20 __
Exam Seat No. :_____________________

LABORATORY MANUAL FOR

DRONE TECHNOLOGY (316335)

ELECTRONICS ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the following

- Skill development in line with industry requirements
- Industry readiness and improved employability of Diploma holders
- Synergistic relationship with industry
- Collective and Cooperative development of all stake holders
- Technological interventions in societal development
- Access to uniform quality technical education

A Laboratory Manual

for

Drone Technology

(316335)

Semester – VI

(AO/DE/EJ/EK/ET/EX/IE/TE)

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)

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Board of Technical Education, Mumbai
(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai- 400051.

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr./Ms………………………............................... Roll No.…………. of Sixth Semester of Diploma in ………… …..………………………………………………… of Institute …….………………………………………… (Code: ………) has completed the term work satisfactorily in course **Drone Technology (316335)** for the academic year 20…... . to 20…….. as prescribed in the curriculum.

Place: …………….. Enrollment No. : ……….…….

Date: …………….. Exam Seat No.: ………………

Subject Teacher **Head of department** **Principal**

Seal of Institute

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, a relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher, instructor and student realize that every minute of the laboratory time needs to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical course has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through "chalk and duster" activity in the classroom situation. Accordingly, the "K' scheme laboratory manual development team designed the practical to focus on the outcomes, rather than the traditional age-old practice of conducting practical to 'verify the theory" (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the predetermined outcomes. It is expected. From each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware of the skills they will achieve through the procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

In the 21st century electronic communication plays vital role in every aspect of human life. Diploma Engineers (also called technologists) have to deal with the various electronic communication circuits while maintaining electronics communication systems. The study of basic operating principles and handling of various electronics communication system will help them to troubleshoot and maintain electronics communication systems used for various types of communication. This course is developed in such a way that students will be able to apply the domain knowledge to solve broad communication engineering application problems in electronic communication engineering field.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome

Program Outcomes (POs)

Following programme outcomes are expected to be achieved through the practical of the course.

PO1. Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science `and engineering fundamentals and engineering specialization to solve the broad-based Electronic Engineering group program problems.

PO2. Problem analysis: Identify and analyze well-defined Electronic Engineering group program problems using codified standard methods.

PO3. Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of Electronic Engineering group program systems components or processes to meet specified needs.

PO4. Engineering Tools, Experimentation and Testing: Apply modern Electronic Engineering group program tools and appropriate technique to conduct standard tests and measurements.

PO5. Engineering practices for society, sustainability and environment: Apply appropriate Electronic Engineering group program technology in context of society, sustainability, environment and ethical practices.

PO6. Project Management: Use Electronic Engineering group program management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO7. Life-long learning: Ability to analyze individual needs and engage in updating in the context of Electronic Engineering group program technological changes.

Program Specific Outcomes (PSO)

Practical-Course Outcome Matrix

COURSE LEVEL LEARNING OUTCOMES (COS)

CO1 - Classify different types of Drones.
CO2 - Interpret drone technology along with its rules and regulations.
CO3 - State function of Drone system and subsystems.
CO4 - Test the drone system.
CO5 - Select drone for a given application.

Sr. No.	Title of the Practical	CO1	CO2	CO3	CO4	CO5
1	Preparation of a report/chart on the history of flight and illustrate the evolution timeline of UAV technology till date	✓	-	-	-	-
2	Exploration of Digital sky platform	✓	-	-	-	-
3	* Identification of zones (Red, Yellow, Green) by using Airspace map for any district and area near the airport	✓	-	-	-	-
4	Preparation of a report/chart on the classification of drones by weight categories and define the related terminologies as per Drone Rules 2021	✓	-	-	-	-
5	Identification of mechanical components in drones, and describe their specifications and functions	-	✓	-	-	-
6	*Identification of electrical components in drones, describing their specifications and functions	-	✓	-	-	-
7	*Identification of electronic components in drones, describing their specifications and functions	-	✓	-	-	-
8	Preparation of a report/chart on DGCA Regulations & Safety Protocols for Drone Operation	-	✓	-	-	-
9	Plot the speed-torque characteristics of Drone's BLDC motor	-	-	✓	-	-
10	*Inspection of a battery pack for bulges and leakage	-	-	-	✓	-
11	*Calculation of the flying time based on battery capacity	-	-	✓	-	-

12	*Assemble the quadcopter Drone using the given components	-	-	-	✓	-
13	Configuration and operation of Drone transmitter and receiver	-	-	-	✓	-
14	*Test the assembled drone	-	-	-	✓	-
15	*Preparation of a report/chart on application of Drone technology in Agriculture	-	-	-	-	✓
16	Preparation of a report/chart on the application of Drone technology in cinematography	-	-	-	-	✓

List of Industry Relevant Skills

The aim of this course is to help students to attain the following industry/expected outcome through various teaching-learning experiences: Maintain various components of Drone System, are expected to be developed in students by undertaking the practical.

1. Classify different types of Drones.
2. Interpret drone technology along with its rules and regulations.
3. State function of Drone system and subsystems.
4. Test the drone system.
5. Select drone for a given application.

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each practical.
3. Involve students in the performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
5. Teachers should give opportunities to students for hands-on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected of the students by the industry.
8. Finally give practical assignments and assess the performance of students based on tasks assigned to check whether it is as per the instructions.
9. Teacher is expected to refer to the complete curriculum document and follow guidelines for implementation
10. At the beginning of the practical, which is based on the simulation, teacher should make the students acquainted with any simulation software environment.

Instructions for Students

1. Listen carefully to the lecture given by the teacher about course, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make a record of all observations.
3. Do the calculations and plot the graph wherever it is required in the practical
4. Students shall develop maintenance skills as expected by industries.
5. Student shall attempt to develop related hand-on skills and gain confidence.
6. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual
7. Student should develop the habit to submit the practical on date and time.
8. Student should prepare well while submitting a write-up of exercise.

Content Page

List of Practical's and Progressive Assessment Sheet

15	*Preparation of a report/chart on application of Drone technology in Agriculture	101					
16	Preparation of a report/chart on the application of Drone technology in cinematography	109					
Total							

Note: Out of above suggestive LLOs -
'*' Marked Practicals (LLOs) Are mandatory.
Minimum 80% of above list of lab experiments are to be performed.
Judicial mix of LLOs are to be performed to achieve desired outcomes.

Practical No 1: Preparation of a report/chart on the history of flight and illustrate the evolution timeline of UAV technology till date.

I Practical Significance

Understanding the history and evolution of flight technology provides a foundational perspective on how aerodynamics, materials, and control systems have advanced over time. By studying the progression from early human flight concepts to modern Unmanned Aerial Vehicles (UAVs), students gain insights into the technological innovations that shaped today's aerospace and drone industries. This knowledge builds appreciation for engineering evolution and aids in developing innovative thinking for future aerial systems.

II Industry/Employer Expected Outcome(s)

- Ability to trace and explain the evolution of flight technology, including UAV advancements.
- Understanding the classification, features, and applications of different UAVs used in industry and defense.
- Capability to present technical information visually through well-structured charts or reports.
- Awareness of the historical context influencing current aerospace and UAV innovations.

III Course Level Learning Outcome(s)

CO1 - Classify different types of Drones.

IV Laboratory Learning Outcome(s)

- LLO 1.1 Prepare a report/chart on the history of flight and ancient concepts of aerodynamics (IKS).
- LLO 1.2 Prepare of a report/chart on the overview of drones, including their history, types, and applications.

V Relevant Affective Domain Related Outcome(s)

- Develop appreciation for technological advancements and human innovation in flight.
- Foster teamwork, creativity, and presentation skills while preparing the report/chart.
- Encourage curiosity and research-oriented learning about aerospace and UAV systems.
- Cultivate attention to detail in gathering, organizing, and presenting historical and technical data.

VI Relevant Theoretical Background

Fig 1.1 Evolution of UAV technology

The history of flight spans from ancient myths and early aerodynamic studies to modern UAV technology. The concept of flight began with the observation of birds and early mechanical attempts, such as Leonardo da Vinci's ornithopter designs in the 15th century. The Wright brothers' successful powered flight in 1903 marked the beginning of modern aviation.

Over the decades, significant milestones shaped flight evolution:

- 1903–1945: Birth of aviation and military aircraft development during World Wars.
- 1950s–1970s: Jet propulsion and advancements in aerodynamics and materials.
- 1980s–2000s: Introduction of autonomous and remotely controlled UAVs for military reconnaissance.
- 2010s–Present: Rapid growth of UAV applications in photography, agriculture, logistics, defense, and disaster management.

Modern UAVs are categorized into fixed-wing, rotary-wing, and hybrid designs, varying by range, endurance, and payload. They integrate technologies from multiple fields — aerodynamics, electronics, communication systems, GPS navigation, and AI-based autonomy.

Understanding the evolution of flight and UAVs allows engineers to appreciate the integration of mechanical design, control theory, and digital innovation — forming the basis for future aerial systems and smart autonomous vehicles.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested	Quantity
1	Presentation/Chart Software	MS PowerPoint / Canva / Google Slides	1
2	Word Processing Software	MS Word / Google Docs	1
3	Printer or Chart Paper	A4/A3 sheets or chart paper	As req.
4	Reference Material	Books, research papers, online sources	As req.
5	Desktop Computer	Intel i3/i5, 8GB RAM, 500GB HDD/256GB SSD, Windows 10/11	02
6	UPS 6 KVA online	Online UPS, 6 KVA capacity, input: 230V AC, output: 230V AC, Backup: 10–15 min, LCD display	01
7	Ethernet Switch	Ethernet Switch- 4/8/16/24/32	01
8	Router	Router-256MB Memory storage capacity, compatible with Desktop and Laptop, Rack Mountable, Wireless Connectivity	01
9	Antivirus Software	Quick Heal Total Security, Version 24.0 (or the latest available version, or any equivalent antivirus software)	01

VIII Precautions to be followed

1. Ensure reliable internet access and proper functioning of the computer or laptop.
2. Use only verified and authentic sources for historical and technical information.
3. Cross-check dates, facts, and UAV models before finalizing the chart or report.
4. Maintain clarity and neatness while preparing the timeline/chart.
5. Save and back up the report/chart regularly to prevent data loss.

IX Procedure

1. Start the computer/laptop and open suitable software (MS PowerPoint, Canva, or Google Slides) for preparing the chart/report.
2. Research the history of flight, beginning from early concepts (e.g., Leonardo da Vinci's designs) to modern aviation milestones (e.g., Wright brothers' first flight).
3. Collect data on the evolution of UAVs, covering major developments such as early military drones, autonomous UAVs, and modern commercial applications.
4. Organize the collected information in chronological order to form a clear timeline.
5. Design the timeline/chart with labeled sections, relevant images, and key dates for each milestone.
6. Include details about types of drones, their uses, and technological advancements over time.
7. Review the chart/report for factual accuracy, proper labeling, and visual appeal.
8. Print or present the final report/chart as per instructor guidelines.

X Resources used

Sr. No.	Name of Resource	Suggested	Quantity

XI Actual Procedure

XII Observation Table

Table 1.1 Evolution timeline of UAV Technology

Sr. No.	Year / Period	UAV Model / Development	Key Features / Observations
1	Before 1500	Early Concepts of Flight (IKS and Leonardo da Vinci)	
2	1916	Aerial Target (UK)	
3	1935	DH.82 Queen Bee (UK)	
4	1950s	Early Reconnaissance Drones (USA)	
5	1970s	Firebee and Lightning Bug (USA)	
6	1980s	Scout & Mastiff (Israel)	
7	1990s	Predator (MQ-1, USA)	
8	2000s	Global Hawk (RQ-4, USA)	
9	2010s	Commercial Drone Boom	
10	2020s	AI-Enabled & Hybrid UAVs	

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Share your opinion on the role of early flight concepts (IKS and Leonardo da Vinci, Before 1500) in shaping the development of UAV technology.
2. Explain how UAV capabilities changed from the 1950s reconnaissance drones to the 1970s Fire bee and Lightning Bug.
3. Share your opinion on the impact of Predator (MQ-1, 1990s) on modern UAV technology.
4. Give your perspective on the significance of the Commercial Drone Boom (2010s) in civilian UAV applications.
5. Summarize the technological shift seen in UAVs during the 2020s with the introduction of AI-enabled and hybrid systems.

[Space for Answers]

XVII References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.
2 Anderson, J. D. (2017). A History of Aerodynamics and Its Impact on Flying Machines. Cambridge University Press. Explains the development of flight and the key aerodynamic discoveries that shaped modern aviation.
3. FAA (Federal Aviation Administration). Unmanned Aircraft Systems (UAS) Regulations and Policies. Official FAA website with updated UAV guidelines and usage information.
https://www.faa.gov/uas
4. DJI Official Website. Drone Technology and Applications. Provides insights into the latest commercial UAV technologies and innovations.
https://www.dji.com
5. Digital Sky Platform – Directorate General of Civil Aviation (DGCA), India
The Digital Sky Platform is an online portal developed by the Directorate General of Civil Aviation (DGCA), Ministry of Civil Aviation, Government of India. It serves as the primary interface for drone operators, manufacturers, and pilots to comply with India's drone regulations.
https://digitalsky.dgca.gov.in

XVIII Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Handling of software tools	10%
2	Correct identification of key events, UAV models, milestones	20%
3	Using suitable tools and sources to collect accurate data and information	20%
4	Working in teams	10%
	Product Related: 10 Marks	**40%**
5	Applying theoretical knowledge of aerodynamics, propulsion, and UAV systems to compile an accurate history of UAV technology.	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
	Total (25 Marks)	**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.2: Exploration of Digital sky platform

I Practical Significance

The Digital Sky Platform is India's official site for registering drones, obtaining flight permissions, and following DGCA rules. Knowing its features helps ensure safe, legal, and responsible drone operations.

II Industry/Employer Expected Outcome(s)

- Ability to navigate the Digital Sky portal.
- Knowledge of drone registration and pilot enrolment process.
- Understanding of obtaining flight permissions (NPNT – No Permission, No Take-off).
- Awareness of legal compliance in drone operations.

III Course Level Learning Outcome(s)

CO1 - Classify different types of Drones.

IV Laboratory Learning Outcome(s)

LLO 2.1 Explore Digital sky platform.

V Relevant Affective Domain related outcome(s)

- Developing a sense of responsibility for following regulations.
- Encouraging safe and ethical use of drone technology.

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VI Relevant Theoretical Background

The Digital Sky platform is created by the Directorate General of Civil Aviation (DGCA), Government of India. It allows:

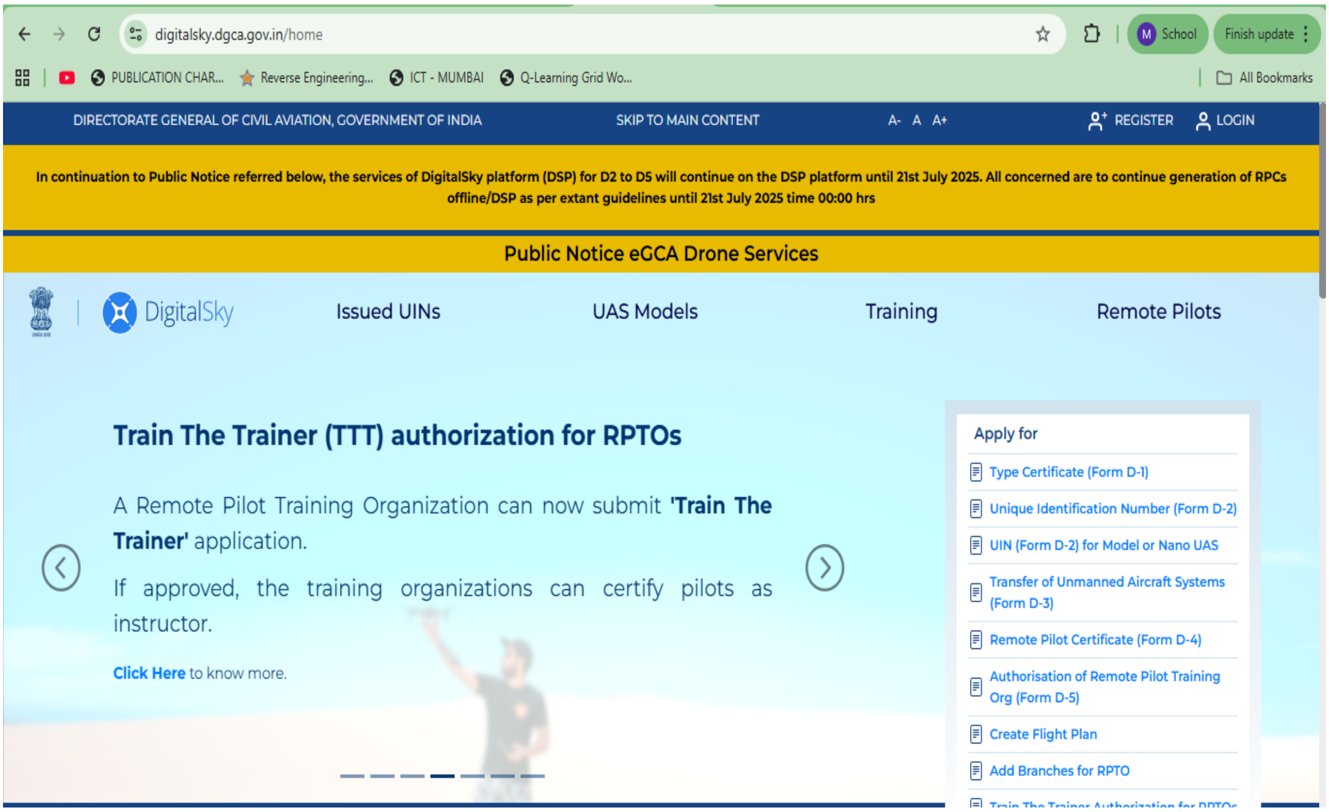

Fig. 2.1 DGCA Digital Sky Website

- Online registration of drones and pilots.
- Real-time permission for flights through NPNT.
- Compliance with "Drone Rules, 2021."
- Monitoring and control of drone operations in Indian airspace.

