Reg. No.										

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

IV SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, June - July 2018

SUBJECT: FLIGHT MECHANICS [AAE 2203]

REVISED CREDIT SYSTEM
(21/06/2018)

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
- International Standard Atmospheric (ISA) Table is given at the end.

1A. Maximum load factor feasible 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). Derive an expression for feasible n_{max} in terms of these two design and performance parameters **(03)**

1B. The following data set is given for a fighter aircraft for estimating its turn performance: **(04)**

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.

1C. Obtain corner speed and attained turn rate at sea level for the aircraft in Q1B above. Is this turn rate at the corner speed achievable in level flight with engine at full throttle? If not why? **(03)**

2A. A jet powered aircraft weighing 200 kN with a wing area of 60 m^2 and a drag polar of $C_D = 0.021 + 0.042C_L^2$ is flying at density altitude of 1500 m. ($\rho = 1.0581$ kg/m^3). The outside air temperature (OAT) measured during flight is 268 K. Lift curve of the aircraft has a slope of 5.2/rad, zero lift angle of attack of -2.0^0 and $C_{Lmax} = 1.6$. Given Gas constant R = 287.058 J/kg/K. What is the pressure altitude measured by the altimeter onboard for this flight? **(03)**

2B. When the aircraft in Q2A above flies at 200 m/s at 1500 m density altitude it has a maximum rate of climb of 20 m/s. If the pilot chooses to accelerate by holding the altitude constant, what is the maximum initial acceleration that can be achieved? **(03)**

2C. Determine maximum steady level flight speed of the aircraft in Q2A at density altitude of 1500 m. **(04)**

3A. For estimation of take-off distance and balanced filed length for a twin engined aircraft the following data is given: **(04)**

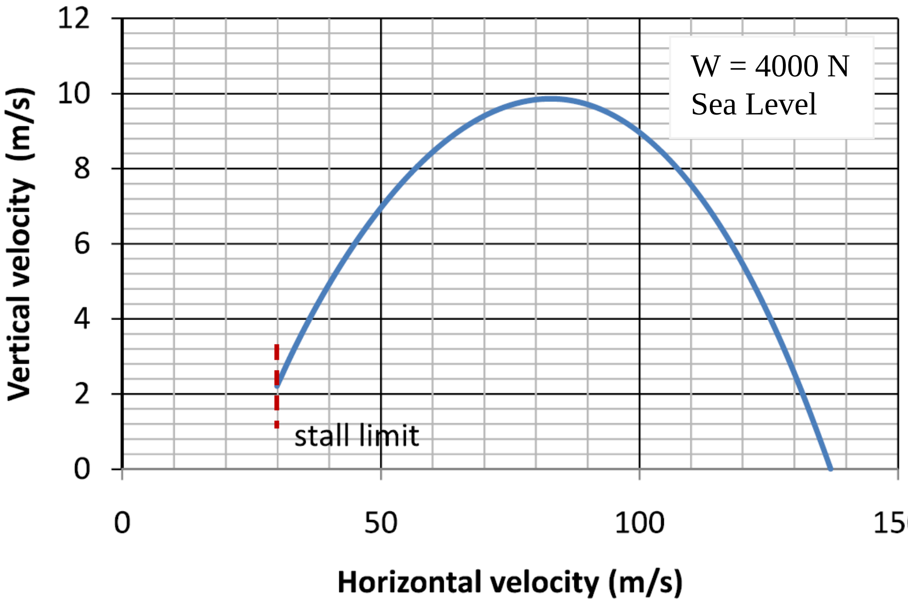
Aircraft Take-off Weight = 294.3 kN Wing area = 100 m^2
Engine Thrust (Total) = 85.5 kN Drag Characteristics : $C_D = 0.02 + 0.05C_L^2$
C_L for take off ground run = 0.1 C_{LmaxTO} = 1.8
ΔC_{D0} for take off ground run = 0.009 ΔC_{D0} for climb segment = 0.004
C_L for climb segment = 0.75 C_{LmaxTO} Throttle setting for climb : 100%
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, total ground run distance including rotation (and transition) phase and climb distance to clear an obstacle of 10.7 m

3B. If the decision speed (or engine failure recognition speed) for the 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 10.7 m obstacle **(03)**

