Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

VI SEMESTER B.TECH (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, MAY 2016

SUBJECT: AIRCRAFT DESIGN [AAE 304]

REVISED CREDIT SYSTEM

Time: 3 Hours Max Marks: 50

Instructions to Candidates:

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

1A) Consider a subsonic turbofan passenger airplane with 135 passenger's capacity travelling at 840km/hr cruising velocity at altitude of 11km. Then consider the followings: **(05)**

Aspect ratio=9.5, S=69m^2, $\Lambda_{c/4}=32^0$, Safe range=4200km, Speed of sound at 11km=295.4m/s, ρ at 11km=0.38kg/m^3. 100kgf for passenger and 85kgf for crew weight including the luggage (1 crew for 30 passengers). σ=density ratio, μ=bypass ratio=6, Alternate airport is 400km away from destination.

$$C_D = 0.02686 \cdot s^{-0.1} + \frac{1}{\pi A}\left(1 - 0.447 + \frac{0.2078}{\cos^2 \Lambda_{\frac{c}{4}}}\right) {C_L}^2,$$

$$TSFC = 0.363[1 + 0.28(1 + 0.063\mu^2)M]\sigma^{0.08}$$

$$\frac{W_{warmup+taxiing+take-off}}{W_{take\ off\ weight}} = 0.98, \frac{W_{climb}}{W_{warmup+taxiing+takeoff}} = 0.99, \frac{W_{landing+taxiing}}{W_{descent}} = 0.98,$$

i) Calculate fuel fraction for cruise (with a forward gust with 32km/h)

ii) Calculate fuel fraction for loiter (consider sea level condition, M=0.3)

iii) Calculate empty weight ratio and weight (const values A=0.92, c=-0.05, initial guess W_0=42000kgf)

iv) Calculate take off weight, fuel weight and empty weight through iterative method

1B) Explain the classification of aircraft fuselage(external and internal structures) consideration and also write down the advantages and disadvantages of flying wing configuration **(05)**

2A) What is meant by a mission profile? Draw a typical mission profile diagram for a commercial transport aircraft, low level strike and air superiority. **(03)**

2B) Consider a high subsonic jet airplane with an initial estimate of gross weight 78500kgf and wing loading of 6800N/m^2. Given parameters are: A=9.1, λ=0.32. $\Lambda_{c/4}=31^0$, t/c of airfoil=0.16, diameter of fuselage=4.2m, S_{HT}/S=0.31, S_{VT}/S=0.26, S_{WET}/S=5.8, speed of sound at 11km=295m/s, ρ at 11km=0.364 kg/m^3, M_{cr}=0.82, H_{cr}=11km, Range=3850km, TSFC=0.75, $(S_{wet})_w = 2 * S_{exposedwing} * (1 + 0.2\left(\frac{t}{c}\right))$ **(05)**

i) Calculate C_{fe} and drag polar in terms of constants F_1, F_2 and F_3 (use drag polar equations from question 1A)
ii) Obtain wing loading under consideration of absolute ceiling

2C) What is decision speed and how it's influencing the runway length for the aircraft? **(02)**

3A) Describe the followings: **(05)**

a) Aerodynamical& Structural requirements in aircraft design.
b) Instantaneous turn rate
c) Upsweep angle and Closure angle of the fuselage
d) Difference between general aviation and civil aviation
e) Landing run & Landing distance

3B) Obtain the engine rating required for the aircraft under the consideration of Vmax and rate of clime (R/C)with assumption of wing loading 3600N/m^2. V_{MAX}=600kmph, H=5km, density at altitude = 0.7768kg/m^3. $(R/C)_{MAX}$=560m/min. W_0= 23000kgf, η=0.85, $C_D=0.02224+0.36\ C_L^2$ **(03)**

3C) How propulsive efficiency variation with flight speed controls the selection of engines that is to be used for particular aircraft? **(02)**

4A) Explain the effect of sweep angle on slope of lift curve, maximum lift coefficient and induced drag. **(03)**

4B) Define the following terms. (a) Ramp weight (b) Take-off gross weight (c) Operational empty weight (d) landing weight. **(03)**

4C) Select a NACA airfoil section (C_{Li} and C_{Lmax}) for the wing for a jet non-maneuverable GA aircraft with the following characteristics: **(04)**
m_{TO} = 4000 kg, S = 30 m^2, V_c = 250 knot (at 3000 m), V_s = 65 knot (sea level)
The high lift device (split flap) will provide ΔC_L = 0.8 when deflected.

