INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	:	AIRCRAFT MODELING
Course Code	:	AAE802
Regulation	:	IARE - R16
Year	:	2019 – 2020
Semester	:	VI Semester
Branch	:	Aeronautical Engineering
Course Coordinator	:	Mr. M Vijay Kumar, Assistant Professor, AE

COURSE OBJECTIVES

S. No	Description
I.	Understand the basic ideas Conservation of the Angular Momentum Equations
II.	Learn the Modeling of the Longitudinal Steady-State Aerodynamic Forces and Moment.
III.	Understand the technology and basic components modelling.
IV.	Discuss the Modeling of Lateral Directional Aerodynamic Forces and Moments.

COURSE OUTCOMES (COs)

S. No	Description
I.	Demonstrate concept of stability and application to dynamic systems like Aircraft, and the role of primary controls and secondary controls in longitudinal stability
II.	Understand the concept of slide slip angle, roll angle and yaw angle their concepts related to lateral directional stability.
III.	Learn about the mathematical modeling of an aircraft in longitudinal, lateral and directional cases.
IV.	Estimate the longitudinal and directional parameters with the help of the linearized equations of aircraft motion.
V.	Analyze the different type of dynamic modes in longitudinal, lateral and directional motion of aircraft, and recovery from those modes.

COURSE LEARNING OUTCOMES (CLOs)

AAE802.01	Demonstrate the aircraft axis systems and reference frame for the development of the aircraft equations of motion.
AAE802.02	Discuss the importance of conservation of linear and angular momentum equations and angular momentum equations with rotor effects.
AAE802.03	Derive the kinematic equations involving variables like Euler angles to describe the complete aircraft problem.

AAE802.04	Derive the aircraft equations of motion which includes steady state and perturbed variables.
AAE802.05	Describe the modeling of longitudinal steady state aerodynamic forces and moments and the importance of their derivatives.
AAE802.06	Discuss about the aircraft stability axes used to derive the aerodynamic forces and moments.
AAE802.07	Describe the modeling of longitudinal perturbed aerodynamic forces and moments and the importance of their derivatives.
AAE802.08	Describe the modeling of lateral steady state aerodynamic forces and moments and the importance of their derivatives.
AAE802.09	Describe the modeling of directional steady state aerodynamic forces and moments and the importance of their derivatives.
AAE802.10	Demonstrate the contribution of wing, tail and fuselage components for the modeling of lateral-directional aerodynamic forces and moments of the aircraft.
AAE802.11	Describe the modeling of lateral perturbed aerodynamic forces and moments and the importance of their derivatives.
AAE802.12	Describe the modeling of directional perturbed aerodynamic forces and moments and the importance of their derivatives.
AAE802.13	Demonstrate the contribution of wing, tail and fuselage components for the modeling of perturbed lateral-directional aerodynamic forces and moments of the aircraft.
AAE802.14	Demonstrate different types of propulsion systems used in an aircraft like piston engine, turboprop, turbo jet, turbofan and ramjet engines.
AAE802.15	Determine the critical conditions of the aircraft like maximum aerodynamic efficiency, minimum aerodynamic drag and minimum power required.
AAE802.16	Describe the modeling of steady state and perturbed thrust forces and moments and the importance of their derivatives.

Tutorial Question Bank

UNIT - I			
AIRCRAFT EQUATIONS OF MOTION			
PART - A (SHORT ANSWER QUESTIONS)			
S No	**QUESTIONS**	**Blooms Taxonomy Level**	**Course Learning Outcomes**
1	What is steady-state flight	Remember	AAE802.01
2	Explain perturbed flight with neat sketches	Understand	AAE802.01
3	Define steady-state rectilinear fight	Remember	AAE802.01
4	Explain steady-state turning fight with an example	Understand	AAE802.02
5	Define steady-state symmetrical pull-up with neat sketch	Remember	AAE802.02
6	Explain large perturbation with an expression	Understand	AAE802.02
7	Define medium perturbation with an equation	Remember	AAE802.03
8	Define small perturbation with an expression	Understand	AAE802.03
9	Derive expression for small perturbation equations from a steady-state level flight	Remember	AAE802.03
10	Write short note on Flight Path Equations (FPEs).	Understand	AAE802.03
PART - B (LONG ANSWER QUESTIONS)			
1	Derive reference frames with three assumptions assumptions1: The aircraft is assumed to be a rigid body assumptions2: The aircraft is assumed to be a rigid body assumptions 3: The mass distribution is assumed to be time constant with time	Remember	AAE802.01
2	Derive equations of the linear momentum equation(CLMEs)	Understand	AAE802.01
3	Derive conservation of the angular momentum equations (CAMEs)	Remember	AAE802.01
4	Conservation of the angular momentum equations (CAMEs) with rotor effects	Understand	AAE802.02
5	Write about Euler Angles with the use of the Euler angles for expressing the orientation of the body frame X, Y, Z with respect to the Earth based inertial frame X', Y', Z' is critical for navigational purposes	Remember	AAE802.02
6	Obtain an expression for Flight Path Equations (FPEs) with the use of The use of the Euler angles?	Understand	AAE802.02
7	Explain The Euler angles which allow expressing the angular velocity along the body frame X, Y, Z in terms of rates of changes of the Euler angles of kinematic equations (KEs)	Remember	AAE802.02
8	Derive gravity equations (GEs) for different condition with few examples?	Remember	AAE802.03
9	Derive the summary of the aircraft equations of motion? Based on the previous discussion, the complete set of equations describing the dynamics of the aircraft is given by the following: CLMEs and CAMEs	Understand	AAE802.03
10	Derive an expression for Aircraft' equations of motion at steady-state conditions	Remember	AAE802.03
UNIT - II			
MODELING OF LONGITUDINAL AERODYNAMIC FORCES AND MOMENTS			
PART - A (SHORT ANSWER QUESTIONS)			
1	Discuss different aircraft stability axes?	Remember	AAE802.04
2	What is wetted area?	Remember	AAE802.04

