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```
clc
clear all
close all
```

Quiz Week 2

```
p = 0.2360; % Pressure Ratio (35,000 ft SL)
rho = .953;   % Density ratio sea level (84F hot day)
PAX = 250;
taper = .35;
Tech = 1; % 1 = Conventional, 0 = Adv. Tech
Airfoil = 1; % 1 = Conventional, 0 = Supercritical
TOFL = 9000; % Feet
Range = 6000; %* 6076.12; % Nautical Miles to Feet
fuel_used = 0;
W_Cargo = 8000; % Pounds
Cruise_Alt = 35000; % Feet
M_cruise = 0.80;
SOS = 576; % @ 35,000 ft in knots
V_approach = 140; %* 1.68781; % Knots to ft/s
Engine_Num = 2;
Engine_Type = 0; % 1 = JT8D
N_aisle= 2;
N_abreast = 7;
IN = 1; % Domestic Rules
```

Initialization

```
AR_min = 5;
AR_max = 20;
AR_step = .5;
i_max = (AR_max - AR_min)/AR_step + 1;

sweep_min = 0;
```

```
sweep_max = 30;
sweep_step = 2.5;
j_max = (sweep_max - sweep_min)/sweep_step + 1;
```

Cl Convergence

```
for sweep1 = 10:5:35

    for i = 1:1:i_max

        AR1 = AR_min + (i-1)*AR_step;
%  AR1 = 15;
        AR(i) = AR1;

        Aj_f=0;
        Range_allout = 1;
        V_cruise = M_cruise*SOS; % Cruise Velocity
        R_ao = Range + 200 + V_cruise*.75;

        while abs(R_ao - Range_allout) > 10

            Cl = .5; % Guess Cl
            Cl_f = .1;

            while abs(Cl_f - Cl) > .05
                if Airfoil == 1
                    DeltaM_div = -0.3496*Cl + 0.1921;
                elseif Airfoil == 0
                    DeltaM_div = 0.8245*Cl^3 - 1.7586*Cl^2 + 1.0304*Cl -
0.1718;
                end
                M_div = (M_cruise + .004) - DeltaM_div;

                if Airfoil == 1
                    if sweep1 < 10
                        TC = ((-0.6171*M_div + 0.5644) - (-0.6348*M_div +
0.5732))*((sweep1 - 5)/(10 - 5)) + (-0.6348*M_div + 0.5732);
                    elseif sweep1 >= 10 && sweep1 < 15
                        TC = ((-0.5933*M_div + 0.5516) - (-0.6179*M_div +
0.5639))*((sweep1 - 10)/(15 - 10)) + (-0.6179*M_div + 0.5639);
                    elseif sweep1 >= 15 && sweep1 < 20
                        TC = ((-0.5667*M_div + 0.5378) - (-0.5933*M_div +
0.5516))*((sweep1 - 15)/(20 - 15)) + (-0.5933*M_div + 0.5516);
                    elseif sweep1 >= 20 && sweep1 < 25
                        TC = ((-0.5323*M_div + 0.5189) - (-0.5667*M_div +
0.5378))*((sweep1 - 20)/(25 - 20)) + (-0.5667*M_div + 0.5378);
                    elseif sweep1 >= 25 && sweep1 < 30
                        TC = ((-0.5047*M_div + 0.5057) - (-0.5323*M_div +
0.5189))*((sweep1 - 25)/(30 - 25)) + (-0.5323*M_div + 0.5189);
                    elseif sweep1 >= 30 && sweep1 < 35
                        TC = ((-0.4673*M_div + 0.4854) - (-0.5047*M_div +
0.5057))*((sweep1 - 30)/(35 - 30)) + (-0.5047*M_div + 0.5057);
                    elseif sweep1 >= 35 && sweep1 < 40
                        TC = ((-0.4292*M_div + 0.4649) - (-0.4673*M_div +
0.4854))*((sweep1 - 35)/(40 - 35)) + (-0.4673*M_div + 0.4854);
                    elseif sweep1 == 40
                        TC = -0.4292*M_div + 0.4649;
                    end
                end