5A) What are the features of the fuselage of a military airplane. **(02)**

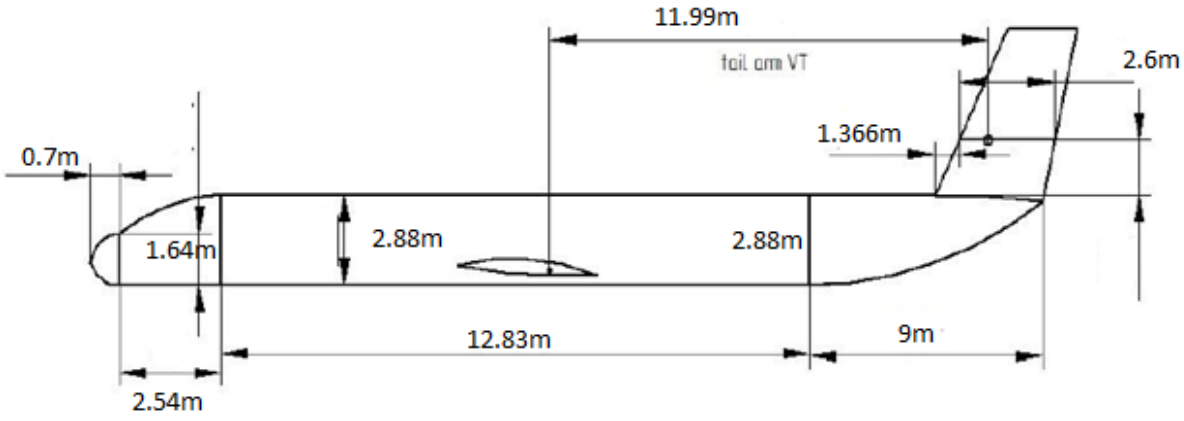
5B) Consider a 60 seaterturboprop airplane with following parameters: W_0= 98000kgf, wing loading=6800m^2, V_{cr}=870Km/hr, AR=12, taper ratio=0.28, ρ_{11}=0.414kg/m^3,wing is having straight section up to 35% of the semi span on either side of root chord. **(06)**
Determine the following : a) airfoil section b) Root chord and tip chord c) mean aerodynamic chord and d) the location of aerodynamic Centre

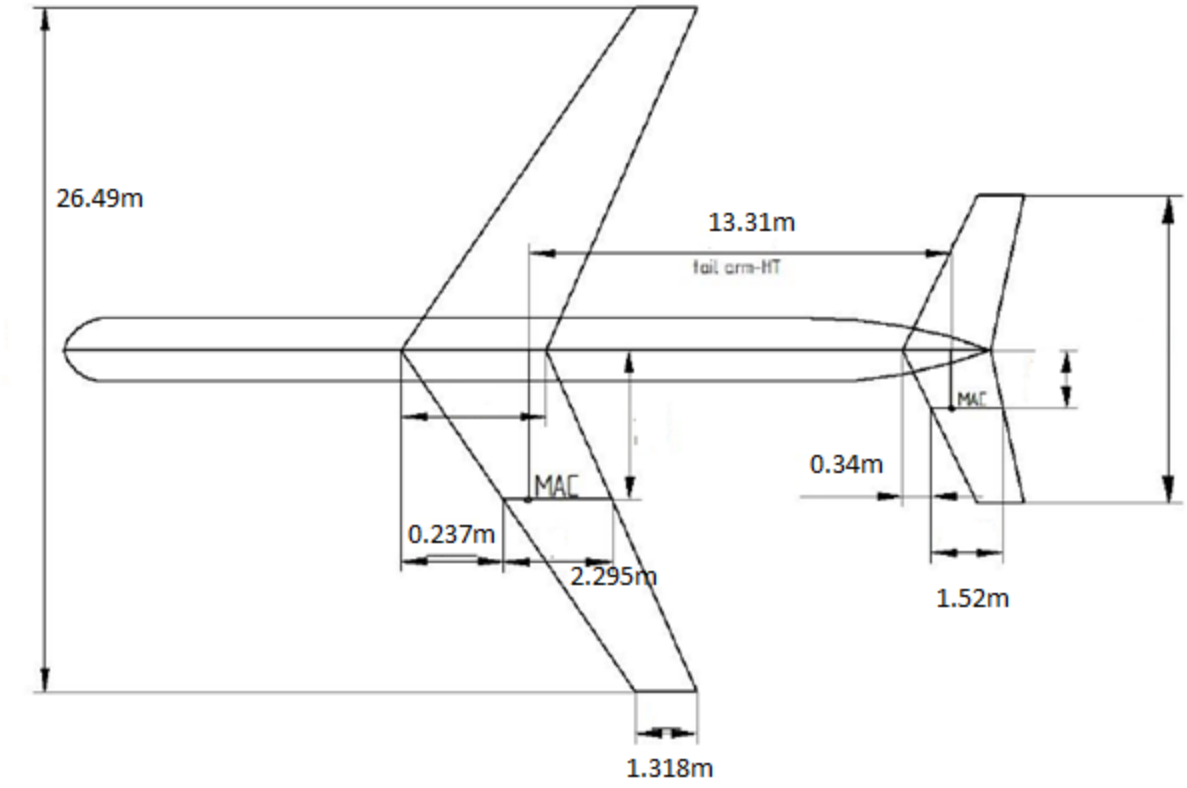
5C) Also determine the root chord, tip chord of the equivalent trapezoidal wing for the above problem. **(02)**

6A) Consider a 60 seater Turboprop airplane with following parameters: **(07)**
Wing loading= 3570N/m^2, S_{HT}=11.11m^2 (T-tail), S_{VT}=12.92m^2, W_0=21280 kgf, W_{empty}/W_0=0.54, W_{fuel}/W_0=0.143, $W_{payload+crew}$=62195N, (From the diagram all dimensions are in meters and all passengers are in fuselage mid-section) .
Weight of 1 engine=450kgf, length of engine=2.13 m, engine is 1.36m ahead of wing LE and C.G location of engine=41% of its length and engines are placed on the wing.
Landing gear(LG) wheel base=9.78 m, W_{LG}/W_0=0.097

6B) Calculate the center of gravity shift from question 6A under consideration of **(03)**
i) Full payload but no fuel
ii) No payload (passenger + crew) and no fuel
iii) No payload but full fuel

FIG.1.





Approximate weight buildup table:

Structures	Weight Factor	multiplier	≡C.G location
wing	49	$S_{exposed}$	40% of MAC
H.T & V.T	27	$S_{exposed}$	40% of MAC
Fuselage	24	S_{wetted}	45% of its length
Landing gear	0.097	W_0	
Installed Engine	1.3	Empty Weight	