Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

IV SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, APRIL 2018

SUBJECT: FLIGHT MECHANICS [AAE 2203]

REVISED CREDIT SYSTEM
(25/04/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Draw schematic plot/s whenever data is taken from given plot/s

1A. In a gliding competition, participants are tasked to fly in an isosceles triangular path (see Fig. 1 below) covering three towns mutually separated by 25 km. The glider is initially towed by a powered aircraft and left at a pre-determined altitude above the first town A. After performing initial turn manoeuvre to set the heading towards the next town B, the pilot commences the gliding, maintaining the glide angle and angle of attack chosen for all the 3 flight segments of AB, BC and CA. In the flight profile for the glider mission, four 120^0 turn manoeuvres are added – the first one at A to orient the glider towards B, followed by the turns at B, C and finally at A to align the glider with the run way for home landing. A loss of height of 15 m is estimated for each of the turn. Assume that all the three towns A, B and C are at sea level. (ρ = 1.225 kg/m^3) (03)

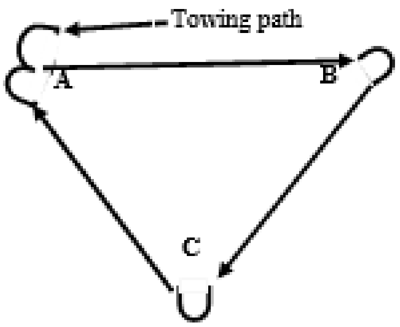


Fig. 1. Triangular Path AB, BC and CA for Gliding with Turn Manoeuvres at Way Points A, B, C and for Home Landing

Glider data is given below:

Maximum all up weight: 4500 N; Wing area : 7.5 m^2

Drag characteristics: $C_D = 0.0125 + 0.025C_L^2$ $C_{Lmax} = 1.2$

Obtain glide angle and corresponding lift coefficient for such a gliding mission covering the distance between the Way Points A, B, C.

1B. Using glider data from Q1A, calculate the minimum altitude at which the glider has to be initially towed before the commencement of the gliding task, taking into account loss of altitude in four turn manoeuvres described above. (03)

1C. Also calculate the altitude and speed of the glider in Q1B at three Way Points A, B, C when it starts gliding and finally when it lands at A (sea level). You may use for ISA, the relationship h = 44.3 (1- $\sigma^{0.235}$), between altitude h (km) and density ratio σ. (04)

2A. Maximum load factor attainable in a sustained level turn of an aircraft is known to depend solely on its aerodynamic efficiency (L/D) and thrust to weight ratio (T/W). The following data set is given for a fighter aircraft for estimating its turn performance: (03)

Drag characteristics: $C_D = 0.018 + 0.08C_L^2$, $C_{Lmax} = 1.1$,
Aircraft Weight = 80,000 N Wing Area = 25 m^2
Engine Thrust = 30,000 N Design load factor = 6

What is the maximum load factor feasible in level turn for the above aircraft at sea level? Calculate the C_L, flight speed and turn rate for such a level turn manoeuvre.

2B. For the aircraft Q 2A, obtain corner speed and attained turn rate at sea level for the above aircraft. Is this turn rate at the corner speed achievable in level flight with engine at full throttle? If not why? (03)

2C. For n = 3 and C_{Lmax} condition, calculate for the aircraft in Q2A, the flight speed, turn rate and throttle setting. If available excess thrust is used for climbing in such a turn, calculate possible height gain in a 180^0 turn at sea level. (04)

3A. For estimation of take-off distance for a twin engine aircraft the following data is given: (03)

