Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, DEC/JAN 2020-2021

SUBJECT: AIRCRAFT DESIGN [AAE 3155]

REVISED CREDIT SYSTEM
(28/01/2021)

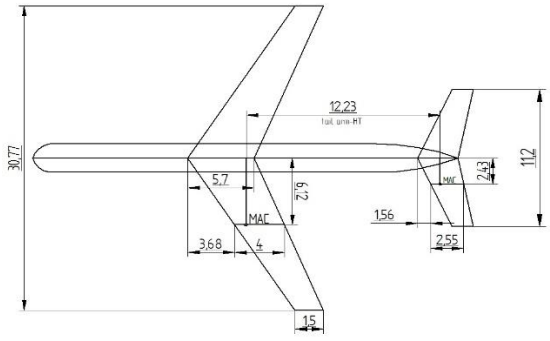
Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Formula chart will be provided

			Co	BT
1A.	Consider a twin turboprop passenger airplane carrying 40 passengers on board with cruise velocity of 450km/hr at altitude of 4km. Aspect ratio=10.5, S=55m^2, Safe range=900km, Alternate airport is 300km away from destination, consider 4 crews in airplane. $C_D = 0.03354 \cdot s^{-0.1} + \frac{1.356}{\pi A} {C_L}^2$, $\eta_{\text{cruise}} = 0.85, \eta_{\text{loiter}} = 0.75$, $\text{BSFC}_{\text{cruise}} = \frac{2.7\text{N}}{\text{kw.hr}}$, $\text{BSFC}_{\text{loiter}} = \frac{2.85\text{N}}{\text{kw.hr}}$, $\frac{W_{\text{warmup+taxiing+take-off}}}{W_{\text{take off weight}}} = 0.98$, $\frac{W_{\text{climb}}}{W_{\text{warmup+taxiing+takeoff}}} = 0.99$, $\frac{W_{\text{landing+taxiing}}}{W_{\text{descent}}} = 0.98$, i) Calculate fuel fraction for cruise (consider forward gust with 12m/s) and loiter ii) Calculate empty weight ratio(constant values A=0.92, c=-0.05) iii) Calculate take off weight (guess W_0=16000kgf and number of crew=4), fuel weight and empty weight through iterative process	(05)	CO2	L4
1B.	Explain classification of aircraft fuselage (external and internal structures) consideration and also write down the advantages and disadvantages of BWB configuration	**(03)**	**CO1**	**L2**

1C.	Distinguish between variable pitch and constant speed propeller	**(02)**	**CO3**	**L1**
2A.	Consider twin engine subsonic jet airplane with an initial estimate of gross weight 70000kgf and wing loading of 6200N/m^2. Given parameters are: A=11, λ=0.33. $\Lambda_{c/4}=31^0$, thickness of airfoil=0.16, diameter of fuselage=4.1m, S_{HT}/S=0.33, S_{VT}/S=0.25, S_{WET}/S=6, $(S_{wet})_{wing} = 2 * S_{exposedwing} * (1 + 0.2\left(\frac{t}{c}\right))$, $C_D = 0.02686 \cdot s^{-0.1} + \frac{1}{\pi A}\left(1 - 0.447 + \frac{0.2078}{Cos^2\Lambda_{\frac{c}{4}}}\right) {C_L}^2$ i) Calculate drag polar in terms of constants F_1, F_2 and F_3 ii) Obtain wing loading under consideration of absolute ceiling and consider $\pm 5\%$ iii) Obtain wing loading under consideration of balanced field length at take off (BFL=0.2613TOP, $C_{L.max} = 2.8$, $\left(\frac{T}{W}\right)_{Take\ Off} = 0.32$) and consider $\pm 10\%$	**(06)**	**CO2**	**L4**
2B.	Write down methods and procedure to obtain the diameter of the propeller and Calculate the diameter of propeller from the consideration of 40 seater turboprop airplane with following parameters: V_{cr}=500kmph, H_{cr}=4km, A=11, N=1400, wing loading=3200N/m^2, W_0=215000N, ρ at 4km=0.7768kg/m^3, $C_D = 0.0335 \cdot s^{-0.1} + \frac{1.356}{\pi A} {C_L}^2$ Choose appropriate values from the design chart: C_S | β | J | η 1.5 | 25^0 | 0.95 | 0.82 2 | 30^0 | 1.4 | 0.81 2.5 | 40^0 | 1.75 | 0.84	**(04)**	**CO3**	**L4**
3A.	Consider a turbo propeller passenger aircraft with following parameters and calculate the engine rating required at Rate of climb with minimum power and maximum velocity at altitude. W/S=3850N/m^2, V_{MAX}=530km/h, ρ_{cruise}=0.7768kg/m^3, $(R/c)_{climb}$=480m/min, η=0.83, W_0=19000kgf, thrust at cruise / thrust at sea level=0.72, $C_D=0.02224+0.038\ C_L^2$.	**(05)**	**CO3**	**L2**

