INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**FLIGHT MECHANICS - I**			
Course Code	A42105			
Regulation	**R13 – JNTUH**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	-	-	4
Course Coordinator	DR.P.K.DASH , Professor			
Team of Instructors	DR.P.K.DASH , Professor			

I. COURSE OVERVIEW:

Flight mechanics is the science that investigates the control of aircraft and other flying vehicles. From the time of the Wright brothers it was recognized that flight without control is impossible. Since then, several different concepts for controlling aircraft flight have been devised including control surfaces, deformable surfaces, rockets and others. This course introduces some of these concepts and describes their operation, as well as the degree of stability that they can provide. Both aircraft and helicopters are addressed. Modern aircraft control is ensured through automatic control systems. Their role is to increase safety, facilitate the pilot's task and improve flight qualities. The course will introduce modern aircraft control and discuss some of its objectives and applications.

II. PREREQUISITE(S)

Level	Credits	Periods/ Week	Prerequisites
UG	4	4	Concepts on Introduction of AerospaceEngineering

III MARKS DISTRIBUTION

Sessional Marks	University End Exam marks	Total marks
Mid Semester Test There shall be two midterm examinations. Each midterm examination consists of subjective type and objective type tests. The subjective test is for 10 marks of 60 minutes duration. Subjective test of shall contain 4 questions; the student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks of 20 minutes duration. It consists of 10 Multiple choice and 10 objective type questions, the student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion **Assignment** Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course.	75	100

IV. EVALUATION SCHEME

S. No	Component	Duration	Marks
1.	I Mid Examination	80 minutes	20
2.	I Assignment	-	5
3.	II Mid Examination	80 minutes	20
4.	II Assignment	-	5
5.	External Examination	3 hours	75

V. COURSE OBJECTIVES:

1. **Discuss** the concepts of Flight performance.
2. **Understand** the parameters affecting the performance.
3. **Formulate** the equations of motion for an aircraft in atmospheric flight.
4. **Motivate** the assumptions made to simplify a flight mechanics problem.
5. **Explain** the basic modes of motion and related mechanisms of an aircraft.
6. **Perform** a simple trajectory calculations using simplifies equations of motion.
7. **Present** your results in a well written report.

VI. COURSE OUTCOMES:

At the end of the course the students are able to:

1. **Estimate** math models of flight vehicles.
2. **Demonstrate** knowledge of a variety of aerospace flight vehicles.
3. A**nalyze** the aircraft equations of rigid-body motion.
4. **Evaluate** aircraft flight characteristics using computational techniques.
5. **Understand** the effects of aerodynamic and propulsive controls on equilibrium conditions.
6. **Identify** the significance of flight stability and its impact of aircraft operations and pilot workload.
7. **Explain** the meaning of aerodynamic stability derivatives and their sources.
8. **Relate** the effects of aerodynamic derivatives on flight stability.
9. **Describe** the impact of flight stability and trim on all atmospheric flight vehicles.
10. **Analyze** dynamics and control of flight vehicles.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program Outcomes		Level	Proficiency assessed by
PO1	Knowledge in fundamentals of mathematics, science and engineering.	S	Discussions
PO2	An ability to identify, formulate and solve problems in key areas of Aerodynamics, Structures, Propulsion, Flight Dynamics and Control, Design, Testing, Space and Missile Technologies and Aviation of Aeronautical Engineering discipline	H	Assignments
PO3	An ability to design and conduct experiments, analyze and interpret data related to various areas of Aeronautical Engineering.	H	Seminars
PO4	An ability in conducting investigations to solve problems using research based knowledge and methods to provide logical conclusions.	S	Assignments
PO5	Skills to use modern engineering and IT tools, software and equipment to analyze the problems in Aeronautical Engineering.	H	Assignments
PO6	Understanding of impact of engineering solutions on the society to assess health, safety, legal, and social issues in Aeronautical Engineering.	S	Discussions
PO7	The impact of professional engineering solutions in environmental context and to be able to respond effectively to the needs of sustainable development.	N	Projects
PO8	The knowledge of Professional and ethical responsibilities.	N	Discussions
PO9	An ability to work effectively as an individual and as a team member/leader in multidisciplinary areas.	N	Assignments
PO10	An ability to critique writing samples (abstract, executive summary, project report), and oral presentations.	S	Presentations
PO11	Knowledge of management principles and apply these to manage projects in multidisciplinary environments.	S	Assignments
PO12	The need of self-education and ability to engage in life - long learning.	H	Discussions

N-None **S-Supportive** **H-Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency Assessed by
PSO 1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	H	Lectures and Assignments
PSO 2	**Problem solving skills:** imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	H	Discussions
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	H	projects
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats	S	Seminars and Projects

IX. SYLLABUS

UNIT I

INTRODUCTION TO AIRCRAFT PERFORMANCE- THE FORCE SYSTEM OF THE AIRCRAFT :

The role and design mission of an Aircraft Specification of the Performance requirements and mission profile Importance of performance analysis, estimation, measurement, operational safety and economy Scheduled performance and operational performance of the Aircraft The standard atmosphere Off-standard and design atmosphere Measurements of air data Air data computers.