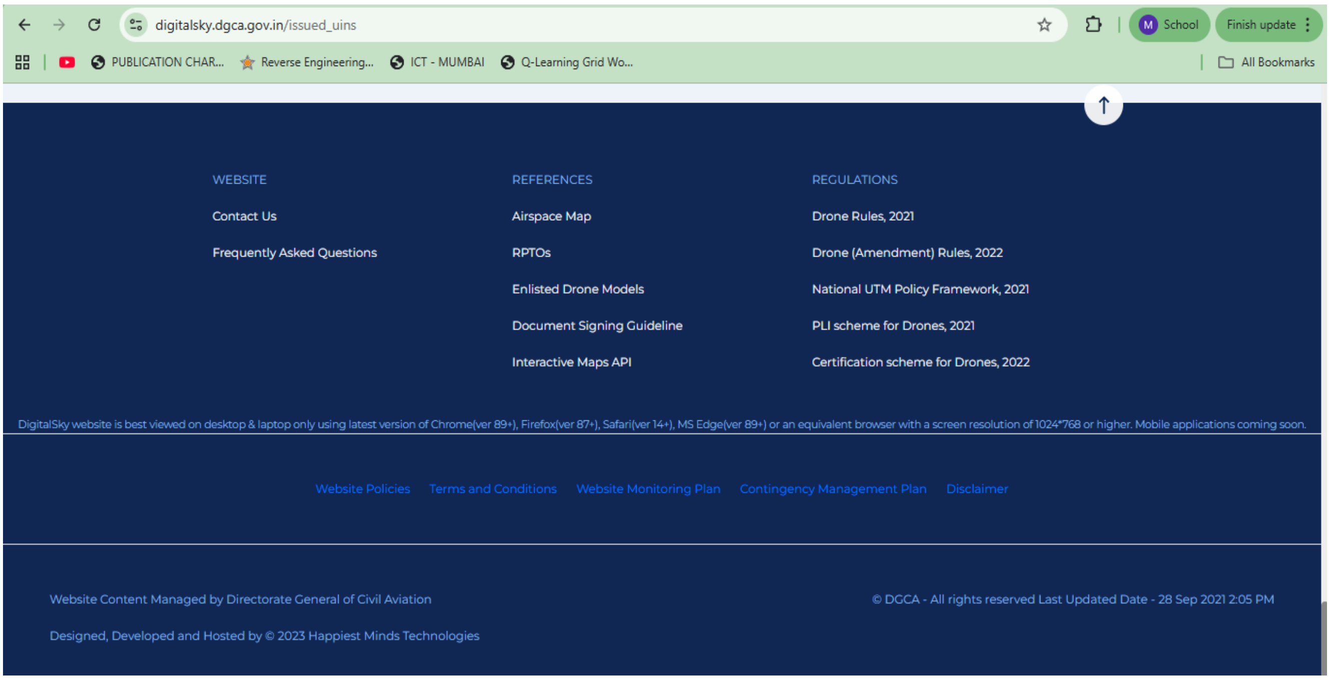

Fig. 2.2 Link for Drone Rules, 2001

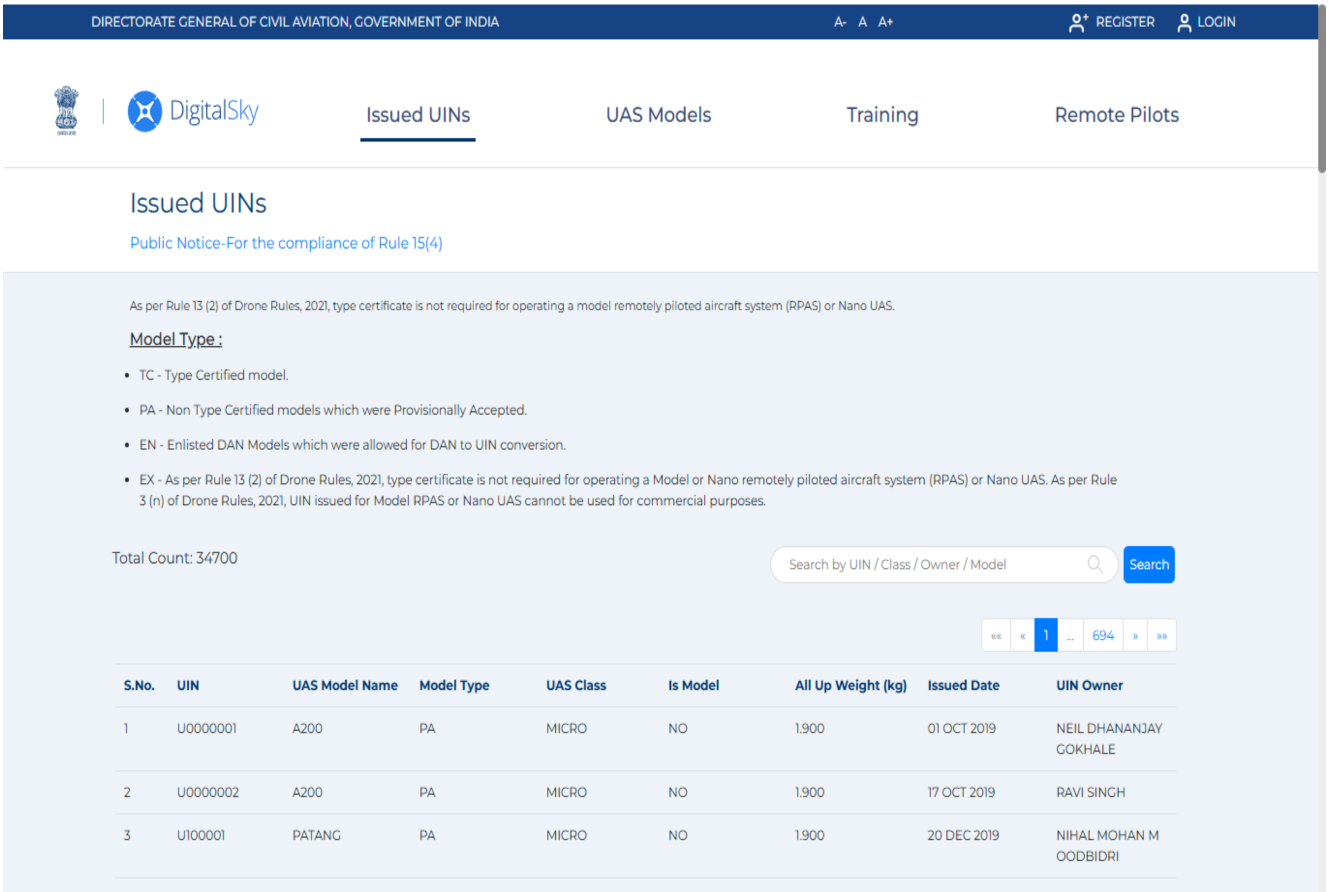

Fig. 2.3 Listed Unique Identification Number issued

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Desktop Computer	Intel i3/i5, 8GB RAM, 500GB HDD/256GB SSD, Windows 10/11	02
2	UPS 6 KVA online	Online UPS, 6 KVA capacity, input: 230V AC, output: 230V AC, Backup: 10–15 min, LCD display	01
3	Ethernet Switch	Ethernet Switch- 4/8/16/24/32	01
4	Router	Router-256MB Memory storage capacity, compatible with Desktop and Laptop, Rack Mountable, Wireless Connectivity	01
5	Antivirus Software	Quick Heal Total Security, Version 24.0 (or the latest available version, or any equivalent antivirus software)	01
6	Simulation Software	Simulation Software: CISCO Packet Tracer, CORE Network Emulator, GNS3 or any other simulator	01

VIII Precautions to be followed

1. Use official portal only.
2. Do not attempt fake registrations.
3. Avoid sharing personal credentials.
4. Follow DGCA rules and regulations.

IX Procedure

1. Open the Digital Sky portal in a web browser.
2. Explore sections: Drone Registration, Pilot Enrollment, and Permission to Fly.
3. Observe the process of applying for Unique Identification Number (UIN) for drones.
4. Check the NPNT permission request module.
5. Note down the requirements for registration and permissions.

X Resources used

Sr. No.	Name of Resource	Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 2.1 Process details of Digital Sky Platform

Sr. No.	Feature Explored	Observation / Notes
1	Registration Process	
2	Pilot Enrollment	
3	NPNT Permission	
4	Compliance Documents	

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. Mention the significance of the NPNT policy
2. Differentiate between drone registration and pilot enrolment.
3. State the purpose of Digital Sky platform in India
4. Give the key compliance requirements for drone operations

[Space for Answers]

XVII References/Suggestions for further reading

1. DGCA Drone Rules, 2021 – https://dgca.gov.in
2. Digital Sky Portal – https://digitalsky.dgca.gov.in

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Understanding of Aim & Procedure	10%
2	Identification of Components / Tools / Software	15%
3	Execution of Experiment / Simulation Steps	20%
4	Measurement / Parameter Observation	10%
5	Teamwork & Lab Safety / Discipline	5%
Product Related: 10 Marks		**40%**
6	Observation Table Completion	10%
7	Result & Interpretation	10%
8	Conclusion	5%
9	Viva / Practical Related Questions	10%
10	Timely Submission of Journal / Record	5%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.3: Identification of zones (Red, Yellow, Green) by using Airspace map for any district and area near the airport

I Practical Significance

Airspace zoning is essential for ensuring safe, legal, and responsible drone operations. It categorizes airspace into distinct zones based on restrictions and requirements, guiding operators on where drones can be flown and what permissions are needed. These zones are typically classified into three types: Red, Yellow, and Green. Red zones indicate restricted or no-fly areas, such as near airports or sensitive locations, where drone operations are generally prohibited without special authorization. Yellow zones represent controlled airspace, where permissions are required due to potential risks or regulatory oversight. Green zones signify areas where drone flights are permitted with minimal restrictions, provided operators comply with standard regulations. Understanding these zones and their associated rules is critical for navigating airspace responsibly and ensuring compliance with aviation regulations.

II Industry/Employer Expected Outcome(s)

- Ability to interpret airspace maps and zone classifications.
- Skills in selecting safe flight areas and planning flight operations near airports.
- Compliance with DGCA / Civil Aviation Authority regulations.

III Course Level Learning Outcome(s)

CO1 - Classify different types of Drones.

IV Laboratory Learning Outcome(s)

- LLO 3.1 Identify the zones (Red, Yellow, Green) by using Airspace map for any district and area near the airport.

V Relevant Affective Domain related outcome(s)

- Develop caution and respect for aviation safety and regulations.
- Cultivate responsibility in planning drone operations.

VI Relevant Theoretical Background

The Digital Sky Airspace Map is an online platform developed by the Directorate General of Civil Aviation (DGCA), Government of India, to help drone operators understand and comply with national airspace regulations. It is a part of the Digital Sky ecosystem that enables registration, licensing, and permission management for drone flights under the “No Permission, No Takeoff” (NPNT) policy.

The map provides a detailed, color-coded representation of India’s airspace, showing areas where drones can fly freely, areas where prior permission is required, and regions where flying is strictly prohibited. These are categorized into Red, Yellow, and Green zones, each serving a specific regulatory purpose.

The Red Zone represents highly restricted airspace where drone operations are prohibited unless special authorization is obtained from the Central Government. Such areas are typically located near airports, defence installations, international borders, or government facilities. These restrictions ensure the safety of manned aircraft and national security. The Red Zone is the most sensitive and controlled area for drone operations.

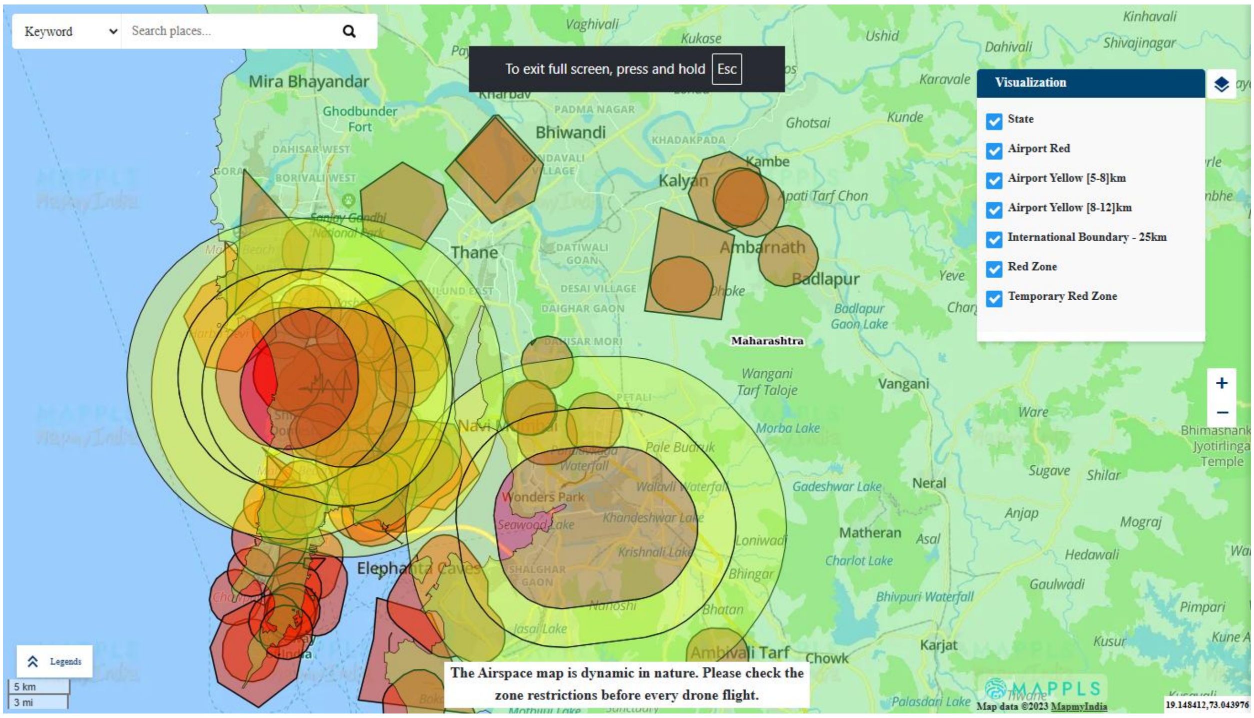

Fig 3.1: Digital Sky showing a Red Zone near an airport (Mumbai International Airport).

The Yellow Zone refers to controlled airspace where drone operations are allowed only with prior permission from the concerned Air Traffic Control (ATC) authority. This zone generally surrounds the Red Zone, extending several kilometres outward from airport boundaries. The purpose of this zone is to maintain a buffer between high-security no-fly regions and open-fly areas, ensuring that any drone activity remains coordinated and does not interfere with manned air traffic.

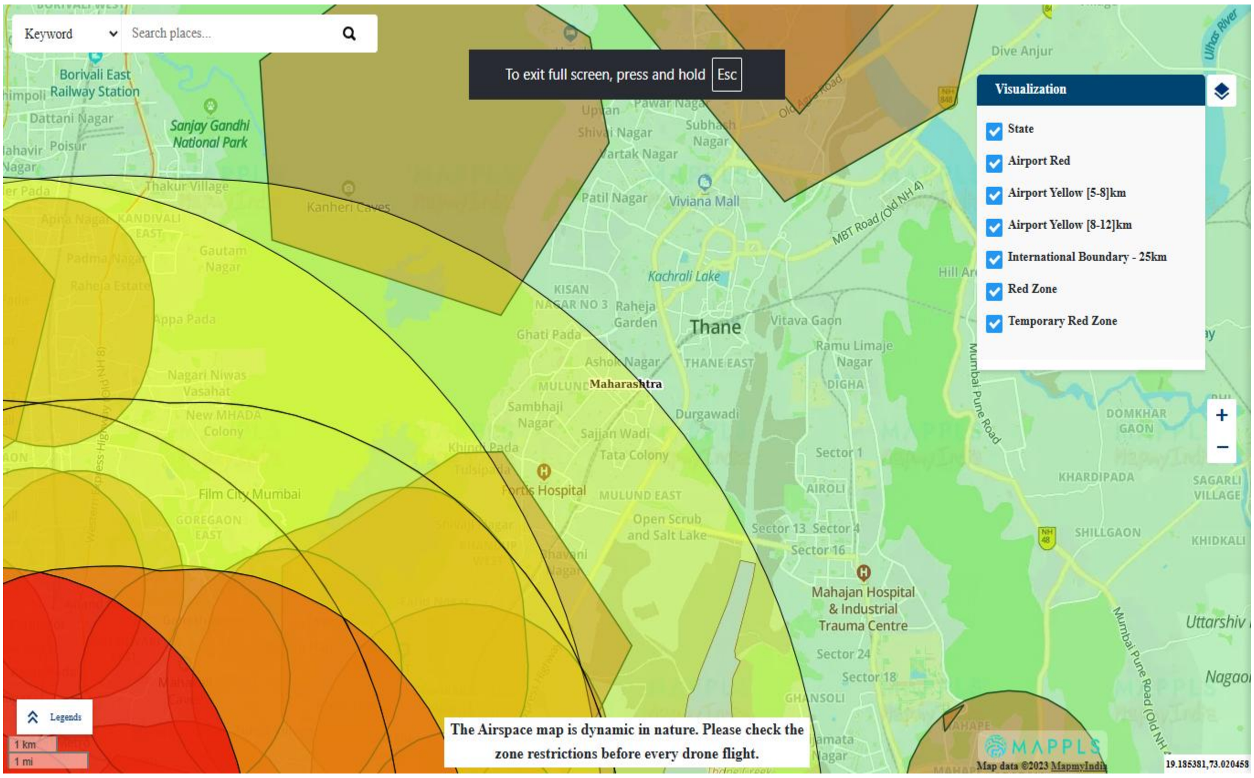

Fig 3.2: Digital Sky showing a Yellow Zone (suburban area near an airport buffer zone).

The Green Zone denotes unrestricted airspace where drone operations can be carried out without prior permission, up to a maximum altitude of 120 meters (400 feet) above ground level. These zones are typically found in rural, agricultural, or industrial regions away from airports and restricted facilities. However, operators must still comply with general safety guidelines and maintain visual line-of-sight operations.

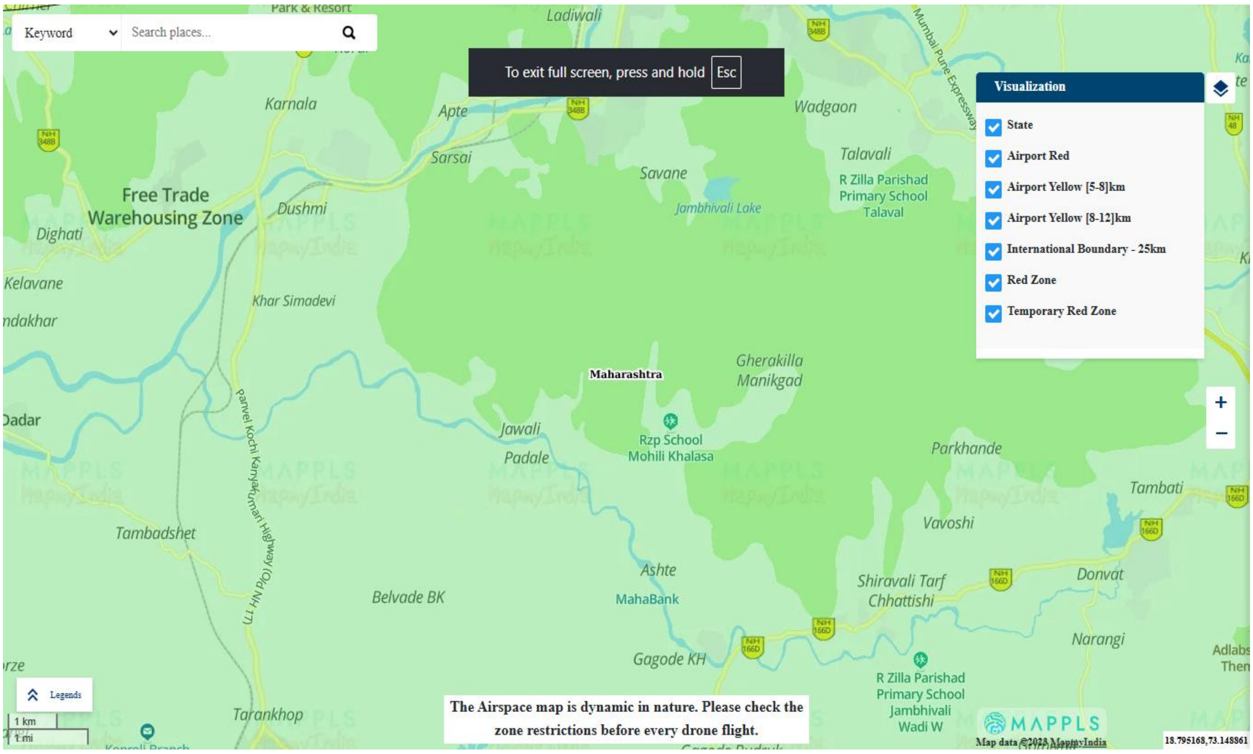

Fig 3.3: Digital Sky showing a Green Zone (rural areas in Panvel or Raigad district).

Understanding airspace zoning is vital for every drone operator, as it directly affects flight planning, operational safety, and legal compliance. Violating airspace restrictions can lead to penalties, confiscation of equipment, or even criminal liability. By using the Digital Sky Airspace Map, operators can ensure that every flight is both safe and authorized.

In an educational context, exploring this platform helps students develop real-world awareness of aviation safety norms and regulatory practices. It enables them to interpret digital maps, recognize restricted and permitted areas, and plan drone missions responsibly. Moreover, it fosters an understanding of how technology, geography, and law come together to shape the modern drone ecosystem in India.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Desktop PC with Internet Browser	Computer with a modern processor (e.g., Intel i3-i5 or equivalent, RAM > 2GB) and a stable internet connection	01
2	Airspace Zoning Map	Interactive digital map displaying airspace zones (e.g., Red, Yellow, Green) for drone operations	01
3	Regulatory Manual/Documentation	Official guide or documentation outlining drone operation rules, zoning regulations, and platform usage instructions	01
4	Ethernet Switch	Ethernet Switch- 4/8/16/24/32	01
5	Router	Router-256MB Memory storage capacity, compatible with Desktop and Laptop, Rack Mountable, Wireless Connectivity	01
6	Antivirus Software	Quick Heal Total Security, Version 24.0 (or the latest available version, or any equivalent antivirus software)	01

VIII Precautions to be followed

- Ensure using the official Digital Sky Airspace Map (to avoid outdated or inaccurate data).
- Do not rely solely on map layers without verifying altitude or other restrictions.
- Cross-check boundaries near airport zones carefully.
- Use zoomed-in and high-resolution views to avoid misinterpretation.

IX Procedure

- Open the Digital Sky website and navigate to Airspace Map.
- Search for your district and zoom into the vicinity of the nearest airport.
- Enable layers that show Red, Yellow, Green zones.
- Identify and annotate the zones (Red / Yellow / Green) on your selected area.
- For each zone, note the boundaries, relevant airports, height restrictions, and any special rules.
- Compare across multiple zoom levels (e.g. 1:50,000, 1:10,000) to see finer zoning.
- Export the screenshot or map snapshot for inclusion in the manual.

X Resources used

Sr. No.	Name of Resource	Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 3.1 Classification of Given area w.r.t zone

Sr. No	Location / Area	Zone (Red / Yellow / Green)	Observations / Notes
1	Near runway (airport)		
2	Suburban area in district		
3	Outskirts / rural area		
4	Any boundary overlap zone		

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. Describe the criteria used to differentiate Red, Yellow, and Green zones for drone operations.
2. Explain the reason for classifying areas around airports as Red zones.
3. Outline the steps to plan a drone flight crossing from a Yellow zone into a Green zone.
4. Identify additional restrictions, beyond no-fly rules, that may apply in Yellow or Red zones.

[Space for Answers]

XVII References/Suggestions for further reading

1. Digital Sky — Airspace Map Tool (DGCA India)
2. DGCA Drone Rules, 2021 / related advisory documents
3. Aeronautical Information Publication (AIP) India for airport zone definitions

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Understanding of Aim & Procedure	10%
2	Identification of Components / Tools / Software	15%
3	Execution of Experiment / Simulation Steps	20%
4	Measurement / Parameter Observation	10%
5	Teamwork & Lab Safety / Discipline	5%
Product Related: 10 Marks		**40%**
6	Observation Table Completion	10%
7	Result & Interpretation	10%
8	Conclusion	5%
9	Viva / Practical Related Questions	10%
10	Timely Submission of Journal / Record	5%
Total (25 Marks)		100 %

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No 4: Preparation of a report/chart on the classification of drones by weight categories and define the related terminologies as per Drone Rules 2021

I Practical Significance

Understanding the classification of drones by weight and related terminologies as per Drone Rules 2021 is essential for safe, legal, and efficient drone operations. By studying the different categories of drones, students gain knowledge of regulatory compliance, operational limitations, and practical applications across industries. This helps build awareness of UAV technology standards, promotes responsible use, and supports innovation in aerial systems.

II Industry/Employer Expected Outcome(s)

- Ability to classify drones accurately according to weight categories defined in Drone Rules 2021.
- Understanding the legal and operational definitions of various UAV-related terminologies (e.g., nano, micro, small, medium, and large drones).
- Capability to present technical data visually through well-structured reports or charts.
- Awareness of safety, regulatory compliance, and industry practices in UAV operations.

III Course Level Learning Outcome(s)

CO1 - Classify different types of Drones.

IV Laboratory Learning Outcome(s)

- LLO 4.1 Prepare a report/chart on the classification of drones by weight categories and define the related terminologies as per Drone Rules 2021.