                if Airfoil == 0
                    if sweep1 >= 0 && sweep1 < 5
                        TC = ((15.1147*exp(-6.6227*M_div) +
7.2596*10^6*exp(-28.8216*M_div)) - (0.2809*exp(-2.2459*M_div) +
463.1043*exp(-12.0909*M_div)))*((sweep1 - 0)/(5 - 0)) +
(0.2809*exp(-2.2459*M_div) + 463.1043*exp(-12.0909*M_div));
                    elseif sweep1 >= 5 && sweep1 < 10
                        TC = ((14.4804*exp(-6.4949*M_div) +
2.2228*10^6*exp(-27.1108*M_div)) - (15.1147*exp(-6.6227*M_div) +
7.2596*10^6*exp(-28.8216*M_div)))*((sweep1 - 5)/(10 - 5)) +
(15.1147*exp(-6.6227*M_div) + 7.2596*10^6*exp(-28.8216*M_div));
                    elseif sweep1 >= 10 && sweep1 < 15
                        TC = ((11.5069*exp(-6.0790*M_div) +
2.0833*10^7*exp(-29.8909*M_div)) - (14.4804*exp(-6.4949*M_div) +
2.2228*10^6*exp(-27.1108*M_div)))*((sweep1 - 10)/(15 - 10)) +
(14.4804*exp(-6.4949*M_div) + 2.2228*10^6*exp(-27.1108*M_div));
                    elseif sweep1 >= 15 && sweep1 < 20
                        TC = ((11.7020*exp(-5.9514*M_div) +
8.2563*10^8*exp(-34.9086*M_div)) - (11.5069*exp(-6.0790*M_div) +
2.0833*10^7*exp(-29.8909*M_div)))*((sweep1 - 15)/(20 - 15)) +
(11.5069*exp(-6.0790*M_div) + 2.0833*10^7*exp(-29.8909*M_div));
                    elseif sweep1 >= 20 && sweep1 < 25
                        TC = ((2.1536*10^8*exp(-31.7782*M_div)
+ 11.5437*exp(-5.7878*M_div)) - (11.7020*exp(-5.9514*M_div) +
8.2563*10^8*exp(-34.9086*M_div)))*((sweep1 - 20)/(25 - 20)) +
(11.7020*exp(-5.9514*M_div) + 8.2563*10^8*exp(-34.9086*M_div));
                    elseif sweep1 >= 25 && sweep1 < 30
                        TC = ((116.7257*exp(-8.5913*M_div) +
0.0008*exp(3.6374*M_div)) - (2.1536*10^8*exp(-31.7782*M_div) +
11.5437*exp(-5.7878*M_div)))*((sweep1 - 25)/(30 - 25)) +
(2.1536*10^8*exp(-31.7782*M_div) + 11.5437*exp(-5.7878*M_div));
                    elseif sweep1 >= 30 && sweep1 < 35
                        TC = ((72.9298*exp(-7.5603*M_div) +
2.2249*10^14*exp(-47.0361*M_div)) - (116.7257*exp(-8.5913*M_div) +
0.0008*exp(3.6374*M_div)))*((sweep1 - 30)/(35 - 30)) +
(116.7257*exp(-8.5913*M_div) + 0.0008*exp(3.6374*M_div));
                    elseif sweep1 >= 35 && sweep1 < 40
                        TC = ((1.3588*10^-11*exp(22.6706*M_div) +
2.0835*10^4*exp(-13.7095*M_div)) - (72.9298*exp(-7.5603*M_div) +
2.2249*10^14*exp(-47.0361*M_div)))*((sweep1 - 35)/(40 - 35)) +
((72.9298*exp(-7.5603*M_div) + 2.2249*10^14*exp(-47.0361*M_div)));
                    elseif sweep1 >= 40
                        TC = 1.3588*10^-11*exp(22.6706*M_div) +
2.0835*10^4*exp(-13.7095*M_div);
                    end
                end
                cc = cosd(sweep1).^2.*TC.^2.*AR1;
                Clmax_takeoff = -15.7160*exp(-4.2422*cc) +
16.7680*exp(-2.9683*cc);
                Clmax_landing = 3.3287*exp(0.3480*cc) +
-1.4142*exp(-13.6025*cc); %
                WS_landing = (V_approach/1.3)^2*((rho*Clmax_landing)/296); %
Wing Loading Landing
                R_ao = Range + 200 + .75*V_cruise;

                if Engine_Type == 1 % Select Engine
                    WF_WT = 0.3804*exp(0*R_ao) - 0.3789*exp(-0.0003*R_ao) +
Aj_f;
                elseif Engine_Type == 0
                    WF_WT = (0.3804*exp(0*R_ao) - 0.3789*exp(-0.0003*R_ao))
* 0.7820512 + Aj_f; % Scaled for JT9D
                end

