Unit 1: Design & Documentation

Unit 1 Vocabulary
Unit 1 Concepts
Unit 1 Performance Objectives
1.1 - What is Engineering?
1.2 – Engineering Design
1.3 – The Design Process
1.4 – Importance of Documentation
1.5 – Working in Teams
1.6 – Effective Team Practices
1.7 - Quantitative vs. Qualitative Arguments
1.8 – Engineering Notebooks
1.9 – Software and Tools for Drone Design
Unit 1 Summary

Unit 2: Safety Considerations

Unit 2 Vocabulary
Unit 2 Concepts
Unit 2 Performance Objectives
2.1 – Safety First
2.2 – Your Safety Responsibility
2.3 – Establishing a Safety Culture
2.4 – Workshop Safety Issues
2.5 – Workshop Safety Rules
2.6 – Soldering Safety Rules
2.7 – Increase Your Drone Design Knowledge
2.8 – Increase Your Flight Skills
2.9 – Flight Safety Organizations
2.10 – Educational Regulations
2.11 – Drone Registration
2.12 – Definition of Recreational Use
2.13 – Safety Guidelines for sUAS Recreational Users
2.14 – Privacy Policy
2.15 – Safe Flying Locations
2.16 – No-Fly Zones
2.17 – Safe Weather Conditions
2.18 – Safe Flight Clearance
2.19 – Visual Line of Sight
2.20 – Start Out Slowly
2.21 – Ground Effect & Prop Wash
2.22 – Propeller Dangers
2.23 – Pre-Flight Inspection
Unit 2 Summary

Unit 3: Introduction to Drones

Unit 3 Vocabulary
Unit 3 Concepts
Unit 3 Performance Objectives
3.1 – What is a Drone?
3.2 – Drone Uses Besides Aerial
3.3 – Brief History of Aerial Drones
3.4 – Drone Reputation
3.5 – Development of Small UAVs
3.6 – What's in a Name?
3.7 – Types of Small UAVs (sUAV)
3.8 – Choosing a Multicopter Configuration
3.9 – Drone Components
3.10 – Current Uses and Future Potential
Unit 3 Summary

Unit 4: Fundamentals of Flight

Unit 4 Vocabulary
Unit 4 Concepts
Unit 4 Performance Objectives
4.1 – What is Aerodynamics?
4.2 – Brief History of Flight
4.3 – Newton's Laws of Force and Motion
4.4 – Bernoulli's Principle
4.5 – Airfoils
4.6 – Four Forces of Flight
4.7 – Mechanical Design of an Airplane
4.8 – Three Axes of Flight
4.9 – Airspace
4.10 – Traffic Patterns and Minimum Safe Altitudes
4.11 – Weather Factors for Drone Flight
4.12 – Pilot-in-Command/Remote Pilot-in-Command
4.13 – How Multicopters Fly
4.14 – Vectors Applied to Flight Physics
4.15 – Calculating Values of Combined Maneuvers
Unit 4 Summary

Unit 5: Airframes

Unit 5 Vocabulary
Unit 5 Concepts
Unit 5 Performance Objectives
5.1 – Airframe Characteristic
5.2 – History of Helicopter Design
5.3 – Early Multirotor Aircraft Design
5.4 – Advancements in Control and Design
5.5 – Multirotor Configurations
5.6 – Choosing/Building a Multicopter Configuration
5.7 – Airframe Sizes
5.8 – Airframe Materials
5.9 – Tensile Strength
Unit 5 Summary

Unit 6: Electric Motors

Unit 6 Vocabulary
Unit 6 Concepts
Unit 6 Performance Objectives
6.1 – Introduction to Electric Motors
6.2 – Brief History of the Electric Motor
6.3 – AC/DC Motor Differences
6.4 – Brushed vs. Brushless DC Motors
6.5 – Classification of Load Capability (Kv rating)
6.6 – Calculation of Motor Ratings
6.7 – Choosing the Best Motors for Your Needs
6.8 – Sample Build for Determining Motors
Unit 6 Summary

Unit 7: Propellers

Unit 7 Vocabulary
Unit 7 Concepts
Unit 7 Performance Objectives
7.1 – Introduction to Propellers
7.2 – History of Propeller Design
7.3 – Propeller Design Theory
7.4 – Fixed Pitch, Variable-Pitch, and Constant Speed Blades
7.5 – Size, Pitch, Direction, and Blade-count
7.6 – Safety and Use of Prop Guards
7.7 – Balancing Your Propellers
7.8 – Materials Used in Prop Construction
7.9 – Choosing Your Propellers
7.10 – Using *eCalc*© to Determine Best Prop Selection
Unit 7 Summary