3	Write short note on Prandtl relationship?	Remember	AAE802.04
4	Write the general expressions for the lift stability and control derivatives.	Understand	AAE802.05
5	What is Longitudinal static margin?	Remember	AAE802.05
6	Write typical ranges of values for the absolute value of *SM*.	Remember	AAE802.05
7	Discuss the typical ranges for the value of x_{Ac}?	Understand	AAE802.06
8	What is u – derivatives?	Remember	AAE802.06
9	What is final relationship for C_{Lq}?	Remember	AAE802.06
10	What is final relationship for C_{Mq}?	Remember	AAE802.07
PART - B (LONG ANSWER QUESTIONS)			
1	Describe about polar curve for the entire aircraft. Write about different parameters affecting the curve.	Remember	AAE802.04
2	Explain about wing span vs fuselage diameter graph and the parameters that influence the graph.	Understand	AAE802.04
3	Write about different longitudinal forces and different aerodynamic angles.	Remember	AAE802.04
4	Write about different geometric parameters necessary for modeling the different contributions to the pitching moment from the aircraft components.	Remember	AAE802.05
5	Explain in detail about aircraft aerodynamic center and how it is calculate.	Understand	AAE802.05
6	Identify which aircraft geometric parameters affect the values OF THE longitudinal stability derivatives $c_{l\alpha}$, $c_{m\alpha}$ Next, Explain the effect of an increase of each of the geometric parameters on each of the above stability derivatives.	Remember	AAE802.06
7	The modeling of the aerodynamic longitudinal forces and moments has been introduced for a conventional subsonic aircraft with a wing and a horizontal tail. Provide closed-form relationships for $C_{l\alpha}$, $C_{m\alpha}$ if the aircraft features a pair of canards with a fixed surface, along with a portion of the surface that can be deflected by the pilot.	Remember	AAE802.06
8	Consider an aircraft with a horizontal featuring both stabilators and elevators. Identify which aircraft geometric parameters affect the values of the longitudinal stability derivatives $c_{l\delta e}$, $c_{m\delta e}$, c_{lih}, c_{mih}. NEXT, explain the effect of an increase of each of the geometric parameters on each of the preceding stability derivatives.	Remember	AAE802.06
9	The modeling of the aerodynamic longitudinal forces and moments has been introduced for a conventional subsonic aircraft with a wing and a horizontal tail. Assume that the aircraft features a pair of canards with a fixed surface, along with a portion of the surface that can be deflected by the pilot by an angle δc (positive for down deflections). Provide Closed-form relationships for $c_{l\delta e}$, $c_{m\delta e}$.	Remember	AAE802.07
10	Identify which aircraft geometric parameters affect the values of the longitudinal stability derivatives $c_{l\alpha}$, $C_{m\alpha}$, c_{lq}, C_{mq}.Next, explain the effect of an increase of each of the geometric parameters on each of the preceding stability derivatives.	Remember	AAE802.07
11	Write about the modeling of the longitudinal small perturbation aerodynamicforces and moments with help of a sketch.	Understand	AAE802.07
UNIT - III			
MODELING OF LATERAL DIRECTIONAL AERODYNAMIC FORCES AND MOMENTS			
PART - A (SHORT ANSWER QUESTIONS)			
1	Explain in detail the lateral aerodynamic forces and moments that are acting on an airplane with a neat sketch.	Understand	AAE802.08
2	Explain about the sideslip and side slip angle and its effects.	Understand	AAE802.08
3	Explain in detail about dihedral effect.	Understand	AAE802.08
4	What is wing twist angle?	Understand	AAE802.08