                WS_takeoff = WS_landing/(1-fuel_used*WF_WT);
                WS_IC = WS_takeoff*0.965;
                Cl_f = WS_IC/(1481*M_cruise^2*p);

                if Cl_f>Cl
                    Cl = Cl + 0.01;
                else
                    Cl = Cl - 0.01;
                end
            end
```

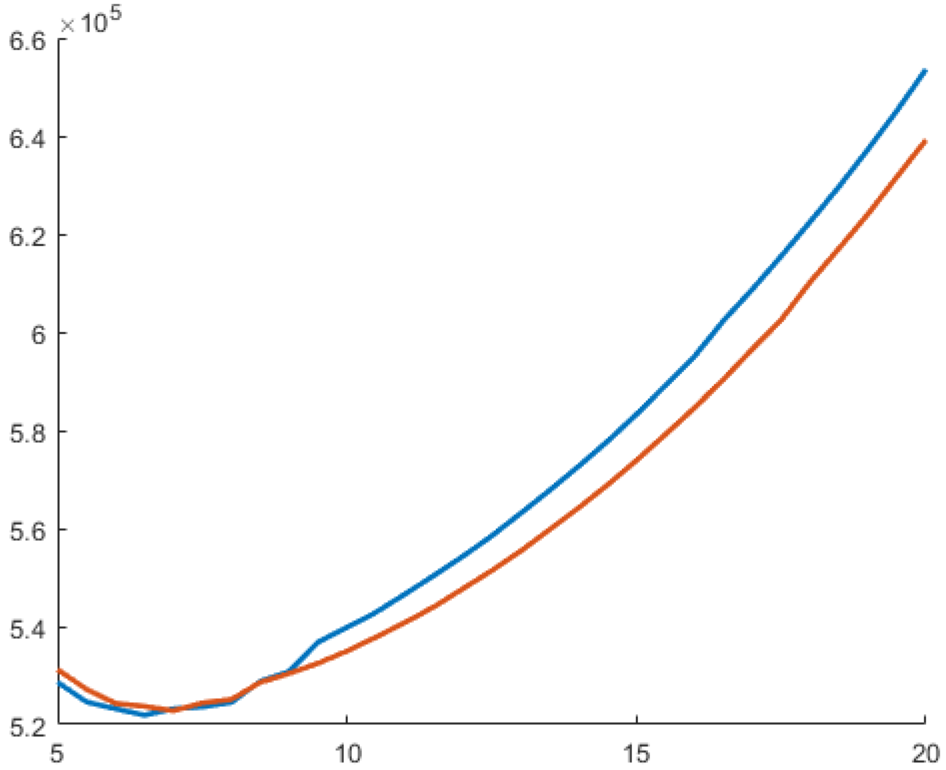
Max Thrust Sizing

```
            if Engine_Num == 2
                X = 28.2045*(TOFL*10^-3) - 8.0939;
                WT_VLO_70 = (X*rho*Clmax_takeoff)/(WS_takeoff);
            end

            V_LO = 1.2*sqrt((296*WS_takeoff)/(rho*Clmax_takeoff));
            M_LO = V_LO/SOS/sqrt(rho);
            M_7LO = .7*M_LO;

            if Engine_Type == 0 % JT9D Selection
                TSLST = 45500;
                T_7M = (40.8149*exp(-1.3944*M_7LO) +
4.6534*exp(1.6605*M_7LO))*1000;
            end

            WT_STATIC = WT_VLO_70*(T_7M/TSLST);
```



Weight Calculations

```
            k_w = 1.00; % Wing Engines
            k_f = 11.5; % PAX > 135
            k_ts = .17; % Wing Engines
            n = 1.5*2.5;

% Wing
            if Tech == 1
                W_Wing = ((.00945*AR1^.8*(1+taper)^.25*k_w*n^.5)/
(TC^.4*cosd(sweep1)*WS_takeoff^.695))*.94;
            elseif Tech == 0
                W_Wing = ((.00945*AR1^.8*(1+taper)^.25*k_w*n^.5)/
(TC^.4*cosd(sweep1)*WS_takeoff^.695))*.70;
            end

