| Reg. No. | | | | | | | | | | |
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# Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

**V SEMESTER B.TECH (AERONAUTICAL ENGINEERING)**

**END SEMESTER EXAMINATIONS, NOV/DEC 2015**

SUBJECT: FLIGHT MECHANICS [AAE 301]

**REVISED CREDIT SYSTEM**

Time: 3 Hours. MAX.MARKS: 50

**Instructions to Candidates:**

- Answer **ANY FIVE FULL** questions.
- Missing data may be suitably assumed.

**1A.** An airplane weighing $60{,}330\ N$ has a wing area of $64\ m^2$ and is equipped with an engine-propeller combination which develops $500\ kW$ of $THP$ at $180\ Kmph$ under standard sea-level conditions. Calculate the rate of climb at this flight speed. The drag polar is given in the table below. **(06)**

| $C_L$ | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 |
|---|---|---|---|---|---|---|---|
| $C_D$ | 0.022 | 0.0225 | 0.024 | 0.026 | 0.030 | 0.034 | 0.040 |

| $C_L$ | 0.7 | 0.8 | 0.9 | 1.0 | 1.2 |
|---|---|---|---|---|---|
| $C_D$ | 0.047 | 0.055 | 0.063 | 0.075 | 0.116 |

**1B.** If we define the ratio of $V/V_{(L/D)_{max}} = n$, and assume a parabolic drag polar with constant coefficients $(C_{D,0},\ K)$, show that $L/D\ /(L/D)_{max}$ varies as a function of $n$ as $\frac{2n^2}{n^4+1}$. **(04)**

**2A.** An aircraft weighs $30{,}000\ lbs$, has a wing area of $750\ ft^2$, and a $C_{L_{max}} = 2.2$. The runway friction coefficients are, $\mu = 0.02$ for rolling, and $\mu_b = 0.5$ during braking. The touchdown velocity is $V_{TD} = 1.3\,V_{Stall}$, and braking occurs when the airspeed is $V_b = 0.8\,V_{TD}$. Additionally, at touchdown speed $L/D = 8.0$. Assume $T = 0\ (C_{L_g} = C_L@1.3\,V_{Stall})$ before braking. Calculate the total ground run. **(06)**

**2B.** Determine the load factor, bank angle, and turn radius for an aircraft in a level turn at a true airspeed of $120\ kn$ and a turn rate of $15\ deg/s$. **(04)**

**3A.** A model is being tested in the wind tunnel at a speed of $100\ miles/hour$ (@sea-level $P = 2116{,}2\ lbs/ft^2$). The flow in the test section is at standard sea-level conditions. **(06)**

a) What is the pressure at the model's stagnation point, $(lbs/ft^2)$?
b) If the tunnel speed is measured by a pitot-static tube connected to a U-tube manometer, what is the reading of the manometer in inches of water?
c) At one point on the model, the pressure is measured at $2058\ lbs/ft^2$. What is the local airspeed at that point?

**3B.** Explain the V-n diagram for an airplane. For instantaneous maneuver performance, the maneuver point is very important in the V-n diagram and also the corner velocity. Why? **(04)**

**4A.** A propeller aircraft weighs $50{,}000\ N$ and has a wing area of $30\ m^2$. Its reciprocating engine produces a thrust of $840\ KW$ and the propulsive efficiency is $0.85$. The airplane drag polar is given by $C_D = 0.025 + 0.05{C_L}^2$ and $C_{L_{max}} = 1.60, SFC = 3.0\ N/KWh$. For the fuel load of $10000\ N$ determine the best range and best endurance if the aircraft flies at an altitude of $3000\ m$ $(\sigma = 0.7423)$. **(06)**

**4B.** An aircraft has the following specifications: $W = 24{,}000\ lbs,\ S = 600\ ft^2, C_{D,0} = 0.015\ and\ K = 0.056$. This aircraft has run out of fuel at an altitude of $30{,}000\ ft$. **(04)**

a) Find the initial and final values of its airspeed for best range glide.
b) Find the glide angle for best range.
c) Find the rate of descent at $30{,}000\ ft\ (\rho = 0.000890\ slug/ft^3)$, $15{,}000\ ft\ (\rho = 0.001497\ slug/ft^3)$, and sea-level.
d) Estimate (find) the time to descend to sea-level

**5A.** An aircraft weighing $156{,}960\ N$ is powered by the jet engine whose thrust is independent of flight speed. The maximum rate of climb at sea level occurs at $152.5\ m/s$. The wing area is $46\ m^2$. The drag polar is given by $C_D = 0.016 + 0.045{C_L}^2$ and $C_{L_{max}} = 1.5$. Determine the **(06)**

a) Sea level thrust $T_0$ developed by the engine.
b) Lift coefficient
c) Maximum and Minimum speeds in sea level and
d) Absolute ceiling assuming that thrust varies with altitude as $T = T_0\sigma^{0.6}$.

**5B.** For minimum power required in a level un-accelerated flight, show that $C_{D,0} = C_{D_i}/3$. **(04)**

**6A.** A large transport aircraft with four engines is performing a cruise flight at $11km$ altitude. At the start of the cruise flight, the following data are available for this aircraft: **(06)**

| | |
|---|---|
| Aircraft Weight ($W_{start}$): | $3500\ kN$ |
| Fuel weight $(W_f)$: | $1340\ kN$ |
| Wing surface area ($S$): | $520\ m^2$ |
| True airspeed ($V_{start}$) : | $936\ km/hr$ |
| Air density at $11km$ altitude: | $0.3648\ kg/m^3$ |
| Temperature at $11km$ altitude: | $216.7\ K$ |
| Thrust specific fuel consumption : (constant and independent of airspeed) | $0.65\ [N/N\ hr]$ |
| Gas constant of air ($R$): | $287.05\ m^2/s^2K$. |

The aircraft is performing the cruise flight at constant altitude and constant angle of attack. Calculate the minimum aspect ratio $'A'$ that will allow this aircraft to fly a distance (range) of $10000\ km$ in the cruise phase with the amount of fuel given above. Next, calculate the required span of this aircraft and the Mach number at the start and end of the cruise flight. For lift drag polar of the aircraft $C_{D,0} = 0.018, e = 0.85$.

**6B.** As far as $P_S$ contours in energy methods are concerned for a jet driven airplane why there are dents at Mach $1$? Why do for modern jets like Lockheed F-16, dents are less pronounced in transonic region. In energy height contours, at any constant given energy height, how can
an aircraft “zoom” to higher altitudes? **(04)**