3C. For stopping distance calculations of the aircraft in Q3A, assume a 3 seconds response time for working engine to be shut off following which brakes are applied to bring the aircraft to rest. Allowing for continued ground run at reduced acceleration level (OEI case) for 3 s after the engine failure, calculate deceleration level required to bring the aircraft to rest within BFL calculated in Q3B **(03)**

4A. A small turbojet aircraft has a maximum gross weight of 4000 N, wing span of 5.2 m and planform area of 4 m^2. Figure 1 below shows hodograph of this aircraft flying at sea level with its maximum takeoff weight. Stall limit is also shown in the figure. The engine thrust is given by T = 900 σ N is independent of speed. The TSFC of the engine is independent of speed and altitude and is 0.00036 N/N/s. **(04)**



For above aircraft flight at sea level with max take-off weight, obtain using hodograph data climb angle, flight speed and thrust required to achieve steady maximum rate of climb.

4B. What is the maximum steady level speed of the aircraft in Q4A for the sea level flight with max take-off weight? **(02)**

4C. Determine maximum steady climb angle and minimum thrust required for the aircraft in Q4A for sea level flight. **(04)**

5A. A turboprop cargo aircraft has an initial gross weight of 136 kN which includes 13 kN of supply to be air-dropped at a distance of 2000 km away from its base depot. Wing area of the aircraft is 28 m^2 and the drag polar is $C_D = 0.02 + 0.05C_L^2$. Propeller efficiency during cruise is 0.87 and its engine SFC is 7.4 x 10^{-7} N/W/s, independent of flight speed and altitude. **(03)**

The aircraft is flying at an altitude of 8.5 km (= 0.4951 kg/m^3) at a speed to maximise range performance. Determine the fuel consumed for onward flight leg of 2000 km and return flight after air-dropping 13 kN of supply.

5B. For the air drop mission of 2000 km to and fro flight of Q5A, estimate the flight speeds at the beginning and the end of the two constant altitude flight segments and comment on how pilot manages such constant altitude and constant C_L flights with varying flight speed. **(04)**

5C. Although advantage seems to be there, a turboprop aircraft is rarely flown at the condition that maximises range. Give two reasons why so? **(03)**

Characteristics of the International Standard Atmosphere, SI Units

Altitude, *h* km	Temperature, *T* K	Pressure, *P* N/m^2	Density, ρ kg/m^3	Speed of Sound, *a* m/s	Viscosity, μ kg/m s
0	288.16	101325	1.225	340.3	1.79E-05
0.5	284.91	95461	1.1673	338.4	1.77E-05
1	281.66	89876	1.1117	336.4	1.76E-05
1.5	278.41	84560	1.0581	334.5	1.74E-05
2	275.16	79501	1.0066	332.5	1.73E-05
2.5	271.92	74692	0.95696	330.6	1.71E-05
3	268.67	70121	0.90926	328.6	1.69E-05
3.5	265.42	65780	0.86341	326.6	1.68E-05
4	262.18	61660	0.81935	324.6	1.66E-05
4.5	258.93	57752	0.77704	322.6	1.65E-05
5	255.69	54048	0.73643	320.5	1.63E-05
5.5	252.44	50539	0.69747	318.5	1.61E-05
6	249.2	47217	0.66011	316.5	1.6E-05
6.5	245.95	44075	0.62431	314.4	1.58E-05
7	242.71	41105	0.59002	312.3	1.56E-05
7.5	239.47	38299	0.55719	310.2	1.54E-05
8	236.23	35651	0.52578	308.1	1.53E-05
8.5	232.98	33154	0.49575	306	1.51E-05
9	229.74	30800	0.46706	303.9	1.49E-05
9.5	226.5	28584	0.43966	301.7	1.48E-05
10	223.26	26500	0.41351	299.6	1.46E-05
10.5	220.02	24540	0.38857	297.4	1.44E-05
11	216.78	22700	0.3648	295.2	1.42E-05
11.5	216.66	20985	0.33743	295.1	1.42E-05
12	216.66	19399	0.31194	295.1	1.42E-05
12.5	216.66	17934	0.28837	295.1	1.42E-05
13	216.66	16579	0.26659	295.1	1.42E-05
13.5	216.66	15327	0.24646	295.1	1.42E-05
14	216.66	14170	0.22785	295.1	1.42E-05
14.5	216.66	13101	0.21065	295.1	1.42E-05
15	216.66	12112	0.19475	295.1	1.42E-05