Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

V SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

END SEMESTER EXAMINATIONS, DECEMBER 2021

SUBJECT: AIRCRAFT DESIGN [AAE 3155]

REVISED CREDIT SYSTEM
(21/12/2021)

Time: 75 mins MAX. MARKS: 20

Instructions to Candidates:

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

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. **(05)** **CO3** **L4**

$$C_D = 0.03354 \cdot s^{-0.1} + \frac{1.356}{\pi A} {C_L}^2, \eta_{\text{cruise}} = 0.85, \eta_{\text{loiter}} = 0.75, \text{BSFC}_{\text{cruise}} = \frac{2.7\text{N}}{\text{kw.hr}}, \text{BSFC}_{\text{loiter}} = \frac{2.85\text{N}}{\text{kw.hr}}, \frac{\text{W}_{\text{warmup+taxiing+take-off}}}{\text{W}_{\text{take off weight}}} = 0.98, \frac{\text{W}_{\text{climb}}}{\text{W}_{\text{warmup+taxiing+takeoff}}} = 0.99, \frac{\text{W}_{\text{landing+taxiing}}}{\text{W}_{\text{descent}}} = 0.98,$$

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

iv) If the number of passengers changes to 85 for the same aircraft then what will the new W_0?

1B. Consider subsonic jet airplane with the following parameters and if then 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 28% cranked wing (Λ_{TE}=25deg). Draw the wing diagram with full specifications. **(05)** **CO2** **L6**

Given parameters are : W_0=98000kgf, p=6800N/m^2, V_{cr}=870km/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,

$$C_{L\alpha} = \frac{2\pi A}{2 + \sqrt{4 + A^2(1 - M^2)\left(1 + \frac{tan^2 \Lambda_{c/2}}{(1 - M^2)}\right)}},$$

2A. Consider a passenger twin bypass engines airplane with following parameters: **(08)** **CO3** **L5**
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, (In figures all dimensions are in meters and all passengers are at fuselage mid-section)
Approximate weight buildup:

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	

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.

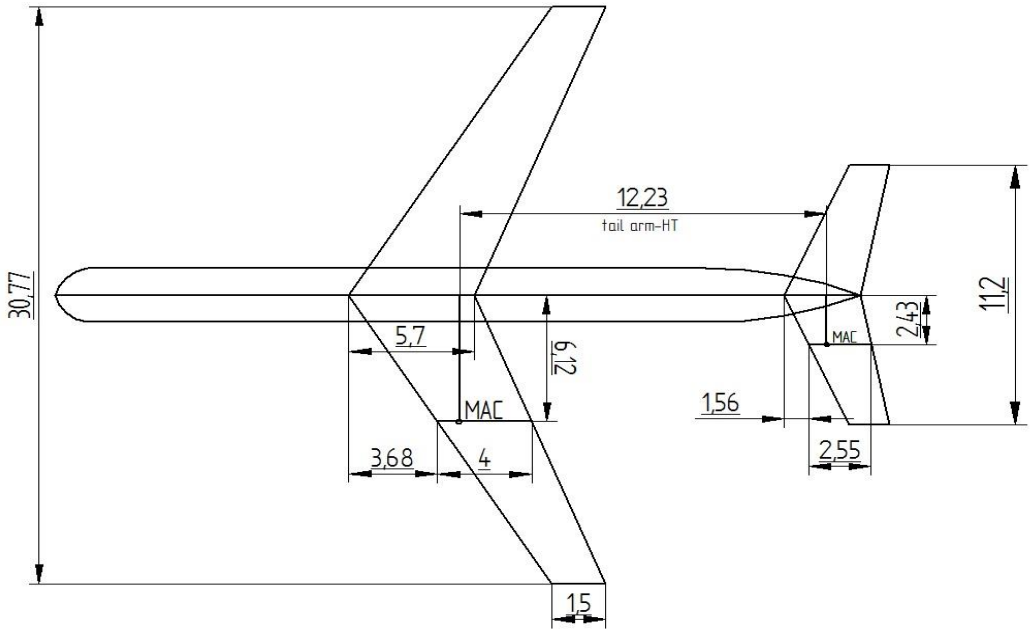

Figure-1

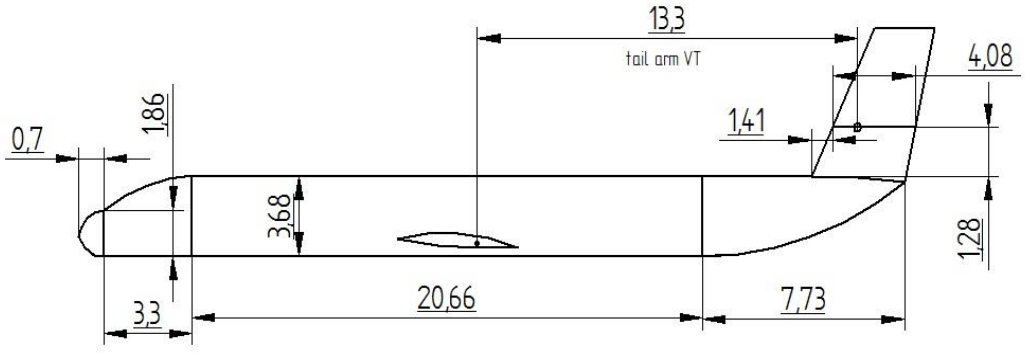

Figure-2

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

- Calculate the weights and Centre of gravity locations of each structures
- Find the Centre of gravity location of the airplane from the nose section of fuselage under consideration of center of gravity is at 0.25% of wing MAC.

2B. Calculate the Centre of gravity shift from previous question 2A under consideration of **(02)** **CO5** **L5**

a) Full payload but no fuel
b) No payload but full fuel