3B.	Explain the classification of aircraft under number of engines & engine locations and write down their advantages and disadvantages. Briefly explain the conditions and considerations for positioning of engines on span wise location of the wing.	**(03)**	**CO3**	**L3**
3C.	Identify the criteria to use turboprop or jet engines for a designed aircraft	**(02)**	**CO3**	**L2**
4A.	Consider subsonic jet airplane with the following parameters and design the wing under consideration of a) airfoil selection, b) aspect ratio, c) sweep angle, d) taper ratio, e) twist, f) incident angle, g) consider at trailing edge 38% cranked wing (Λ_{TE}=25deg). Draw the wing diagram with full specifications. Given parameters are : W_0=98500kgf, p=6820N/m^2, V_{cr}=880km/h, A=12, λ=0.28 $\Lambda_{c/4}$=31deg, Λ_0=38deg, ρ_{11}=0.414kg/m^3, speed of sound at altitude=295m/s, initial twist angle= -3deg, $$C_{L\alpha} = \frac{2\pi A}{2 + \sqrt{4 + A^2(1-M^2)\left(1 + \frac{tan^2\Lambda_{c/2}}{(1-M^2)}\right)}},$$ $$tan\Lambda_{c/2} = tan\Lambda_{c/4} - \frac{4}{A}(0.25 \cdot \frac{1-\lambda}{1+\lambda})$$	**(05)**	**CO4**	**L5**
4B.	Describe the methods and procedures to determine a standard civil aviation passenger fuselage cabin layout dimensions.	**(03)**	**CO4**	**L4**
4C	Distinguish the concept of wide body fuselage and write down what are the parameters influencing to determine the diameter of the fuselage.	**(02)**	**CO4**	**L2**
5A.	Consider a passenger twin bypass engines airplane with following parameters: S_{wing}=109.5m^2, S_{HT}=28.13m^2 (T-tail), S_{VT}=22.89m^2, W_0=39750kgf, W_{empty}/W_0=0.54, W_{fuel}/W_0=0.19, $W_{payload+crew}$=121720N, (From the diagram all dimensions all are in meters and all passengers are at fuselage mid-section)  Figure – 1	**(07)**	**CO5**	**L6**

Weight of 1 engine=1500kgf, length of engine=2.95m, 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.

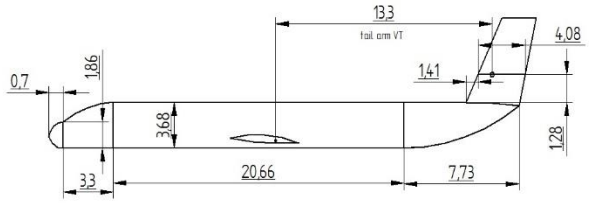


Figure – 2

Landing gear(LG) wheel base=15.2m, W_{LG}/W_0=0.097

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	

i) Calculate the weights and center of gravity locations of each structures

ii) Find the center of gravity location of the airplane from the nose section of fuselage under the consideration of center of gravity is at 25% of wing MAC.

5B.	Calculate the center of gravity shift from question 5A under consideration of i) Full payload but no fuel ii) No payload (passenger + crew) and no fuel iii) No payload but full fuel	**(03)**	**CO5**	**L6**