% Fuselage
            Fuselage_Length = (3.76*(PAX/N_abreast) + 33.2)*IN;
            Fuselage_Diameter = (1.75*N_abreast + 1.58*N_aisle + 1)*IN;

            if Tech == 1
                W_Fuse =
(.6727*k_f*Fuselage_Length^.6*Fuselage_Diameter^.72*n)*.94;
            elseif Tech == 0
                W_Fuse =
(.6727*k_f*Fuselage_Length^.6*Fuselage_Diameter^.72*n)*.85;
            end

% Landing Gear
            W_LG = .040;

% Nacelle & Pylons
            if Tech == 1
                W_NP = .0555/WT_STATIC;
            elseif Tech == 0
                W_NP = (.0555/WT_STATIC)*0.8;
            end

% Tail Surface
            if Tech == 1
                W_TS = (k_ts*W_Wing)*0.94;
            elseif Tech == 0
                W_TS = (k_ts*W_Wing)*0.85;
            end

% Power Plant
            if Tech == 1
                W_PP = 1/(3.58*WT_STATIC);
            elseif Tech == 0
                W_PP = (1/(3.58*WT_STATIC))*1.10;
            end

% Fuel
            W_F = 1.0275*WF_WT;
            W_Tank = .0175*W_F;
            Fuel_Unusable = .01*W_F;

% Payload
            W_P = PAX*215 + W_Cargo;

% Fixed Equipment
            if Tech == 1
                W_FE =  132*PAX + 300*Engine_Num + 260*2 + 170*(PAX/50);
            elseif Tech == 0
                W_FE =  (132*PAX + 300*Engine_Num + 260*2 + 170*(PAX/
50))*0.9;
            end

            FC = 2;
            CA = PAX/50;

            a = W_Wing;
            B = W_Fuse;
            C = W_LG + W_NP + W_PP + W_F + .035 - 1;
            DD = W_P + W_FE;

            W_TO = 400000; % Guess Weight
            while a*W_TO^1.195 + B*W_TO^.235 + C*W_TO + DD > 1000 % Adjust
tolerances as nessesary; these are obviouly too much
```

```
                a*W_TO^1.195 + B*W_TO^.235 + C*W_TO + DD;
                if a*W_TO^1.195 + B*W_TO^.235 + C*W_TO + DD < 1000
                    W_TO = W_TO - 100; % Adjust increment as nessesary to
prevent over/undershooting correct value
                else
                    W_TO = W_TO + 100;
                end
            end

            W_TO1(i) = W_TO;

            S = W_TO/WS_takeoff;
            b = sqrt(AR1*S);
            c_avg = S/b;
            Thrust = W_TO/WT_STATIC;
            T_e = Thrust/Engine_Num;
```

Drag

```
            Rn = (7.36627*10^-4*V_cruise)/(3.01681*10^-7);

% Wing & Tail
            Rn_wing =Rn*c_avg;
            Cf_wing = (230.7517*Rn_wing^-0.2891 + 1.0836)/1000;
            K_wing = 0.2328*exp(9.1022*TC) - 0.2337*exp(-11.4513*TC);
            Swet_wing = 2*1.02*(S - Fuselage_Diameter*30);
            f_wing = K_wing.*Cf_wing.*Swet_wing;
            f_tail = f_wing*.38;

% Fuselage
            LD_fuselage = Fuselage_Length/Fuselage_Diameter;
            Rn_fuselage = Rn*Fuselage_Length;
            Cf_fuselage = (230.7517*Rn_fuselage^-0.2891 + 1.0836)/1000;
            K_fuselage = 4.8900*exp(-0.9110*LD_fuselage) +
1.3902*exp(-0.0243*LD_fuselage);
            Swet_fuselage = .9*pi*Fuselage_Diameter*Fuselage_Length;
            f_fuselage = Cf_fuselage*Swet_fuselage*K_fuselage;

% Nacelle & Pylons
            Swet_nacelle = 2.1*Engine_Num*(T_e)^.5;
            f_nacelle = 1.25*Cf_wing*Swet_nacelle;
            f_pylon = .20*f_nacelle;

% Total
            f_total = (f_wing + f_fuselage + f_tail + f_nacelle +
f_pylon)*1.06;
            Cd_0 = f_total/S;
            e = 1/(1.035 + .38*Cd_0*pi*AR1);
```

Climb