5	Explain about the control surfaces that are involved to control the lateral and directional motion of an airplane.	Remember	AAE802.09
6	Explain the effect of downwash on an airplane.	Understand	AAE802.09
7	What is the effect of leading edge flap on aerodynamic performance of an aircraft?	Remember	AAE802.09
8	Explain about the Dutch roll mode of an airplane.	Understand	AAE802.10
9	Define phugoid mode in aircraft dynamic mode.	Understand	AAE802.10
10	What is the effect of trailing edge flap on aerodynamic performance of an aircraft?	Understand	AAE802.10
PART - B (LONG ANSWER QUESTIONS)			
1	Discuss in detail the geometric parameters for wing fuselage integration.	Understand	AAE802.08
2	Explain the matrix approach to general lateral directional trim problem.	Understand	AAE802.08
3	Explain Aircraft Dynamic Mode shapes and their significance.	Remember	AAE802.08
4	Explain the modeling approach of any two rolling aerodynamic coefficients.	Understand	AAE802.08
5	Explain in detail about the rudder pedal control force.	Remember	AAE802.09
6	Discuss the modeling approach of any two yawing aerodynamic coefficients.	Understand	AAE802.09
7	Explain the wing and body contribution for modeling of rolling aerodynamic coefficients.	Understand	AAE802.09
8	Explain the horizontal tail contribution for modeling of rolling aerodynamic coefficients.	Understand	AAE802.10
9	Write in detail about the vertical tail contribution for modeling of rolling aerodynamic coefficients.	Understand	AAE802.10
10	Explain the vertical tail contribution for modeling of yawing aerodynamic coefficients.	Understand	AAE802.10
UNIT - IV			
MODELING OF THE SMALL PERTURBATION LATERAL DIRECTIONAL AERODYNAMIC FORCE AND MOMENTS			
PART - A (SHORT ANSWER QUESTIONS)			
1	What is a stability derivative?	Remember	AAE802.11
2	Define stability derivatives with the representation of aerodynamic forces and moment	Remember	AAE802.11
3	Define the term longitudinal dynamic stability of the airplane.	Understand	AAE802.11
4	Derive the equation of aircraft force equations	Understand	AAE802.12
5	Derive the equation of aircraft moment equations	Understand	AAE802.12
6	Write a short notes on stability derivatives in longitudinal dynamics	Understand	AAE802.12
7	Define Euler angle rates and body axis rates	Remember	AAE802.12
8	Explain the difference between aerodynamic coefficients and aerodynamic derivatives	Remember	AAE802.13
9	Derive the longitudinal linearized equations of motion with small perturbation approach	Understand	AAE802.13
10	Explain lateral –directional applied forces and moments	Understand	AAE802.13

PART - B (LONG ANSWER QUESTIONS)			
1	Explain the four step approach summarizes the linearization technique	Understand	AAE802.11
2	Explain about the representation of aerodynamic forces and moments	Remember	AAE802.11
3	Summarize the small perturbation approach and develop the linearized aircraft equations of motion	Understand	AAE802.11
4	Explain the conceptual modeling and mathematical modeling of $c_{l\beta}$	Remember	AAE802.12
5	Explain the conceptual modeling and mathematical modeling of $c_{n\beta}$	Remember	AAE802.12
6	Explain the conceptual modeling and mathematical modeling of $c_{Y\beta}$	Understand	AAE802.12
7	Explain Modeling of the Longitudinal Small Perturbation Aerodynamic Forces and Moments	Remember	AAE802.12
8	Explain Modeling of the Longitudinal Small Perturbation Aerodynamic Moments	Understand	AAE802.13
9	Modeling of the Longitudinal Steady-State Aerodynamic Forces	Understand	AAE802.13
10	Modeling of the Longitudinal Steady-State Aerodynamic moments	Understand	AAE802.13
UNIT - V			
Review of Basic Aircraft Performance and Modeling of Thrust Forces and Moments			
PART - A (SHORT ANSWER QUESTIONS)			
1	Name different types of engines used in aircrafts.	Remember	AAE802.14
2	Write down the expression for sustaining level flight	Remember	AAE802.14
3	What is the minimum power required for sustaining level flight?	Understand	AAE802.14
4	What are the different forces acting on an aircraft?	Understand	AAE802.14
5	Write the uses of afterburner in aircraft engine.	Understand	AAE802.15
6	Write the conditions for minimum aerodynamic drag.	Understand	AAE802.15
7	Name the function variables in installed thrust.	Remember	AAE802.15
8	What are the generalized expressions for thrust lateral directional force and moments?	Remember	AAE802.16
9	What are the requirements of propulsion system?	Understand	AAE802.16
10	Draw the graph between aircraft drag and airspeed.	Understand	AAE802.16
PART - B (LONG ANSWER QUESTIONS)			
1	Explain working principle of turbojet aircraft engine with neat sketch.	Understand	AAE802.14
2	Derive expressions for maximum aerodynamic efficiency.	Remember	AAE802.14
3	Explain the modeling of steady state longitudinal thrust force and moments.	Understand	AAE802.14
4	What are the parts in piston propeller aircraft engine and explain the function of engine with simplified diagram.	Remember	AAE802.14
5	Derive minimum power required for sustaining level flight.	Remember	AAE802.15
6	Explain the modeling of the small perturbation thrust forces and moments.	Understand	AAE802.15
7	Explain briefly ramjet aircraft engine with neat sketch.	Remember	AAE802.15
8	Derive minimum aerodynamic drag by using conservation of linear momentum equations.	Understand	AAE802.16

9	Differentiate turboprop and turbo fan aircraft engines.	Understand	AAE802.16
10	Determine power available by the propulsion system at the given flight condition.	Understand	AAE802.16

Prepared by: **HOD, AE**

M Vijay Kumar