INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**UNMANNED AIR VEHICLES**				
Course Code	AAEB32				
Program	B.Tech				
Semester	FIVE				
Course Type	Professional Elective				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Course Coordinator	Dr. Praveen Kumar Balguri, Associate Professor				

I. COURSE OVERVIEW:

The course focuses on more fundamental key concepts related to unmanned aircraft systems (UAS), including major subsystems, basic design phases, aerodynamics, characteristics, current, and future applications. This course provides insight into different types of airframes, power-plants available for UAS. It imparts knowledge about navigation, communications, control, and stability of UAVs. It is designed for users with commercial, private/recreational, and public and educational interest in UAS applications.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AAEB11	IV	Aircraft Performance

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Aircraft Stability and Control	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	PPT	✔	Chalk & Talk	✔	Assignments	✗	MOOCs
✔	Open Ended Experiments	✔	Seminars	✗	Mini Project	✔	Videos
✔	Others						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. **There could be a maximum of two sub divisions in a question.**

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Table 1: The expected percentage of cognitive level of questions in SEE

Percentage of Cognitive Level	Blooms Taxonomy Level
10 %	Remember
50 %	Understand
25 %	Apply
15 %	Analyze
0 %	Evaluate
0 %	Create

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Table 2: Assessment pattern for CIA

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Quiz	AAT	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams

Quiz – Online Examination:

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

Alternative Assessment Tool (AAT):

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning center. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc. The AAT chosen for this course is given in table 3**.**

Table 3: Assessment pattern for AAT

5 Minutes Video	**Assignment**	**Tech-talk**	**Seminar**	**Open Ended Experiment**
20%	30%	30%	10%	10%

VI. COURSE OBJECTIVES:

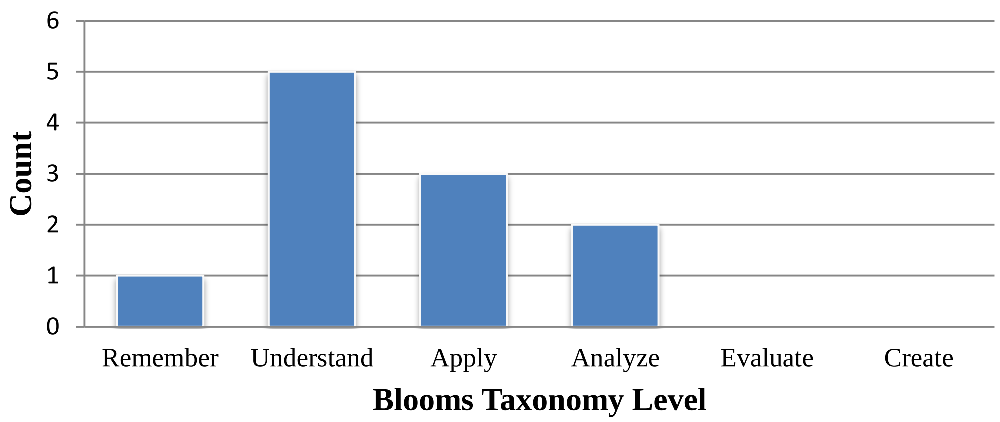
The students will try to learn:	
I	Introduce the major subsystems and the fundamental design phases of Unmanned Air Vehicle Systems (UAS).
II	Familiarize the basic aerodynamics and airframe configurations of unmanned air vehicles (UAVs).
III	Acquaint the various communication and navigation systems of UAVs.
IV	Accustom the basic control and stability aspects of UAVs.

VII. COURSE OUTCOMES:

After successful completion of the course, students will be able to:		
	Course Outcomes	**Knowledge Level (Bloom's Taxonomy)**
CO 1	**Recall** the functions of each major sub-systems of the unmanned air vehicle systems to select the suitable subsystem.	Remember
CO 2	**Demonstrate** the knowledge of basic design phases which will be considered for the design of unmanned air vehicle systems	Understand
CO 3	**Recognize** the significant role requirement parameters which determine the shape, size, performance, and costs of UAV systems as per role requirement	Understand