Unit 8: Electronic Speed Controllers (ESCs)

Unit 8 Vocabulary
Unit 8 Concepts
Unit 8 Performance Objectives
8.1 – Introduction to ESCs
8.2 – How ESCs Work
8.3 – ESC Ratings: Amperage and Voltage
8.4 – Calibrating and Programming ESCs
8.5 – Firmware Options (SimonK / BLHeli)
8.6 – A Few More Considerations
8.7 – Mounting Your ESCs
Unit 8 Summary

Unit 9: Flight Controllers

Unit 9 Vocabulary
Unit 9 Concepts
Unit 9 Performance Objectives
9.1 – Introduction to Flight Controllers
9.2 – How They Work
9.3 – Sensors and Guidance Systems
9.4 – Autonomous Flight
9.5 – Sense-and-Avoid Technology
9.6 – Determining Your Flying Purpose
9.7 – Comparing Flight Controllers
9.8 – Open Source vs. Closed Source
Unit 9 Summary

Unit 10: Batteries, Chargers, & Connectors

Unit 10 Vocabulary
Unit 10 Concepts
Unit 10 Performance Objectives
10.1 – Batteries Defined
10.2 – A Brief History of Batteries
10.3 – Anatomy of a Battery
10.4 – Battery Reactions and Chemistry
10.5 – Battery Purposes
10.6 – Battery Arrangement and Power
10.7 – Rechargeable Batteries
10.8 – LiPo Batteries: The Power of Choice for Drones
10.9 – LiPo Battery Characteristics
10.10 – LiPo Cell Balancing
10.11 – LiPo Chargers
10.12 – LiPo Bags
10.13 – Keeping Tabs on your Battery's Health
10.14 – Connectors
Unit 10 Summary

Unit 11: Transmitters & Receivers

Unit 11 Vocabulary
Unit 11 Concepts
Unit 11 Performance Objectives
11.1 – What is a Radio Control System?
11.2 – History of Radio Control
11.3 – Controllers / Transmitters
11.4 – Receivers
11.5 – Most Common Frequency Bands
11.6 – Control Station Setup and Programming
Unit 11 Summary

Unit 12: Cameras, Gimbals & Other Payloads

Unit 12 Vocabulary
Unit 12 Concepts
Unit 12 Performance Objectives
12.1 – Payload Considerations
12.2 – Camera Options
12.3 – Camera Resolution
12.4 – Camera Sensors
12.5 – Still Photography
12.6 – Video Photography
12.7 – Live Video Output
12.8 – Vibration Isolation, Prop Balancing, and *Jello* Effect
12.9 – Gimbals
12.10 – Camera Lenses
12.11 – Exposure Settings
12.12 – Video Frame Rate
12.13 – Saving Digital Files (RAW, DNG, JPEG, H.264, MP4, MOV)
12.14 – Delivery Payloads and Other Possibilities
Unit 12 Summary

Unit 13: Ground Control Stations & FPV

Unit 13 Vocabulary
Unit 13 Concepts
Unit 13 Performance Objectives
13.1 – What is a Ground Control Station?
13.2 – Telemetry
13.3 – History of Telemetry
13.4 – Data Tracking
13.5 – Mission Planning
13.6 – 3D Mapping and Modeling
13.7 – FPV and Drone Racing
Unit 13 Summary

Unit 14: Regulations & The FAA

Unit 14 Vocabulary
Unit 14 Concepts
Unit 14 Performance Objectives
14.1 – The Need to Regulate Airspace
14.2 – The NTSB (National Transportation Safety Board)
14.3 – The FAA (Federal Aviation Administration)
14.4 – UAS Incidents and FAA Response
14.5 – Regulation of UAS Operations
14.6 – Recreational Use of Drones
14.7 – sUAS Registration
14.8 – Section 333 Exemptions
14.9 – Summary of Small Unmanned Aircraft Rule (Part 107)
14.10 – Future Challenges for Regulation
Unit 14 Summary

Unit 15: Drone Maintenance & Battery Care

Unit 15 Vocabulary
Unit 15 Concepts
Unit 15 Performance Objectives
15.1 – The Commonality of Drones
15.2 – Drone Maintenance not FAA-Required, but …
15.3 – Create a Pre-Flight Checklist
15.4 - Software and Firmware Maintenance
15.5 – Logging Your Flights
15.6 – Documenting Your Logs
15.7 LiPo Battery Maintenance and Care
15.8 LiPo Chargers Revisited
15.9 – Use of LiPo Bags
15.10 – Charging Temperatures
15.11 – Charging Rates
15.12 – Discharging Rates
15.13 – Working Temperatures
15.14 – Battery Puffing
15.15 – “Breaking-in” New LiPo Batteries
15.16 – Handling Damaged LiPo Batteries
15.17 – Storage and Shelf-Life of your LiPo Battery
15.18 – The 80% Rule: Retiring LiPo Batteries
15.19 – Disposal of LiPo Batteries
Unit 15 Summary

