Introduction to Rotorcraft Dynamics

Code	Credit Hours
AE-443	2-0

COURSE DESCRIPTION:

The helicopter is a unique form of aircraft and its usefulness lies in the unique capability of takeoff and land vertically on almost any terrain. This introductory course provides a preliminary treatment of the aerodynamic theory of rotary-wing aircraft to the undergraduate students of Aerospace Engineering. Moreover, the fundamentals of rotor aerodynamics for rotorcraft in hovering flight, axial flight, and forward flight modes are also studied. At the end of this course, students will be able to perform blade element analysis, investigate rotating blade motion, and quantify basic helicopter performance.

TEXT AND MATERIAL

Textbooks:

1. “Principles of Helicopter Aerodynamics”, by J. Gordon Leishman, Cambridge Aerospace Series, Latest Available Edition, ISBN 3781107013353,
2. **“**Basic Helicopter Aerodynamics" by John M. Seddon, Simon Newman; JohnWiley, Latest Available Edition, ISBN 97811997272-3,
3. Propeller by Aviation Maintenance Technician Certification Series, Latest Available Edition
4. Helicopter Aerodynamics, Structures and Systems by Aviation Maintenance Technician Certification Series, Latest Available Edition

PRE-REQUISITE:

Aerospace Vehicle Performance

ASSESSMENT SYSTEM:

Quizzes	10-15%
Assignments	5-10%
Mid Terms	30-40%
ESE	40-50%

TOPICS COVERED

Week No	Description	Ref
1	**Introduction to Rotary-Wing Aircraft** Technical History Rotorcraft Definitions Types of Rotorcraft Rotorcraft Configurations Main Rotor Configuration Tail Rotor Configuration **Propeller Construction** Construction methods and material used in wooden, composite and metal propellers; Blade station, blade face, blade shank, blade back and hub assembly; Fixed pitch, controllable pitch, constant speeding propeller; Propeller/spinner installation.	Text1, Ch1 Ref 1, Ch 1
2	Control System Collective Control Cyclic Control Directional Control Pitch Control (Overspeed Protection)	Ref 1, Ch 1
3	Fundamental of Rotor Aerodynamics Propeller Synchronizing and synchrophasing equipment.	Text 1, Ch 2 Ref 1, Ch 1
4	Momentum Theory (MT) in Hovering Flight Induced Velocity Induced Inflow Ratio Thrust Coefficient (CT) Power Coefficient (CP) Torque Coefficient (CQ)	Text1, Ch2 Ref 1, Ch 2
5	Power Loading Disk Loading Power Requirement Figure of Merit (FoM) Solidity Ratio (σ)	Text1, Ch2 Ref 1, Ch 2
6	Blade Element Theory (BET) Linearly Twisted Blade Ideally Twisted Blade Optimum Twisted Blades	Text 1. Ch 3 Ref 1, Ch 3

7	Combined Blade Element Momentum Theory (CBEMT) Prandtl's Tip Loss Function	Text 1, Ch 3
8	Vertical Climb	Text 1, Ch 2
9	**MID TERM EXAM**	
10	Descent Vortex Ring State Turbulent Wake State	Text 1, Ch 2
11	Windmill Brake State Autorotation	Text 1, Ch 2
12	Forward Flight Performance (Glauret's Flow Model)	Text 1, Ch 2
13-14	Rotating Blade Motion Rotor Reference Axis Hub Plane Tip Path Plane	Text1, Ch4
15	No Feathering Plane Dynamics of Blade Flapping	Text1, Ch4
16	Flapping Lead-Lag Feathering Coning Angle	Text1, Ch4
17	**Propeller Ice Protection** Fluid and electrical de-icing equipment. **Propeller Maintenance** Static and dynamic balancing; Blade tracking; Assessment of blade damage, erosion, corrosion, impact damage, delamination; Propeller treatment/repair schemes; Propeller engine running. **Propeller Storage and Preservation** Propeller Preservation and Depreservation	
18	**END SEMESTER EXAMINATION**	

Note: Instructor may assign one mini project. It can have weightage up to 2-3 assignments. Software like Advanced Rotorcraft Technology (Flightlab / Flight Dynamics Models), NDARC (NASA Design and Analysis of Rotorcraft), RCOTOOLS - Rotorcraft Optimization Tools, RotorCraft Version 1.0, Helicopter Simulator Software (Helistart) may be explored for possible inclusion in assignments or mini-project.