V Relevant Affective Domain related outcome(s)

Develop awareness of regulatory compliance in drone operations.
Encourage teamwork, creativity, and visual presentation skills while preparing the chart/report.
Foster curiosity about UAV technologies, operational safety, and industrial applications.
Cultivate attention to detail in gathering, organizing, and presenting regulatory and technical data.

VI Relevant Theoretical Background

The Drone Rules, 2021 (India) greatly simplified and liberalized drone use by reducing permissions, lowering fees, and shifting most processes to the Digital Sky platform. Drones are classified by weight, and many approvals required earlier—such as certificates of conformance and airworthiness—were removed. Remote pilot licenses are needed only for larger drones, while nano and some micro drones are exempt. Flying is allowed freely in green zones, while yellow and red zones require prior permission. Overall, the rules aim to encourage innovation, ease of doing business, and safe drone operations.

Table 4.1 Drone Rules 2021 classify drones based on weight categories for safe and regulated operation

Category	Weight Range	Examples	Typical Applications
Nano	≤ 250 g	Mini drones	Hobby, indoor training
Micro	250 g – 2 kg	Small UAVs	Surveillance, photography
Small	2 kg – 25 kg	Commercial drones	Agriculture, logistics
Medium	25 kg – 150 kg	Industrial drones	Mapping, inspection
Large	>150 kg	Heavy-lift UAVs	Cargo transport, defense

Key Terminologies:

- UAV (Unmanned Aerial Vehicle): An aircraft operated without a human pilot onboard.
- Remote Pilot: The person controlling the UAV remotely.
- Geofencing: Software-controlled boundaries to restrict drone operation in sensitive areas.
- No-Permission, No-Takeoff (NPNT): Feature that ensures drones cannot operate without regulatory approval.
- Payload: Weight carried by the drone, excluding its own structure and power source.
  Understanding these classifications and definitions ensures safe, compliant, and effective drone operations across commercial, industrial, and recreational contexts. Visual representation of this information in a chart/report enhances comprehension and retention.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested	Quantity
1	Computer	Intel i3/i5, 8GB RAM, 500GB HDD/256GB SSD, Windows 10/11	02
2	Presentation/Chart Software	MS PowerPoint / Canva / Google Slides	1
3	Word Processing Software	MS Word / Google Docs	1
4	Printer or Chart Paper	A4/A3 sheets or chart paper	As req.
5	Reference Material	Books, research papers, online sources	As req.
6	Ethernet Switch	Ethernet Switch- 4/8/16/24/32	01
7	Router	Router-256MB Memory storage capacity, compatible with Desktop and Laptop, Rack Mountable, Wireless Connectivity	01
8	Antivirus Software	Quick Heal Total Security, Version 24.0 (or the latest available version, or any equivalent antivirus software)	01

VIII Precautions to be followed

1. Ensure reliable internet access and proper functioning of the computer or laptop.
2. Use authentic sources such as the official Drone Rules 2021 document for regulatory information.
3. Cross-check weight categories, terminology, and operational details before finalizing the chart/report.
4. Maintain clarity, consistency, and neatness while preparing the chart/report.
5. Save and back up the report/chart regularly to prevent data loss.

IX Procedure

1. Start the computer/laptop and open suitable software (MS PowerPoint, Canva, or Google Slides) for preparing the chart/report.
2. Study the Drone Rules 2021 for weight classifications and definitions of UAV-related terminologies.
3. Collect data on each drone category, including weight range, examples, and applications.
4. Organize the information into a clear and visually appealing table or chart.
5. Add labeled sections for key terminologies and include definitions.
6. Highlight practical applications and operational restrictions for each category.

7. Review the chart/report for accuracy, proper labeling, and visual appeal.
8. Print or present the final report/chart according to instructor guidelines.

X Resources used

Sr. No.	Name of Resource	Suggested	Quantity

XI Actual Procedure

XII Observation Table

Table 4.2 Drone category according to weight

Sr. No	Drone Category	Weight Range	Example Drones	Typical Applications	Related Terminologies / Notes
1	Nano	≤ 250 g			
2	Micro	250 g – 2 kg			
3	Small	2 kg – 25 kg			
4	Medium	25 kg – 150 kg			
5	Large	>150 kg			

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

Note: Below are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. A logistics company wants to move heavy cargo using a drone weighing 200 kg specify its category and justify your answer.
2. Define the following UAV-related terminologies: Nano drone, Micro drone, small drone, medium drone, and large drone.
3. Identify the drone categories that require a remote pilot license and operational permissions under Drone Rules 2021.
4. List and describe the typical applications for each drone weight category.
5. Describe the significance of the NPNT (No Permission, No Takeoff) feature in drone operations.

XVII References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.

2 Anderson, J. D. (2017). A History of Aerodynamics and Its Impact on Flying Machines. Cambridge University Press. Explains the development of flight and the key aerodynamic discoveries that shaped modern aviation.

3. FAA (Federal Aviation Administration). Unmanned Aircraft Systems (UAS) Regulations and Policies. Official FAA website with updated UAV guidelines and usage information.
https://www.faa.gov/uas

4. DJI Official Website. Drone Technology and Applications. Provides insights into the latest commercial UAV technologies and innovations.
https://www.dji.com

5. Digital Sky Platform – Directorate General of Civil Aviation (DGCA), India
The Digital Sky Platform is an online portal developed by the Directorate General of Civil Aviation (DGCA), Ministry of Civil Aviation, Government of India. It serves as the primary interface for drone operators, manufacturers, and pilots to comply with India's drone regulations.
https://digitalsky.dgca.gov.in

6. Drone Rules 2021, Ministry of Civil Aviation, Government of India – Official document outlining UAV classifications, regulations, and operational guidelines.

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of software tools	10%
2	Correct identification of UAV weight categories	20%
3	Using suitable tools and sources to collect accurate data and information	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Determine the regulatory requirements for operating different drone categories under Drone Rules 2021	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 5: Identification of Mechanical Components in Drones and Description of their Specifications and Functions

I Practical Significance

Understanding the mechanical structure of drones is essential for maintenance, design, and troubleshooting. Each component — from the propeller to the landing gear — plays a vital role in stability, flight performance, and payload handling. By identifying these parts and understanding their specifications, students gain insight into drone assembly, aerodynamics, and load distribution principles.

II Industry/Employer Expected Outcome(s)

- Ability to identify and handle basic drone mechanical components.
- Knowledge of selecting suitable materials and configurations for drone design.
- Skill in analysing how each mechanical component contributes to flight efficiency and safety.

III Course Level Learning Outcome(s)

CO2 - Interpret drone technology along with its rules and regulations.

IV Laboratory Learning Outcome(s)

- LLO 5.1: Identify the mechanical components in drones and describe their specifications and functions.

V Relevant Affective Domain related outcome(s)

- Develop appreciation for engineering precision and build quality.
- Foster responsibility in handling delicate drone components with care and respect for safety.

VI Relevant Theoretical Background

A drone (Unmanned Aerial Vehicle – UAV) consists of a combination of mechanical, electrical, and software systems that work together to achieve stable flight. The mechanical components form the physical framework of the drone, determining its aerodynamic stability, payload capacity, and structural durability.

The frame acts as the backbone, holding all parts together. Frames are typically made from lightweight and strong materials such as carbon fiber, aluminum, or reinforced plastic. The arms extend outward to mount the motors and propellers, ensuring equal thrust distribution.

Each motor converts electrical energy into rotational motion. Motors are specified by their KV rating (RPM per volt), which affects the speed and torque characteristics. Attached to each motor are propellers, which generate lift through aerodynamic thrust; their size and pitch directly influence flight stability and efficiency.

The landing gear provides protection during takeoff and landing, absorbing shocks and keeping sensors and payload safe. Fasteners (like screws, nuts, and mounts) ensure mechanical integrity, while gimbals and mounts are used to stabilize cameras or payloads during flight.

Understanding these components allows drone engineers to balance weight, strength, and aerodynamics, ensuring optimal performance, durability, and flight time.

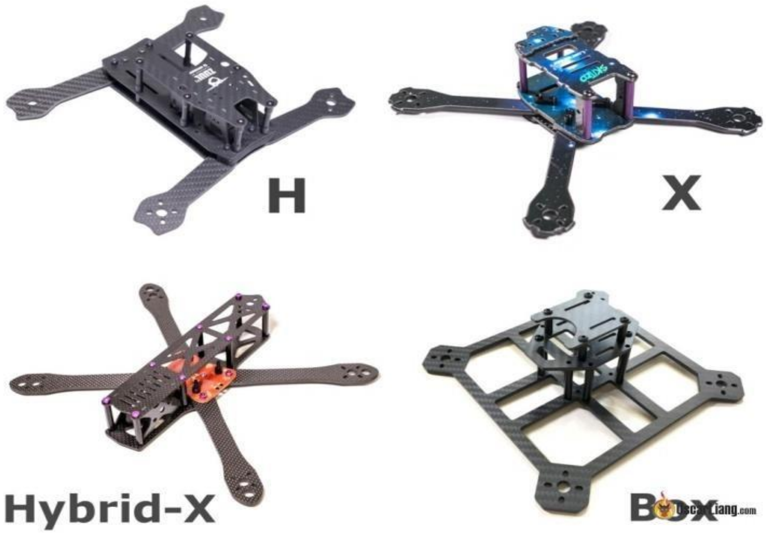

Fig 5.1: Different Types of Frame of Drone

Fig 5.2: Different Size of Propellor

Drone Overview

- Manufacturer: Drona Aviation Pvt. Ltd., Mumbai (India)
- Model: Pluto X – Nano Drone (Programmable FPV Drone)
- Weight: 87 g (with battery)
- Diagonal Length: 170 mm
- Battery: 3.7 V / 1000 mAh Li-Po (Flight time ≈ 12 min)
- Motors: 8520 coreless DC × 4
- Control Range: ≈ 100 m (Wi-Fi based)
- Payload Capacity: Up to 20 g
- Features: FPV camera, Acro mode, Position hold, Modular design, Programmable via Cygnus IDE
- Applications: STEM education, indoor flight training, aerial research projects, drone programming experiments

Table 5.1: Quadcopter Drone Parts

Sr. No.	Component Name	Specification (Suggested)	Material (Suggested)	Function
1	Frame	170 mm diagonal wheelbase (X-shaped)	Carbon-fiber reinforced plastic	Provides structural support to mount all components and ensures lightweight stability
2	Propellers	2-blade propellers, size = 3 inch (75 mm)	ABS / Nylon plastic	Generate lift and thrust for drone flight; paired diagonally for counter-rotation
3	Motors	8520 coreless DC motors (4 pcs)	Aluminum housing with copper winding	Convert electrical energy into rotational motion to spin propellers
4	Landing Gear	Integrated standoff legs on frame	Plastic (ABS)	Protect drone and propellers during take-off / landing; provide clearance from ground
5	Body Shell / Top Plate	Modular open-frame design	Polycarbonate cover	Protects electronic board and supports attachment of accessories
6	Fasteners / Mounts	Mini screws (M1.5 × 4 mm)	Stainless steel	Secure frame, motors, and propellers firmly in position
7	Camera / Sensor Mount	Pluto X Vision Camera (720p)	Plastic mount bracket	Holds FPV / camera module for aerial imaging and experiments
8	Arm Assembly	4 arms (X-configuration)	Plastic arms reinforced with carbon fiber	Connects motors to central board and ensures equal thrust distribution
9	Propeller Guards	Detachable ring-type guards	Plastic (ABS)	Prevents damage to propellers during collisions or indoor flights
10	Expansion Mounts	Payload / Add-on slots (for sensors)	Polycarbonate bracket	Used for mounting additional sensors (LiDAR, Wi-Fi module, etc.) for experiments

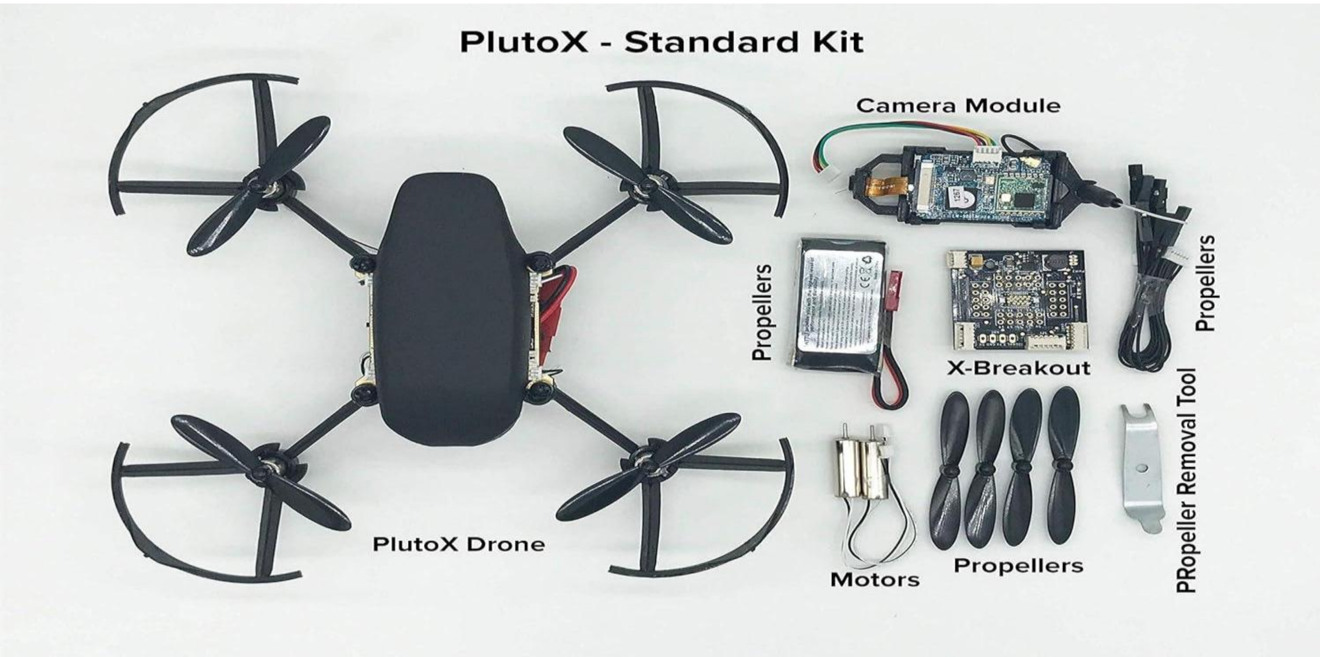

Fig 5.3: Pluto X Drone Assembly Parts

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Component / Tool	Suggested Broad Specification	Quantity
1	Drone frame (quadcopter)	Carbon fiber / plastic composite	1
2	Brushless DC Motors	2200 KV / 1000 KV	4
3	Propellers	10 × 4.5 inch or 9 × 4.7 inch	4
4	Landing gear	Shock-absorbing, lightweight	1 set
5	Screws and Mounts	Stainless steel / aluminum	As required
6	Camera mount or gimbal	2-axis or 3-axis stabilization	1

VIII Precautions to be followed

1. Handle all propellers and motors carefully to avoid cuts or mechanical damage.
2. Avoid applying excessive torque when mounting parts.
3. Ensure components are properly balanced before use.
4. Disconnect power before working on mechanical assemblies.

IX Procedure

1. Observe the drone and identify visible mechanical components.
2. Detach (if possible) and examine the frame, propellers, landing gear, and other mechanical fittings.
3. Record the specifications printed on each component (e.g., motor KV, propeller size).
4. Note the material used for each component (e.g., carbon fiber, ABS plastic, aluminum).
5. Describe the function of each part based on its role in flight and structure.
6. Relate the specifications to performance characteristics such as thrust, stability, and endurance.
7. Compile all information into a tabular form.

X Resources used

Sr. No.	Name of Resource	Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 5.2 Drone Components

Sr. No.	Component Name	Specification	Material	Function

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. Explain the reasons for using carbon fiber in drone frames.
2. Describe the effect of propeller pitch on drone flight performance.
3. Identify the role of motor KV rating in drone operation.
4. Outline the importance of vibration isolation in gimbal mounts.
5. List the factors influencing the selection of landing gear design for drones.

[Space for Answers]

XVII References/Suggestions for further reading

1. Drone Technology for Beginners: Learn | Build | Fly Drones,by Ms. Dharna Nar, Dr. Radhika Kotecha, Drone School India and Ane Books Pvt Ltd, ISBN : 978-8197222184
2. https://oscarliang.com/fpv-drone-frames/

XVIII Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Understanding of Aim & Procedure	10%
2	Identification of Components / Tools / Software	15%
3	Execution of Experiment / Simulation Steps	20%
4	Measurement / Parameter Observation	10%
5	Teamwork & Lab Safety / Discipline	5%
	Product Related: 10 Marks	**40%**
6	Observation Table Completion	10%
7	Result & Interpretation	10%
8	Conclusion	5%
9	Viva / Practical Related Questions	10%
10	Timely Submission of Journal / Record	5%
	Total (25 Marks)	**100 %**

<table>
<tr><th colspan="3">Marks Obtained</th><th>Dated signature of Teacher</th></tr>
<tr><th>Process Related (15)</th><th>Product Related (10)</th><th>Total (25)</th><td rowspan="2"></td></tr>
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Practical No. 6: Identification of Electrical Components in Drones and Description of their Specifications and Functions

I Practical Significance

Electrical components form the core of drone operation, providing power, control, communication, and stabilization. Understanding their specifications and functions helps in assembly, troubleshooting, customization, and safe drone operation. This experiment familiarizes students with key electrical subsystems of drones.

II Industry/Employer Expected Outcome(s)

- Ability to identify and select electrical components used in UAVs.
- Understanding of power distribution and electronic control system.
- Knowledge of how sensors and communication modules integrate in drones.

III Course Level Learning Outcome(s)

CO2 - Interpret drone technology along with its rules and regulations.

IV Laboratory Learning Outcome(s)

- LLO 6.1: Identify electrical components in drones, describing their specifications and functions.

V Relevant Affective Domain related outcome(s)

- Develop appreciation for engineering precision and build quality.
- Foster responsibility in handling delicate drone components with care and respect for safety.

VI Relevant Theoretical Background

Definition Of Drone (Quadcopter)

Quadcopter is an unmanned aerial vehicle (UAV) or drone with four rotors, each with a motor and propeller. A quadcopter can be manually controlled or can be autonomous. It is also called quadcopter helicopter or quadrotor. It belongs to a more general class of aerial vehicles called multicopter or multirotor. Quadcopters provide stable flight performance, making them ideal for surveillance and aerial photography.

Fig 6.1: Quad copter

Principle Of Drone (Quadcopter)

Quadcopters generally have two rotors spinning clockwise (CW) and two counterclockwise (CCW). Flight control is provided by independent variation of the speed and hence lifts and torque of each rotor. Pitch and roll are controlled by varying the net centre of thrust, with yaw controlled by varying the net torque.

Unlike conventional helicopters, quadcopters do not usually have cyclic pitch control, in which the angle of the blades varies dynamically as they turn around the rotor hub. In the early days of flight, quadcopters (then referred to either as 'quadrotors' or simply as 'helicopters') were seen as a possible solution to some of the persistent problems in vertical flight. Torque-induced control issues (as well as efficiency issues originating from the tail rotor, which generates no useful lift) can be eliminated by counter-rotation, and the relatively short blades are much easier to construct. A number of manned designs appeared in the 1920s and 1930s. These vehicles were among the first successful heavier-than-air vertical take-off and landing (VTOL) vehicles. However, early prototypes suffered from poor performance, and latter prototypes required too much pilot workload, due to poor stability augmentation and limited control authority.

Components Of Drone

The first step to building a drone is to understand the components that it required for operation. every drone consists of following basic and essential parts

Arms

The arms of the frame are available in 2 red and 2 white colors which can guide you to fly in the right direction. Arms have support ridges on them, which improves stability and provides faster forward flight

Fig 6.2: Arms

Center Plate

The center plate is a crucial component of a multirotor drone's frame, connecting all structural elements and housing essential electronics. In the event of a crash, while other parts may remain intact, the center plate is susceptible to damage due to its central position and the stresses it endures. Many frame kits include center plates with integrated power distribution boards (PDBs), which streamline the wiring by distributing power from the main battery to the electronic speed controllers (ESCs) and other components. The spacious design of the center plate also facilitates the mounting of gimbals and cameras, enhancing capabilities for first-person view (FPV) flights and aerial photography.

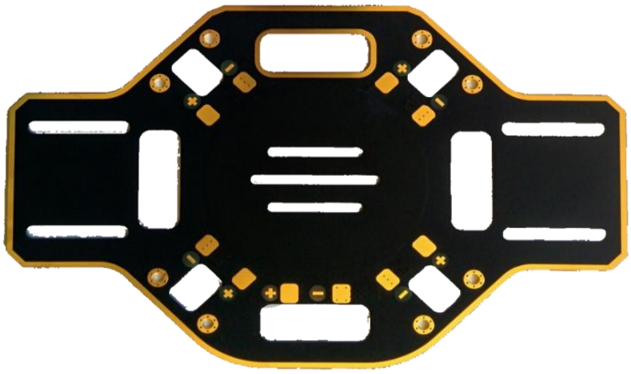


Fig 6.3: Center Mounting Plate

Deans Plugs

Deans Plugs are the smallest high-current connectors we know of, and they are great for projects that involve biggest motors and controllers. Often used to connect batteries in radio control models.

FC (Flight Controller)

A Flight Controller (FC) is the central processing unit of a drone that receives inputs from various sensors (such as gyroscope, accelerometer, and GPS) and processes them to control the drone's stability, orientation, and movement. When connected to Electronic Speed Controllers (ESCs), the flight controller sends precise signals to adjust the motor speeds, ensuring smooth and stable flight. The ESC acts as a bridge between the flight controller and the motors, converting low-power control signals from the FC into high-power electrical pulses that drive the brushless motors. Different drones use various ESC protocols (such as PWM, OneShot, MultiShot, and DShot) to communicate with the flight controller, affecting response time and efficiency. Proper synchronization between the FC and ESCs is crucial for accurate flight control, manoeuvrability, and power efficiency.

