UNMANNED AERIAL SYSTEMS

ENAS 354

Lecture	**: 3**	**Year : III**
Tutorial	**: 1**	**Part : II**
Practical	**: 3/2**	

Course Objectives:

The objective of this course is to provide the fundamental principles of unmanned aerial vehicle (UAV) development, research, and applications, with a focus on program themes such as airframe optimization, flight control, autonomy and navigation, and sensor-based feedback to improve UAV performance and pilot effectiveness.

1 Introduction (3 hours)

1.1 Historical development and evolution of UAVs
1.2 UAV types and classifications
1.3 Unmanned aerial system (UAS) component
1.4 Key applications and industry sectors using UAVs

2 UAV Co-ordinate System, Aerodynamics and Flight Mechanics (5 hours)

2.1 UAV co-ordinate system
2.2 Lift, drag, thrust and weight considerations
2.3 Basic principles of aeromechanics
2.4 Stability and control in fixed-wing and quadrotor UAVs
2.5 Flight dynamics: Pitch, roll, yaw and their control

3 Fixed-Wing UAV Design Principles (10 hours)

3.1 Structural components and materials
3.2 Wing configurations and their impact on flight performance
3.3 Propulsion systems: Types of engines and propellers
3.4 Flight envelope and performance characteristics
3.5 UAV design process

4 Quadrotor UAV Design Principles (8 hours)

4.1 Basic quadrotor design and layout
4.2 Motor and propeller selection
4.3 Frame design and materials
4.4 Power systems and energy management
4.5 Payload integration
4.6 Mathematical modelling of Quadcopter
4.7 PID control of Quadcopter

5 UAV Avionics and Sensors (6 hours)

5.1 Overview of avionics systems in UAVs
5.2 Key sensors: IMUs, GPS, barometers, cameras, optical flow and LIDAR
5.3 Sensor fusion and estimation (Extended Kalman filter)
5.4 Data communication and telemetry systems
5.5 Integration of sensors for autonomous flight

6 Autonomous Navigation and Control Systems (8 hours)

6.1 Introduction to flight control systems (FCS)
6.2 UAS autonomy level
6.3 Autonomous navigation algorithms: Waypoint navigation, path planning(A*)
6.4 Obstacle detection and avoidance systems
6.5 GPS denied navigation: Visual inertial odometry, SLAM, computer vision

7 UAV Applications and Regulations (5 hours)

7.1 UAV regulations and airspace management (CAAN, ICAO)
7.2 Overview of commercial and military UAV applications
7.3 Ethical considerations in UAV operations
7.4 Future trends in UAV technology and industry outlook

Tutorial (15 hours)

1. Mission planning and autonomous flight control using PX4/ArduCopter systems
2. Data collection and processing using on-board UAV sensor systems
3. Integration of ROS 2 with Gazebo for UAV simulation and development
4. Navigation and path planning using ROS 2 navigation stack (Nav2)

Practical (22.5 hours)

1. Conceptual design and analysis of UAV
2. Application of PID controllers and tunning
3. Fabrication of a quadcopter or fixed-wing UAV using 3D printing
4. Automation integration in SITL and real flight

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Mark distribution*
1 and 7	8	12
2	5	6
3	10	14
4	8	12
5 and 6	14	16
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Fahlstrom, P. G., Gleason, T. J. (2012). Introduction to UAV systems. Wiley.
2. Beard, R. W., McLain, T. W. (2012). Small unmanned aircraft: Theory and practice. Princeton University Press.
3. Valavanis, K. P., Vachtsevanos, G. J. (Eds.). (2015). Handbook of unmanned aerial vehicles. Springer.
4. Civil Aviation Authority of Nepal. (2021). Unmanned aircraft system (UAS) requirements.
5. Ministry of Home Affairs. (2018). Drone udaan sambandhi karyabidhi 2075.