Code No: R05312102 **Set No. 1**

III B.Tech I Semester Regular Examinations, November 2008
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) Describe the airfoil section geometry represented by NACA 4412. Plot the lift curve and explain laminar flow and separation of flow over this section. Make use of sketches and plots.
   (b) Describe the formation of starting vortex over an airfoil placed in an air stream at some angle of attack . [8+8]

2. (a) Define the term 'Total Drag' on an airplane. What are its different components? Hence define the Normal pressure drag and surface friction drag on an airplane wing with an example for each.
   (b) Compare the normal pressure drag and the skin friction drag on a flat plate aligned with the free stream and that on a circular cylinder. Describe your finding with sketches and plots. [8+8]

3. An airplane weighing 245,000 N has a wing area of 80 m^2. It has drag polar given by $C_D = 0.016 + 0.04\, C_L^2$. Calculate the minimum thrust required for straight and level flight and the corresponding TAS at sea level and at 10,000 m altitude ($\sigma = 0.3367$). Calculate also the minimum power required and the corresponding TAS at the above altitudes. [8+8]

4. (a) Are the terms:
      i. take-off run and
      ii. take-off distance, same?

   Explain with sketches and plots. Discuss the development of the forces in the process of take-off.
   (b) What are the ways and means to reduce take-off distances of propeller powered airplanes. Elaborate with some details of devices and applications. [8+8]

5. (a) Describe the category of missiles known as Cruise missiles. Comment on its utility in war and peace. What is the general lay out of such missile and launching system?
   (b) Describe the aerodynamics of a tail-less control missile. Explain its control effectiveness. [8+8]

6. Consider the flight of an airplane over a flat Earth in a vertical plane. Develop the five differential equations which describe the motion of airplane in a vertical plane. What are these motions known as? [16]

7. Describe the word TRANSONIC. Hence explain transonic flow over a cambered airfoil placed at zero angle of attack. Could you plot C_L and C_D curves for their variation with Mach number up to unity. Hence define the drag divergence Mach number. Can this M_d be delayed. If so, describe with sketches and plots. [16]

8. A rigid body having a reference frame $Oxyz$ moves with respect to a fixed reference frame $\Omega\xi\eta\zeta$. Prove that the most general velocity field within a rigid body at a point P is given by the expression $V = V_o + \omega \times OP$ and that the distribution of accelerations within the rigid body given by $a = a_o + \omega \times (\omega \times OP) + \dot{\omega} \times OP$. [16]

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Code No: R05312102 **Set No. 2**

III B.Tech I Semester Regular Examinations, November 2008
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. Show on a single plot the variation of C_l - α for
   (a) an airfoil in inviscid flow,
   (b) an airfoil in airstream, and
   (c) a wing in airstream.

   Explain the difference if any with all theoretical considerations. Express the results in the form of an equation. [16]

2. Define the term 'drag polar'. A wind tunnel test was conducted to obtain the following data from a wing of AR=6:

C_L	0	0.2	0.4	0.6	0.8	1.0	1.2
C_D	0.0096	0.011	0.020	0.029	0.047	0.066	0.095

   Plot the Drag polar and hence Determine the value of C_{De} and span efficiency factor. Also plot the C_L, C_D curve. Explain the plot. [2+10+4]

3. An airplane has a wing loading of 2500 N/m^2, and its drag polar is $C_D = 0.016 + 0.055C_L^2$. Obtain its (L/D) ratio, the minimum drag speed and (L/D) at a speed of 100 m/s. Prove the relation used. [8+8]

4. Write a detailed note on takeoff performance of an airplane, defining various terms involved, and bring out differences in take off and landing operations. Discuss various methods employed to shorten the landing ground run. [16]

5. (a) Define a rocket and a missile. What are the uses of each of the two? Explain their geometry and different parts with neatly drawn sketches.
   (b) Classify rockets in as many ways as you may like. Describe each category with sketches and for its uses. [8+8]

6. Show with a detailed figure a system of rotations from the body to the wind axes with reference to the flight of an airplane over a flat Earth. Work out a matrix for the angular relationship between
   (a) wind axis to Body axis.
   (b) Ground to local horizon axes. [8+8]

7. (a) Describe the 'compressibility' of air with a common example and hence define the compressibility of a fluid. What is its significance in aerodynamics?

(b) In aerodynamics of compressible flows a supersonic nozzle acts as a subsonic diffuser. Verify the statement with aerodynamic considerations. [8+8]

8. A rocket with its reference frame $Oxyz$ moves with respect to a fixed reference frame $\Omega\xi\eta\varsigma$. Prove from the theorem of composition of accelerations that at a general point P , the acceleration is given by

   $a = a_o + \dot{\omega} \times OP + \omega \times (\omega \times OP) + 2\omega \times v_r + a_r$

   where ω is the absolute angular velocity of the rocket axes system, a_o is the absolute acceleration of its origin and subscript r is for rocket. [16]

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Code No: R05312102 **Set No. 3**

III B.Tech I Semester Regular Examinations, November 2008
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. Define the terms:
   (a) Critical Mach number,
   (b) Drag divergence Mach number.
   (c) Explain with neat sketches and plots the relative occurrence of these Mach numbers for a wedge of 5^0 and a circular cylinder of the dia. of the same size. Put these on a plot for clarifying your answer. [3+3+5+5]

2. Demonstrate from the finite wing theory that the induced drag varies along the span of the wing as is the variation of the downwash angle along the span. [16]

3. Consider an airplane powered by a piston -prop combination. Explain that such type of power plants provide better and stable rates of climb at low altitudes and low speeds. Hence describe the procedure for determining maximum speed and service ceiling of such airplane. [8+8]

4. (a) Define the terms:
      i. take-off ground run and
      ii. take-off distance.