Unit 16: Efficiency vs. Performance

Unit 16 Vocabulary
Unit 16 Concepts
Unit 16 Performance Objectives
16.1 – Efficiency “OR” Performance
16.2 – Designing for Purpose
16.3 – Configuration Considerations
16.4 – Efficiency in Propellers
16.5 – Efficiency in Motors and Electronics
16.6 – Motor/Prop Combinations
16.7 – Build or Buy?
Unit 16 Summary

CURRICULUM TIMELINE

This curriculum is extremely thorough while allowing for flexibility. The instructor has the option to teach the entire curriculum and have the students compete all the activities, or the instructor can pick, choose, and/or skip any of the activities or quizzes. Instructors may also decide to include projects of their own. Below is a suggested timeline showing minimum and maximum days for each Unit.

(1 day = 60-minute class)

	Description	Minimum # days (if some activities are skipped)	Maximum # days (if all activities completed)
Unit 1: Design & Documentation	Introduces the engineering design process and stresses the importance of cooperation, teamwork, and documentation to solve problems.	3	7
Unit 2: Safety Considerations	Stresses the importance of adopting a "safety attitude" when building and flying a drone. Covers workshop safety and outdoor flying.	3	7
Unit 3: Introduction to Drones	Covers nomenclature, history of aerial drones, reputation, airframe, configurations, basic components, and current/future uses of drones.	4	7
Unit 4: Fundamentals of Flight	Introduces aerodynamics, history of flight, Newton's Laws of Motion, Bernoulli's Principle, four forces of flight, three axes of flight, how they apply to drone flight. Reveals issues aircraft pilots encounter including airspace, traffic patterns, and safe altitudes.	4	7
Unit 5: Airframes	Covers history of helicopter design, early multirotor design, various configurations, airframe sizes, and construction materials.	3	5
Unit 6: Electric Motors	Discusses AC/DC motor differences, history of electric motors, brushed vs. brushless motors, Kv ratings, and calculation of motor capabilities for a drone build.	3	5
Unit 7: Propellers	Covers history of propeller design, fixed-pitch and constant speed blades, airfoil design, size, pitch, and blade-count. Includes balancing tips and construction materials.	3	5
Unit 8: Electronic Speeds Controllers (ESCs)	Introduces role of ESCs, how they work, PWM, PPM, amperage and voltage ratings, ESC calibration, SimonK vs. BLHeli firmware options and BEC, OPTO, and UBEC.	3	5
Unit 9: Flight Controllers	Introduces role of flight controllers, how they work, introduces sensors, sense-and-avoid technology, GPS, open source vs. closed source programming, and compares current FCs on the market.	3	5
Unit 10: Batteries, Chargers & Connectors	Covers history of batteries, various makeups, reactions and chemistry, parallel vs. serial arrangements, rechargeable batteries, LiPo battery characteristics, charging, cell balancing, and various connectors.	3	5
Unit 11: Transmitters & Receivers	Introduces history of radio control systems, controllers, transmitters, and receivers, frequency bands, and programming transmitters.	3	5
Unit 12: Cameras, Gimbals & Other Payloads	Covers payload considerations, camera options, resolution, still photography, video photography, vibration and *Jello™* effect, exposure settings, camera lenses, video frame rate, image files, delivery payloads, and other payload possibilities.	4	5
Unit 13: Ground Control Stations & FPV	Introduces telemetry, data tracking, mission planning, and 3D mapping and modeling. Covers first-person-view flying safety and drone racing options.	3	5
Unit 14: Regulations & The FAA	Covers role of the FAA and NTSB. Stresses importance of regulation, and lists registration and recreational use of drones. Section 333 Exemptions and Part 107 Rules are explained.	2	3
Unit 15: Drone Maintenance & Battery Care	Emphasizes importance of pre-flight checklists and logging flights. Stresses safety when using LiPo batteries including proper charging methods, discharging, handling, and disposal.	3	5
Unit 16: Efficiency vs. Performance	Revisits concepts that influence efficiency and performance in drone builds. Covers configurations, efficiency in propellers and motors. Discusses building or buying a drone.	3	3
	TOTALS:	**50**	**84**