CO 4	**Demonstrate** the knowledge of the different types of drag in fixed, rotary-wing aircraft and UAV response to air turbulence in selecting the suitable airframe configuration	Understand
CO 5	**Illustrate** the different types of airframe configurations available for unmanned air vehicle systems	Understand
CO 6	**Outline** the scaling effects, package density, basic aerodynamics, and structures concepts used during the design of UAVs	Understand
CO 7	**Select** a suitable power-plant based on power generation systems for the given role requirement	Apply
CO 8	**Analyze** the attributes, performance, design issues and compromises of different types of aircrafts for UAV systems	Analyze
CO 9	**Identify** the appropriate communication and navigation systems for the UAVs as per the role requirements	Apply
CO 10	**Categorize** the different techniques used to achieve the control and stability of UAV systems.	Analyze
CO 11	**Apply** the fundamental concepts of UAS in design and development of UAV systems for real-world application	Apply

COURSE KNOWLEDGE COMPETENCY LEVELS



VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	CIE/Quiz/AAT
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	1	CIE/Quiz/AAT
PO 3	**Design/Development of Solutions**: Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with	2	CIE/Quiz/AAT

	Program	Strength	Proficiency Assessed by
	appropriate consideration for the public health and safety, and the cultural, societal, and Environmental considerations.		
PO 4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Seminar/ Conferences/ Research Papers
PO 12	**Life-Long Learning:** Recognize the need for and having the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	Research paper analysis/ Short term courses

3 = High; 2 = Medium; 1 = Low

IX. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

	Program Specific Outcomes (PSOs)	Strength	Proficiency assessed by
PSO 1	Synthesize and analyze aircraft structures, propulsion, production technologies and computer aided engineering in aeronautical systems including air traffic controls standards	3	Research papers/ Group discussion/ Short term courses
PSO 2	Focus on broad knowledge of aeronautical engineering in innovative, dynamic challenging environment for design and development of new products.	1	Research papers/ Group discussion/ Short term courses

3 = High; 2 = Medium; 1 = Low

X. MAPPING OF EACH CO WITH PO(s), PSO(s):

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	√	√	-	√	-	-	-	-	-	-	-	-	-	-	-
CO 5	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	√	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 7	√	-	-	√	-	-	-	-	-	-	-	-	√	-	-
CO 8	√	-	-	-	-	-	-	-	-	-	-	-	-	√	-
CO 9	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-

CO 10	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	√	-	√	-	-	-	-	-	-	-	-	√	-	-	-

XI. JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING - DIRECT

Course Outcomes	POs / PSOs	Justification for mapping (Students will be able to)	No. of Key Competencies
CO 1	**PO 1**	Recognize the functions of each major sub-systems (**scientific principles**) of the unmanned air vehicle systems to the solution of complex UAV engineering design problems by **applying Science and Own and / or other engineering disciplines knowledge.**	2
CO 2	**PO 1**	Apply the knowledge of **science, mathematics** and aeronautical **engineering design** to the design solutions of complex engineering problems.	2
	PO 2	**Identify the problem, formulate the UAV design** using the knowledge of basic design phases **reaching the substantial solution** as per the mission requirements.	3
CO 3	**PO 1**	Apply the knowledge of parameters (**scientific principles**) which determine the shape, size, performance, and costs of UAV systems to the solution of complex **Engineering problems**.	2
CO 4	**PO 1**	Apply the knowledge of different types of drag (**scientific principles** and **mathematical principles**) in fixed, rotary wing aircrafts (UAVs)	2
	PO 2	Identify the **problem statement** (mission requirement), express the airframe configuration by reviewing the literature (**information and data collection**)	2
	PO 4	Use the knowledge of different types of drag (**knowledge of characteristics of particular processes**) in fixed, rotary-wing aircraft and UAV response to air turbulence in selecting the suitable airframe configuration (**Understanding of contexts in which engineering knowledge can be applied**)	2
CO 5	**PO 1**	Apply the knowledge of different types of airframe configurations (**principles of mathematics and own engineering discipline**) to select suitable airframe during the conceptual phase as per the given mission requirement	2
	PO 2	Identify the mission requirement (**problem statement and system definition**) and apply the knowledge of different types of airframe configurations available for UAVs to select the suitable airframe during the conceptual phase	1
CO 6	**PO 1**	Apply the knowledge of scaling effects, package density, basic aerodynamics, and structures concepts (**mathematical principles, own engineering disciplines**)during preliminary design of UAVs	2
CO 7	**PO 1**	Apply the knowledge of different power generation systems includes an energy source, a means of converting that energy into mechanical energy and a means of converting that into a lift or thrust force (**mathematical and engineering principles**) during the selection of a suitable power-plant for the given role requirement	2

