Appendix D:

Python Aircraft Optimization

import math as M

"""

Plane Parameters (Change This)

"""

AR = 3.5 #Aspect Ratio

SweepLE = 0 #Leading Edge Sweep [deg]

TR = 0.7 #Taper Ratio

S = 19.027 #Lifting Surface Area [ft^2]

b = 1 # Wingspan

Wto = 11 #Takeoff Weight [lb]

PropThrust = 6.05 #Propeller Thrust [lbf]

"""

Required Functions for Solution

"""

def sweep(SweepLE,TR,AR):

return M.atan(M.tan(SweepLE)-((1-TR)/AR\*(1+TR)))

def cl3d(SweepQuarter,Cl2d):

return 0.9\*Cl2d\*M.cos(SweepQuarter)

def clto(Cl3d):

return Cl3d\*0.8

def vto(Wto,S,RhoTO,Clmaxto):

return ((2\*Wto)/(S\*RhoTO\*Clmaxto))\*\*0.5

def sexp(S,Sfuselage):

return S - Sfuselage

def cm(S,b):

return S/b

def cdo(Cfe,S,Sexposed):

return Cfe\*(Sexposed/S)

def k(AReff,e):

return 1/(M.pi\*AReff\*e)

def cdi(K,Clmin):

return K\*(Clmin\*\*2)

def cdto(CDo,CDi):

return CDo + CDi

def lto(RhoTO,S,Clmin,Vto):

return 0.5\*RhoTO\*S\*Clmin\*(0.7\*Vto)\*\*2

def dto1(RhoTO,S,CDto,Vto):

return 0.5\*RhoTO\*S\*CDto\*(0.7\*Vto)\*\*2

def amean(G,Wto,PropThrust,Dto,Fc,Lto):

return (G/Wto)\*(PropThrust-Dto-Fc\*(Wto-Lto))

def sg(Vto,Amean):

return (0.7\*(Vto\*\*2))/(2\*Amean)

def vclimb(PropThrust,Dto,Wto,Vto):

return ((PropThrust - Dto)/Wto)\*Vto

def mach(Vto):

return (Vto)/1126

def beta2(Mach):

return 1-(Mach\*\*2)

def calalfa(AReff,Beta2,AirfoilE,SweepMaxt,Sexposed,S,F):

return ((2\*M.pi\*(AReff))/(2+((4 +(((AReff)\*\*2\*Beta2)/AirfoilE\*\*2)\*(1 +(M.tan(SweepMaxt)\*\*2/Beta2)))\*\*0.5)))\*(Sexposed/S)\*F

def clcruise(CLalfa,AoA):

return CLalfa\*AoA

def vcruise(RhoCruise,CLcruise,Wto,S):

return ((2/(RhoCruise\*CLcruise))\*(Wto/S))\*\*0.5

def tr(G,LoadF,Vcruise):

return ((G\*((LoadF\*\*2)-1)\*\*0.5)/Vcruise)\*57.3

"""

Processing Steps

"""

#flight parameters

RhoTO = 0.00227

RhoCruise = 0.002176

G = 32.2

#Airplane Parameter

Cfe = 0.0055

Fc = 0.03

#Surface Area of fuselage only obtained through XFLR5 [ft^2]

Sfuselage = 10.4

Cl2d = 1.68

SweepMaxt = 0

AoA = 10

AReff = 1.2\*AR

SweepQuarter = sweep(SweepLE,TR,AR)

Cl3d = cl3d(SweepQuarter,Cl2d)

Clmaxto = clto(Cl3d)

Clmin = 0.5368

#Take off Velocity

Vto = vto(Wto,S,RhoTO,Clmaxto)

#Exposed Surface

Sexposed = sexp(S,Sfuselage)

Cmac = cm(S,b)

#Calculation of Take Off Drag Coeff

e = 1.78\*(1-(0.045\*(AR\*\*0.68)))-0.64

K = k(AReff,e)

CDo = cdo(Cfe,S,Sexposed)

CDi = cdi(K,Clmin)

CDto = cdto(CDo,CDi)

#Calculation of Mean Take off Acceleration

Lto = lto(RhoTO,S,Clmin,Vto)

Dto = dto1(RhoTO,S,CDto,Vto)

Amean = amean(G,Wto,PropThrust,Dto,Fc,Lto)

#Calculation of Take Off Distance

SG = sg(Vto,Amean)

# Climb Rate

VClimb = vclimb(PropThrust,Dto,Wto,Vto)

#Calculation of Wing Lift Slope & Cruise Lift Coefficient

Mach = mach(Vto)

Beta2 = beta2(Mach)

F = 0.98

AirfoilE = 0.95

CLalfa = calalfa(AReff,Beta2,AirfoilE,SweepMaxt,Sexposed,S,F)

CLcruise = clcruise(CLalfa,AoA)

#Calculation of Cruise Velocity, Thrust & Lift

Vcruise = vcruise(Wto,RhoCruise,CLcruise,S)

#Turn Rate

LoadF = 1.3

TurnRate = tr(G,LoadF,Vcruise)

"""

Output

"""

print("Takeoff Velocity [ft/s]:\t"),

print(Vto)

print("Lift Force at Takeoff [lbf]:\t"),

print(Lto)

print("Takeoff Drag [lbf]:\t\t"),

print(Dto)

print("Mean Acceleration [ft/s^2]:\t"),

print(Amean)

print("Takeoff Distance [ft]:\t\t"),

print(SG)

print("Climb Velocity [ft/s]:\t\t"),

print(VClimb)

print("Coeff of Lift at Cruise [lbf]:\t"),

print(CLcruise)

print("Velocity at Cruise [ft/s]:\t"),

print(Vcruise)

print("Turn Rate [deg/s]:\t\t"),

print(TurnRate)

print("Exposed Surface Area [ft^2]:\t"),

print(Sexposed)

"""

End

"""