Equations of motion for performance - Aircraft force system Lift-Drag and side force Total airplane drag - estimation, drag reduction methods The propulsive forces-The thrust producing engines, power producing engines, variation of thrust, propulsive power and specific fuel consumption with altitude and flight speed The minimum drag speed, minimum power speed. Aerodynamic relationships for a parabolic drag polar.

UNIT II

CRUISE PERFORMANCE:

Max and Min speeds in level flight Range and endurance with thrust producing and power producing engines Cruise Techniques - constant angle of attack, constant Mach number, constant altitude methods - comparison of performance The effect of alternative fuel flow laws, weight, altitude and temperature on cruise performance. Cruise performance with mixed power-plants.

UNIT III

CLIMB, DESCENT AND MANOEUVRE PERFORMANCE:

Climb and Descent Techniques, safety considerations, performance analysis- maximum climb gradient, climb rate Energy height and specific excess power, optimal climbs-minimum time, minimum fuel climbs Measurement of climb performance Descent performance in aircraft operations Effect of wind on climb and descent performance.

Accelerated motion of aircraft- equations of motions-the maneuver envelope Longitudinal maneuvers-the pull-up push over maneuver Lateral maneuvers-turn performance-turn rates, turn radius-limiting factors Instantaneous and sustained turns, specific excess power, energy turns Maneuvers boundaries Maneuver performance of military aircraft, transport aircraft.

UNIT IV

TAKE-OFF AND LANDING-SAFETY REQUIREMENS – FLIGHT PLANNING:

Estimation of Takeoff distances the effect on the take-off distance of weight, wind, runway conditions, ground effect Take off performance safety factors Estimation of Landing distances - the discontinued landing, baulked landing Air safety procedures and requirements on landing performance.

Flight safety criteria Performance classification of civil aircraft Flight planning - performance planning and fuel planning - fuel requirements, trip fuel, environmental effects, reserves tankering.

UNIT V

AIRCRAFT PERFORMANCE MEASUREMENT AND DATA HANDLING-APPLICATION OF PERFORMANCE DATA:

Purpose of performance measurement in flight. Flight testing-principal performance variables-weight, altitude and ambient temperature (WAT).Parametric performance data analysis. Dimensional analysis Measurement of cruise, climb, take-off and landing performance-data reduction equivalent weight method Corrections for weight and temperature.

Operational performance data for flight planning – take-off field performance, runway correction, aircraft datum performance (WAT) charts determination of the maximum take-off weight. Performance summary for fleet selection-the block performance, payload- range diagram Route analysis and optimization. Operational analysis procedure.

Text books:

1. Eshelby, M.E., Aircraft performance: Theory and Practice
2. Brandt, S.A. et.al., Introduction to Aeronautics : A Design Perspective
3. Anderson, J.D. Jr., Aircraft Performance and Design

References:

1. Dole, C.E., Flight Theory and Aerodynamics: a Practice Guide for Operational Safety
2. McCormick, B.W, Aerodynamics, Aeronautics and Flight Mechanics
3. Shevel, R.S., Fundamentals of flight
4. Raymer, D.P., Aircraft Design: A Conceptual Approach
5. Yechout, T.R. et al., Introduction to Aircraft Flight Mechanics

X. COURSE PLAN:

At the end of the course, the students are able to achieve the following course learning outcomes.