```
            W_climb = 0.9825*W_TO;
            V_climb = (1.3*12.9)/(f_total*e)^(1/4)*sqrt(W_climb/(.5702*b));
```

```
% Knots
            M_climb = V_climb/SOS;
            T_climb = (.5702*f_total*V_climb^2)/296 + 94.1/
(.5702*.852)*(W_climb/b)^2*(1/(V_climb^2)); % Required Climb Thrust

% Climb Thrust and SFC at 20,000 ft
            if Engine_Type == 0
                if Tech == 1
                    T_a_JT9D_20k = (((-7.7840*M_climb^4 +
15.3111*M_climb^3 - 7.1619*M_climb^2 - 2.7651*M_climb + 16.3830) +
(5.0094*exp(-4.5144*M_climb) + 22.3030*exp(-0.3502*M_climb)))/2)*1000;
                    SFC_20k = ((0.3684*M_climb + 0.3434) + (0.1104*M_climb^2
+ 0.3203*M_climb + 0.3448))/2;
                elseif Tech == 0
                    T_a_JT9D_20k = (((-7.7840*M_climb^4 +
15.3111*M_climb^3 - 7.1619*M_climb^2 - 2.7651*M_climb + 16.3830) +
(5.0094*exp(-4.5144*M_climb) + 22.3030*exp(-0.3502*M_climb)))/2)*1000;
                    SFC_20k = (((0.3684*M_climb + 0.3434) +
(0.1104*M_climb^2 + 0.3203*M_climb + 0.3448))/2)*.9;
                end
            end

            T_a = (T_e/TSLST)*T_a_JT9D_20k;

            RC = (101*V_climb*((T_a*Engine_Num) - T_climb))/W_climb; % ft/min
            time_climb = Cruise_Alt/RC; % min
            range_climb = V_climb*(time_climb/60); % nautical miles
            W_fuel_climb = SFC_20k*Engine_Num*T_a*(time_climb/60); % lbs
```

Range

```
            W_0 = W_TO - W_fuel_climb;
            W_1 = (1 - WF_WT) * W_TO;

            Cl_avg = ((W_0 + W_1)/(2*S))/(1481*p*M_cruise);
            C_Di = Cl_avg^2/(pi*AR1*e);
            C_D = Cd_0 + C_Di + .001;
            LD = Cl_avg/C_D;
            T_req = ((W_0 + W_1)/2)/LD;
            T_req_JTD = (T_req/Engine_Num)*(TSLST/T_e);

            if Engine_Type == 0
                if Tech == 1
                    SFC_35k = 0.9367*exp(-0.5761*(T_req_JTD/1000)) +
0.5352*exp(0.0124*(T_req_JTD/1000));
                elseif Tech == 0
                    SFC_35k = 0.9367*exp(-0.5761*(T_req_JTD/1000)) +
0.5352*exp(0.0124*(T_req_JTD/1000));
                end
            end

            R_cruise = (V_cruise./SFC_35k).*LD.*log(W_0./W_1);
            Range_allout = R_cruise + range_climb;
            WF_WT0 = (W_0-W_1)/W_TO;

            if Range_allout < R_ao
                Aj_f = Aj_f + .0001; % Adjust tolerances as nessesary; these
are obviouly too much
            else
                Aj_f = Aj_f - .0001; % Adjust tolerances as nessesary; these
are obviouly too much
            end

        end
```

Thrust Check

```
        Cl_IC = (W_0/S)/(1481*p*M_cruise^2);
        Cdi_IC = Cl_IC^2/(pi*AR1*e);
        CD_IC = Cd_0 + Cdi_IC + .001;
        LD_IC = Cl_IC/CD_IC;
        Treq_IC = (W_0/LD_IC)/Engine_Num;

        TReqJT9D_IC = Treq_IC*(TSLST/T_e);

        if Engine_Type == 0
            T_avail_cruise = 10000;
        end

        if TReqJT9D_IC > T_avail_cruise
            fprintf('NOT ENOUGH THRUST TOP OF CLIMB')
        end
```

Climb Gradients (TO BE CONTINUED)

