AER 1120

Intro to aircraft performance

Names: Amr Ehab Abd El-Hameed **49**

Mohamed Salah Mohamed **61**

Youssef Ahmed El-Badry **90**

Youssef Ahmed Ramadan **91**

Youssef Salah El-Dein **94**

Doctor: Hesham Mahmoud Abd-ElRaheem ElBanna

Teaching assistant: Ahmed Hussein Hafez

CP-1 Airplane

Aerospace Engineering Department, Faculty of Engineering,

Cairo University

Warren CP-1

Airplane & flow data sheet			
Part I: Body Geometric & Material Design		[C] Fuselage	
[A] Airplane		Material	fabric-covered welded steel tubing
Designation	Warren, R. L. Jones	[D] Wing	
Code	CP-1	Area	174 ft^2
Manufacturer	California Polytechnic college	Aspect ratio	7.37
Country	United States	Span	35.8 ft
First flight	September 1929	Airfoil	Clark Y
Mission	Aerial Photography	-	
Type of engine	Propeller	Part II : Aerodynamics	
Number of engines	1	[A] Airfoil	
Length	29 ft	Lift curve slope	0.896
Gross weight	2950 lb	Zero lift angle	-4.13°
Fuel capacity	65 gal	Stall angle	14.367°
[B] Engine		C_L maximum	1.51
Name	Comet 7D seven-cylinder air-cooled radial engine	[B] Airplane	
Manufacturer	Comet Engine Corporation	C_{Do}	0.025
Country	United States	K	0.053
Year	1928	Oswald efficiency factor (e)	0.8
Fuel type	gasoline	-	
Fuel consumption	0.45 lb/hp/h	-	
Power	150 HP	-	
Propellers	2-bladed Westinghouse Micarte adjustable	-	

CP-1 Propeller Aircraft.

Parameters:

- Span "b" = 35.8 ft
- Wing Area "S" = 174 ft²
- Gross weight "W" = 2950 lb
- Fuel Capacity = 65 gal gasoline
- Power one piston = 230 hp
- Fuel consumption = 0.45 lb/(hp)
- Parasite drag coefficient "C_{D_o}" = 0.025
- oswald efficiency factor "e" = 0.8
- Propeller efficiency "η_p" = 0.8

Let V_∞ = 200 ft/sec

ρ_∞ at sea level = 0.002377

Lift coefficient "C_L" = $\frac{2W}{\rho_\infty V_\infty^2 S}$ = 0.357 ∴ $C_L = 0.357$

Aspect Ratio "AR" = $\frac{b^2}{S}$ = 7.37 ∴ $AR = 7.37$

Drag coefficient "C_D" = $C_{D_o} + \frac{C_L^2}{\pi e AR}$ = 0.0319 ∴ $C_D = 0.0319$

Thrust Required "T_R" = $\frac{W}{C_L/C_D}$ = 263 lb ∴ $T_R = 263$ lb

Thrust available "T_A" = $\frac{\eta_p P}{V_\infty}$ = 506 lb ∴ $T_A = 506$ lb

Power Required "P_R" = $T_R * V_\infty$ = 52725 lb.ft/s ∴ $P_R = 52725$ lb.ft/s

Power available "P_A" = ηP = 101200 lb.ft/s ∴ $P_A = 101200$ lb.ft/s

Max velocity and Minimum Velocity — From Curve

$V_{max} = 264$ ft/s

$V_{min} = 22$ ft/sec ∴ $V_{min} = 97.196$ ft/s

$V_{stall} = \sqrt{\frac{2W}{\rho S C_{L_{max}}}}$ = 97.196 ft/sec

Rate of climb "R/C" = $\frac{P_A - P_R}{W}$ = 16.432 ft/s ∴ $R/C = 16.432$ ft/s

from Curve $R/C_{max} = 24.9606$ ft/sec

~~Max climb angle~~ $\theta_{max} = \sin^{-1}\left(\frac{1}{4KC_{D_o}}\right)$

Minimum glide angle "θ_{min}" = $\tan^{-1}\left(\frac{1}{(L/D)_{max}}\right)$

$\theta_{min\ glide} = 4.2°$

$V_\infty)_{R/C_{max}} = 107$ ft/sec ⇒ $V_\infty)_{R/C_{max}} = \sqrt{\frac{2W}{\rho S}\sqrt{\frac{K}{3C_{D_o}}}}$

∴ $\theta_{max\ climb} = 5.627°$

@ h = 10,000 ft

Maximum Range during Gliding = "R_{max}" = $\frac{h}{\sqrt{4KC_{D_o}}}$ = 136000 ft $R_{max} = 136000$ ft

absolute height and service height (h_{ab}, h_{ser})

