INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR
DEPARTMENT OF AEROSPACE ENGINEERING
Supplementary Exam, Flight Mechanics AE31007, 2013-14
Please carryout all the problems

Marks: 100 Time: 3 Hrs

1. On a certain day the pressure at the sea level is 101500 N/m^2 and the temperature is $25^0\,C$. The temperature is found to fall linearly with height to -55^0C at $11300\,m$, above which the altitude temperature is constant. Calculate the pressure, density and absolute and kinematic coefficient of viscosity at (a) $10,000\,m$ (b) $11,300\,m$ and (c) $15,000\,m$. Moreover, an altimeter fitted on an aircraft which has no instrument error and which is calibrated on the assumption that the atmosphere fulfills the I.S.A. specification. With the atmospheric condition as mentioned above, the altimeter reads $5000\,m$. What is the true altitude of the aircraft above mean sea level? What would be the indicated altitude after landing on an aerodrome at sea level?

Marks 10

2. An aircraft flies at a velocity of $250\,m/s$ at $18,000\,m$ altitude where the atmospheric pressure is $7,160\,N/m^2$ and the temperature is $-56.5^0\,C$. A model of $1/10$ scale is to be tested in high speed wind tunnel. Calculate the static pressure of the tunnel stream necessary to give dynamic similarity if the tunnel static temperature is $9^0\,C$ and tunnel stream speed is $287\,m/s$.

Marks 10

3. For an aircraft wing with a leading edge swept of 45^0, root chord of $5\,m$, tip chord of $2\,m$, and semi span of $10\,m$, determine the aspect ratio, mean aerodynamic chord, and span wise location of the mean aerodynamic chord.

Marks 10

4. A certain airplane weighs $44,440\,N$ and has a wing loading of $1433.55\,N/m^2$. The drag polar is given by $C_D = 0.02 + 0.04C_L^2$ and $C_{L,max} = 1.2$. For a power-off glide for $600\,m$, determine (a) the maximum distance it can cover and (b) the maximum time it can remain in air.

Marks 10

5. A jet airplane weighs $1,60,000\,N$ and has a zero-lift drag coefficient of 0.008 and a wing area of $42\,m^2$. At $100\,m/s$ at sea level, the rate of climb is $11.5\,m/s$. The thrust developed by the engine is equal to $27,000\,N$. Determine the maximum rate of climb and the corresponding flight speed at sea level.

Marks 10

6. Determine the thrust required for a turbojet aircraft weighting $85,000\,N$ with a wing area of $32\,m^2$, $C_{L,max} = 1.50$, $C_D = 0.04 + 0.0833C_L^2$, and $n_{lim} = 6.0$ so that it can execute a sea level coordinated 90^0 turn in 6 seconds. First derive the equation and then solve the problem.

Marks 10

7. A light combat aircraft weighs $78,480\,N$ and has wing area of $25\,m^2$, lift-curve slope of 0.06 per degree, $C_{L,max} = 0.95$, and $C_D = 0.0254 + 0.178C_L^2$. This aircraft is required to land at an airstrip located at an altitude of $1000\,m$ ($\sigma = 0.9074$). Assuming that the coefficient of friction between the tires and the runway is equal to 0.02 and approach glide angle is 3.5 degree, estimate (a) airborne distance including flare and (b) ground run. Assume that flaps are lowered at the touchdown and give an increase in $C_{L,max}$ of 0.54 and an increase in C_D of 0.05. Further assume that the brakes are simultaneously applied giving an increment in friction coefficient of 0.4.

Marks 10

8. Under the assumption of shallow flight during the cruise climb find the corrected range in terms of the altitude gained during the cruise climb. Assume an exponential atmosphere ($\sigma = \exp(-\lambda n h)$, troposphere). Show that $\Delta h = \frac{1}{\lambda n}\log\left(\frac{W_i}{W_f}\right)$. Here, $n = 0.7$ for the troposphere and $n = 1.0$ for the stratosphere. Hence find out the expression for the corrected range in troposphere only. For the troposphere the specific fuel consumption c is defined as $\frac{c}{c_{sl}} = \sigma^{0.2}$, $\frac{T}{T_{sl}} = \sigma^{0.7}$ and for the stratosphere $\frac{c}{c_{35}} = 1$ and $\frac{T}{T_{35}} = \frac{\rho}{\rho_{35}}$ with the suffix 35 denoting the values at the tropopause.

Marks 10

9. It is well know that a total of six cruise programs are available, out of which two are having infinite number of solutions. Among the remaining four, show the range in decreasing order. Carry out this analysis graphically.

Marks 20