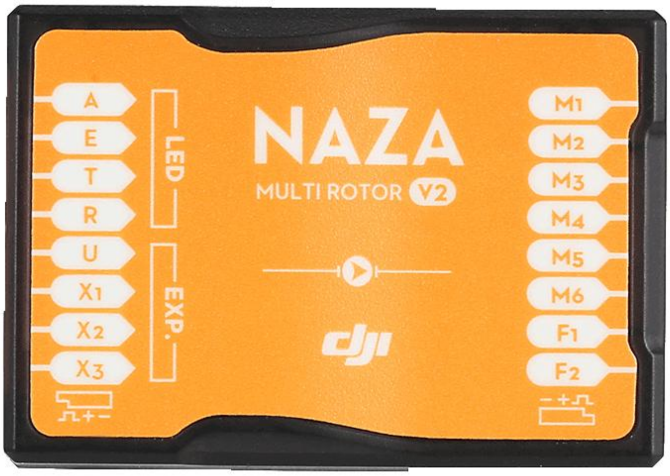


Fig 6.4: DJI Naza Flight Controller

ESC (Electronic Speed Controller)

An ESC is a device that interprets signals from the flight controller, and translates those signals into phased electrical pulses to determine the speed of a brushless motor. Make sure that both your FC and ESC's are capable of running the same ESC protocol ie. DShot 600. When selecting an ESC, remember that the current rating must be higher than the amperage drawn by your combination of motors and props. These days an ESC has 4 input terminals, 2 are for signals coming from the FC. Signal and signal ground are wired to the FC, the 2 heavier wires are for Positive and Negative, they carry the high current to the ESC to supply the motor. These Positive and negative are wired to the PDB. An ESC has 3 output terminals, one for each of the wires of a brushless motor. Some ESC's now offer telemetry.

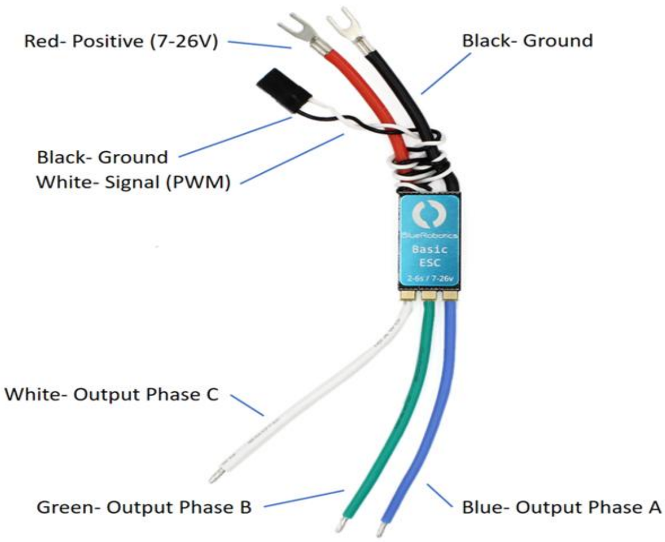


Fig 6.5: Typical ESC unit

Method for a User to Check ESC Protocol:

To check the ESC protocol used in a drone, a user can follow a few simple steps. First, connect the drone's Flight Controller (FC) to a computer using a USB cable and open a configuration software like Betaflight, BLHeli Configurator, or INAV. Navigate to the ESC/Motor settings section, where the current ESC protocol (such as PWM, OneShot, MultiShot, or DShot) is displayed. If the protocol is not explicitly mentioned, users can try changing it in the settings and testing motor response. Another method is to check the ESC specifications provided by the manufacturer, which usually list the supported protocols. Additionally, experienced users can observe the motor response; faster protocols like DShot result in smoother and quicker throttle response compared to traditional PWM signals. Properly identifying and setting the right ESC protocol ensures optimal performance and responsiveness in flight.

Example of Comparing Current Rating When Choosing the Right ESC:

When choosing the right ESC (Electronic Speed Controller), comparing the current rating is crucial to ensure safe and efficient operation. For example, if a drone motor has a maximum current draw of 20A, selecting an ESC rated at 20A or slightly higher (e.g., 25A or 30A) is ideal to prevent overheating or failure. If the ESC is underrated, such as using a 15A ESC for a 20A motor, it may overheat and burn out under load. On the other hand, choosing an ESC with a much higher rating, like 50A for a 20A motor, would work but might add unnecessary weight and cost. Therefore, it is best to choose an ESC with a current rating slightly higher than the motor's maximum draw to ensure reliability and performance while maintaining efficiency.

Diagram Showcasing the Arrangement (Connections) Between ESC, FC, PDB:

Motors

The motors are the main drain of battery power on your quad, therefore getting an efficient combination of propeller and motor is very important. Motor speed is rated in kV, generally a lower kV motor will produce more torque and a higher kV will spin faster, this however is without the prop attached. There are many aspects to motor performance aside from raw thrust, high among these is how much current the motor draws from the battery. Remember to check the specs of your motors for their maximum amp draw, and ensure that your ESC's are rated to withstand this amperage.

Builders tip : The brushless motors that are most commonly used on a miniquad have 3 wires, it doesn't really matter which of the 3 output terminals these are connected to on the ESC, swapping any of the 3 will change the direction of rotation. Motor rotation can be set in BL_Heli configurator.

Note- Remember to ensure that the motor mounting screws are not too long and that they do not touch the stator windings of the motor. This contact can cause a short in the windings, spelling the end for your motor, also make sure that any grub screws are fitted and tightened.

Propellers

Propellers are essential components of a drone that generate thrust by rotating and pushing air downwards, enabling lift and movement. They come in various sizes and pitches, with larger propellers providing more lift but requiring higher torque. The material of the propeller, such as plastic or carbon fiber, affects durability and performance. Balanced propellers reduce vibrations, ensuring smoother flights and better stability.

Builder's Tip: Propellers are often labeled with dimensions such as 5x3, where "5" indicates the diameter in inches and "3" represents the pitch. Balancing propellers before flight is crucial for minimizing vibrations.

Propeller-Motor Interrelations

The performance of a drone depends on the correct pairing of propellers and motors. A motor's KV rating (RPM per Volt) determines how fast it spins, which directly influences the thrust output of the propeller.

Low-KV motors are suited for larger propellers, providing efficient thrust at lower RPMs.

High-KV motors are ideal for smaller propellers, delivering faster response and agility.

Choosing the right propeller-motor combination ensures optimal efficiency, flight time, and maneuverability based on the drone's intended application.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Component / Tool	Suggested Specification	Qty
1	Flight Controller	Example: Naze32 / Pixhawk / Pluto FC	1
2	ESCs	12 A – 30 A (depending on motor)	4
3	Li-Po Battery	3.7 V (Nano) or 11.1 V/2200mAh (Quadcopter)	1
4	BLDC Motors	8520 / 2200 KV / 1000 KV type	4
5	Power Distribution Board / Hub	DC Power Rail	1
6	GPS / Compass Module	U-Blox / QMC5883L	Optional
7	Camera / FPV Unit	720p/1080p	Optional

VIII Precautions to be followed

1. Never short Li-Po battery terminals; risk of fire.
2. Always disconnect power before making wiring changes.
3. Do not touch motors while they are spinning.
4. Ensure ESCs are rated for motor current draw.
5. Handle PCBs with anti-static precautions.

IX Procedure (As Per Virtual Lab Simulation)

1. Visit the Virtual Lab: https://drone-iitd.vlabs.ac.in/ → Assembling Electrical Components –
2. Click Enter the Lab → Next → OK.
3. Drag the center plate to the table.
4. Use the soldering iron to pre-solder the power pads.
5. Drag ESC near the plate and solder red and black wires to the center plate.
   Repeat for all four ESCs.
6. Pre-solder again, drag Deans Plug, and solder its wires.

7. Drag PMU and solder its wires to the plate.
8. Use Digital Multimeter to check continuity of all connections.
9. Apply Hot Glue to all solder points to prevent short circuits.
10. Drag Arms and Motors, mount motors on arms using screws and the Allen Key.
11. Attach all arms to the center plate and tighten.
12. Connect motor wires to ESC terminals:
13. Yellow → Socket 1
14. Black → Socket 2
15. Red → Socket 3
16. Use Cable Tie to secure ESC to arm.
17. Complete simulation and submit.

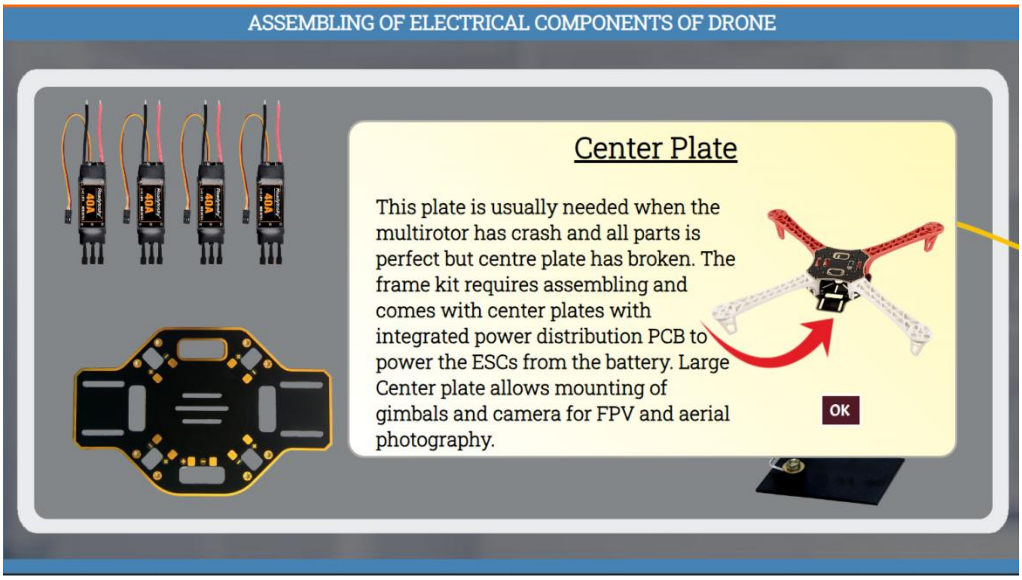


Fig 6.6: IIT-Delhi Drone Simulator Lab Screenshot (Source: IIT Delhi Virtual Drone Lab)

X Resources used

Sr. No.	Name of Resource	Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 6.1 Drone Electrical Component

Sr. No.	Component Name	Specification	Function

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. Describe the function of a Flight Controller in a drone.
2. Explain the reasons for using Li-Po batteries instead of standard rechargeable batteries in drones.
3. Outline the role of the Electronic Speed Controller (ESC) in drone operation.
4. Explain how the Inertial Measurement Unit (IMU) contributes to flight stabilization.
5. Define the significance of the C-rating in drone batteries.

[Space for Answers]

XVII References/Suggestions for further reading

1. Drone Technology for Beginners: Learn | Build | Fly Drones,by Ms. Dharna Nar, Dr. Radhika Kotecha, Drone School India and Ane Books Pvt Ltd, ISBN : 978-8197222184
2. **https://oscarliang.com/fpv-drone-frames/**

XVIII Assessment Scheme

	Performance Indicators	Weightage
	Process Related : 15 Marks	**60 %**
1	Understanding of Aim & Procedure	10%
2	Identification of Components / Tools / Software	15%
3	Execution of Experiment / Simulation Steps	20%
4	Measurement / Parameter Observation	10%
5	Teamwork & Lab Safety / Discipline	5%
	Product Related: 10 Marks	**40%**
6	Observation Table Completion	10%
7	Result & Interpretation	10%
8	Conclusion	5%
9	Viva / Practical Related Questions	10%
10	Timely Submission of Journal / Record	5%
	Total (25 Marks)	**100 %**

<table>
<tr><th colspan="3">Marks Obtained</th><th>Dated signature of Teacher</th></tr>
<tr><th>Process Related (15)</th><th>Product Related (10)</th><th>Total (25)</th><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Practical No 7: Identification of electronic components in drones, describing their specifications and functions.

I Practical Significance

Understanding the electronic components of drones provides students with hands-on insight into how UAVs operate and the role each component plays in their performance. By identifying and analyzing components such as sensors, microcontrollers, motors, ESCs (Electronic Speed Controllers), and communication modules, students gain practical knowledge essential for drone design, troubleshooting, and maintenance. This experiment builds foundational skills in electronics and UAV systems, fostering technical competence for future engineering applications.

II Industry/Employer Expected Outcome(s)

- Ability to identify and describe the specifications and functions of electronic components in drones.
- Understanding the role of each component in UAV performance, navigation, and control.
- Capability to communicate technical information clearly through diagrams, charts, or reports.
- Awareness of industry standards and technological requirements for drone electronics.

III Course Level Learning Outcome(s)

CO2 - Interpret drone technology along with its rules and regulations.

IV Laboratory Learning Outcome(s)

- LLO 7.1 Identify electronic components used in drones, describing their specifications and functions.

V Relevant Affective Domain Related Outcome(s)

- Develop appreciation for the complexity and innovation in drone electronics.
- Foster teamwork, creativity, and presentation skills while preparing the report/chart.
- Encourage curiosity and research-oriented learning about UAV systems.
- Cultivate attention to detail in identifying, analyzing, and documenting drone components.

VI Relevant Theoretical Background

DJI F450 Quadcopter drone frame

1045 Propeller 10in 10x4.5

2200mah 11.1v 35C 3S Zop Power Lipo Battery

FlySky FS-i6 2.4G 6CH AFHDS Transmitter

Max B3 Lipo balance Charger for 2-3 cell Lipo Battery

A2212 1000KV Brushless Motor

DJI Naza M Lite Multi-Rotor Flight Controller

FlySky FS-i6 2.4G 6CH AFHDS Receiver

Fig 7.1 Components of a Quadcopter Drone System, Including Frame, Propeller, LiPo Battery, Transmitter, Battery Charger, Flight Controller, Receiver, Electronic Speed Controller, Power Distribution Board, XT60 Connector, GPS Module.

Drones, or Unmanned Aerial Vehicles (UAVs), rely on a combination of mechanical, electrical, and software components to operate effectively. Key electronic components include:

- Flight Controller: The brain of the drone that manages stability, navigation, and control signals.
- Motors and ESCs (Electronic Speed Controllers): Provide thrust and control rotor speed.
- Battery and Power Distribution Board (PDB): Supply power to all drone components safely.
- Sensors: Include gyroscopes, accelerometers, GPS modules, barometers, and ultrasonic sensors for orientation, altitude, and positioning.
- Communication Modules: Transmit and receive data between the drone and the ground control station (e.g., RF, Wi-Fi, or telemetry modules).
- Payload Components: Cameras, LiDAR, or other specialized instruments depending on the drone application.

Understanding these components’ specifications (voltage, current rating, weight, type, range) and their integration is critical for designing efficient and reliable UAVs. Accurate identification and knowledge of these components also aids troubleshooting and innovation in UAV systems.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1	Flight Controller	Straight Pin, supports multirotor stabilization and control	1
2	DJI F450 Quadcopter Frame Kit	Includes integrated PCB for power distribution and mounting	1
3	SimonK 30A Brushless ESC	2–3S LiPo support, firmware: SimonK, controls motor speed	4
4	1045 Propeller Pair	Durable plastic propellers, 10x4.5 inch, clockwise & counterclockwise	2
5	A2212 1000KV Brushless Motor	Motor Type: Brushless DC Motor (BLDC) KV Rating: 1000KV Max Voltage: Typically, 11.1V (3S LiPo battery)Weight: Approximately 50-60 grams Shaft Diameter: 3.17mm (5mm is also available in some versions) Size: 22mm x 12mm (the 22mm is the stator diameter)	4

Sr. No.	Name of Resource	Suggested Specifications	Quantity
6	FlySky FS-CT6B 2.4G 6CH Remote Transmitter with FS-R6B Receiver	6 channels, 2.4 GHz, compatible with flight controller	1
7	Nylon Strap Belt for RC LiPo Battery	Adjustable strap for secure mounting of battery on frame	1
8	XT60 Male Connector with 14AWG Silicon Wire 10cm	For safe power connection between battery and PCB	1
9	Battery	Battery: Gens Ace 3000mAh 4S 30C LiPo Battery Voltage: 14.8V (4S) Capacity: 3000mAh Discharge Rate: 30C Weight: 380g Dimensions: 140mm x 45mm x 30mm Charge Rate: 1C (3000mAh max charge rate of 3A)	1

VIII Precautions to be followed

1. Handle all electronic components carefully to avoid static discharge or physical damage.
2. Verify component specifications (voltage, current rating, pin configuration) before connecting to the power supply.
3. Avoid short circuits while connecting motors, ESCs, or battery leads.
4. Ensure propellers are removed or the drone is secured when powering components for testing.
5. Maintain neatness and clarity when labeling and documenting components.
6. Record all measurements and observations accurately and back up digital reports regularly.
7. Follow safety guidelines while using tools, soldering, or testing electrical connections.

IX Procedure

1. Gather all drone components: Flight Controller, DJI F450 Frame, ESCs, motors, propellers, battery straps, connectors, and transmitter/receiver.
2. Identify each component physically and note its specifications from datasheets or manuals.
3. Describe the function of each component in drone operation (e.g., flight stabilization, propulsion, power distribution, communication).
4. Test electrical parameters where applicable using a multimeter or other measurement tools (e.g., ESCs, battery voltage).
5. Organize the information in a table or chart format showing: Component Name | Specifications | Function | Observations.
6. Include diagrams or images to illustrate how each component integrates within the drone system.
7. Review the chart/report for completeness, accuracy, and clarity.
8. Present or submit the final report/chart according to instructor guidelines.

X Resources used

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1			
2			
3			
4			
5			
6			
7			
8			
9			

XI Actual Procedure

XII Observation Table

Table 7.1 Drone electronic components

Sr. No.	Component Name	Specifications	Function in Drone	Remarks
1	Flight Controller			
2	DJI F450 Quadcopter Frame Kit			

Sr. No.	Component Name	Specifications	Function in Drone	Remarks
3	SimonK 30A Brushless ESC			
4	A2212 1000KV Brushless Motor			
5	1045 Propeller Pair			
6	FlySky FS-CT6B Transmitter with FS-R6B Receiver			
7	Nylon Strap Belt for RC LiPo Battery			
8	XT60 Male Connector with 14AWG Silicon Wire 10cm			
9	Battery			

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Identify the flight controller in the drone kit and write down its function.
2. Find the brushless motor and note its specifications and purpose in the drone.
3. How do ESCs (Electronic Speed Controllers) work with brushless motors to control drone movement.
4. Locate the propeller pair and explain how it works with the motor.
5. Find the transmitter and receiver and write down how they help control the drone.

XVI References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.
2. Valavanis, K. P., & Vachtsevanos, G. J. (2015). Handbook of Unmanned Aerial Vehicles. Springer. Detailed reference on UAV systems, including electronics, sensors, and control mechanisms.
3. Beard, R. W., & McLain, T. W. (2012). Small Unmanned Aircraft: Theory and Practice. Princeton University Press. Focuses on the engineering, flight control, and electronics of small UAVs.
4. Johnson, W. (2017). Rotorcraft Aeromechanics. Cambridge University Press. Provides insights into drone propulsion, motor-ESC interactions, and component-level dynamics.
5. Floreano, D., & Wood, R. J. (2015). Science, Technology and the Future of Small Autonomous Drones. Nature. Discusses modern UAV technologies, sensors, and integration of electronic components for autonomous operation.

XVII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the drone components	10%
2	Identification of drone components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Recognition and description of drone components, their specifications, and functions	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8: Preparation of a report/chart on DGCA Regulations & Safety Protocols for Drone Operation

I Practical Significance

Every drone pilot and engineer must operate within the legal and safety framework defined by the DGCA, Government of India. Understanding these rules ensures compliance, prevents accidents, and promotes responsible use of drone technology. Preparing a summary chart or report helps students visualize and memorize the essential guidelines that govern drone operation across different zones and categories.

II Industry/Employer Expected Outcome(s)

- Ability to identify and apply DGCA rules related to drone operation and registration.
- Awareness of legal responsibilities for drone ownership, flying, and data collection.
- Knowledge of national and local airspace safety protocols and risk management practices.

III Course Level Learning Outcome(s)

CO2 - Interpret drone technology along with its rules and regulations.

IV Laboratory Learning Outcome(s)

- LLO 8.1 Prepare a report/chart on DGCA Regulations & Safety Protocols for Drone Operation.

V Relevant Affective Domain related outcome(s)

- Develop discipline and accountability in adhering to aviation regulations.
- Encourage responsible flying culture and promote safety-first mindset.

VI Relevant Theoretical Background

The rapid growth of drone technology in India has created tremendous opportunities across sectors such as agriculture, infrastructure, surveillance, mapping, and logistics. However, this expansion also brings significant challenges in terms of airspace safety, privacy, and security. To address these concerns and ensure orderly development, the Directorate General of Civil Aviation (DGCA) under the Ministry of Civil Aviation (MoCA) introduced a comprehensive set of policies and regulations known as the Drone Rules, 2021.

These rules replaced the earlier Unmanned Aircraft System (UAS) Rules, 2020, making drone operations in India simpler, more transparent, and digitally integrated. The DGCA now uses the Digital Sky Platform as a centralized online system for drone registration, pilot certification, and flight permission management. This platform operates on the principle of “No Permission, No Takeoff” (NPNT) — meaning that a drone cannot take off without prior digital authorization through the portal.

The Drone Rules, 2021, classify drones into five categories based on their maximum all-up weight:

- Nano (below 250 g)
- Micro (250 g to 2 kg)
- Small (2 kg to 25 kg)
- Medium (25 kg to 150 kg)
- Large (above 150 kg).