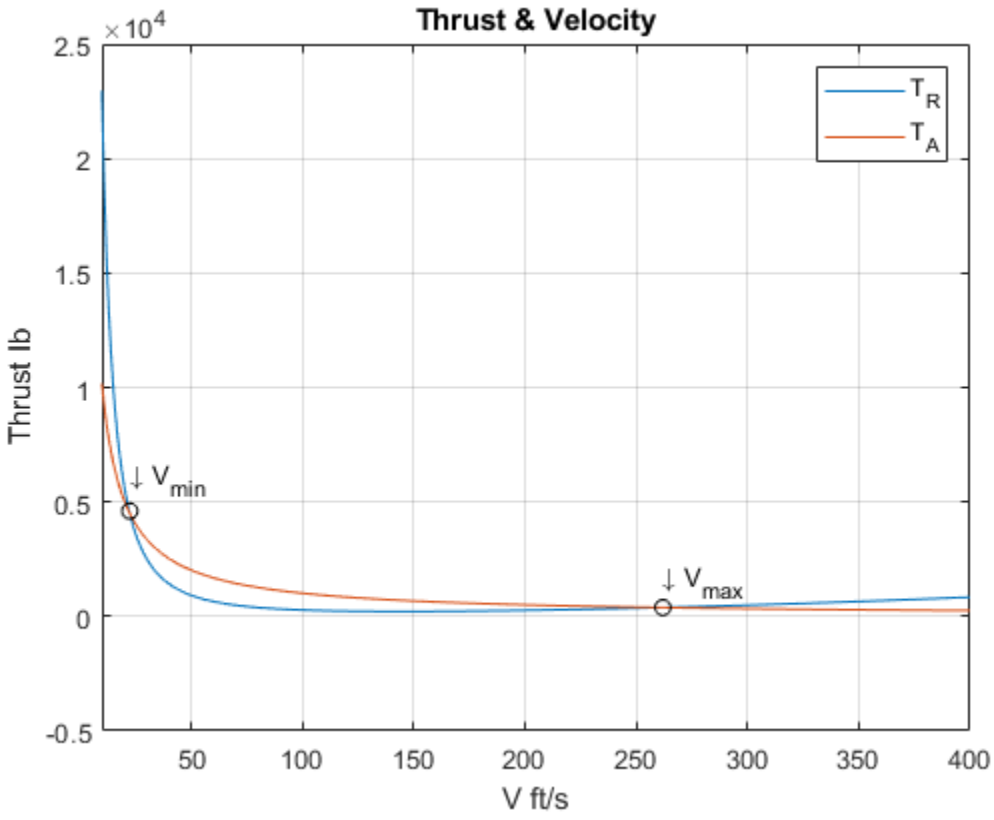
@ $R/C_{max} = \frac{P_A}{W} - 0.8776\sqrt{\frac{W/S}{\rho_\infty C_{D,0}}} \cdot \frac{1}{(L/D)^{3/2}_{max}}$

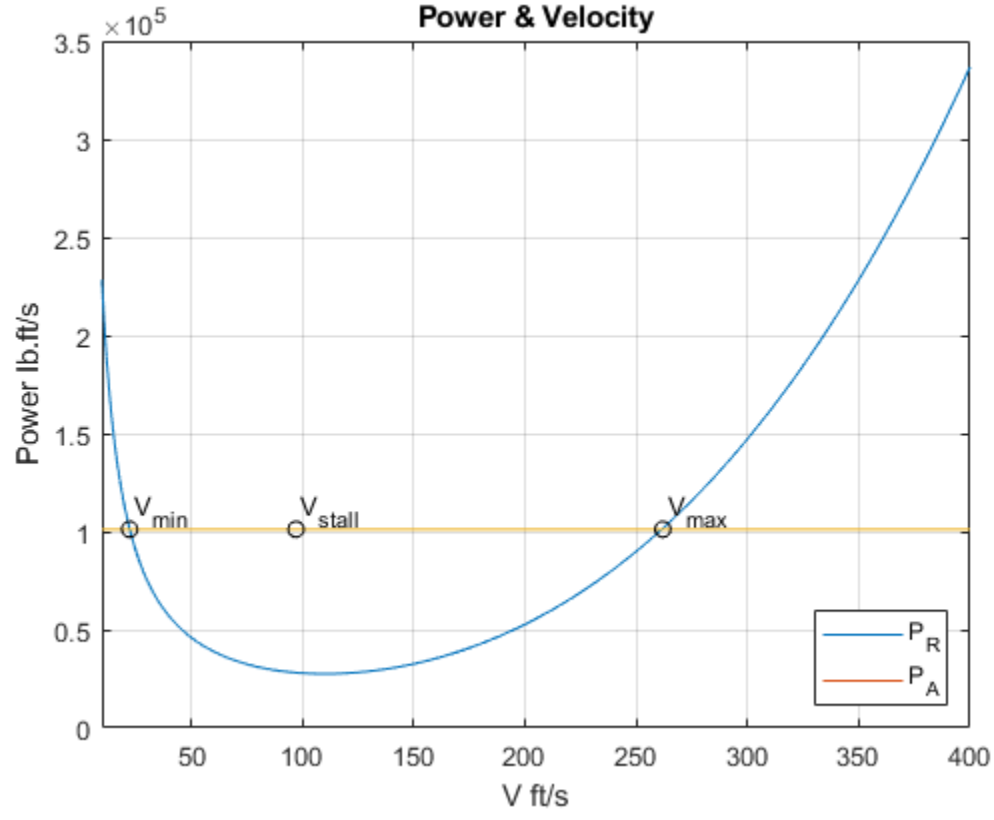
@ R/C = 0 ∴ $\rho = 1.76 \times 10^{-4}$

