

COURSE CODE	COURSE TITLE	L	T	P	C
1152AE219	Flapping Wing Dynamics	2	0	2	3

Course Category:

Programme Elective

a. Preamble :

This course deals with the basic aerodynamics and flight dynamics of flapping wing vehicle and provide practical exposure of parameter estimation of flapping wings.

b. Prerequisite Courses:

Flight Mechanics

c. Related Courses:

- Aircraft stability and control

d. Course Educational Objectives :

- Understand the concept of flapping wing vehicles
- To impart practical skill on force measurement on flapping wing

e. Course Outcomes :

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Articulate the nature, structures and functions of flapping Wing	K2, S3
CO2	Describe flexible and flapping wing aerodynamics	K2
CO3	Describe the Aero dynamical Model for Flapping flight	K2
CO4	Demonstrate Parameter estimation for flapping wing vehicle	K3, S3
CO5	Demonstrate design and fabrication of flapping wing vehicle	K2, S3

f. Correlation of COs with POs :

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H				H	H			
CO2	H		H	H				H	H			
CO3	H		H	H				H	H			
CO4	H	H	H	H				H	H			
CO5	H	H	H	H				H	H			

H- High; M-Medium; L-Low

g. Course Content :

UNIT-I Flapping Flight in Nature

6L+3P

Introduction - Parts and functions of flapping flyers - Gliding, Forward and Hovering - Structures and occurrences of wings - Muscles associated with the wings - Movements of the wings - Drag and Power - Upper and lower limits - Wing beat frequency

Exp: Design and fabrication of flapping mechanism & Wings

UNIT-II Aerodynamics of flexible and flapping wing flight 6

Introduction - Flexible wing models - Linear and hyperplastic model - Coupled elastic structures and aerodynamics model - Flapping motion - Kinematics - Reynolds number - strouhal number and reduced frequency

UNIT-III Flapping-Wing Aerodynamics Model 6

Lift and Thrust Evaluation from wing motion - Dynamic Stall - Leading-Edge Vortex - Rapid Pitch-Up - Wake Capture - DeLaurier Modified strip theory - Various Mechanism for wing motion - Effects of Reynolds Number, Reduced Frequency, and Kinematics on Hovering Aerodynamics

UNIT-IV Flapping flight Mechanics 6L + 6P

Introduction - Concepts of blade element theory and momentum theory - Equations of motion - Wing kinematics - Force calculations - Forward flight performance - Hovering flight performance - Roll Pitch & Yaw - flapping wing motion comparison with fixed wing and helicopter - Linearized dynamical model for flapping wing - Concepts of flapping wing stability
EXP: 1. Estimation of Aero dynamical Parameter of flapping wing
2. Estimation of Thrust for flapping wing

UNIT-V Instrumentation for flapping wing 6L + 6P

Design and fabrication of flapping wing models - Flow visualization techniques - Sensors for measuring forces - moments - flapping frequency - data acquisition using modern tools - wind tunnel limitations - free flight testing - in flight testing
EXP: 1. Design and fabrication of Flapping Wings
2. Flow visualization over flapping wing and identification of figure eight motion

Total: 45 Periods

h. Learning Resources

i. Text Books :

1. R. F. Chapman ,The Insects Structure and Function, 4th edition, Cambridge University.
2. Wei Shyy, Hikaru Aono, Chang-kwon Kang, Hao Liu, An Introduction to Flapping Wing Aero dynamics, Cambridge University.

ii. Reference:

1. Sujoy Mukherjee & Ranjan Ganguli, Nonlinear dynamic analysis of dragonfly-inspired piezoelectric unimorph actuated flapping and twisting wing International Journal of Smart and Nano Materials ISSN: 1947-5411 (Print) 1947-542X (Online)
2. Aditya A. Paranjapee, Michael R. Dorothy, Soon-Jo Chung, Ki D. Lee, A Flight Mechanics-Centric Review of Bird-Scale Flapping Flight, Int'l J. of Aeronautical & Space Sci. 13(3), 267–282 (2012)
3. Wei Shyy and Michael J. Rycroft, Aerodynamics of Low Reynolds Number Flyers, Cambridge Aerospace Series