Each category has specific rules related to registration, pilot training, permissible flight altitude, and safety requirements. For example, Nano drones can be flown without registration, whereas Micro and above require both registration and a Remote Pilot Certificate (RPC).

Airspace in India is divided into three color-coded zones — Red, Yellow, and Green — to ensure safe segregation of drone and manned aircraft operations.

The Red Zone represents restricted areas such as airports, military bases, and international borders, where drone flight is prohibited unless explicitly authorized by central authorities.

The Yellow Zone represents controlled airspace, typically surrounding the Red Zone, where flying is allowed only with prior permission from Air Traffic Control (ATC).

The Green Zone represents open airspace where drones can operate without prior permission, up to a maximum height of 120 meters above ground level.

The DGCA also prescribes a set of standard safety protocols to be followed by all drone operators. These include conducting pre-flight inspections, ensuring battery health and GPS connectivity, maintaining visual line of sight (VLOS) during operations, avoiding populated or sensitive areas, and adhering to daylight-only operations unless otherwise permitted. Drone pilots must also ensure that their firmware supports NPNT compliance to prevent unauthorized takeoffs.

Furthermore, operators are required to maintain flight logs, incident reports, and maintenance records for their drones. These records help in post-flight analysis, accountability, and future audits by regulatory bodies. Drones equipped with cameras or sensors must respect data protection and privacy laws, ensuring that no unauthorized surveillance or photography occurs in restricted or private areas.

In addition to operational safety, the DGCA emphasizes organizational safety management through the development of a Safety Management System (SMS). This includes risk identification, hazard mitigation, and continuous monitoring of safety performance. For academic and industrial purposes, following DGCA protocols ensures that drone operations remain lawful, safe, and ethical.

Table 8.1 Summarize Report on DGCA rules & regulation

Category	Key Points	Explanation
Purpose & Scope	Rules apply across India (except armed forces), focus on safe & regulated drone usage via Digital Sky platform. Based on NPNT (No Permission, No Takeoff).	A digital system ensures drones fly only with permission and in safe zones.
Drone Categories (by Weight)	Nano: <250g (mostly free to fly) Micro: 250g–2kg (basic rules) Small: 2–25kg (moderate rules) Medium: 25–150kg (strict certification) Large: >150kg (heavy commercial use, strictest).	Bigger drones = higher risk = more rules. Nano drones are easiest to use.
Registration (UIN)	All drones except Nano must register on Digital Sky to get UIN within 7 days.	Helps government track drone ownership.
Pilot Certification (RPC)	Needed for Micro and above category drones. Training only via DGCA-approved RPTOs. Valid for 10 years.	Only trained pilots can fly bigger drones.
Drone Type Certification	Medium & Large → DGCA Type Approval required. Micro & Small → Manufacturer issues safety compliance certificate.	Ensures the drone model is safe and reliable.
Airspace Zones	Green Zone: Free flying up to 400 ft, no permission required. Yellow Zone: Controlled zone (around airports), permission required via NPNT. Red Zone: No-fly areas (military/strategic areas).	Like traffic lights: Green = Go, Yellow = Caution/Permission, Red = Stop.

Operational Rules	Fly within Visual Line of Sight (VLOS). No flying over crowds or at night (unless specially approved). No dangerous goods.	Keep drone in sight, avoid risky areas.
Insurance & Logging	Insurance mandatory for non-nano drones. Pilots must log flight data & report incidents within 24 hours.	Ensures accountability & safety record.
Commercial Use	Allowed mainly in Green Zones. 2022 rules allow one pilot to control multiple drones in clusters (special permission).	Supports drone business applications like delivery, mapping.
Penalties	Fines up to ₹1 lakh, drone seizure, pilot certificate cancellation, or imprisonment for serious violations.	Breaking rules can lead to heavy punishment.
Safety Requirements	Geo-fencing, anti-collision, tracking ID, minimum 50m distance from people/structures. RPTOs must train emergencies & ethical flying.	Safety tech + trained operator = reduced accidents.

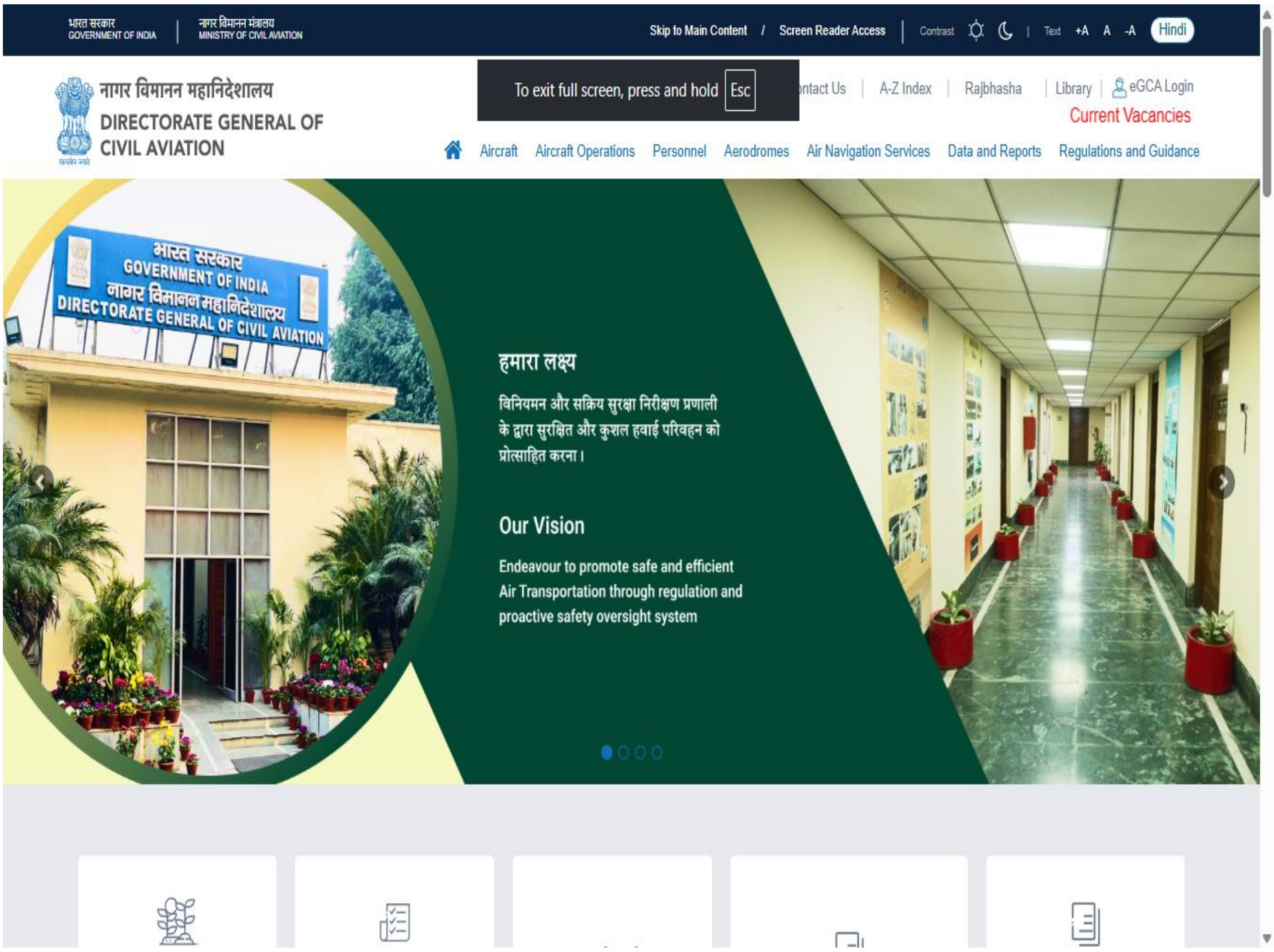


Fig 8.1: Illustration showing DGCA Regulatory Structure and Digital Sky workflow

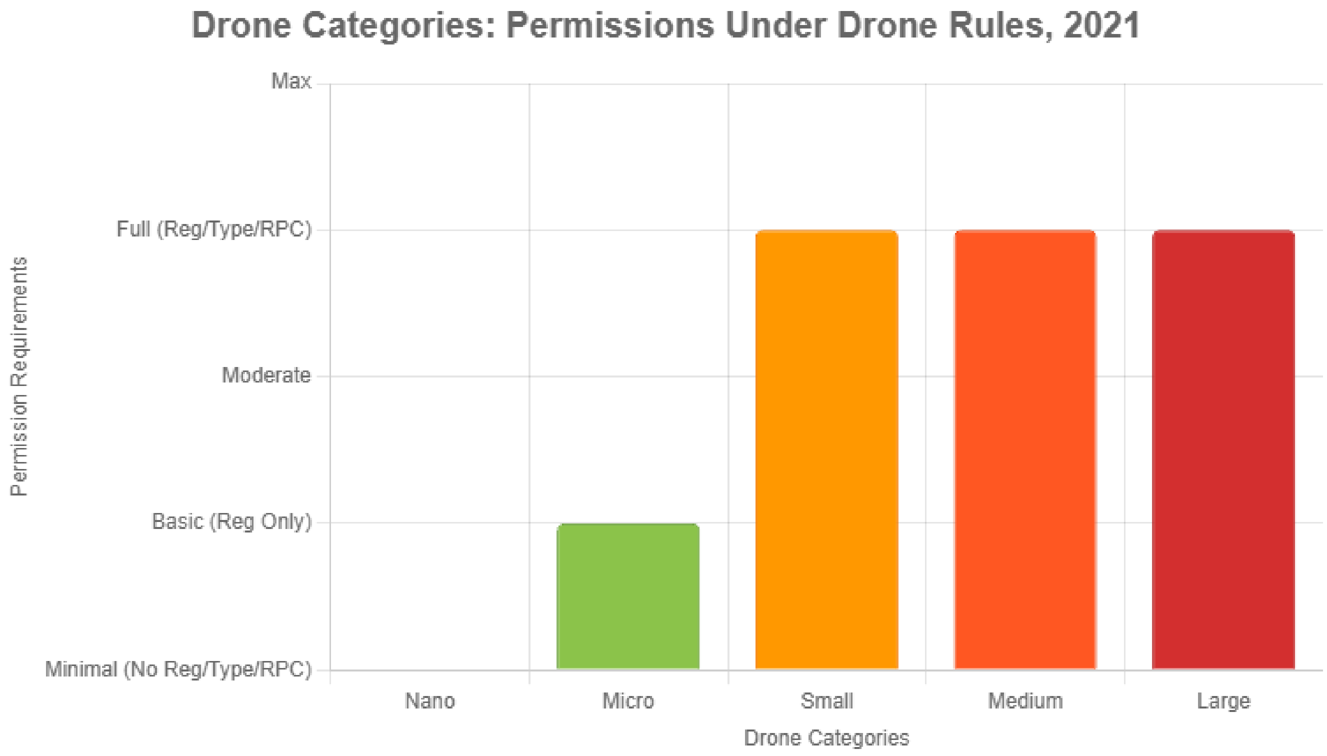


Fig 8.2: Chart showing Drone Categories and Permissions under Drone Rules, 2021

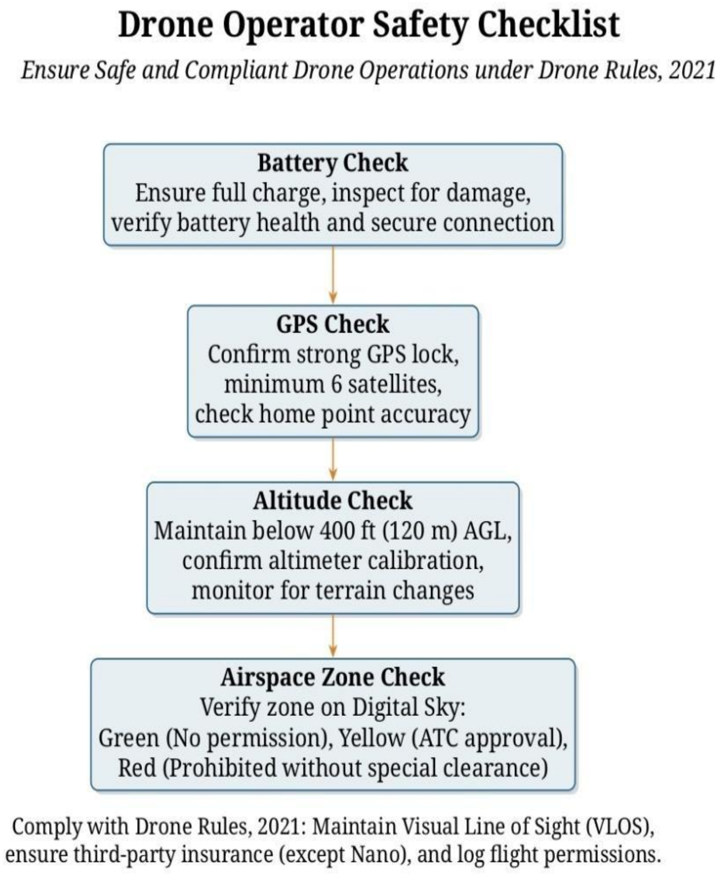


Fig 8.3: Info graphic of Drone Operator Safety Checklist — Battery, GPS, Altitude, Airspace Zone

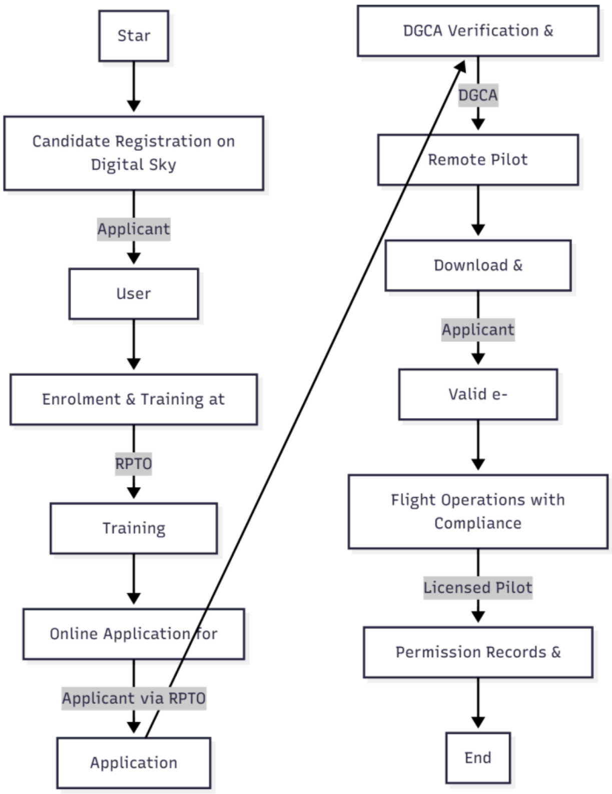


Fig 8.4: DGCA Drone pilot Licenses Steps

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Airspace Zoning Map	Interactive digital map displaying airspace zones (e.g., Red, Yellow, Green) for drone operations	01
2	Regulatory Manual/Documentation	Official guide or documentation outlining drone operation rules, zoning regulations, and platform usage instructions	01
3	Desktop Computer	Intel i3/i5, 8GB RAM, 500GB HDD/256GB SSD, Windows 10/11	02
4	UPS 6 KVA online	Online UPS, 6 KVA capacity, input: 230V AC, output: 230V AC, Backup: 10–15 min, LCD display	01
5	Ethernet Switch	Ethernet Switch- 4/8/16/24/32	01
6	Router	Router-256MB Memory storage capacity, compatible with Desktop and Laptop, Rack Mountable, Wireless Connectivity	01
7	Simulation Software	Simulation Software: CISCO Packet Tracer, CORE Network Emulator, GNS3 or any other simulator	01
8	Antivirus Software	Quick Heal Total Security, Version 24.0 (or the latest available version, or any equivalent antivirus software)	01

VIII Precautions to be followed

1. Always refer to the latest version of DGCA Drone Rules (2021 and amendments).
2. Verify information from official government websites only.
3. Clearly differentiate between legal and safety procedures.
4. Use accurate data when preparing the chart/report.

IX Procedure

1. Visit the DGCA website and download the Drone Rules, 2021.
2. Open the Digital Sky portal and review operational guidelines for drones.
3. Identify and list major categories, airspace rules, registration steps, and licensing requirements.
4. Summarize safety protocols for flight preparation, emergency handling, and compliance.
5. Prepare a report or visual chart combining regulatory and safety information.
6. Review the report for completeness, accuracy, and visual clarity.

X Resources used

Sr. No.	Name of Resource	Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 8.1 Drone rules as per DGCA

Sr. No.	Category / Rule	Description	Remarks
1	Drone Classification		
2	Registration		
3	Pilot License		
4	Flight Zones		
5	NPNT System		
6	Safety Checks		
7	Data Policy		

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. State the reason for mandatory Remote Pilot Certificate for drone operators.
2. Describe the penalties for flying in a Red Zone without permission.
3. Explain the importance of pre-flight safety checks.
4. How can a drone operator ensure airspace compliance using Digital Sky?

[Space for Answers]

XVII References/Suggestions for further reading

1. DGCA Drone Rules, 2021 – **https://dgca.gov.in**
2. Digital Sky Platform – **https://digitalsky.dgca.gov.in**
3. The Drone Law In India, by Dr Raja Mogili Amirisetty, Gogia Law Agenency , ISBN : 978-8193978559

XVIII Assessment Scheme

Performance Indicators		**Weightage**
Process Related: 15 Marks		**60 %**
1	Understanding of Aim & Procedure	10%
2	Identification of Components / Tools / Software	15%
3	Execution of Experiment / Simulation Steps	20%
4	Measurement / Parameter Observation	10%
5	Teamwork & Lab Safety / Discipline	5%
Product Related: 10 Marks		**40%**
6	Observation Table Completion	10%
7	Result & Interpretation	10%
8	Conclusion	5%
9	Viva / Practical Related Questions	10%
10	Timely Submission of Journal / Record	5%
Total (25 Marks)		**100 %**

<table>
<tr><th colspan="3">Marks Obtained</th><th>Dated signature of Teacher</th></tr>
<tr><th>Process Related (15)</th><th>Product Related (10)</th><th>Total (25)</th><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Practical No. 9: Plot the Speed-Torque Characteristics of Drone's BLDC Motor

I Practical Significance

This experiment helps in understanding how a BLDC motor used in drones behaves under different operating conditions. The Speed–Torque curve shows the relationship between how fast the motor rotates and how much torque it can produce. By simulating this curve, we can identify the stable operating point of the drone during hover. This practical is important because it helps in selecting the correct motor, propeller, and battery combination for safe and efficient drone flight. It also reduces trial-and-error during hardware assembly and prevents damage to components.

II Industry/Employer Expected Outcome(s)

- Ability to generate a Speed–Torque graph of a BLDC motor.
- Ability to compare performance at different voltages and propeller sizes.
- Ability to choose suitable motor–battery combinations for drone applications..

III Course Level Learning Outcome(s)

CO3 - State function of Drone system and subsystems.

IV Laboratory Learning Outcome(s)

- LLO 9.1 Plot the Speed-Torque Characteristics of a BLDC Motor used in Drone.

V Relevant Affective Domain related outcome(s)

- Develops awareness of the importance of correct motor selection for safe and stable drone operation.
- Encourages careful and responsible use of simulation tools before actual hardware testing.

VI Relevant Theoretical Background

- Torque–Speed Characteristics of a BLDC Motor (Simple Linear Model)

Introduction

A Brushless DC (BLDC) motor is a type of synchronous motor where the rotor is equipped with permanent magnets and the stator carries windings supplied by an electronic speed controller (ESC).
BLDC motors are widely used in drone propulsion systems due to their high efficiency, compact size, and linear torque–current relationship.
Understanding the torque–speed characteristics is essential for selecting motors, designing controllers, and predicting flight performance.

Fig 9.1: BLDC motor UAV Motor KV120

Principle of Operation

When a BLDC motor is energized, a three-phase current produces a rotating magnetic field in the stator. The rotor's permanent magnets align with this field, producing torque.

The back electromotive force (back EMF) is proportional to rotor speed: $E = Ke * \omega$, where E is back EMF (V), Ke is back EMF constant (V·s/rad), and ω is angular speed (rad/s).

Simplified Linear Torque Equation

For surface-mounted BLDC motors (most drone motors), torque and current have a linear relation:

$Te = Kt * I$,

Where Te is electromagnetic torque (Nm)

Kt is torque constant (Nm/A)

I is armature current (A).

Since in SI units Kt = Ke, this model simplifies analysis and simulation.

Relationship between Speed, Torque, and Voltage

From the voltage balance:

$V = E + I*R = Ke*\omega + (R/Kt)*Te$.

Thus, $Te = (Kt/R) * (V - Ke*\omega)$.

This shows torque decreases linearly with speed since back EMF increases with ω.

At zero speed (stall), $Te = (Kt*V)/R$. At no-load, $\omega = V/Ke$.

Torque–Speed Characteristic Regions

1. Constant Torque Region – At low speeds, torque ≈ constant.
2. Constant Power Region – Torque decreases with increasing speed.
3. No-Load Region – Torque tends to zero at maximum speed.

Detail information   Specifications

Test Data   Export to Excel

Type	Voltage (V)	Propeller	Throttle	Thrust (g)	Torque (N*m)	Current (A)	RPM	Power (W)	Efficiency (g/W)	Operating Temperature (℃)
U11-II KV120	48	T-MOTOR 26*8.5" CF	40%	2357	0.71	4.25	1978	206	11.45	85 (Ambient Temperature: 19℃)
			42%	2613	0.78	4.91	2095	238	10.97	
			44%	2882	0.85	5.62	2214	272	10.58	
			46%	3127	0.93	6.33	2312	307	10.19	
			48%	3359	0.98	6.99	2401	338	9.92	
			50%	3595	1.09	7.71	2513	374	9.61	
			52%	3833	1.15	8.47	2608	411	9.33	
			54%	4134	1.25	9.41	2715	456	9.06	
			56%	4422	1.31	10.35	2818	502	8.81	
			58%	4679	1.42	11.26	2914	546	8.56	
			60%	4931	1.49	12.39	3023	601	8.21	
			62%	5361	1.62	13.69	3123	664	8.07	
			64%	5683	1.72	14.97	3245	727	7.82	
			66%	6077	1.81	16.23	3344	787	7.71	
			68%	6340	1.92	17.61	3440	855	7.42	

$349.90

USD200 Consumption Free Shipping by International Express (Excl. Remote Areas and Special Items).

