Assignment 1

Flight Mechanics (AE321A)

August 2019

Total Marks : 100

Question 1. An aircraft takes off from a runway located at an altitude of 1.5 km with a velocity of 50 m/s. If the same aircraft has to take off from a runway located at an altitude of 2.5 km by maintaining the same total pressure, what would be the percentage change in velocity? **(10)**

Question 2. Show that maximum endurance of a glider is given by

$$t_{max} = \frac{3E_m}{2\sqrt[4]{3}V_R}(h_i - h_f)$$

where, E_m is maximum aerodynamic efficiency and V_R is the reference velocity corresponding to E_m. **(10)**

Question 3. The drag polar of a turbojet airplane is given by

$$C_D = C_{D_0} + \frac{C_L^2}{\pi eAR}$$

Assume that thrust is independent of flight speed, show that the dynamic pressure when the rate of climb is maximum is given by

$$q = \frac{T}{6SC_{D_0}} + \sqrt{\left(\frac{T}{6SC_{D_0}}\right)^2 - \frac{W^2}{3\pi eARS^2C_{D_0}}}$$

where, AR is the aspect ratio. **(10)**

Question 4. For a particular airfoil section, the pitching-moment coefficient about 0.33 chord behind the leading-edge varies with C_l as shown in Table 1. Determine the location of aerodynamic

Table 1: C_l vs C_m

C_l	C_m
0.2	-0.02
0.4	0
0.6	0.02
0.8	0.04

center from the leading-edge of the airfoil and center of pressure for $C_l = 0.5$ from the leading-edge

of the airfoil. **(10)**

Question 5. A glider weighs 5500 N and has a wing loading of 500 N/m^2, its drag polar is given by $C_D = 0.01 + 0.022C_L^2$. It is launched from a height of 500 m in still air. Find, (a) greatest possible distance it can cover, (b) the maximum time it can remain in air, (c) flattest glide angle, and (d) minimum sink rate. (Assume air density at sea level). **(10)**

Question 6. A piston-prop aircraft has a wing loading of 1400 N/m^2, wing area of 24 m^2, and its drag polar is given by $C_D = 0.025 + 0.05C_L^2$. The maximum lift coefficient is 1.5. The reciprocating engine develops 700 kW at sea level, and propulsive efficiency of the engine-propeller combination is 0.85. Determine, the maximum climb angle and the maximum rate of climb at sea level as well as the velocities and lift coefficients at which they occur. **(10)**

Question 7. A light turbojet airplane weighs 20000 N, has a wing loading of 1000 N/m^2 and produces a sea level thrust of 3500 N. Thrust varies with altitude as $T = T_0\sigma^{0.8}$. Assuming $C_D = 0.015 + 0.024C_L^2$ and $C_{L,max} = 1.4$. Find, (a) maximum and minimum speed in level flight at sea level, (b) minimum thrust required at sea level and corresponding velocity, and (c) minimum stable speed in level flight at sea level. **(10)**

Question 8. A piston-prop aircraft has a wing loading of 1500 N/m^2, wing area of 25 m^2, and its drag polar is given by $C_D = 0.025 + 0.05C_L^2$. The maximum lift coefficient is 1.5. The reciprocating engine develops 750 kW at sea level, and propulsive efficiency of the engine-propeller combination is 0.85. Draw power required and power available curve at sea level. Determine, maximum and minimum speed in level flight at sea level.
What is the minimum power required for level flight at sea level, and the corresponding velocity and lift coefficient. **(10)**

Question 9. A jet aircraft weighs 10000 N and has a wing area of 28 m^2. Its drag polar is given by $C_D = 0.015 + 0.025C_L^2$. The sea level thrust T_0 is equal to 2300 N, and thrust at an altitude is given by $T = T_0\sigma$. The specific fuel consumption at sea level c_0 is 1.1 N/Nh, and at an altitude, $c = c_0\sigma$. Determine, (a) fuel load and cruise velocity for a Breguet range of 200 km, (b) gain in altitude with constant-velocity range of 200 km, (c) minimum fuel load required to cover a range of 200 km with constant-altitude range program, and (d) maximum endurance at sea level if the fuel weight is 803 N. **(10)**

Question 10. A propeller airplane weighs 55000 N and has a wing loading of 2000 N/m^2. The aspect ratio of the wing is 6.5; zero-lift drag coefficient is equal to 0.021, Oswald's efficiency factor is equal to 0.920. The airplane produces power of 700 kW at a propeller efficiency of 0.82 and specific fuel consumption of 3.3 N/kWh. What minimum fuel load should the airplane carry (a) to cover still air range of 1500 km, and (b) to remain in the air for 7 hr. Assume airplane operates at an altitude of 2.4 km ($\sigma = 0.7892$). **(10)**