Code No: 07A52101 **R07** **Set No. 2**

III B.Tech I Semester Examinations,November 2010
FLIGHT MECHANICS-I
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Explain the different flight regimes based on the Mach number with neat sketches
   (b) What are sensors? Classify them with neat sketches. [8+8]

2. (a) Define
      i. aerodynamic centre,
      ii. centre of pressure for an airfoil.
   (b) For a typical airfoil in low speed flow, plot the variation of each of the above with angle of attack.
   (c) State when the above two coincide with each other. [4+8+4]

3. What is meant by the term Critical Mach number as applied to air foils? Explain with neat sketches. How can its value be increased for a swept back wing when compared to a straight wing? [16]

4. (a) If Ψ, θ, Φ are the Euler angles, explain with neat sketches, the rotation through Ψ, rotation through θ, and rotation through Φ.
   (b) Using the above three rotations derive the transformation vector from earth axis system to body axis system. [8+8]

5. (a) Write down the equations of motion for an airplane in a constant speed, constant 'g' symmetric push over (acceleration towards the bottom of the aircraft) maneuver in terms of the design parameters of the airplane and the instantaneous flight path angle.
   (b) Derive an expression - as a function of the variation with the angle of flight path angle - for
      i. The instantaneous radius of the loop,
      ii. The rate of change of flight path angle,
      iii. Lift coefficient and for
      iv. The thrust required to execute such maneuver. [8+8]

6. Compare the rocket with the jet engine and explain in detail. Explain the types of rockets on the basis of fuel used with neat sketches and plots. [16]

7. For a turbojet propelled high subsonic airplane, it is desired that the steepest angle of climb at sea level be increased by 10%. Assuming that this should be achieved solely through changes in the aerodynamic design of the wing,

(a) Propose the required changes and their extent (in percentage) in any two aerodynamic characteristics of the airplane by which the above objective may be most effectively achieved

(b) Discuss how the proposed measures can meet the desired objective and also how they may adversely affect the performance of the airplane in other respects.

(c) Discuss how the proposed measures can meet the desired objective and also how they may adversely affect the performance of the airplane in other respects. [8+4+4]

8. (a) Describe for each of the following types of drag , viz. Skin friction drag, Leakage drag of an airplane

   i. the physics of their generation,
   ii. how they may be estimated
   iii. measures to be taken for their reduction and
   iv. what the favorable and also adverse effects of the measures at iii) above on the performance of the aircraft will be

   (b) The power required to generate static thrust of T by a propeller is 700 kW. Using momentum theory, determine the power required to generate the same static thrust if the diameter of the propeller is increased by 30%. [8+8[

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Code No: 07A52101 **R07** **Set No. 4**

III B.Tech I Semester Examinations,November 2010
FLIGHT MECHANICS-I
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) Name and describe how two principal aerodynamic characteristics each, of an airfoil that most significantly affected by the following geometric parameters .
   i. Reynolds number
   ii. Mach number
   iii. Surface roughness

   (b) Name two geometric parameters of a wing (other than those of the wing section) that most significantly affect its 'stalling characteristics' and describe how. [12+4]

2. (a) Derive an expression for maximum range achievable by a turbojet propelled subsonic airplane. Assume constant parabolic drag polar and assume specific fuel consumption to be inversely proportional to density ratio at altitude but invariant with Mach no.

   (b) Discuss the variation of maximum range of the airplane with wing loading and T/W ratio (take- off value at sea level) and altitude of flight. [12+4]

3. (a) Derive the equations of motion for an airplane in a constant speed, constant radius symmetric pull up (vertical loop) maneuver in terms of the design parameters of the airplane and the instantaneous flight path angle.

   (b) Derive an expression - as a function of the angle of flight path angle - for
   i. The rate of change of flight path angle,
   ii. Normal load factor
   iii. Lift coefficient and for
   iv. The thrust required to execute such maneuver. [8+8]

4. (a) What are sonic booms? Explain with neat sketches.

   (b) What are the flow conditions before and after an oblique shock wave? Draw neat sketches. [8+8]

5. Derive the rolling moment & Pitching moment of a rigid body in terms of angular acceleration, gyro precession, and coupling terms. [16]

6. (a) Explain and derive expression for energy height and specific excess power

(b) Consider an a/c flying with instantaneous acceleration of 3 m/s^2 at an instantaneous velocity of 300 m/s, excess power is 100 m/s. Calculate the instantaneous minimum rate of climb that can be obtained at the accelerated flight conditions.

[8+8]

7. (a) Describe in brief, the principal features of the following propulsion systems and their application; also discuss in brief, the relative merits and demerits.

   i. Propeller, piston engine propulsion
   ii. Turboprop propulsion

   (b) The skin friction drag on a flat plate of length 1 m at zero angle of attack is 1000 N. Assuming turbulent flow, determine the drag on a flat plate of length 2 m. [8+8]

8. (a) Explain any two types of controls employed for missiles with neat figures.