Fig 9.2: BLDC motor Torque-Speed Characteristic

Torque–Speed Curve Shape

A BLDC motor exhibits a linear torque–speed curve that decreases from maximum torque at stall to zero torque at no-load speed.

This linear relationship is ideal for drone propulsion because it allows predictable torque control via PWM or current regulation.

Practical Relevance for Drones

In drones, each motor's torque determines propeller thrust (T_thrust ∝ ω^2).
Torque–speed control affects lift, stability, and efficiency. ESCs use PWM to adjust voltage and current, controlling torque and thrust.

MATLAB Simulation Code

```
clc; clear; close all;
% --------------------------------------------
% DATASET-1 (U11-II KV120 Motor, 26x8.5 Prop)
% Torque values are taken DIRECTLY from table
% --------------------------------------------
% Throttle (%)
throttle = [40 42 44 46 48 50 52 54 56 58 ...
            60 62 64 66 68 70 75 80 90 100];
% Speed in rad/s (already provided in table)
speed = [1978 2095 2214 2312 2401 2513 2608 2715 2818 2914 ...
         3023 3123 3245 3344 3440 3539 3768 3988 4425 4818];
% Torque in Nm (DIRECT from table, no calculations)
torque = [0.71 0.78 0.85 0.93 0.98 1.09 1.15 1.25 1.31 1.42 ...
          1.49 1.62 1.72 1.81 1.92 2.00 2.28 2.58 3.14 3.78];
% Power (W) from table
power = [206 238 272 307 338 374 411 456 502 546 ...
         601 664 727 787 855 916 1100 1310 1788 2370];
% ---------------------------
% Plot: Torque vs Speed
% ---------------------------
figure;
plot(speed, torque, 'LineWidth', 2);
grid on;
title('Torque vs Speed (U11-II KV120 Motor)');
xlabel('Speed (rad/s)');
ylabel('Torque (Nm)');
% ---------------------------
% Plot: Torque vs Throttle
% ---------------------------
figure;
plot(throttle, torque, 'LineWidth', 2);
grid on;
title('Torque vs Throttle (%)');
xlabel('Throttle (%)');
ylabel('Torque (Nm)');
% ---------------------------
% Plot: Power vs Speed
% ---------------------------
figure;
plot(speed, power, 'LineWidth', 2);
grid on;
```

```
title('Power vs Speed');
xlabel('Speed (rad/s)');
ylabel('Power (W)');
```

Interpretation of matlab code output

- Torque–Speed Curve: Linear decrease from stall torque to zero torque at no-load speed.
- Power–Speed Curve: Peaks near half of no-load speed.
- Efficiency: Highest around 75–85% of no-load speed.

Key Equations

E = Ke * ω

Te = Kt * I

V = Ke * ω + (R/Kt)*Te

Te = (Kt/R) * (V - Ke*ω)

T_stall = (Kt*V)/R

ω_no-load = V/Ke

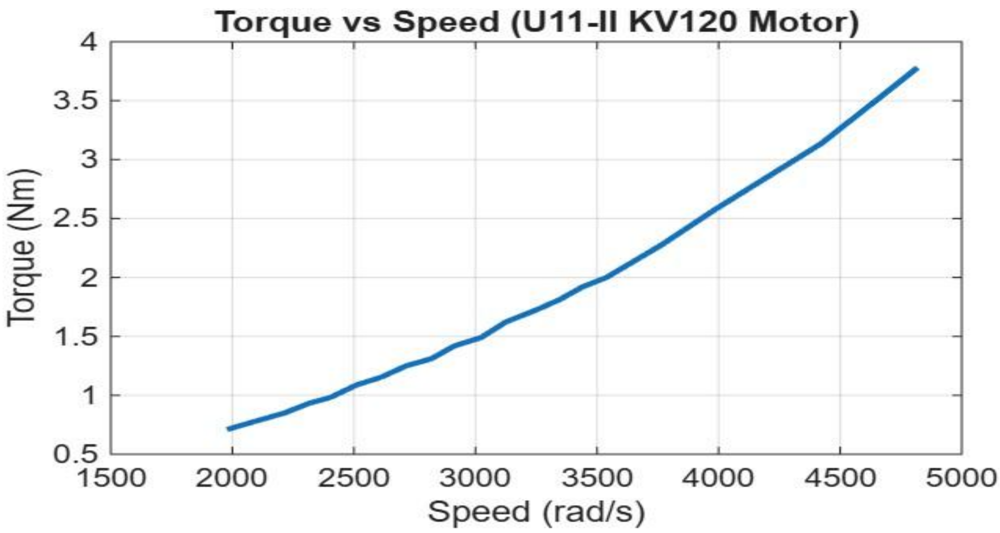


Fig 9.3: Torque Speed Characteristic

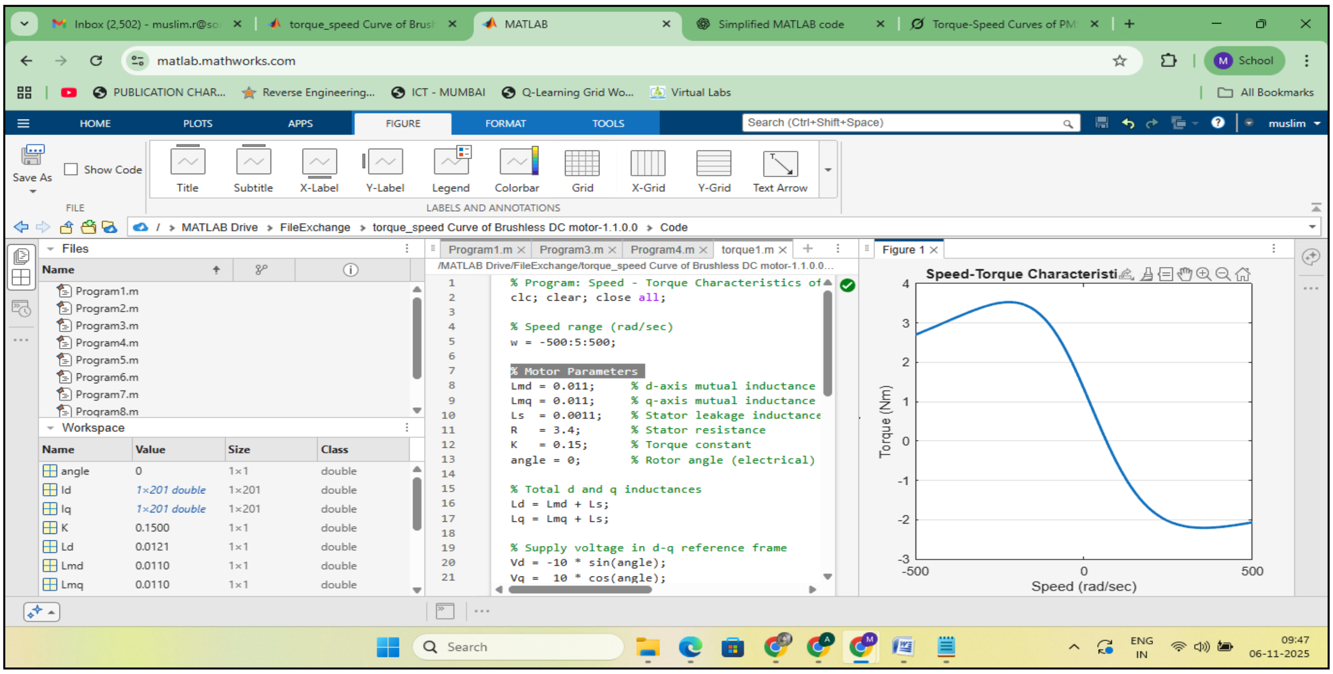


Fig 9.4: Matlab Code Simulation

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Component / Tool	Suggested Specification	Quantity
1	MATLAB / Octave Software	Installed on PC/Laptop	1
2	Desktop Computer	Intel i3/i5, 8GB RAM, 500GB HDD/256GB SSD, Windows 10/11	02
3	BLDC Motor Data Sheet	Any standard BLDC motor specifications	01
4	Ethernet Switch	Ethernet Switch- 4/8/16/24/32	01
5	Router	Router-256MB Memory storage capacity, compatible with Desktop and Laptop, Rack Mountable, Wireless Connectivity	01
6	Antivirus Software	Quick Heal Total Security, Version 24.0 (or the latest available version, or any equivalent antivirus software)	01

VIII Precautions to be followed

1. Ensure correct motor parameter values are entered into the program.
2. Use consistent units (e.g., inductance in Henry, speed in rad/sec).
3. Before running code, verify syntax carefully to avoid logical errors.
4. While analyzing the graph, observe the trend properly and avoid wrong interpretation.

IX Procedure

1. Open MATLAB / Octave on your computer.
   Launch the MATLAB software to create a new script for simulation.
2. Create a New Script File.
   Click on File → New → Script, and copy the provided MATLAB code for the BLDC motor torque–speed calculation (linear model).
3. Define Motor Parameters.
   Enter known parameters of the motor, such as:

a. Supply voltage (V)
b. Armature resistance (R)
c. Motor speed constant (Kv)
d. Torque constant (Kt)
e. These can be taken from the BLDC motor datasheet (typically used in drones).

4. Derive Relationships.
   Compute the back EMF constant using (Ke = Kt).
   Derive no-load speed and stall torque using:

$$\boldsymbol{w(no-load\ speed) = \frac{V}{Ke}}$$

$$\boldsymbol{Tstall = \frac{Kt * V}{R}}$$

5. Define the Speed Range.
   Create a vector for speed variation from 0 (stall) to no-load speed using the linspace function.
6. Calculate Torque for Each Speed.
   Use the linear torque–speed relationship:

$$\boldsymbol{Te = \frac{Kt}{R} * (V - Ke * w)}$$

7. Plot the Graph.
   Use the MATLAB plot() function to generate the Torque vs Speed graph.
   Label axes properly and add grid lines for clarity.
8. Run the Simulation.
   Execute the code and observe how torque decreases linearly as speed increases, eventually reaching zero at the no-load speed.

X Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Component / Tool	Suggested Specification	Quantity

XI Actual Procedure

XII Observation Table

Table 9.1 Speed Torque Characteristic

Sr. No.	Speed (rpm)	Torque (Nm)
1		
2		
3		
4		
5		
6		
7		

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. Relation between torque and increase in motor speed.
2. Function of Iq (quadrature current) in torque production.
3. Influence of torque constant (K) on motor torque output.
4. Effect of back EMF on current at higher motor speeds.
5. Parameters that affect torque at higher speeds.

[Space for Answers]

XVII References/Suggestions for further reading

1. Ms. Dharna Nar, Dr. Radhika Kotecha,
   Drone Technology for Beginners: Learn | Build | Fly Drones,
   Drone School India and Ane Books Pvt. Ltd.,
   ISBN: 978-8197222184.
2. Aalok Tripathi,
   Drone Technician Theory,
   Arihant Publications India Ltd.,
   ISBN: 978-9364378895.
3. MathWorks — MATLAB & Simulink Documentation (Motor Control / Simscape Electrical).

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Understanding of Aim & Procedure	10%
2	Identification of Components / Tools / Software	15%
3	Execution of Experiment / Simulation Steps	20%
4	Measurement / Parameter Observation	10%
5	Teamwork & Lab Safety / Discipline	5%
Product Related: 10 Marks		**40%**
6	Observation Table Completion	10%
7	Result & Interpretation	10%
8	Conclusion	5%
9	Viva / Practical Related Questions	10%
10	Timely Submission of Journal / Record	5%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No 10: Inspection of a battery pack for bulges and leakage.

I Practical Significance

Battery packs are crucial components in electronic devices, drones, and electric vehicles. Understanding their condition, specifically identifying bulges or leakage, is essential for ensuring safety, reliability, and optimal performance. This experiment teaches students to visually and physically inspect battery packs, recognize signs of damage, and prevent potential hazards such as short circuits, fires, or device failure. By developing these skills, students gain practical knowledge in battery maintenance, safety protocols, and troubleshooting, which are vital in electronics, robotics, and UAV applications.

II Industry/Employer Expected Outcome(s).

- Ability to identify battery pack defects, such as swelling, leakage, or physical damage.
- Understanding the safety protocols associated with handling defective batteries.
- Capability to document inspection results in a clear and structured report.
- Awareness of preventive maintenance techniques to enhance battery longevity.

III Course Level Learning Outcome(s)

CO4 - Test the drone system.

IV Laboratory Learning Outcome(s)

- LLO 10.1 Inspect battery pack for bulges and leakage.

V Relevant Affective Domain Related Outcome(s)

- Develop awareness of safety risks associated with damaged batteries.
- Foster responsibility and diligence in inspecting and handling electronic components.
- Encourage careful observation and systematic documentation of technical data.
- Promote proactive problem-solving and maintenance-oriented thinking.

VI Relevant Theoretical Background

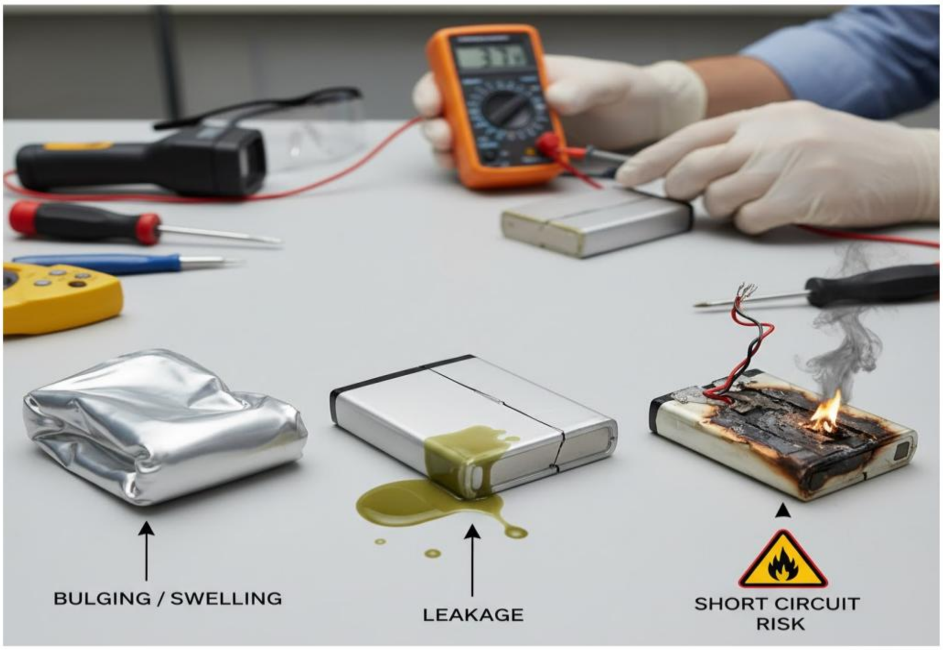


Fig 10.1 Drone Battery Issues: Bulging/Swelling, Leakage, and Short Circuit

Battery packs, particularly lithium-ion types, are widely used in electronics, drones, and electric vehicles due to their high energy density. However, they are susceptible to physical and chemical degradation. Common issues include:

- Bulging/Swelling: Caused by gas formation inside the battery due to overcharging, overheating, or chemical breakdown.
- Leakage: Electrolyte leakage occurs when the battery casing is damaged or internal pressure builds up.
- Short Circuit Risk: Damaged batteries can cause sparks, overheating, or fire hazards.

Inspection involves both visual and tactile checks, often accompanied by measuring voltage to identify anomalies. Understanding these failure modes is critical for ensuring operational safety and device longevity.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1	Multimeter	Digital Multimeter 600vAC/DC, 10A:2M ohms	1
2	Insulating gloves	Electrical Insulated Gloves 1000V	1 pair
3	Safety goggles	Robustt Safety Goggles for Chemical Protection (Free-size)	1 pair
4	Battery packs	Battery: Gens Ace 3000mAh 4S 30C LiPo Battery Voltage: 14.8V (4S) Capacity: 3000mAh Discharge Rate: 30C Weight: 380g Dimensions: 140mm x 45mm x 30mm Charge Rate: 1C (3000mAh max charge rate of 3A)	As required
5	Notepad	Ruled Pages	As required

VIII Precautions to be followed

1. Wear insulating gloves and safety goggles during inspection.
2. Do not puncture or apply excessive force on the battery pack.
3. Handle swollen or leaking batteries carefully; avoid contact with skin or eyes.
4. Use a multimeter to check voltage only after a visual inspection.
5. Dispose of defective batteries according to safety and environmental regulations.

IX Procedure

1. Collect the battery packs to be inspected and place them on a non-conductive surface.
2. Wear safety gloves and goggles before starting the inspection.
3. Perform a visual examination to detect bulges, swelling, corrosion, or leakage.
4. Gently press the battery surface to feel for unusual softness or rigidity.
5. Use a multimeter to measure voltage and identify abnormal readings.
6. Document all observations, noting the type of battery, condition, and any defects.
7. Recommend corrective actions, such as safe disposal or replacement of damaged batteries.
8. Prepare a structured report summarizing findings and safety precautions.

X Resources used

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1			
2			
3			
4			
5			

XI Actual Procedure

XII Observation Table

Table 10.1 Battery Specification

Sr. No.	Battery Type	Rated Voltage	Visual Condition (Bulge/No bulge)	Leakage (Yes/No)	Measured Voltage (V)	Remarks / Action Required
1	Li-ion					
2	Li-ion					

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Describe the safety implications of a Li-ion battery showing a bulge but no leakage.
2. Determine the appropriate action if the measured voltage of a Li-ion battery is significantly lower than its rated voltage.
3. Evaluate the condition of a Li-ion battery when leakage is present but no bulge is observed.
4. Assess the reliability of a battery based on a comparison between its rated voltage and measured voltage.
5. Recommend an action for a battery that shows both bulge and leakage during inspection.

[Space for Answers]

XVII References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.
2. Valavanis, K. P., & Vachtsevanos, G. J. (2015). Handbook of Unmanned Aerial Vehicles. Springer. Detailed reference on UAV systems, including electronics, sensors, and control mechanisms.
3. Beard, R. W., & McLain, T. W. (2012). Small Unmanned Aircraft: Theory and Practice. Princeton University Press. Focuses on the engineering, flight control, and electronics of small UAVs.
4. Johnson, W. (2017). Rotorcraft Aeromechanics. Cambridge University Press. Provides insights into drone propulsion, motor-ESC interactions, and component-level dynamics.
5. Floreano, D., & Wood, R. J. (2015). Science, Technology and the Future of Small Autonomous Drones. Nature. Discusses modern UAV technologies, sensors, and integration of electronic components for autonomous operation.

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11: Calculation of the flying time based on battery capacity

I Practical Significance

Battery endurance is a crucial factor determining how long a drone can stay airborne. Understanding the relationship between battery capacity, current consumption, and flight time enables students to design efficient drone systems and plan safe missions. This experiment builds fundamental knowledge for estimating and optimizing drone endurance.

II Industry/Employer Expected Outcome(s)

- Ability to calculate estimated flight time using battery capacity and power draw.
- Understanding of power consumption, efficiency, and practical endurance limits of UAVs.
- Skill to interpret drone performance data for mission planning and design.

III Course Level Learning Outcome(s)

CO2 - Interpret drone technology along with its rules and regulations.

IV Laboratory Learning Outcome(s)

- LLO 11.1 Calculate the flying time based on battery capacity.

V Relevant Affective Domain related outcome(s)

- Demonstrate accuracy and analytical thinking while performing energy calculations.
- Appreciate the importance of energy management in UAV design and operation.

VI Relevant Theoretical Background

A drone's flight time depends on the battery capacity (Ah) and the average current drawn (A) by its electronic and propulsion systems.

The fundamental relationship is:

$$\text{Flight Time (hours)} = \frac{Battery\ Capacity\ (Ah)}{Average\ Current\ (A}$$

For practical estimation in minutes:

$$\text{Flight Time (mins)} = \frac{Battery\ Capacity\ (Ah)}{Average\ Current\ (A} X\ 60$$

Because Li-Po batteries should not be completely discharged, only about 80% of their rated capacity is usable Therefore:

Practical Flight Time (mins) = Theoretical Flight Time X 0.8

Flight time also depends on factors such as payload weight, wind resistance, motor efficiency, and flight mode (hover or forward flight).

Fig 11.1: Lithium Polymer Battery

For example

Sr. No.	Battery Voltage (V)	Capacity (mAh)	Avg Current (A)	Theoretical Time (min)	Practical Time (80 %) (min)
1	11.1	2200	8.0	(2200 ÷ (8×1000))×60 = 16.5	13.2

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Component / Tool	Specification	Qty
1	Drone (Pluto X / Quadcopter)	3.7 V Li-Po battery	1
2	Battery	11.1 V 2200 mAh (3S)	1

VIII Precautions to be followed

1. Do not over-discharge Li-Po batteries below 3.2 V per cell(For battery voltage is 3.7 V)
2. Use correct average current values (hover or loaded condition).
3. Ensure consistent units while calculating (mAh → Ah).
4. Perform actual flight test only under safe supervision.

IX Procedure

1. Note the battery voltage and capacity from its label.
2. Measure or obtain the average current draw of the drone from datasheet or simulation.
3. Convert battery capacity from mAh → Ah by dividing by 1000.
4. Apply the theoretical formula to calculate flight time.
5. Multiply by 0.8 to estimate the realistic time.
6. Record all readings in the observation table.
7. Compare with the manufacturer's rated flight duration.

