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

**III B.Tech I Semester Regular Examinations, November 2007**
**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 2424. Plot $C_l$ and $C_d$ curves for this section and comment over its use for higher ranges of velocity.
   (b) Consider symmetrical airfoil with a deflected flap. Now describe its aerodynamic behavior as compared with the case when flaps are nested. [8+8]

2. Explain the generation of down wash from the wing vortex system and hence the 'Trailing vortex induced drag'. Hence demonstrate from theory that Induced drag $D_i$ =L $\alpha_i$ , where $\alpha_i$ is the induced angle of attack at the wing. [16]

3. An airplane weighing 235,000 N has a wing area of 80 $m^2$. It has $C_{1max}$ of 2.2 with flaps lowered. Plot a $C_L$ versus EAS curve for this airplane for the usable speed range at sea level. If the maximum $C_L$ of the airplane is 1.5 with flaps nested, below what true airspeed must flaps be lowered at sea level and at 6100 m, where $\sigma$= 0.5333. Explain the theory. [16]

4. (a) Explain 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 a piston-prop airplane.
   (b) What are the means adopted for accelerating the take-off of the propeller powered airplanes. Treat it as an engineering problem. [8+8]

5. Consider an accelerating rocket with its axis inclined at some angle $\theta$ to the vertical. Work out the instantaneous change of the vehicle velocity in flight given by

   $\Delta u = -u_{eq} \ln \frac{M}{M_0}$, 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. Assuming 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. 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) Define a 'Rigid body'. How does the rigid body dynamics differ from that of an isolated particle? Explain with an example each.

   (b) Obtain an expression for the angular motion of one reference frame with respect to another. [8+8]

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

**III B.Tech I Semester Regular Examinations, November 2007**
**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 2421. 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 vortex system over a symmetrical airfoil placed in an air stream at low angle of attack . [8+8]

2. Define the term drag polar. A wind tunnel test was conducted to obtain the following data from a wing of AR=8;

| $C_L$ | 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 weighing 240,000 N has a wing area of 80 $m^2$. It has $C_{lmax}$ of 2.2 with flaps lowered. Plot a $C_L$ versus EAS curve for this airplane for the usable speed range at sea level. If the maximum $C_L$ of the airplane is 1.5 with flaps nested, below what true airspeed must flaps be lowered at sea level and at 6100 m , where $\sigma = 0.5333$. Explain the theory. [16]

4. Discuss in detail various high-lift devices employed in landing operation of an aircraft. Also mention various methods employed to reduce the landing distance. Brind out major differences between landing and take-off operations. [16]

5. Describe a Boost-Glide trajectory of a missile in detail. Explain the iterative 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 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. Define sub critical Mach number, critical Mach number and super critical Mach number. Explain these on a plot and diagram/sketch with an airfoil at zero angle of attack. What will happen if the thickness ratio of the airfoil was increased. Spell out the aerodynamics involved. [16]

8. (a) Define a 'Rigid body'. How does the rigid body dynamics differ from that of an isolated particle? Explain with an example each.

   (b) Obtain an expression for the angular motion of one reference frame with respect to another. [8+8]

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Code No: R05312102

**Set No. 3**

**III B.Tech I Semester Regular Examinations, November 2007**
**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. Describe the requirement of deploying flaps on a lifting wing at the time of take off and landing of an airplane. What are the guiding principles of aerodynamics. Hence explain the design principles and operation of a single slotted flap. Make use of sketches and plots. [16]

2. Explain the generation of down wash from the wing vortex system and hence the 'Trailing vortex induced drag'. Hence demonstrate from theory that Induced drag $D_i$ =L $\alpha_i$ , where $\alpha_i$ is the induced angle of attack at the wing. [16]

3. (a) Show from the thrust required curve that the zero lift thrust and the lift dependent thrust must be equal for minimum thrust condition on the thrust versus velocity curve. Hence obtain the expression for the lift coefficient under such condition.
   (b) Explain the significance of EAS in level flight. Support it with a clear example. [8+8]

4. An airplane weighs 250,000 N and has a wing area of 100 $m^2$. With flaps in the take-off condition the $C_L = 2.2$. The airplane takes off at 1.2 $V_s$. The drag polar in T.O. configuration is given by $C_D = 0.024 + 0.04\ C_L^2$ . The value of $\mu$ be taken as 0.025. The two engines each produce a total of 1.8 MW shaft power. The propeller efficiency at T.O. is 75%, while the static thrust of each engine and airscrew is 29,000 N. Calculate the minimum ground run in standard sea level conditions. [16]

5. (a) Provide main differences between a rocket and a missile. What are the main components of a missile? Elaborate with sketches , different components and their functions.
   (b) Give a brief description of the components of a chemical rocket? Hence describe various types of such rockets with the purpose involved. [8+8]

6. Assuming 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) Obtain the stagnation conditions for pressure, density and temperature ratios along a stream line in adiabatic flow. The velocity may be put in terms of Mach number.

(b) Work out the practical limit of incompressible flow beyond which the compressibility effects are accounted for. [10+6]

8. A rigid body having a reference frame $Oxyz$ moves with respect to a fixed reference frame $\Omega\xi\eta\zeta$. Show that the distribution of velocities at a point P within the rigid body is given by the expression $V = V_o + \omega \times OP$ Hence obtain 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. 4**

**III B.Tech I Semester Regular Examinations, November 2007**
**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) Crest critical Mach number
   (c) Drag divergence Mach number.

   Explain with neat sketches and plots the relative occurrence of these Mach numbers for a wedge of $5^0$ and an airfoil of 10% thickness. Put these on a plot for clarifying your answer. [16]

2. Obtain the induced angle of attack $\alpha_i$ from the vortex system of a lifting wing. Show that when multiplied by the lift vector it results in the generation of 'Induced Drag' $D_i$ = L $\alpha_i$. Hence explain the whole phenomenon. [16]

3. (a) Develop the equations of motion of an airplane normal to and parallel to the flight path and put these in the most used form by explaining the adopted process. Hence show that the thrust required varies as the inverse of the airplane efficiency.
   (b) Plot the thrust required curve vs. airplane velocity. Explain the significance of the curve in aerodynamic performance of an 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 a turbo-prop airplane.
   (b) What are the means adopted for accelerating the take-off of turbo-prop airplanes. Explain such methods with the problem treated as an engineering one. [8+8]

5. Discuss in detail various aerodynamic control methods designed for missile operations, with the help of neat sketches. Mention limitations of their applications, if any. [16]

6. With 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 given below

$T + A + mg = ma = m\frac{dv}{dt}$,

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. 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 $\Omega\xi\eta\zeta$. Obtain the distribution of velocities at a point P within the rigid body and show that it is given by the expression $V = V_o + \omega \times OP$ Also show that the distribution of accelerations is given by $a = a_o + \omega \times (\omega \times OP) + \dot{\omega} \times OP$. [16]

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