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
1	**Define** various mission profiles	**UNIT – 1 INTRODUCTION TO AIRCRAFT PERFORMANCE – THE FORCE SYSTEM OF THE AIRCRAFT :** The role and design mission of an Aircraft Specification of the Performance requirements and mission profile	T 1
2-3	**Estimation** of performance	Importance of performance analysis, estimation, measurement, operational safety and economy	T 1
4-5	**Finding** out the difference in performance	Scheduled performance and operational performance of the Aircraft.	T 1
6-8	**Analyze** standard atmosphere	The standard atmosphere Off-standard and design atmosphere Measurements of air data Air data computers	T 1
9-10	**Evaluating** equations of motion	Equations of motion for performance - Aircraft force system	T 1
11-12	**Explain** various types of force systems	Lift-Drag and side force	T 1
13-15	**Explain** aerodynamic drag relationships	Total airplane drag - estimation, drag reduction methods The propulsive forces-The thrust producing engines, power producing engines, variation of thrust, propulsive power and specific fuel consumption with altitude and flight speed	T 1
16-17	**Discuss** Various speed levels	The minimum drag speed, minimum power speed, Aerodynamic relationships for a parabolic drag polar	T 1
18	**Explain** about range and endurance	**UNIT – 2 CRUISE PERFORMANCE:** Max and Min speeds in level flight	T 1
19-20	**Review** cruise techniques	Range and endurance with thrust producing and power producing engines	T 1
21-23	**Describe** the effect of fuel flows	Cruise Techniques - constant angle of attack, constant Mach number, constant altitude methods - comparison of performance	T 1
24-26	**Describe** the effect of fuel flows	The effect of alternative fuel flow laws, weight, altitude and temperature on cruise performance.Cruise performance with mixed power-plants.	T 1
27-30	**Explain** different techniques for climb and decent	**UNIT – 3 CLIMB DESCENT AND MANOEUVRE PERFORMANCE:** Climb and Descent Techniques, safety considerations, performance analysis- maximum climb gradient, climb rate	T 1
31-32	**Discuss** various types of climb performance	Energy height and specific excess power, optimal climbs-minimum time, minimum fuel climbs	T 1
33-34	**Define** measurement of climb performance	Measurement of climb performance, Descent performance in aircraft operations	T 1
35-36	**Describe** effects of wind	Effect of wind on climb and descent performance	T 1

37-38	**Explain** the manoeuvre envelop	Accelerated motion of aircraft - equations of motions- the manoeuvre envelope	T 1
39-40	**Discuss** types of manoeuvre	Longitudinal manoeuvre-the pull-up, push over manoeuvre	T 1
41-42	**Describe** turn rates	Lateral manoeuvre-turn performance-turn rates, turn radius-limiting factors, Instantaneous and sustained turns, specific excess power, energy turns	T 1
43-44	**Discuss** Manoeuvre boundaries	Manoeuvre boundaries Manoeuvre performance of military aircraft, transport aircraft	T 1
45-46	**Estimation** of takeoff distances	**UNIT – 4 TAKE OFF AND LANDING-SAFETY REQUIREMENTS-FLIGHT PLANNING:** Estimation of Takeoff distances The effect on the take-off distance of weight, wind, runway conditions, ground effect	T 1
47-48	**Discuss** safety factors	Take off performance safety factors Estimation of Landing distances - the discontinued landing, baulked landing Air safety procedures and requirements on landing performance	T 1
49-51	**Explain** performance classifications	Flight safety criteria Performance classification of civil aircraft Flight planning - performance planning and fuel planning - fuel requirements, trip fuel, environmental effects, reserves tankering	T 1
52-55	**Discuss** purpose of performance measurement	**UNIT – 5 AIRCRAFT PERFORMANCE MEASUREMENT AND DATA HANDLING- APPLICATION OF PERFORMANCE DATA:** Purpose of performance measurement in flight Flight testing - principal performance variables - weight, altitude and ambient temperature (WAT) Parametric performance data analysis	T 1
56-58	**Explain** performance data	Dimensional analysis Measurement of cruise, climb, take-off and landing performance-data reduction - equivalent weight method	T 1
59	**Discuss** various correction methods	Corrections for weight and temperature	T 1
60-65	**Explain** operational analysis procedure	Operational performance data for flight planning - takeoff field performance, runway correction chart, aircraft datum performance (WAT) charts, determination of the maximum take-off weight Performance summary for fleet selection - the block performance.	T 1

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

Course objectives	Program Outcomes												Program specific outcomes			
	A	B	C	D	E	F	G	H	I	J	K	L	PSO1	PSO2	PSO3	PSO4
I	S	H	H	S	H	S			S	S		H			H	
II	H	S		S		S				S			H		S	
III	H	H	H	S			S			H		S		H		
IV	H	H	S							S			S			H
V	S	H	S	S					S			S		H		
VI	S	H	H	S				S		S		S	H			
VII	S	H	S	S		S		S	H			S				H

N = None S = Supportive H = Highly related

XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcomes	Program Outcomes												Program specific outcomes			
	A	B	C	D	E	F	G	H	I	J	K	L	PSO1	PSO2	PSO3	PSO4
1	S	H	S	S						S		H		H		
2	S	H	S	H			S		S	S			S			
3	S	S	H	S			S			S		S			H	
4	H	S	S	H				S	H	S						
5	S	H	H	H	S	S	S	S	H	S		S		H		
6	H	H	S	S	S	H	S	H	S	S	S	S	H		S	
7	S	S	H	H	S	S	H	S	H	S		S				H
8	S	S	H	S	S	H	S	S	H	S		S				
9	H	H	S	S	S	S	H	S	S	H		S		H		
10	S	S	H	H	S	S	S	S	S	H		S				
11	H	H	S	S	H	S	H	S	S	H		S	H			
12	H	H	S	S	S	H	S	S	S	H		S				H

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Prepared by: Dr. P.K Dash, Professor

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