INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

AEROSPACE ENGINEERING

COURSE DESCRIPTOR

Course Title	**UAV SYSTEMS**				
Course Code	BAEB06				
Programme	M.Tech				
Semester	I	AE			
Course Type	Elective				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. Kasturi Rangan, Assistant Professor, Aeronautical Engineering				
Course Faculty	Mr. Kasturi Rangan, Assistant Professor, Aeronautical Engineering				

I. COURSE OVERVIEW:

This course introduces the basic concepts of formulation, boundary conditions, steps toward constructing a numerical solution which is the foundation for core Aerodynamics of the Aeronautical Engineering discipline. The emphasis of this course is laid on the basic analysis of boundary condition, formulation and physical considerations, steps to constructing a numerical solution which will also develop the ability to use experimental and advanced computational methods. This is designed to enhance students' knowledge of flow physics and their ability to use state-of-the-art computational tools to improve industrial designs

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
-	-	-	-	-

III. MARKSDISTRIBUTION

Subject	SEE Examination	CIA Examination	Total Marks
UAV Systems	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	LCD / PPT	✔	Seminars	✔	Videos	✘	MOOCs
✘	Open Ended Experiments						

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 units and each Unit carries equal weight age in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each Unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
30 %	To test the analytical skill of the concept.
20 %	To test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper.

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	**CIE Exam**	**Technical Seminar and Term Paper**	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration, consisting of 5 one mark compulsory questions in part-A and 4 questions in part-B. The student has to answer any 4 questions out of five questions, each carrying 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Technical Seminar and Term Paper:

Two seminar presentations are conducted during I year I semester and II semester. For seminar, a student under the supervision of a concerned faculty member, shall identify a topic in each course and prepare the term paper with overview of topic. The evaluation of Technical seminar and term paper is for maximum of 5 marks. Marks are awarded by taking average of marks scored in two Seminar Evaluations.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	Identify, formulate and solve complex engineering problems by applying advanced principles of engineering	3	Seminar
PO 3	Formulate and solve complex engineering problems related to aerospace materials, propulsion, aerodynamics, structures, avionics, stability and control.	1	Final Exam
PO 5	Independently carry out research / investigation and development work to solve practical problems	2	Seminar

3 = High; 2 = Medium; 1 = Low

VII. COURSE OBJECTIVES:

The course should enable the students to:

I	Acquire the knowledge of various disciplines contributing to the design, development and deployment of UAVs.
II	Explain the design of UAV systems and their configuration
III	Develop and deploy the UAV systems.

VIII. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand the various applications of UAS and be able to describe the categories of UAV systems.	CLO 1	Understand the concept of unmanned aircraft and UAV and UAS.
		CLO 2	Explain the various roles of unmanned aircraft.
		CLO 3	Emphasize the basic composition of UAV systems.
CO 2	Demonstrate knowledge in design the UAV systems.	CLO 4	Develop the basic systems in the designs of UAV systems.
		CLO 5	Describe the aerodynamics of UAV vehicles
		CLO 6	Describe the signature of UAV vehicles
CO 3	Demonstrate knowledge in communications and media of UAV systems.	CLO 7	Illustrate the various aspects of payloads.
		CLO 8	Understand the Sensors used in UAVs
		CLO 9	Explain the Navigation systems used in UAVs
CO 4	Illustrate concepts in system design and development of UAVs.	CLO 10	Explain various navigation systems and the design for maintenance.
		CLO 11	Describe the system certifications
		CLO 12	Describe the system certifications in UAV terminology
CO 5	Describe the trials and operations in UAV systems.	CLO 13	Understand the UAV sub-assemblies
		CLO 14	Explain the various aspects of the documentation of flight testing
		CLO 15	Discuss various aspects of the UAVs integration into naval carriers