	PO 4	Use the knowledge of different types of power-plants (**knowledge of characteristics of particular products**) in selecting the suitable power-plant (**Understanding of contexts in which engineering knowledge can be applied, Understanding use of technical literature and other information sources**)	3
	PSO 1	Synthesize and analyze different power plants in aeronautical systems to provide the power plant for the UAV	1
CO 8	**PO 1**	Apply the knowledge of attributes, performance, design issues and compromises of different types of aircraft (**principles of mathematics and own engineering discipline**) to select suitable airframe during the preliminary phase as per the given mission requirement	2
	PSO 2	Focus on broad knowledge of attributes, performance, design issues and compromises of different types of aircraft for design and development of new UAV systems	1
CO 9	**PO 1**	Identify the appropriate communication and navigation systems for the UAVs as per the role requirements by applying the knowledge of communication and navigation systems (**principles of mathematics and other engineering discipline**)	2
	PO 2	**Identify the problem statement** (mission requirement), select the appropriate communication and navigation systems by reviewing the literature (**information and data collection**) suitable to mission requirement	2
CO 10	**PO 1**	Apply the knowledge of **mathematics, engineering** fundamentals to justify the need of control and stability of UAV systems and means of achieving the control and stability of UAV systems	2
	PO 2	**Identify the problem statement** (mission requirement) **formulate** the need (**problem**) for control and stability of UAVs, and justify the need and means of achieving the control and stability of UAV systems by reviewing the literature (**information and data collection**) suitable to mission requirement	3
CO 11	**PO 1**	Apply the knowledge of **mathematics, engineering** fundamentals to design and development of unmanned air vehicle systems for real-world application	2
	PO 3	**Investigate and define a problem and identify constraints, understand the customer needs**, attempt to deliver basic design (**innovative solution**) of UAV systems for real-world application considering economic context	3
	PO 12	**Keeping current** in UAV engineering concepts, recognize the need for and have the preparation and ability to continue in **ongoing learning, staying up with industry trends/ new technology**.	2

XII. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING

Course Outcomes	**Program Outcomes / No. of Key Competencies Matched**												**PSOs / Number of key competencies**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**2**	**2**	**2**

CO 1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	2	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 7	2	-	-	3	-	-	-	-	-	-	-	-	1	-	-
CO 8	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 9	2	2	-	-	-	-	-	-	-	-	-	-	-		-
CO 10	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	2	-	3	-	-	-	-	-	-	-	-	2	-	-	-

XIII. PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

Course Outcomes	**Program Outcomes / No. of key competencies**												**PSOs / No. of key competencies**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
	3	**10**	**10**	**11**	**1**	**5**	**3**	**3**	**12**	**5**	**12**	**12**	**2**	**1**	**2**
CO 1	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 2	66.7	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 3	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 4	66.7	20.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 5	66.7	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 6	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 7	66.7	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
CO 8	66.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3	0.0
CO 9	66.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 10	66.7	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO 11	66.7	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0

XIV. COURSE ARTICULATION MATRIX (PO – PSO MAPPING)

COs and POs and COs and PSOs on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

0 – 0≤ C≤ 5% – No correlation　　　**2** − 40 % <C< 60% –Moderate

1 – 5 <C≤ 40% – Low/ Slight　　　**3** – 60% ≤ C< 100% – Substantial /High

Course Outcomes	Program Outcomes												Program Specific Outcomes		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO 1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 2	3	1	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 7	3	-	-	1	-	-	-	-	-	-	-	-	3	-	-
CO 8	3	1	-	-	-	-	-	-	-	-	-	-	-	1	-
CO 9	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 10	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 11	3	2	2	-	-	-	-	-	-	-	-	1	-	-	-
TOTAL	33	8	4	2	-	-	-	-	-	-	-	1	3	1	-
AVERAGE	**3.0**	**1.14**	**2.0**	**1.0**								**1.0**	**3.0**	**1.0**	

XV. ASSESSMENT METHODOLOGY - DIRECT

CIE Exams	PO 1,PO 2 PO 3,PO 4	SEE Exams	PO 1,PO 2 PO 3,PO 4	Assignments	PO 1,PO 2 PO 3,PO 4	Seminars	PO 1,PO 2 PO 3,PO 4
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 1,PO 2 PO 3,PO 4	5 Minutes Video	PO 4	Tech talk	PO 4	Open Ended Experiments	-

XVI. ASSESSMENT METHODOLOGY - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✗	Assessment of Mini Projects by Experts		