      Explain with sketches/ diagrams. Explain the variation of all the forces in the process of take-off with a single plot for an airplane.
   (b) What are the means adopted for accelerating the take-off of airplanes. Explain such methods with the problem treated as an engineering one. [8+8]

5. Consider an accelerating rocket with its axis inclined at some angle θ to the vertical. Work out the instantaneous change of the vehicle velocity in flight given by $\Delta u = u_{eq} \ln \frac{M_0}{M}$, where $u_{eq} = u_e + \left[\frac{p_e - p_a}{\dot{m}}\right] A_e$, M is the instantaneous mass and M_0 is the initial mass of the rocket. u_e is the steady exit velocity and $\dot{m}$ is the propellant flow rate. Other notations are consistent with terminology in use and self explanatory. [16]

6. Taking the Earth to be flat and non rotating for simple analysis of flight trajectories of airplanes, show that the general dynamical equations reduce to the form: $T + A + mg = ma = m\frac{dv}{dt}$,

   Where T, A, m, g and a are thrust, aerodynamic force, mass, acceleration due to gravity and the acceleration of the airplane with respect to the Earth. [16]

7. (a) Consider an airfoil of the type of NACA 6 series. Place it in an air stream which has increasing velocity and its effect on the resulting flow field is being monitored. You are required to show with sketches such effects with increasing velocity.

   Make your conclusions. Keep the incidence of the airfoil zero throughout.

   (b) Repeat the above process with the incidence now changed to say 5^0. What do you notice? Comment on the situation thus arising. [8+8]

8. A rocket with its reference frame $Oxyz$ moves with respect to a fixed reference frame $\Omega\xi\eta\varsigma$. Show from the theorem of composition of accelerations that at a general point P, the relationship which describes its translational motion is given by

   $$F = ma_o + \dot{\omega} \times \int_m OPdm + \omega \times (\omega \times \int_m OPdm) + 2\omega \times \int_m v_r dm + \int_m a_r dm$$

   where ω is the absolute angular velocity of the rocket axes system, a_o is the absolute acceleration of its origin and subscript r is for rocket. [16]

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Code No: R05312102

Set No. 4

III B.Tech I Semester Regular Examinations, November 2008
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) Consider an airfoil described by NACA 4421. Plot representative C_L and C_D curves for this section and comment over its use for higher ranges of velocity.
   (b) Consider a cambered airfoil with a deflected flap at non zero δ. Now describe its aerodynamic behavior as compared with the case when flaps are nested. [8+8]

2. Consider total drag of
   (a) a flat plate at zero angle of attack,
   (b) a symmetrical airfoil at zero angle of attack , and
   (c) a stationary circular cylinder.

   Provide the breakdown of drag for these three cases. Hence make a comparison of pressure drag and skin friction drag for these three on single plot each. [6+5+5]

3. (a) Show that for minimum power condition of flight of airplane in straight and level flight $C_{Di} = 3C_{D0}$. Hence obtain the values of C_{Lmp} and V_{mp} in terms of C_{Lmd} and V_{md} respectively.
   (b) Show from the straight and level flight condition that $\frac{D}{D_{\min}} = \frac{1}{2}[m^2 + m^{-2}]$, where airplane is flying at some multiple m of the minimum drag speed. [8+8]

4. An airplane accelerates from rest to a velocity $V_{T.o}$. Show with a diagram all the forces acting in the process till the airplane leaves the ground. Hence develop an expression for the take-off run and the time to cover the above take off run. [16]

5. Describe a Boost-Glide trajectory of a missile in detail. Explain the graphical procedure involved in making calculations for this trajectory. Which types of missiles utilize this kind of trajectories? Make use of sketches and plots. [16]

6. Consider a system of rotations from the body to the wind axes with reference to the flight of an airplane over a flat Earth. Work out a matrix for the angular relationship between
   (a) wind axis to Body axis.
   (b) Wind axis to local horizon axis [8+8]

7. Derive from the fundamentals, Bernoulli's equation for a compressible fluid flow. Hence obtain the relationship $\frac{a^2}{\gamma-1} + \frac{v^2}{2} = const.$ Comment on the result. [16]

8. A rocket with its reference frame $Oxyz$ moves with respect to a fixed reference frame $\Omega\xi\eta\varsigma$. Prove from the theorem of composition of accelerations that at a general point P within the rocket, the relationship which describes its translational motion is given by

$$F = ma_o + \dot{\omega} \times \int_m OPdm + \omega \times (\omega \times \int_m OPdm) + 2\omega \times \int_m v_r dm + \int_m a_r dm$$

where ω is the absolute angular velocity of the rocket axes system , a_o is the absolute acceleration of its origin and sub. r is for rocket. [16]

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