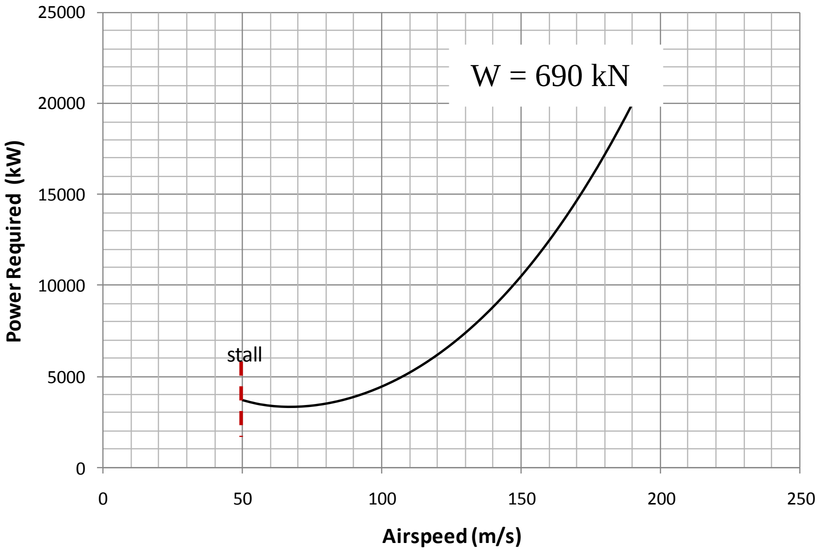
Aircraft Take-off Weight = 294.3 kN Wing area = 100 m^2
Engine Thrust = 85.5 kN Drag Characteristics : $C_D = 0.02 + 0.05C_L^2$
C_L for take-off ground run = 0.1 $C_{LmaxTO} = 1.8$
ΔC_{D0} for take-off ground run = 0.009 ΔC_{D0} for climb segment = 0.004
Coefficient of rolling friction μ= 0.04 Rotation speed = 1.2 V_{stall}
Rotation time including transition (part of flare) = 3 s

For all engine operative (AEO) case calculate average ground acceleration and total ground run distance including rotation (and transition) phase.

3B. Calculate for the aircraft in Q3A, climb segment distance for AEO case to clear an obstacle of 10.67 m, by using 100% of available thrust and C_L of 0.75 C_{LmaxTO}. (03)

3C. If the decision speed (or engine failure recognition speed) for the above aircraft in Q3A is 48 m/s, calculate balanced field length (BFL) for this aircraft assuming the following: Ground acceleration for one engine in operative (OEI) case is reduced to half that for AEO case. No change in rotation phase. Climb distance estimated for OEI case to clear an obstacle of 10.67 m, by adopting 100% of available OEI thrust and C_L of 0.75 C_{LmaxTO}. (04)

4A. Figure 2 below shows Power required curve for a twin engine turboprop aircraft plotted against equivalent air speed (EAS) for aircraft weight of W= 690 kN. The shaft power of the turboprop per engine is 12500 kW at sea level. The engine power is independent of flight speed but known to vary linearly with air density. The propulsive efficiency of the propeller is 0.85. The aircraft wing area is 230 m^2. Using the power characteristics given in Fig 2, obtain level flight speeds V_{min}, V_{max} at sea level and an altitude of 6600 m where (04) density ratio σ= 0.5. Also calculate aircraft C_{Lmax} from the data given in the power curve.



Equivalent Air Speed EAS m/s

Fig. 2 Power Required Curve Prob. 4

4B. Also obtain from the power curve given for above aircraft in Q4A, speed for minimum drag and minimum drag value at 6600 m altitude. Using this, calculate C_{D0} and k for aircraft (03)

4C. Calculate absolute ceiling of the aircraft in Q4A from available power required data. For ISA, use the relationship $h = 44.3\ (1- \sigma^{0.235})$, between altitude h (km) and density ratio σ. (03)

5A. A turboprop aircraft of 60 kN weight has a wing of area 30m^2. Its drag characteristics is given by: $C_D = 0.021 + 0.0577C_L^2$. The shaft power of the turboprop engine is 750 kW, with a propulsive efficiency of 0.82 and its power specific fuel consumption 3.5 N/kW/h. (03)

i) Estimate the minimum fuel required for a range of 1500 km in still weather condition at an altitude of 2400 m where the air density ratio is 0.7892.

ii) Calculate flight speed for minimum fuel range flight.

5B. i) For the aircraft in Q5A, estimate minimum fuel required for endurance of 8 hours. (03)

ii) Calculate corresponding flight speed and altitude

5C. Discuss briefly the effect of head wind and tail wind on aircraft range and endurance and also the adjustment required in TAS for flying for maximum range and endurance. Illustrate this using typical Power Polar curve for turboprop aircraft. (04)