X Resources used

Sr. No.	Name of Resource	Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 11.1 Flying time calculation.

Sr. No	Battery Voltage (V)	Capacity (mAh)	Avg Current (A)	Theoretical Time (min)	Practical Time (80 %) (min)
1					
2					
3					

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. Describe the reason only 80% of Li-Po battery capacity is considered usable during flight.
2. Relate payload weight to the change in current drawn by the drone.
3. Interpret the role of battery C-rating during high-power flight operations.
4. Propose methods to increase drone flight endurance without changing the battery capacity.

[Space for Answers]

XVII References/Suggestions for further reading

1. Drone Technology for Beginners: Learn | Build | Fly Drones,by Ms. Dharna Nar, Dr. Radhika Kotecha, Drone School India and Ane Books Pvt Ltd, ISBN : 978-8197222184
2. https://oscarliang.com/fpv-drone-frames/

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Understanding of Aim & Procedure	10%
2	Identification of Components / Tools / Software	15%
3	Execution of Experiment / Simulation Steps	20%
4	Measurement / Parameter Observation	10%
5	Teamwork & Lab Safety / Discipline	5%
Product Related: 10 Marks		**40%**
6	Observation Table Completion	10%
7	Result & Interpretation	10%
8	Conclusion	5%
9	Viva / Practical Related Questions	10%
10	Timely Submission of Journal / Record	5%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No 12: Assemble the quadcopter drone using the given components

I Practical Significance

Assembling a quadcopter provides hands-on understanding of UAV systems, including mechanical structure, electronics, and control systems. Students gain practical insights into aerodynamics, propulsion, flight stability, and integration of sensors and microcontrollers. This exercise enhances problem-solving skills, technical competence, and familiarity with real-world UAV components, laying a foundation for advanced drone design and autonomous flight applications.

II Industry/Employer Expected Outcome(s)

- Ability to assemble, test, and troubleshoot a quadcopter drone.
- Understanding the classification, features, and applications of UAVs in commercial, research, and defense contexts.
- Capability to present technical findings visually via diagrams, charts, or reports.
- Awareness of current UAV technologies and industry standards.

III Course Level Learning Outcome(s)

CO4 - Test the drone system.

IV Laboratory Learning Outcome(s)

- LLO 12.1 Assembling of the quadcopter Drone

V Relevant Affective Domain related outcome(s)

- Develop appreciation for UAV technology and innovation in flight systems.
- Foster teamwork, coordination, and problem-solving during assembly.
- Encourage curiosity and hands-on experimentation with electronics and mechanical systems.
- Cultivate attention to detail in assembly, wiring, calibration, and flight testing.

VI Relevant Theoretical Background

A quadcopter is a type of rotary-wing UAV consisting of four rotors arranged in a cross configuration. Its flight stability and control are achieved by varying the speed of individual motors, allowing lift, pitch, roll, and yaw control. Key components include:

- Frame: Provides structural support for all components.
- Motors and Propellers: Generate lift and thrust.
- Electronic Speed Controllers (ESCs): Regulate motor speed.
- Flight Controller: Acts as the brain of the drone, processing sensor data and controlling motor outputs.
- Battery and Power Distribution: Supplies electrical energy to motors and electronics.
- Sensors (optional): Gyroscope, accelerometer, GPS for stability and navigation.

Understanding the design, wiring, and configuration principles of quadcopters allows students to integrate electronics, control theory, and aerodynamics in practical UAV systems.

Frame Assembly:
Connect the arms of the frame using the provided fasteners.
Attach motors to each arm using appropriate screws.

Fig 12.1 Drone Frame Assembly

Motor and ESC Connection:
Connect each motor to its corresponding Electronic Speed Controller (ESC).
Connect the ESCs to the Power Distribution Board (PDB).

Fig 12.2 Motor and ESC Connections

Flight Controller Installation:
Mount the flight controller on the quadcopter frame.
Connect the flight controller to the ESCs, ensuring proper motor mapping.

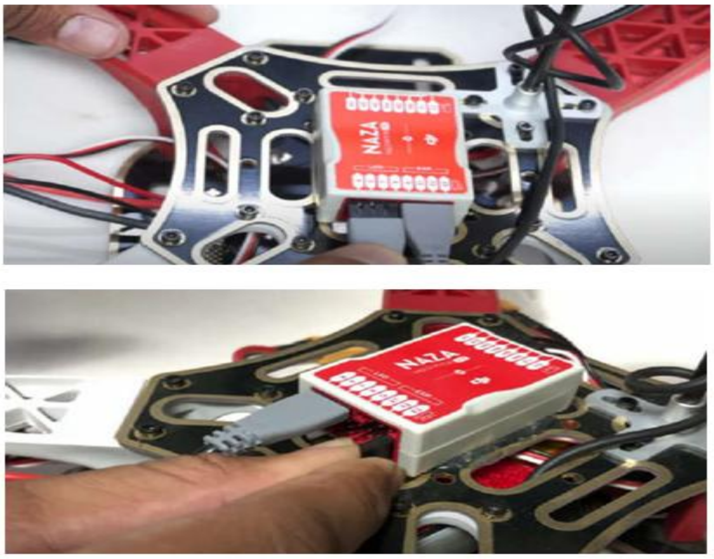


Fig 12.3 Flight Controller Installation

Propeller Attachment:
Attach the propellers to each motor, ensuring correct rotation direction.

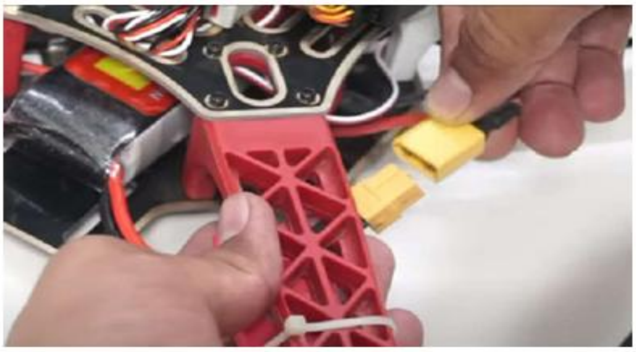
Fig 12.4 Propeller Attachment

Radio Transmitter and Receiver Setup:
Bind the radio transmitter to the receiver.
Connect the receiver to the flight controller.

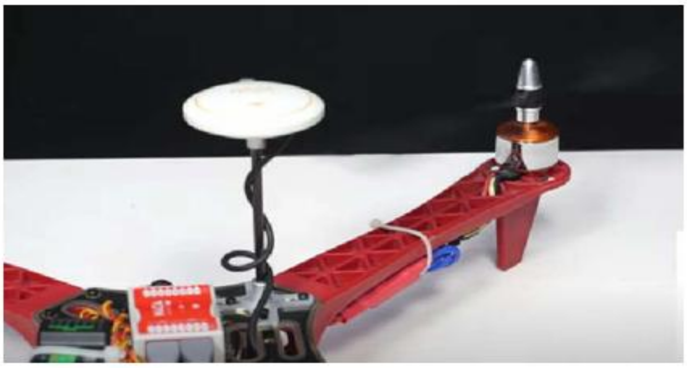
Fig 12.5 Radio Transmitter and Receiver Setup

Power System Integration:
Connect the battery to the Power Distribution Board.

Fig 12.6 Inspection of Drone Wiring and Component Integrity & Power Supply Integration



System Check:
Power on the transmitter and quadcopter.
Verify motor spin direction and check for any abnormal sounds or vibrations.



Fine-tuning:
Use the flight controller software to calibrate sensors and set up flight modes.

Fig 12.7 Software Calibration Process for Drones

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1	Flight Controller	Straight Pin, supports multirotor stabilization and control	1
2	DJI F450 Quadcopter Frame Kit	Includes integrated PCB for power distribution and mounting	1
3	SimonK 30A Brushless ESC	2–3S LiPo support, firmware: SimonK, controls motor speed	4
4	1045 Propeller Pair	Durable plastic propellers, 10x4.5 inch, clockwise & counterclockwise	2
5	A2212 1000KV Brushless Motor	Compatible with 2–3S LiPo, provides rotor thrust	4
6	FlySky FS-CT6B 2.4G 6CH Remote Transmitter with FS-R6B Receiver	6 channels, 2.4 GHz, compatible with flight controller	1
7	Battery	LiPo 3S–4S, 1500–3000 mAh	1
8	Nylon Strap Belt for RC LiPo Battery	Adjustable strap for secure mounting of battery on frame	1
9	XT60 Male Connector with 14AWG Silicon Wire 10cm	For safe power connection between battery and PCB	1
10	Desktop Computer	Intel i3/i5, 8GB RAM, 500GB HDD/256GB SSD, Windows 10/11	02
11	Connecting Cables and Tools	Soldering kit, screwdrivers, multimeter	As req.
12	UPS 6 KVA online	Online UPS, 6 KVA capacity, input: 230V AC, output: 230V AC, Backup: 10–15 min, LCD display	01
13	Simulation Software	Simulation Software: CISCO Packet Tracer, CORE Network Emulator, GNS3 or any other simulator	01

VIII Precautions to be followed

1. Verify all electronic connections and polarity before powering the drone.
2. Keep propellers removed during initial testing to avoid injuries.
3. Ensure proper calibration of the flight controller before flight.
4. Handle LiPo batteries carefully; avoid short circuits or punctures.
5. Test in an open area free of obstacles and people.
6. Follow manufacturer instructions for ESC and motor setup.

IX Procedure

1. Unpack all components and identify each part.
2. Assemble the drone frame and attach motors to the designated arms.
3. Connect ESCs to the motors and to the flight controller.
4. Mount the flight controller on the frame and connect the battery power distribution.

5. Connect sensors (gyro, accelerometer, GPS) as per instructions.
6. Configure the flight controller software on the computer and calibrate sensors.
7. Attach propellers only after initial system checks are complete.
8. Perform a basic hover test in a safe environment.
9. Observe stability, control response, and troubleshoot if required.
10. Document assembly steps, configurations, and flight observations in a report.

X Resources used

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

XI Actual Procedure

XII Observation Table

Table 12.1 Component use for Quadcopter Drone Assembly

Sr. No.	Assembly Step / Component	Expected Condition / Parameter	Remarks
1	Unpack Components	All parts present and undamaged	
2	Assemble the Frame	Arms and body firmly fixed	
3	Mount the Motors	Motors aligned and screwed securely	
4	Install ESCs	Each ESC connected to its motor and secured	
5	Install Flight Controller	Mounted at center, correct orientation	
6	Connect Motors to Flight Controller	ESC signal wires correctly connected	
7	Connect Battery & Power Distribution	Correct voltage, polarity, and secure connection	
8	Install Sensors (Gyroscope/Accelerometer/GPS)	Properly mounted, unobstructed	
9	Attach Propellers (after checks)	Correct orientation (CW/CCW), securely fixed	
10	Wiring and Cable Management	Wires neatly arranged and secured	
11	Calibrate Flight Controller and Sensors	Sensors calibrated, motor directions correct	
12	Pre-Flight Check	Motors rotate correctly without propellers, throttle responsive	

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Describe the correct sequence for assembling a quadcopter drone. Why is following this sequence important.
2. During assembly, how do you ensure that motors and propellers are installed correctly for proper flight control.
3. Explain the process of calibrating the flight controller and sensors before performing the first hover test.
4. Explain the risks of not properly orienting propellers (CW/CCW) during installation.
5. Explain the role of a pre-flight check in ensuring throttle responsiveness and motor operation.

[Space for Answers]

XVII References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.
2. Valavanis, K. P., & Vachtsevanos, G. J. (2015). Handbook of Unmanned Aerial Vehicles. Springer. Detailed reference on UAV systems, including electronics, sensors, and control mechanisms.
3. Beard, R. W., & McLain, T. W. (2012). Small Unmanned Aircraft: Theory and Practice. Princeton University Press. Focuses on the engineering, flight control, and electronics of small UAVs.
4. Johnson, W. (2017). Rotorcraft Aeromechanics. Cambridge University Press. Provides insights into drone propulsion, motor-ESC interactions, and component-level dynamics.
5. Floreano, D., & Wood, R. J. (2015). Science, Technology and the Future of Small Autonomous Drones. Nature. Discusses modern UAV technologies, sensors, and integration of electronic components for autonomous operation.

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No 13: Configuration and operation of Drone transmitter and receiver

I Practical Significance

Understanding the configuration and operation of drone transmitters and receivers is essential for controlling UAVs accurately and safely. This practical enables students to learn the principles of radio frequency communication, signal modulation, and pairing of controllers with drones. Mastery of transmitter-receiver systems helps in troubleshooting connectivity issues, optimizing drone performance, and ensuring safe flight operations across various applications such as aerial photography, agriculture, and defense.

II Industry/Employer Expected Outcome(s)

- Ability to configure and operate drone transmitters and receivers.
- Understanding signal transmission, channel selection, and frequency management in UAV systems.
- Capability to present technical information visually through diagrams or operational charts.
- Awareness of safety protocols and communication standards in drone operations.

III Course Level Learning Outcome(s)

CO4 - Test the drone system.

IV Laboratory Learning Outcome(s)

- LLO 13.1 Configure and operate the Drone transmitter and receiver.

V Relevant Affective Domain Related Outcome(s)

- Develop appreciation for precision and accuracy in UAV communication systems.
- Foster teamwork and hands-on technical skills while configuring and testing drones.
- Encourage curiosity about RF communication, signal interference, and drone control technologies.
- Cultivate attention to detail in operational setup and documentation of drone communication systems.

VI Relevant Theoretical Background

A drone transmitter and receiver form the core of UAV control systems. The transmitter sends control signals from the pilot to the drone, while the receiver interprets these signals to actuate motors and other onboard systems. Key concepts include:

Frequency and Channels: Different frequencies (2.4 GHz, 5.8 GHz, etc.) and channels prevent interference between multiple drones.

Binding/Pairing: The process of linking a transmitter with a specific receiver so that only the paired transmitter can control the drone.

Signal Modulation: Techniques such as Pulse Position Modulation (PPM) and Pulse Width Modulation (PWM) are used to transmit control data reliably.

Troubleshooting: Includes identifying signal loss, interference, or misconfigured channels.

Understanding these principles is crucial for safe and effective drone operation, as well as for designing robust UAV communication systems.

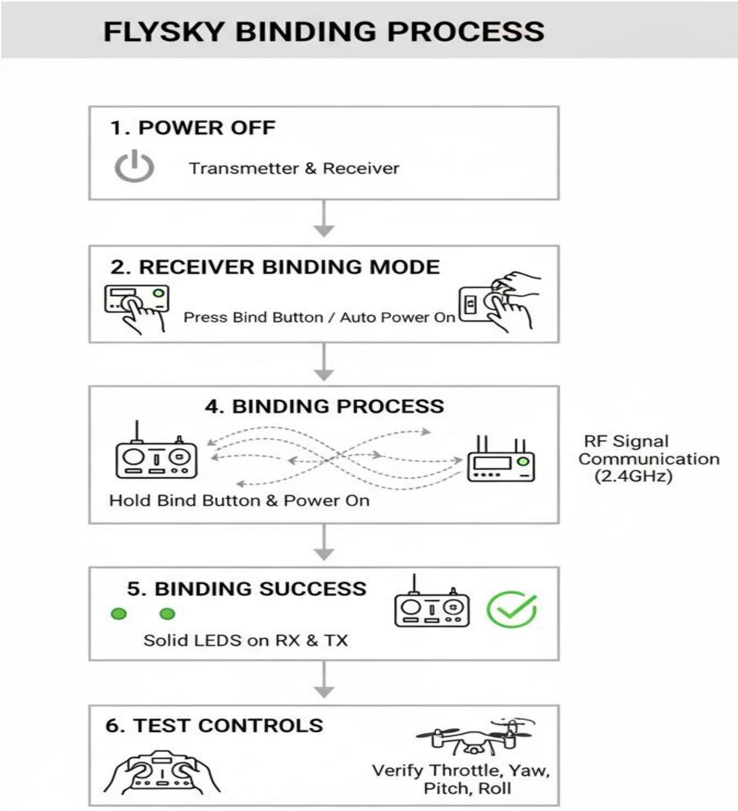


Fig 13.1 Binding Procedure for Drone Transmitter and Receiver

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1	Drone with receiver	4–6 channel, compatible with transmitter	1
2	Drone transmitter/controller	Frequency: 2.4 GHz or compatible	1
3	Battery and charger	As per drone specifications	1 set
4	Signal range tester (optional)	To check transmitter-receiver range	1
5	Reference Material	User manuals, datasheets, online sources	As req.
6	Simulation Software	Simulation Software: CISCO Packet Tracer, CORE Network Emulator, GNS3 or any other simulator	01
7	Desktop Computer	Intel i3/i5, 8GB RAM, 500GB HDD/256GB SSD, Windows 10/11	02
8	Ethernet Switch	Ethernet Switch- 4/8/16/24/32	01
9	UPS 6 KVA online	Online UPS, 6 KVA capacity, input: 230V AC, output: 230V AC, Backup: 10–15 min, LCD display	01

VIII Precautions to be followed

1. Ensure transmitter and receiver are compatible before pairing.
2. Check battery levels of both transmitter and drone before operation.
3. Select a frequency/channel free from interference from other devices.

4. Keep a safe distance and clear area while testing drone control.
5. Avoid physical damage to antennas; handle with care.
6. Follow manufacturer's guidelines for binding and unbinding procedures.

IX Procedure

1. Charge the drone and transmitter batteries fully.
2. Power on the transmitter first, then the drone.
3. Bind/pair the transmitter with the drone receiver according to the manufacturer's instructions.
4. Verify proper communication by moving the sticks and observing drone responses (motors, LEDs, etc.).
5. Set appropriate channels/frequencies to avoid interference.
6. Test different transmitter functions (throttle, yaw, pitch, roll) to ensure correct operation.
7. Troubleshoot any signal issues by checking binding, channels, and range.
8. Document the configuration, channel settings, and observed behavior in a report/chart.
9. Power off the drone and transmitter after completion.

X Resources used

Sr. No.	Name of Resource	Suggested Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 13.1 Drone System Responses

Sr. No.	Parameter	Description / Setting	Remarks / System Responses
1	Drone Model	Enter drone model used	
2	Transmitter Model	Enter transmitter/controller model	
3	Receiver Model	Enter receiver model	
4	Binding Method	Manual binding via button press or automatic binding via firmware	
5	Binding Status	Success / Failure	
6	LED Indicators	Observe LED behavior on receiver during binding process	
7	Control Response	Test throttle, yaw, pitch, and roll controls	
8	Signal Range	Measure maximum operational distance before signal loss	
9	Interference Issues	Note any observed interference or signal degradation	
10	Failsafe Behavior	Test failsafe response (e.g., loss of signal, low battery)	
11	Battery Status	Check battery levels of drone and transmitter	
12	Telemetry Data	Verify telemetry data transmission (e.g., RSSI, battery voltage)	
13	Additional Observations	Any other relevant observations during the practical session	

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Identify the drone, transmitter, and receiver models used during the practical session.
2. Describe the LED indicator behavior on the receiver during the binding process.
3. Interpret the battery status readings for both the drone and the transmitter and their effect on performance.
4. Discuss how interference or environmental factors affected signal quality during operation.
5. Explore potential causes if the control response (throttle, yaw, pitch, roll) is sluggish or unresponsive.

XVII References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.
2. Valavanis, K. P., & Vachtsevanos, G. J. (2015). Handbook of Unmanned Aerial Vehicles. Springer. Detailed reference on UAV systems, including electronics, sensors, and control mechanisms.
3. Beard, R. W., & McLain, T. W. (2012). Small Unmanned Aircraft: Theory and Practice. Princeton University Press. Focuses on the engineering, flight control, and electronics of small UAVs.
4. Johnson, W. (2017). Rotorcraft Aeromechanics. Cambridge University Press. Provides insights into drone propulsion, motor-ESC interactions, and component-level dynamics.
5. Floreano, D., & Wood, R. J. (2015). Science, Technology and the Future of Small Autonomous Drones. Nature. Discusses modern UAV technologies, sensors, and integration of electronic components for autonomous operation.

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No 14: Test the assembled drone

I Practical Significance

Testing an assembled drone provides hands-on experience in understanding its mechanical, electronic, and software systems. Students learn how different components motors, propellers, flight controllers, sensors, and power systems work together to achieve stable flight. This practical knowledge strengthens comprehension of aerodynamics, control theory, and UAV operation, which is essential for troubleshooting, optimizing performance, and developing advanced aerial systems.

II Industry/Employer Expected Outcome(s)

- Ability to assemble and test a drone safely and systematically.
- Understanding of flight control, sensor integration, and UAV stability.
- Capability to record and analyze drone performance metrics.
- Awareness of safety standards and operational protocols for UAVs.

III Course Level Learning Outcome(s)

CO4 : Test the assembled drone.

IV Laboratory Learning Outcome(s)

- LLO 14.1 Test the assembled drone.
- LLO 14.2 Troubleshoot the assembled drone.

V Relevant Affective Domain Related Outcome(s)

- Develop careful observation skills and attention to detail during assembly and testing.
- Foster teamwork, communication, and coordination in conducting drone flight tests.
- Encourage problem-solving and troubleshooting in real-time operational scenarios.
- Build confidence and responsibility while handling UAVs safely.

VI Relevant Theoretical Background

Drones, or Unmanned Aerial Vehicles (UAVs), rely on a combination of aerodynamics, electronics, and software control systems to achieve controlled flight. Key components include:

- Frame and Propulsion System: Determines structural integrity and lift generation.
- Flight Controller: Acts as the “brain,” interpreting sensor data to stabilize the drone.
- Motors and ESCs (Electronic Speed Controllers): Provide rotational thrust for lift and maneuvering.
- Sensors (Gyroscope, Accelerometer, GPS, Barometer): Aid in stability, orientation, and navigation.
- Battery and Power Distribution: Supplies energy to all electronic components.