```
% 1st Segment %
        Cmb1C_TO = Clmax_takeoff/(1.2^2);
        DeltaCmb1_CD0 = 0.1529*(Cmb1C_TO/Clmax_takeoff)^4 - 0.1377*(Cmb1C_TO/
Clmax_takeoff)^3 + 0.0846*(Cmb1C_TO/Clmax_takeoff)^2 - 0.0701*(Cmb1C_TO/
Clmax_takeoff) + 0.0327;
        Cmb1C_D = Cd_0 + DeltaCmb1_CD0 + .0145 + Cmb1C_TO^2/(pi*AR1*e);
        Cmb1LD_TO = Cmb1C_TO/Cmb1C_D;
        Cmb1T_R = W_TO/Cmb1LD_TO;

        if Engine_Type == 0
            Cmb1T_a = (T_e/TSLST) * T_7M;
        end

        GCmb1Grad = (Engine_Num - 1)*((Cmb1T_a - Cmb1T_R)/W_TO)*100;

        if Engine_Num == 2
            if GCmb1Grad < 0
                fprintf('C 1 Fail')
            end
        elseif Engine_Num == 3
            if GCmb1Grad < .3
```

```
                fprintf('C 1 Fail')
            end
        elseif Engine_Num == 4
            if GCmb1Grad < .5
                fprintf('C 1 Fail')
            end
        end

% 2nd Segment %
        Cmb2C_D  = Cd_0 + DeltaCmb1_CD0 + Cmb1C_TO^2/(pi*AR1*e);
        Cmb2LD_TO = Cmb1C_TO/Cmb2C_D;
        Cmb2T_R  = W_TO/Cmb2LD_TO;
        GCmb2Grad = (Engine_Num - 1)*((Cmb1T_a - Cmb2T_R)/W_TO)*100;

        if Engine_Num==2
            if GCmb2Grad<2.4
                fprintf('C 2 Fail')
            end
        elseif Engine_Num==3
            if GCmb2Grad<2.7
                fprintf('C 2 Fail')
            end
        elseif Engine_Num==4
            if GCmb2Grad<3
                fprintf('C 2 Fail')
            end
        end

% 3rd Segment %
        if sweep1 < 15
            Cmb3Cl_Max = ((-329.6602*TC^3 + 86.4451*TC^2 - 2.7607*TC +
0.8982) - (-316.2418*TC^3 + 81.6642*TC^2 - 2.3432*TC + 0.9419))*((sweep1 -
0)/(15 - 0)) + (-316.2418*TC^3 + 81.6642*TC^2 - 2.3432*TC + 0.9419);
        elseif sweep1 >= 15 && sweep1 < 35
            Cmb3Cl_Max = ((-330.2443*TC^3 + 87.5851*TC^2 - 3.0298*TC +
0.8612) - (-329.6602*TC^3 + 86.4451*TC^2 - 2.7607*TC + 0.8982))*((sweep1 -
15)/(35 - 15)) + (-329.6602*TC^3 + 86.4451*TC^2 - 2.7607*TC + 0.8982);
        elseif sweep1 >= 35
            Cmb3Cl_Max = (-330.2443*TC^3 + 87.5851*TC^2 - 3.0298*TC +
0.8612)*((sweep1 - 35)/(55 - 35)) + (-330.2443*TC^3 + 87.5851*TC^2 -
3.0298*TC + 0.8612);
        end

        Cmb3V = 1.2*sqrt((296*WS_IC)/(.925*Cmb3Cl_Max)); % Altiude
properties at 1000 ft.
        Cmb3M = Cmb3V/SOS;
        Cmb3Cl = Cmb3Cl_Max/(1.2)^2;
        Cmb3C_D = Cd_0 + Cmb3Cl^2/(pi*AR1*e);
        Cmb3LD = Cmb3Cl/Cmb3C_D;
        Cmb3T_R = W_TO/Cmb3LD ;
        Cmb3T_a = T_e/TSLST * 26500;

        GCmb3Grad  = (Engine_Num - 1)*((Cmb3T_a - Cmb3T_R)/W_TO)*100;
        if Engine_Num==2
```

```
            if GCmb3Grad<1.2
                fprintf('C 3 Fail')
            end
        elseif Engine_Num==3
            if GCmb3Grad<1.5
                fprintf('C 3 Fail')
            end
        elseif Engine_Num==4
            if GCmb3Grad<1.7
                fprintf('C 3 Fail')
            end
        end