IX. COURSE LEARNING OUTCOMES(CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to	PO's Mapped	Strength of Mapping
BAEB06.01	CLO 1	Understand the concept of unmanned aircraft and UAV and UAS.	PO 3	3
BAEB06.02	CLO 2	Explain the various roles of unmanned aircraft.	PO 1, PO 3, PO 5	2
BAEB06.03	CLO 3	Emphasize the basic composition of UAV systems.	PO 1, PO 3	2
BAEB06.04	CLO 4	Develop the basic systems in the designs of UAV systems.	PO 1, PO 3	2
BAEB06.05	CLO 5	Describe the aerodynamics of UAV vehicles	PO 1, PO 5	2
BAEB06.06	CLO 6	Describe the signature of UA1 vehicles	PO 3 , PO 5	2
BAEB06.07	CLO 7	Illustrate the various aspects of payloads.	PO 1	2
BAEB06.08	CLO 8	Understand the Sensors used in UAVs	PO 3	3
BAEB06.09	CLO 9	Explain the Navigation systems used in UAVs	PO 1, PO 5	2
BAEB06.10	CLO 10	Understand the navigation systems that are used in UAVs	PO 1	2
BAEB06.11	CLO 11	Explain various navigation systems and the design for maintenance	PO 3	2
BAEB06.12	CLO 12	Describe the system certifications	PO 3	3
BAEB06.13	CLO 13	Describe the system certifications in UAV terminology.	PO 1, PO 3	1
BAEB06.14	CLO 14	Explain the various aspects of the documentation of flight testing	PO 3, PO 5	2
BAEB06.15	CLO 15	Discuss various aspects of the UAVs integration into naval carriers	PO 1	2

3 = High; 2 = Medium; 1 = Low

X. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)		
	PO 1	PO 3	PO 5
CO 1		3	
CO 2	2	2	2
CO 3	2	2	
CO 4	2	2	
CO 5		3	2

3 = High; 2 = Medium; 1 = Low

XI. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Learning Outcomes (CLOs)	Program Outcome (PO)						
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CLO 1			3				
CLO 2	2		2		2		
CLO 3	2		2				
CLO 4	2		2				
CLO 5	2				2		
CLO 6			1		1		
CLO 7	2						
CLO 8			3				
CLO 9	2		2				
CLO 10	2						
CLO 11			2				
CLO 12			3				
CLO 13	1		1				
CLO 14			2		2		
CLO 15	2						

3 = High; 2 = Medium; 1 = Low

XII. ASSESSMENT METHODOLOGIES –DIRECT

CIE Exams	PO1, PO3, PO5	SEE Exams	PO1, PO3, PO5	Seminar and Term Paper	PO1, PO3, PO5
Viva	-	Mini Project	-	Laboratory Practices	-

XIII. ASSESSMENT METHODOLOGIES -INDIRECT

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

XIV. SYLLABUS:

Unit-I	INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS
Applications of UAS, categories of UAV systems, roles of unmanned aircraft, composition of UAV system	
Unit-II	**DESIGN OF UAV SYSTEMS-I**
Introduction to design and selection of the systems-conceptual phase, preliminary design, detailed design; Aerodynamics and airframe configurations-Lift-induced Drag, Parasitic Drag, Rotary-wing Aerodynamics, Response to Air Turbulence, Airframe Configurations; Medium-range, Tactical Aircraft, 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, Aspects of Airframe Design: Scale Effects, Packaging Density, Aerodynamics, Structures and Mechanisms, Selection of power- plants, Modular Construction, Ancillary Equipment, Design for Stealth: Acoustic Signature, Visual Signature, Thermal Signature, Radio/Radar Signature, Payload Types: Nondispensable and dispensable payloads.	
Unit-III	**DESIGN OF UAV SYSTEMS-II**
Communications-Communication Media, Radio Communication, Mid-air Collision (MAC) Avoidance, Communications Data Rate and Bandwidth Usage, Antenna Type; Control and Stability: HTOL Aircraft, Convertible Rotor Aircraft, Payload Control, Sensors, Autonomy; Navigation: NAVSTAR Global Positioning System (GPS), TACAN, LORAN C, Inertial Navigation, Radio Tracking, Way-point Navigation; Launch and Recovery. Design for Reliability: Determination of the Required Level of Reliability, Achieving Reliability, Reliability Data Presentation, Multiplexed Systems, Reliability by Design, Design for Ease of Maintenance; Design for Manufacture and Development	
Unit-IV	**THE DEVELOPMENT OF UAV SYSTEMS:**
System Development and Certification-System Development, Certification, Establishing Reliability; System Ground Testing: UAV Component Testing, UAV Sub- assembly and Sub-system Testing, Testing Complete UAV, Control Station Testing , Catapult Launch System Tests, Documentation; System In - flight Testing: Test Sites, Preparation for In-flight Testing, In- flight Testing, System certification	
Unit-V	**DEPLOYMENT AND FUTURE OF UAV SYSTEMS**
Operational trials and full certification; UAV System Deployment- Network-centric Operations (NCO), Teaming with Manned and Other Unmanned System; Naval, arm and air force roles, civilian, paramilitary and commercial roles.	
Text Books:	
1. Reg Austin, Wiley, "Unmanned Aircraft Systems, UAVS Design and Deployment", 2nd Edition, 2010.	
Reference Books:	
1. Richard K. Barnhart, Stephen B. Hottman, Douglas M. Marshall, Eric Shappee, (eds.), "Introduction to Unmanned Aircraft Systems", CRC Press, 2012. 2. Valavanis, Kimon P., Vachtsevanos, George J. "Handbook of Unmanned Aerial Vehicles" AIAA series, 3rd Edition, 2004.	

