GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Aeronautical Engineering
Subject Code: BE05001031
Subject Name: Flight Mechanics

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	Aeronautical Mechanics of Solid, Fundamentals of Aerodynamics
Rationale:	Flight Mechanics characterizes the motion of a flight vehicle in the atmosphere. This course imparts basic knowledge related to aircraft performance, stability and control. This will help to design the propeller and jet airplane.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Define different types of altitudes and standard atmosphere.	10
CO-2	Apply engineering mechanics theory to evaluate airplane performance in steady and accelerated flight.	35
CO-3	Define different types of stability and control	05
CO-4	Analyze static longitudinal stability and control derivatives, and criteria for a stable airplane.	40
CO-5	Understand basic concepts of static lateral and directional stability and control.	10

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	03	70	30	20	30	50	200

Content:

Sr. No.	Content	Total Hrs	Marks% weightage
1	**Standard Atmosphere and Altitudes** Definition of altitude (geometric, geopotential, absolute), hydrostatic equation,	6	10

	relation between geopotential & geometric altitudes, standard atmosphere, pressure, density & temperature altitudes		
2	**Airplane Performance – Steady Flight** Equations of motion for steady level flight, Thrust required and thrust available, maximum velocity concept, Power required and power available for propeller and jet engine airplanes, Effect of altitude on power and performance, Stall and use of high-lift devices, Climbing flight, gliding flight, absolute and service ceilings, Time to climb, range and endurance calculations for propeller-driven and jet airplanes	**13**	40
3	**Airplane Performance – Accelerated Flight** Level turns, pull-up & pull-down maneuvers, V-n diagram, accelerated rate of climb (energy method), take-off & landing performance	**9**	10
4	**Basics of Stability and Longitudinal Stability & Control** Importance of stability and control in flight dynamics; Forces acting on an airplane and degrees of freedom for a rigid body; Stick-fixed longitudinal static stability: Contributions of wing, horizontal tail, fuselage and power, Stick-fixed neutral point and static margin, Elevator angle for trim and forward/rearward c.g. limits; Stick-free longitudinal static stability: Hinge moments and their variation with tail and elevator deflection, Stick-free neutral point, stick force and stick force gradient, Elevator requirement in pull-up and maneuver point limitations.	**12**	35
5	**Static Lateral and Directional Stability & Control** Directional stability & control, lateral stability, roll control	**5**	05

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**30**	**30**	**10**	**10**	**0**

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

The syllabus of Flight Mechanics directly contributes to

No.	SDG	Relevance to Syllabus
SDG 9	Industry, Innovation and Infrastructure	Understanding aircraft performance, stability, and control supports the design of safer and more efficient aerospace systems.
SDG 11	Sustainable Cities and Communities	Knowledge of standard atmosphere, altitude effects, and aircraft performance helps in designing efficient air transport systems, which improves connectivity, reduces fuel consumption and supports sustainable aviation operations impacting urban and regional mobility.
SDG 13	Climate Action	Analysis of aircraft performance and stability contributes to optimizing fuel efficiency and reducing emissions.

Reference Books:

1. R. F. Stengel, *Flight Dynamics*, Princeton, NJ, USA: Princeton University Press, 2004.
2. J. Roskam, *Airplane Flight Dynamics and Automatic Flight Controls*, Lawrence, KS, USA: DAR Corporation, 1995.
3. R. C. Nelson, *Flight Stability and Automatic Control*, New York, NY, USA: McGraw-Hill International, 1990.
4. B. Etkin and L. D. Duffy, *Dynamics of Flight: Stability and Control*, New York, NY, USA: John Wiley, 1995.
5. C. D. Perkins and R. E. Hage, *Airplane Performance, Stability and Control*, New York, NY, USA: Wiley, 1949.
6. J. D. Anderson Jr., *Introduction to Flight*, 8th ed., New York, NY, USA: McGraw-Hill Education, 2015.
7. J. D. Anderson Jr., *Aircraft Performance and Design*, 5th ed., New York, NY, USA: McGraw-Hill Education, 2010.

List of Experiments:

1. **Calculation of Pressure, Density and Temperature Altitudes** – Determine various altitude types using standard atmosphere data.
2. **Estimation of Thrust Required for Steady Level Flight** – Calculate thrust needed for maintaining level flight at different speeds and altitudes.
3. **Estimation of Power Required for Steady Level Flight** – Compute power requirements for propeller and jet-driven airplanes.
4. **Study of Climbing Flight** – Analyze climb performance, rate of climb and service ceilings.
5. **Study of Gliding Flight** – Examine glide path, glide angle and distance.
6. **Determination of Range and Endurance for Propeller-Driven Airplane** – Calculate maximum distance and endurance based on performance parameters.
7. **Determination of Range and Endurance for Jet Airplane** – Evaluate range and endurance for jet-powered aircraft.

8. **Study of Turning Flight** – Investigate level turns, pull-up and pull-down maneuvers with associated load factors.
9. **Estimation of Takeoff and Landing Distance** – Determine runway requirements for safe takeoff and landing.
10. **Study of Longitudinal, Directional and Lateral Stability & Control** – Examine stick-fixed and stick-free longitudinal stability, lateral stability and directional control using control surfaces.

Major Equipment: MATLAB / Simulink, X-Plane / FlightGear / AeroSim, AVL (Athena Vortex Lattice), Engine Performance Software (e.g., GasTurb, NPSS), Excel / Spreadsheet

List of Open Source Software/learning website:

- https://nptel.ac.in/courses/101106041
- https://nptel.ac.in/courses/101106043

List of suggested activities for Problem Based Learning:

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit (Power converters/electronics/drives company)	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning on-line course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex	Complex problem solving	Maximum 2	Based on the depth of the

	Problem-Solving targeting relevant SDGs. / Mini Project		problem. Study of the problem and solution finding, Total = 15 hrs	solution submitted.
5	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (SCOPUS Index/any reputed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluation critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	Micro Project	Working/non-working model on technical topics	Working = 10 hrs Non-working = 10 hrs	Based on inter department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth, knowledge etc.
		Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10hrs	Based on quiz scores and reflection report after each quiz.
9	Case Study Analysis	Real world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject *Flight Mechanics* incorporates;
   - Micro Project – 5 Marks

   These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of Flight Mechanics. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication and research competencies essential for professional engineering practice.
2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

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