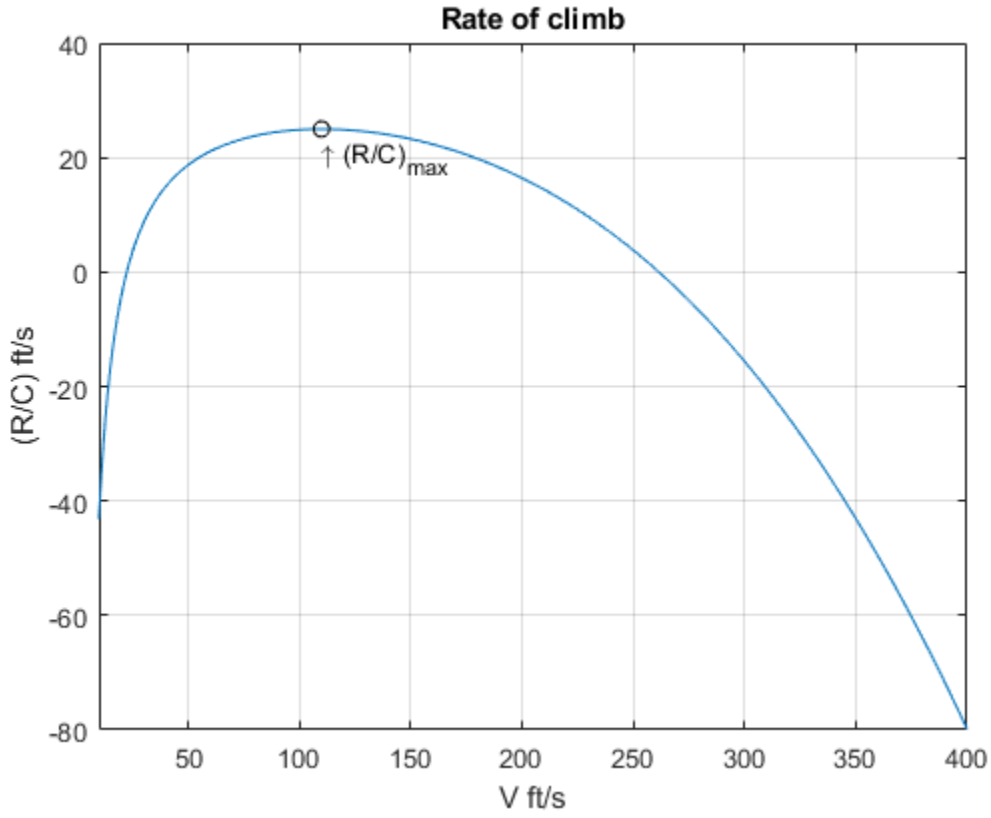
∴ $H_{abs} = 27000$ ft

@ R/C = 100 ft/min ∴ $\rho = 1.9449 \times 10^{-4}$

∴ $H_{ser} = 25000$ ft


Thrust & Velocity
×10^4
2.5
2
1.5
1
0.5
0
-0.5
Thrust lb
50
100
150
200
250
300
350
400
V ft/s
T_R
T_A
↓ V_min
↓ V_max


Power & Velocity
×10^5
3.5
3
2.5
2
1.5
1
0.5
0
Power lb.ft/s
50
100
150
200
250
300
350
400
V ft/s
V_min
V_stall
V_max
P_R
P_A



@h = 20000 ft

- Time to climb "t_{min}" $= \frac{1}{b}\left[\ln(a+bh) - \ln(a)\right]$

$a = (R/C)_{max}$ @h=0 $= 24.961$, @h=27000, $(RC)_{max} = 0$

$b = \text{slope} = \frac{h_2 - h_1}{RC_{max_2} - RC_{max_1}} = \frac{27000 - 0}{0 - 24.961} = -1081.687$