XV. COURSE PLAN:

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

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-3	Applications of UAS, categories of UAV systems	CLO 1	T2 : 5.5
4-5	Roles of unmanned aircraft,	CLO 2	T1 : 4.1.3,
6-9	Composition of UAV system	CLO 3	T1 :6.4, T2:6.2-6.4
10	Introduction to design and selection of the systems-conceptual phase, preliminary design, detailed design;	CLO 4	T1:6.4.2;
11-12	Aerodynamics and airframe configurations-Lift-induced Drag, Parasitic Drag, Rotary-wing Aerodynamics, Response to Air Turbulence, Airframe Configurations	CLO 5	T1 : 3.6 R4:4.3
13-14	Medium-range, Tactical Aircraft, 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	CLO 4	T1:3.8 R2:6.4

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
14-15	Aspects of Airframe Design: Scale Effects, Packaging Density, Aerodynamics, Structures and Mechanisms, Selection of power-plants, Modular Construction, Ancillary Equipment	CLO 4	T1: 4.1.5, 4.1.3
16-17	Design for Stealth: Acoustic Signature, Visual Signature, Thermal Signature, Radio/Radar Signature,	CLO 5	T1:4.2, 4.5.1,
18	Payload Types: Nondispensable and dispensable payloads.	CLO 6	T1:4.1.7, 4.1.8
19-21	Communications - Communication Media, Radio Communication, Mid-air Collision (MAC) Avoidance, Communications Data Rate and Bandwidth Usage, Antenna Type;	CLO 5	T1:9.1-9.3 T2:13.3
22-23	Control and Stability: HTOL Aircraft, Convertible Rotor Aircraft, Payload Control, Sensors, Autonomy	CLO 7	T1:5.3 T2:13.4
24	Navigation: NAVSTAR Global Positioning System (GPS), TACAN, LORAN C, Inertial Navigation, Radio Tracking, Way-point Navigation; Launch and Recovery.	CLO 8	T1:6.1-6.2
25-27	Design for Reliability: Determination of the Required Level of Reliability, Achieving Reliability	CLO 7	T2:8.1-8.3
28-29	Reliability Data Presentation, Multiplexed Systems, Reliability by Design	CLO 9	T2:8.3-8.6
30-31	Design for Ease of Maintenance; Design for Manufacture and Development	CLO 8	T2:8.7-8.9
32-33	System Development and Certification-System Development, Certification, Establishing Reliability;	CLO 10	R1:11.2
34-35	System Ground Testing: UAV Component Testing, UAV Sub-assembly and Sub-system Testing, Testing Complete UAV,	CLO 10	R1:11.3, 11.4
36-37	Control Station Testing , Catapult Launch System Tests, Documentation	CLO 11	R1:11.5,11.7, 11.8
38-40	System In - flight Testing: Test Sites, Preparation for In-flight Testing, In- flight Testing, System certification	CLO 12	R1:11.7, 11.6
41-42	Operational trials and full certification; UAV System Deployment- Network-centric Operations (NCO)	CLO 13	T3:9.1- 9.3
43-44	Teaming with Manned and Other Unmanned System	CLO 14	T3:9.4- 9.6
45	Naval, arm and air force roles, civilian, paramilitary and commercial roles	CLO 15	T3:9.7-,9.8

XVI. GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

S No	Description	Proposed Actions	Relevance with POs
1	Encourage students to perform analysis on Control and Dynamic UAV systems.	Seminars	PO 1
2	Encourage students to solve various UAV flow equations.	Seminars / NPTEL	PO 3

Prepared by:
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HOD, AE