XVII. SYLLABUS

Module-I	INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS
The systemic basis of UAS-system composition; Conceptual phase; Preliminary design; Selection of the system; Some applications of UAS.	
Module-II	**AERODYNAMICS AND AIRFRAME CONFIGURATIONS**
Lift-induced Drag; Parasitic Drag; Rotary-wing aerodynamics; Response to air turbulence; Airframe configurations scale effects; Packaging density; Aerodynamics; Structures and mechanisms; Selection of power-plants; Modular construction; Ancillary equipment.	
Module-III	**CHARACTERISTICS OF AIRCRAFT TYPES**
Long-endurance, long-range role aircraft; Medium-range, tactical aircraft; Close-range / battlefield aircraft; MUAV types; MAV and NAV types; UCAV; Novel hybrid aircraft configurations; Research UAV	
Module-IV	**COMMUNICATIONS NAVIGATION**
Communication media; Radio communication; Mid-air collision (MAC) avoidance; communications data rate and bandwidth usage; Antenna Types NAVSTAR Global Positioning System (GPS) - TACAN -LORAN C - Inertial Navigation - Radio Tracking - Way-point Navigation	
Module-V	**CONTROL AND STABILITY**
HTOL Aircraft - Helicopters - OTE/OTE/SPH - Convertible Rotor Aircraft - Payload Control - Sensors – culmon filter- Autonomy	
Textbooks:	
1. Reg Austin., Unmanned Aircraft Systems, John Wiley and Sons., 2010.	
Reference Books:	
1. Milman &Halkias —Integrated Electronics, McGraw Hill, 1999. 2. Malvino & Leach—Digital Principles & Applications, McGraw Hill, 1986. 3. Collinson R.P.G —Introduction to Avionics, Chapman and Hall, India, 1996 4. Bernad Etikin— Dynamic of flight stability and control, John Wiley, 1972	

XVIII. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be Covered	COs	Reference
1	Introduction to UAS, need of UAS;	CO 1	T1:1.3
2-3	The systemic basis of UAS-system composition;	CO 1	T1:1.4
4	Conceptual phase; Preliminary design;	CO 2	T1:2.1.2.2
5-6	Selection of the system;	CO 3	T1:2.4
7	Some applications of UAS;	CO 1	T1:1.1
8-9	Lift-induced Drag; Parasitic Drag; Rotary-wing aerodynamics;	CO 4	T1:3.1, 3.2, 3.3
10-14	Response to air turbulence; Airframe configurations;	CO4, CO5	T1:3.4,3.5
15-17	Scale effects, Packaging density; Aerodynamics;	CO 6	T1:6.1, 6.2,6.3

Lecture No	Topics to be Covered	COs	Reference
18-19	Structures and mechanisms;	CO 6	T1:6.5
20-21	Selection of power-plants;	CO 7	T1:6.5
22-24	Modular construction; Ancillary equipment;	CO 6	T1:6.6, 6.7
25-26	Long-endurance, long-range role aircraft;	CO 8	T1:4.1
27-28	Medium-range, tactical aircraft;	CO 8	T1:4.2
29-30	Close-range / battlefield aircraft;	CO 8	T1:4.3
31-34	MUAV types; MAV and NAV types; UCAV;	CO 8	T1:4.4, 4.5, 4.6
35	Novel hybrid aircraft configurations; Research UAV;	CO 8	T1:4.7, 4.8
36-39	Communication media; Radio communication;	CO 9	T1:9.1
40-41	Mid-air collision (MAC) avoidance; communications data rate and bandwidth usage;	CO 9	T1:9.3, 5.2.2
42	Antenna Types;	CO 9	T2: 9.5
43	NAVSTAR Global Positioning System (GPS) ;	CO 9	T1:9.5,11.1 R3: 6.5, 10
44	TACAN -LORAN C - Inertial Navigation;	CO 9	T1:11.2, 11.3, 11.4 R3: 6.2,10
45	Radio Tracking - Way-point Navigation;	CO 9	T1:11.5, 11.6
46	HTOL Aircraft;	CO 10	T1:10.1 R4:3.5,3.6, 3.9
47-48	Helicopters;	CO 10	T1:10.2
49	Convertible Rotor Aircraft;	CO 10	T1:10.3
50-51	OTE/OTE/SPH, Payload Control -Sensors;	CO 10	T1:10.4
52	Culmon (Kalman) filter- Autonomy;	CO 10	T1:11.1, 10.6 R4: 12.2,12.3, 12.4

Prepared by:
Dr. Praveen Kumar Balguri, Associate Professor **HOD, AE**