$t_{min} = 24.34 \text{ min}$

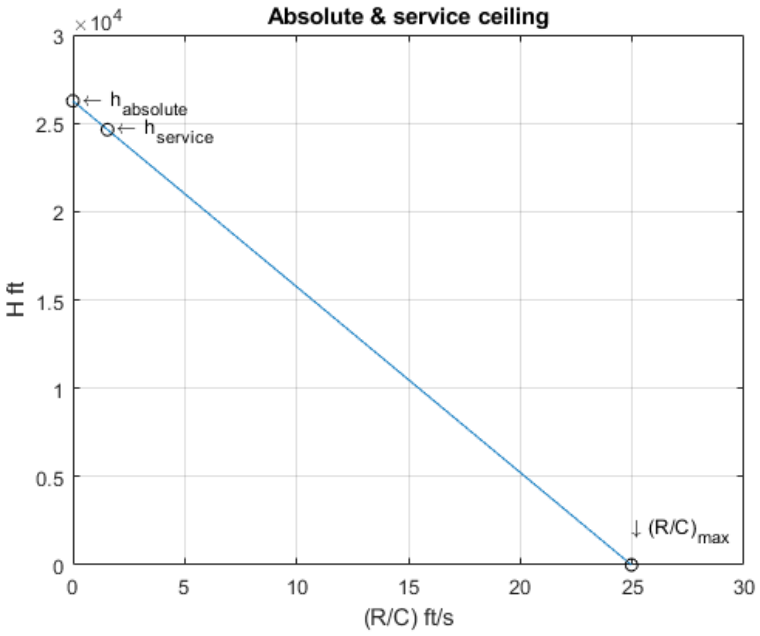
- Range "R_{Max}" $= \frac{\eta}{C}\frac{C_L}{C_D}\ln\frac{W_0}{W_1} = 6.38 \times 10^6 \text{ ft}$

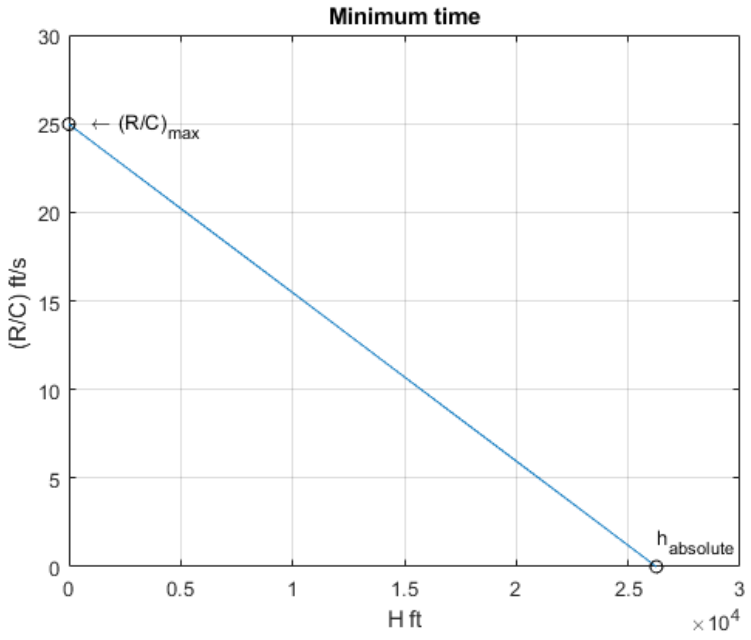
Max. Range $= 6.38 \times 10^6$ ft

- Endurance "E" $= \frac{\eta}{C}\frac{C_L^{3/2}}{C_D}(2\rho_\infty S)^{1/2}(W_1^{1/2} - W_0^{1/2})$

$= 5.19 \times 10^4 \text{ s} \simeq 14.4167 \text{ hr}$

Endurance $= 14.4167$ hr





Questions	Performance Variable (imperial units)		Calculated value
How fast in level flight?	Maximum speed	V_{max}	264 ft/s
How slow in level flight? (in landing, in takeoff)	Minimum Speed	V_{min}	97.196 ft/s
	Stall Speed	V_{stall}	97.196 ft/s
How fast can a powered A/C Climb?	Max. Rate of climb	$(R/C)_{max}$	24.9606
How far can a powered/unpowered A/C travel?	Maximum Range	R_{max}	6.38e6 ft (powered) 136e3 ft (gliding)
How high can it reach?	Max. Alt Ceiling	h_{abs}	27000 ft
	(absolute & service)	h_s	25000 ft
How steep can it clear an obstacle?	Max. Climb angle	θ_{max}	0.0982 rad
How long does it take to reach a specific altitude?	Min. Time to climb	t_{min}	24.34 min
How long can it stay in the air?	Max. Endurance	E_{max}	14.4167 hr