Testing a drone ensures that these systems interact correctly, that the vehicle responds to input commands, and that it can perform stable flight under expected environmental conditions. Understanding the test outcomes informs further design optimization and operational safety.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Specifications	Quantity
1	Flight Controller	Straight Pin, supports multirotor stabilization and control	1
2	DJI F450 Quadcopter Frame Kit	Includes integrated PCB for power distribution and mounting	1
3	SimonK 30A Brushless ESC	2–3S LiPo support, firmware: SimonK, controls motor speed	4
4	1045 Propeller Pair	Durable plastic propellers, 10x4.5 inch, clockwise & counterclockwise	2
5	A2212 1000KV Brushless Motor	Compatible with 2–3S LiPo, provides rotor thrust	4
6	FlySky FS-CT6B 2.4G 6CH Remote Transmitter with FS-R6B Receiver	6 channels, 2.4 GHz, compatible with flight controller	1
7	Battery	LiPo 3S–4S, 1500–3000 mAh	1
8	Nylon Strap Belt for RC LiPo Battery	Adjustable strap for secure mounting of battery on frame	1
9	XT60 Male Connector with 14AWG Silicon Wire 10cm	For safe power connection between battery and PCB	1

VIII Precautions to be followed

1. Conduct pre-flight checks for loose connections or damaged components.
2. Calibrate all sensors before flight.
3. Test in an open, obstacle-free area to prevent accidents.
4. Keep spectators at a safe distance.
5. Ensure batteries are fully charged and do not overheat.
6. Follow manufacturer instructions for motor and propeller installation.
7. Record all data carefully to identify anomalies or performance issues.

IX Procedure

1. Inspect the assembled drone for correct mechanical assembly and electrical connections.
2. Charge the battery fully and connect it to the power distribution system.
3. Power on the flight controller and remote transmitter.
4. Calibrate the sensors (gyroscope, accelerometer, compass, and GPS if available).
5. Arm the motors and perform a short hover test to check stability.
6. Conduct basic maneuvers: takeoff, hover, forward/backward flight, and landing.
7. Record flight parameters such as altitude, speed, battery consumption, and response time.
8. Analyze the performance for stability, maneuverability, and efficiency.
9. Power off the drone, inspect for wear or damage, and log observations in the lab report.

X Resources used

Sr. No.	Name of Resource	Suggested Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 14.1 Drone test details.

Sr. No.	Test Parameter	Remarks / observation
1	Pre-flight check	
2	Motor response	
3	Take off	
4	Hover stability	

Sr. No.	Test Parameter	Remarks / observation
5	Forward/Backward flight	
6	Battery usage	
7	Landing	
8	Overall performance	

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

Note: Below are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identifies CO.

1. Describe the steps involved in a pre-flight safety check of an assembled drone.
2. How does the flight controller maintain stability during hover and maneuvering.
3. What are common issues observed during drone testing, and how can they be corrected.
4. Measure the battery voltage before takeoff and after landing. Explain what the readings tell you about the battery's performance.
5. Describe the procedure to achieve a safe and controlled takeoff.

XVII References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.
2. Valavanis, K. P., & Vachtsevanos, G. J. (2015). Handbook of Unmanned Aerial Vehicles. Springer. Detailed reference on UAV systems, including electronics, sensors, and control mechanisms.
3. Beard, R. W., & McLain, T. W. (2012). Small Unmanned Aircraft: Theory and Practice. Princeton University Press. Focuses on the engineering, flight control, and electronics of small UAVs.
4. Johnson, W. (2017). Rotorcraft Aeromechanics. Cambridge University Press. Provides insights into drone propulsion, motor-ESC interactions, and component-level dynamics.
5. Floreano, D., & Wood, R. J. (2015). Science, Technology and the Future of Small Autonomous Drones. Nature. Discusses modern UAV technologies, sensors, and integration of electronic components for autonomous operation.

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related: 15 Marks		**60 %**
1	Handling of the components	10%
2	Identification of components	20%
3	Measuring value using suitable instrument	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Performing real-life checks and drone operations	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 15: Preparation of a Report/Chart on Application of Drone Technology in Agriculture

I Practical Significance

The integration of drones in agriculture has transformed traditional farming practices into modern, data-driven systems. Drones help farmers monitor crop health, assess field conditions, and manage resources efficiently. Preparing a report or chart on agricultural drone applications enables students to connect drone mechanics and data technology with sustainable farming methods.

II Industry/Employer Expected Outcome(s)

- Understanding the use of UAVs for precision agriculture and crop management.
- Awareness of how aerial data collection supports decision-making in farming.
- Ability to identify Indian and global agricultural drone use-cases.

III Course Level Learning Outcome(s)

CO5 - Select drone for a given application.

IV Laboratory Learning Outcome(s)

- LLO 15.1 Prepare a report/chart on application of Drone technology in Agriculture.

V Relevant Affective Domain related outcome(s)

- Develop respect for sustainable and precision farming practices.
- Encourage awareness of how technology can support food security and rural livelihoods.

VI Relevant Theoretical Background

Agricultural Drones:

Agricultural drones, or unmanned aerial vehicles (UAVs), are transforming agriculture by enhancing efficiency, reducing costs, and enabling precision farming. These drones are equipped with advanced sensors and technology to support farmers, growers, agricultural cooperatives, and service agencies in optimizing crop production and monitoring.

Key Applications of Agricultural Drones

Crop Spraying

Drones use ultra-low volume (ULV) spraying technology to apply fertilizers and pesticides efficiently.

Compared to traditional methods, drones spray crops faster, saving time and reducing labor costs.

Precision spraying minimizes chemical overuse, protecting crops and the environment.

Fig 15.1: Pesticide spraying drone

Soil and Field Analysis

Drones equipped with sensors analyze soil moisture, terrain conditions, nutrient levels, fertility, and erosion.

This data supports efficient field planning and informed decision-making for crop management.

Crop Monitoring

Drones enable real-time crop surveillance using infrared cameras to monitor growth stages, pest attacks, and weather impacts.

They help farmers detect issues early, ensuring timely interventions to prevent crop failure.

Multispectral imaging identifies subtle differences in crop health, such as stress, that may be invisible to the human eye.

Fig 15.2: Crop Health Monitoring

Plantation

Drones can plant trees and crops, reducing the need for labour-intensive methods.

They offer an eco-friendly alternative to traditional machinery like tractors, which emit harmful gases.

Livestock Management

Drones with high-resolution infrared cameras monitor livestock, detecting sick animals for prompt action.

They support precision dairy farming by providing real-time data on animal health.

Weather Preparedness

Drones, including specialized storm drones, help predict weather patterns, allowing farmers to plan crop types and care strategies.

Early warnings about storms or droughts enable better crop protection and planning.

Geofencing and Security

Thermal cameras on drones detect animals or humans, protecting fields from external damage, especially at night.

Benefits of Agricultural Drones

1. High Efficiency: Drones work faster than human labor, with no operational delays, doubling productivity.
2. Water Conservation: ULV spraying technology reduces water usage compared to traditional methods.
3. Cost-Effective and Low Maintenance: Drones feature sturdy designs, detachable containers, and low-cost frames, requiring minimal upkeep.
4. Environmental Protection: Precise chemical application prevents overuse of pesticides and fertilizers, reducing environmental harm.
5. Security: Operated by trained pilots, drones minimize the risk of misuse.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Desktop PC with Internet Browser	Computer(i3-i5 processor with RAM> 2GB Preferable)	01
2	Virtual Learning reference	IIT Delhi Virtual Lab for drone	

VIII Precautions to be followed

1. Check that all parameters input into the simulation (altitude, speed, flow) are realistic.
2. Do not ignore constraints (e.g. battery, turn radius) that may be built into the virtual lab.

IX Procedure

1. Access the Virtual Lab: Open the link: **https://drone-iitd.vlabs.ac.in/exp/operation-agricultural-drone** **drone-iitd.vlabs.ac.in**
2. Review the Aim and Theory sections in the virtual lab.
3. Perform the Pretest (if available) to gauge initial understanding.
4. Execute the Procedure / Simulation:
   a. Set the field dimensions (length, width) as in the virtual lab interface.
   b. Choose parameters: flight altitude, speed, nozzle flow rate, overlap, direction, etc.
   c. Run the simulation and observe spray patterns, coverage uniformity, drift, etc.
5. After simulation, take screenshots of the spray pattern, coverage density, etc.
6. Complete the Posttest / Questions in the virtual lab.
7. Using the simulation results, prepare a report/chart that describes:
   - The parameter settings used (altitude, speed etc.)
   - Observed patterns and performance (coverage, under/overlap, drift)
   - Recommendations and optimum parameter values
   - Application to real-world agricultural context

Fig 15.3: Virtual Lab view of IIT Delhi (Source IIT Delhi Virtual Lab)

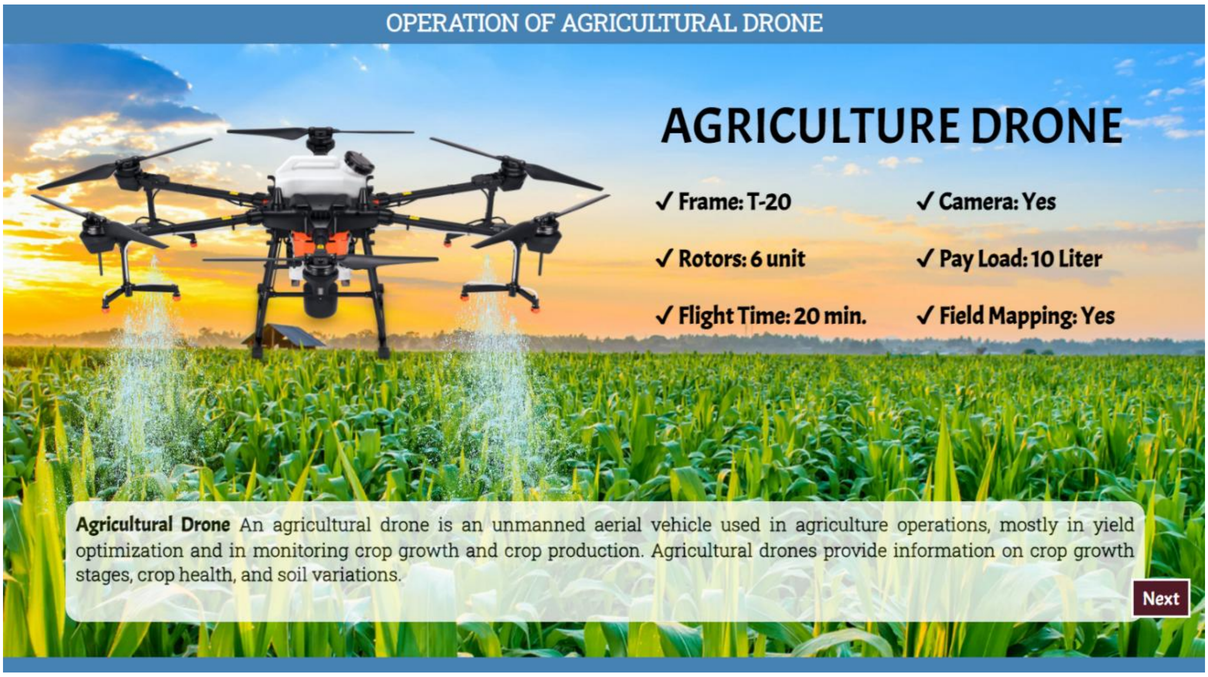


Fig 15.4: Start of Virtual Experiment (Source IIT Delhi Virtual Lab)

X Resources used

Sr. No.	Name of Resource	Specifications	Quantity

XI Actual Procedure

XII Observation Table

Table 15.1 Agricultural Drone details

Sr. No.	Application of Drone	Purpose in Agriculture	Notes / Observation
1	Crop Spraying		
2	Crop Health Monitoring		
3	Soil / Field Inspection		
4	Livestock Monitoring		
5	Security & Field Surveillance		

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

1. Generally, how much voltage and rating batteries are used in agricultural drones?
   a. 22.7V, 16000 mAh
   b. 11.1V, 5000 mAh
   c. 14.8V, 2000 mAh
   d. 3.7V, 20000 mAh
2. In case of communication loss with the pilot, what safety action needs to be taken first?
   a. Disarm
   b. Return to Launch
   c. Turn off transmitter
   d. Run towards drone
3. Before powering up the drone, you need to cross-check the:
   a. Propeller orientation
   b. Battery
   c. Transmitter
   d. Tank
4. For safety purposes, before filling the tank, cross-check:
   a. Drone is in disarm state
   b. Drone in arm state
   c. Motors are working
   d. N/A
5. At what conditions are drone flights recommended?
   a. Low temperature ranging from 5°C to 30°C
   b. High wind velocity
   c. Rain
   d. Tornado

[Space for Answers]

XVII References/Suggestions for further reading

1. https://drone-iitd.vlabs.ac.in/exp/operation-agricultural-drone
2. Baichtal, "Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs", Que Publishing, 2016.
3. Austin, Unmanned Aircraft Systems: UAVS Design, Development and Deployment. Wiley, 2010.
4. Terry Kilby and Belinda Kilby, "Make:Getting Started with Drones ",Maker Media, Inc, 2016.
5. VasilisTzivaras, "Building a Quadcopter with Arduino", Packt Publishing, 2016.
6. **https://www.dronezon.com/learn-about-drones-quadcopters/**
7. **https://ardupilot.org/copter/docs/advanced-multicopter-design.html/**

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of the components	10%
2	identification of components	20%
3	Measuring value using suitable instrument	20%
4	working in teams	10%
Product Related: 10 Marks		**40%**
5	Calculated theoretical values of given component	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No 16: Preparation of a report/chart on the application of Drone technology in cinematography

I Practical Significance

Studying the use of drones in cinematography helps students understand how aerial imaging and camera stabilization technologies enhance visual storytelling. By exploring drone types, camera payloads, flight techniques, and cinematic applications, students gain practical insights into modern film-making processes. This knowledge encourages creative thinking, technical understanding, and innovative approaches to capturing aerial footage.

II Industry/Employer Expected Outcome(s)

- Ability to identify drones suitable for cinematic purposes based on flight range, payload, and stability.
- Understanding the integration of camera systems, gimbals, and flight control software in cinematography.
- Capability to prepare clear, visually appealing reports/charts demonstrating drone applications in film-making.
- Awareness of industry trends and historical milestones in aerial cinematography using UAVs.

III Course Level Learning Outcome(s)

CO5: Select drone for a given application.

IV Laboratory Learning Outcome(s)

- LLO 16.1 Prepare a report/chart on the application of Drone technology in cinematography.

V Relevant Affective Domain Related Outcome(s)

- Develop appreciation for technological innovations that enable creative visual storytelling.
- Foster teamwork, creativity, and presentation skills while preparing the report/chart.
- Encourage curiosity about drone operations, camera technology, and cinematic techniques.
- Cultivate attention to detail in organizing and presenting historical and technical information.

VI Relevant Theoretical Background

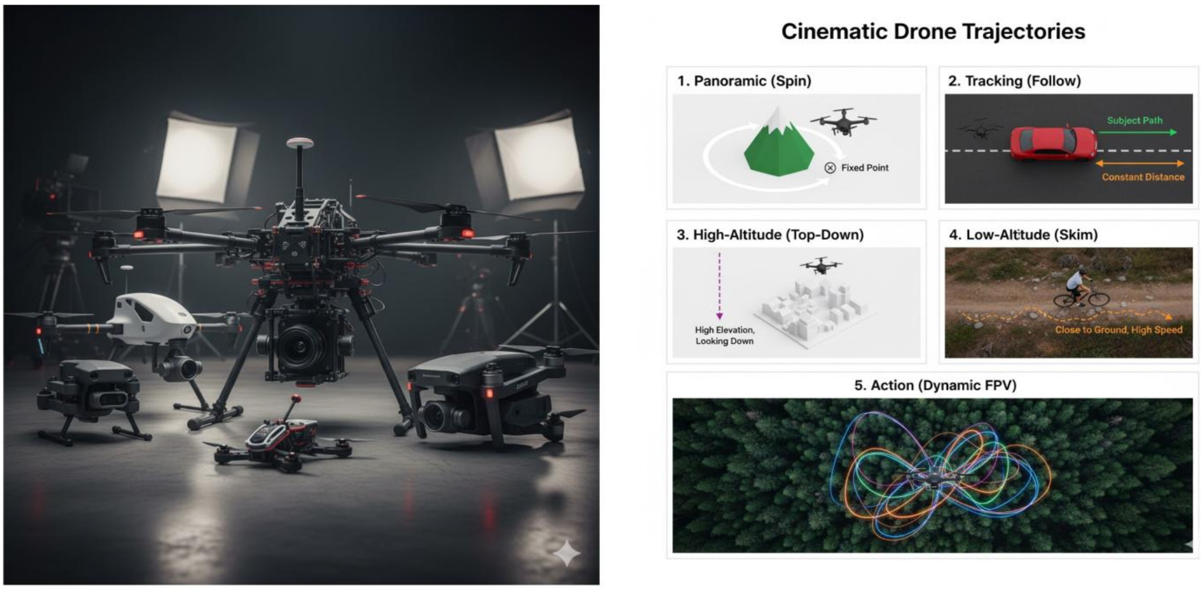


Fig 16.1 Camera Drones and Trajectories of Camera Drones

The use of drones in cinematography is a recent extension of UAV technology, combining aerial flight with imaging innovations. Key milestones include:

- Early 2000s: Limited use of small UAVs for aerial photography in independent films.
- 2010s: Introduction of drones equipped with stabilized gimbals and HD cameras, revolutionizing film production.
- 2020s: Adoption of AI-assisted flight paths, autonomous tracking, and high-resolution cameras in feature films, documentaries, and advertising.

Modern cinematic drones are categorized into:

- Rotary-wing drones: Ideal for maneuverability, stable shots, and dynamic tracking.
- Fixed-wing drones: Suitable for long-range aerial scenes and landscape shots.
- Hybrid drones: Combine endurance and maneuverability for complex cinematography.

Understanding these drones' applications in cinematography enhances knowledge of mechanical design, camera stabilization, flight control, and creative filming techniques.

VII Required Resources/apparatus/equipment with specifications

Sr. No.	Name of Resource	Suggested	Quantity
1	Computer	Min. 4GB RAM, 500GB HDD/SSD, Internet access	1
2	Presentation/Chart Software	MS PowerPoint / Canva / Google Slides	1
3	Word Processing Software	MS Word / Google Docs	1
4	Printer and Chart Paper	A4/A3 sheets or chart paper	As req.
5	Reference Material	Books, research papers, online sources	As req.

VIII Precautions to be followed

1. Ensure reliable internet access and proper functioning of the computer or laptop.
2. Ensure reliable internet access and proper functioning of the computer/laptop.
3. Use verified and authentic sources for drone and cinematography information.
4. Cross-check facts about drones, camera systems, and film applications before finalizing the chart.
5. Maintain clarity, organization, and visual appeal in the report/chart.
6. Save and back up the report/chart regularly to prevent data loss.

IX Procedure

1. Start the computer/laptop and open suitable software (MS PowerPoint, Canva, or Google Slides).
2. Research the evolution of drone technology in cinematography, from early aerial shots to modern UAV filming.
3. Collect data on drones used in film-making, including types, camera payloads, and notable projects.
4. Organize information in chronological or thematic order to form a clear timeline or chart.
5. Design the timeline/chart with labeled sections, relevant images, and key milestones.
6. Include details about drone types, camera systems, cinematic techniques, and major films utilizing drones.
7. Review the chart/report for accuracy, proper labeling, and visual appeal.
8. Print or present the final report/chart as per instructor guidelines.

X Resources used

Sr. No.	Name of Resource	Suggested	Quantity

XI Actual Procedure

XII Observation Table

Table 16.1 Use of relevant Drone in cinematography

Sr. No	Shot Type	Drone Model	Camera/ Quality	Ease of Use (1-5)	Stability (1-5)	Advantages	Limitations
1	Panoramic						
2	Tracking						
3	High altitude						
4	Low-altitude						
5	Action						

XIII Result(s)

XIV Interpretation of results

XV Conclusion and recommendation

XVI Practical related questions

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identifies CO.

1. Rate the ease of use for each shot type from easiest to hardest.
2. Arrange the shot types in order of stability from highest to lowest.
3. Analyze which advantages make tracking shots ideal for moving subjects.
4. Evaluate which shot type is most suitable for capturing landscapes.
5. Evaluate which drone model offers the best balance between stability and ease of use.

[Space for answer]

XVII References/Suggestions for further reading

1. Austin, R. (2010). Unmanned Aircraft Systems: UAVs Design, Development and Deployment. Wiley. A comprehensive book covering the design principles, applications, and evolution of UAVs.
2. Valavanis, K. P., & Vachtsevanos, G. J. (2015). Handbook of Unmanned Aerial Vehicles. Springer. Detailed reference on UAV systems, including electronics, sensors, and control mechanisms.
3. Beard, R. W., & McLain, T. W. (2012). Small Unmanned Aircraft: Theory and Practice. Princeton University Press. Focuses on the engineering, flight control, and electronics of small UAVs.
4. Johnson, W. (2017). Rotorcraft Aeromechanics. Cambridge University Press. Provides insights into drone propulsion, motor-ESC interactions, and component-level dynamics.
5. Floreano, D., & Wood, R. J. (2015). Science, Technology and the Future of Small Autonomous Drones. Nature. Discusses modern UAV technologies, sensors, and integration of electronic components for autonomous operation.

XVIII Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		**60 %**
1	Handling of software tools	10%
2	Correct identification of shot type and drone models	20%
3	Using suitable tools and sources to collect accurate data and information	20%
4	Working in teams	10%
Product Related: 10 Marks		**40%**
5	Analyze how the choice of drone model affects the quality of each shot type.	10%
6	Interpretation of result	05%
7	Conclusion	05%
8	Practical related questions	15%
9	Submitting the journal in time	05%
Total (25 Marks)		**100 %**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	