   (b) Describe the long range ballistic trajectory of missiles. What are the performance parameters to be estimated? Explain the procedure in brief for the following

   i. Powered flight & equation of motion
   ii. Unpowered flight [8+8]

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Code No: 07A52101 **R07** **Set No. 1**

III B.Tech I Semester Examinations,November 2010
FLIGHT MECHANICS-I
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. How many degrees of freedom does an aircraft have? How many are translational and how many are rotational? Derive the equations of motion. [16]

2. (a) Name anddescribehow two devices each that may significantly improve the following - aerodynamic characteristics of a wing, .
   i. Increasing maximum lift coefficient
   ii. Increasing stalling angle of attack
   iii. Decreasing minimum drag coefficient

   (b) Name two geometric parameters of a wing (other than those of the wing section) that most significantly affect its 'pitching moment coefficient at zero lift' and describe how. [12+4]

3. Describe for Pressure drag of an airplane
   (a) The physics of its generation,
   (b) How it may be estimated
   (c) Measures to be taken for its reduction and
   (d) What the favorable and also adverse effects if any of the measures at 'c' above on the performance of the aircraft will be. [4×4]

4. (a) Classify the different flight regimes in terms of Mach number.
   (b) Explain about sonic booms and control problems due to sonic booms. [8+8]

5. (a) Assuming that the thrust is much larger than the drag and ground friction on the aircraft during take off, estimate the percentage of the total increase (or decrease) of the distance of ground roll for take off on account of 1% increase in the
   i. Wing area,
   ii. Take off thrust of the aircraft.

   (b) Describe how the 'Balanced (take off) field length' for an aircraft may be determined. [8+8]

6. (a) What is a trajectory?
   (b) Describe the long range cruise trajectory of missiles. What are the performance parameters to be estimated? Explain the procedure in brief for the rate of climb & maximum range [4+12]

7. For a turbojet propelled high subsonic airplane, it is desired that the minimum time to climb to a given altitude from sea level be decreased by 10%. Assuming that this should be achieved solely through changes in the aerodynamic design of the wing,

   (a) Propose the required changes and their extent (in percentage) in any two aerodynamic characteristics of the airplane by which the above objective may be most effectively achieved

   (b) Thereby, identify the required changes in the corresponding geometrical parameters of the wing / aerofoil.

   (c) Discuss how the proposed measures can meet the desired objective and also how they may adversely affect the performance of the airplane in other respects. [8+4+4]

8. (a) Explain the Power vs speed contours (power required and power available) for an airplane.

   (b) Draw and explain Rate of climb and Rate of sink curves as functions of speed. [8+8]

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Code No: 07A52101 **R07** **Set No. 3**

III B.Tech I Semester Examinations,November 2010
FLIGHT MECHANICS-I
Aeronautical Engineering

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. (a) For an airplane of gross weight = 10 tonnes, gross wing area = 33 m^2 , drag polar ($C_D = 0.01 + 0.05\ C_L^2$), in a symmetric pull up (vertical loop) maneuver at constant speed = 100 m/s and constant radius = 1,000 m, determine
   i. The normal load factor,
   ii. The thrust required to execute such maneuver, when the flight path angle = 30 degrees to the horizon

   (b) For an airplane in steady, coordinated turn, derive an equation for the radius of turn in terms of the normal load factor and speed of flight. [12+4]

2. (a) Discuss the effect of Reynolds number on the drag of
   i. A circular cylinder
   ii. A sphere.

   (b) Discuss the effect of Reynolds number on the drag of a flat plate
   i. Held normal to the free stream
   ii. Held parallel to the free stream. [8+8]

3. (a) Describe the significance of the following aerodynamic characteristics (parameters) in the context of the performance of an airplane.
   i. Maximum lift coefficient
   ii. Stalling angle of attack
   iii. Severity (steepness) of stall

   (b) Name two aspects of airplane performance that are most significantly affected by the parasite drag of the wing and describe how. [12+4]

4. Explain the terms
   (a) Area rule
   (b) Supercritical airfoil
   (c) Prandtl-Glauert singularity
   (d) Buffeting [4 × 4]

5. (a) A turbojet power airplane is required to fly between two ground stations from south to north. Describe the effect of
   i. Head wind,

ii. Tail wind on the time of flight and on the fuel consumed to reach the destination, if the pilot chooses to fly at an airspeed of V.

iii. Consider the special case of headwind w = V and comment.

(b) Assuming the initial weight of the turbojet powered airplane = W_i , gross wing area = S parabolic drag polar ($C_D = C_{D0}+kC_L2$) and constant specific fuel consumption = c, density of air = ρ, determine the optimal speed V^* and optimal heading ϕ^* pilot should choose to fly the airplane for minimum consumption of fuel in a crosswind (east to west) of speed w. [8+8]

6. (a) What is a rocket? What are the different types of rockets with examples?

   (b) Explain in detail about the wing control and jet control employed for a missile. [8+8]

7. Derive the angular acceleration terms, gyro precession terms, and coupling terms acting on a rigid body. [16]

8. Derive the expression for the Velocity of airplane for best rate of climb in terms of wing loading and Thrust to weight ratio. [16]

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