% Approach %
        ApCl        = Clmax_takeoff/1.3^2;
        Ap_ClClMax = ApCl/Clmax_takeoff;
        ApDeltaCD0 = 0.1529*(ApCl/Clmax_takeoff)^4 - 0.1377*(ApCl/
Clmax_takeoff)^3 + 0.0846*(ApCl/Clmax_takeoff)^2 - 0.0701*(ApCl/
Clmax_takeoff) + 0.0327;
        ApC_D = Cd_0 + ApDeltaCD0 + ApCl^2/(pi*AR1*e);
        ApLD = ApCl/ApC_D;
        ApT_R = (WS_landing*S)/ApLD;
        Ap_V = sqrt((296*WS_landing)/(.953*ApCl)); % Sea Level Hot Day
        ApM = Ap_V/SOS;
        ApTa = T_e/TSLST * 29500;

        GApGrad = (Engine_Num - 1)*((ApTa - ApT_R)/W_TO)*100;

        if Engine_Num==2
            if GApGrad<2.1
                fprintf('Ap Fail')
            end
        elseif Engine_Num==3
            if GApGrad<2.4
                fprintf('Ap 2 Fail')
            end
        elseif Engine_Num==4
            if GApGrad<2.7
                fprintf('Ap 2 Fail')
            end
        end

% Landing %
        LCl = Clmax_landing/1.3^2;
        LClClM = LCl/Clmax_landing;
        LDeltaCD0 = 0.0775*(LCl/Clmax_landing)^3 + 0.0104*(LCl/
Clmax_landing)^2 - 0.0692*(LCl/Clmax_landing) + 0.0412;
        LCD = Cd_0 + LDeltaCD0 + .0145 + LCl^2/(pi*AR1*e);
        LLD = LCl/LCD;
        LT_R = (WS_landing*S)/LLD;
        LV = sqrt((296*WS_landing/(.953*LCl))); % Sea Level Hot Day
        LM = LV/SOS; % Sea Level Hot Day
        LTa = T_e/TSLST * 37200;
        GLGrad = (Engine_Num - 1)*((LTa - LT_R)/W_TO)*100;

        if Engine_Num==2
            if GLGrad<3.2
                fprintf('Landing Fail')
            end
        elseif Engine_Num==3
            if GLGrad<3.2
                fprintf('Landing Fail')
            end
        elseif Engine_Num==4
            if GLGrad<3.2
                fprintf('Landing Fail')
            end
        end
```

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```

Direct Operating Cost

```
% Block Speed
        K_a = 1.02;
        D = Range * 1.15; % Statute Miles
        D_CL = range_climb*1.15;
        T_GM = 0.25; % Hours
        T_CL = time_climb/60; % Time to CLimb in Hours
        T_D = 0;
        T_AM = .1;
        T_CR = (D*K_a + 20 - D_CL)/(V_cruise*1.15);

        V_B = D/(T_GM + T_CL + T_D + T_AM + T_CR);

% Block Time
        T_B = T_AM + T_CL + T_D + T_CR + T_GM;

% Block Fuel
        F_CL = W_fuel_climb;
        F_CR_AM = T_req*SFC_35k*(T_CR + T_AM);

        F_B = F_CL + F_CR_AM;

% Flight Operations Cost

% Flight Crew
        P = ((165*PAX+50*PAX)+W_Cargo)/2000; % Tons
        dollar_blockhour = 17.849*(V_B*(W_TO/(1*10^5)))^.3 + 40.83;     %
What is Vc?
        CTM_Crew = dollar_blockhour/(V_B*P);

% Fuel & Oil
        C_F = .40*(1/6.4);
        C_O_T = 2.15; % Cost of Oil
        CTM_Fuel = (1.02*F_B*C_F + Engine_Num*C_O_T*T_B*.135)/(D*P);

% Hull Insurance
        W_A = W_TO*(1-.390) - W_F - W_P - W_TO*(.1046);
        C_A = 2.4*10^6 + 87.5*W_A;
        C_E = 590000 + 16*T_e;
        C_T = C_A + Engine_Num*C_E;
        IR = .01; % Insurance Rate
        U = 630 + 4000/(1 + 1/(T_B + .5));
        CTM_Hull = (IR*C_T)/(U*V_B*P);

% Direct Maintenance

% Airframe-Labor
        K_FHA = 4.9169*log10(W_A/(1*10^3)) - 6.425;
        K_FCA = 0.21256*(log10(W_A/(1*10^3)))^3.7375;
        T_F = T_B - T_AM;
        R_L = 8.60; % Labor Rate
        CTM_AFL = R_L*(K_FHA*T_F + K_FCA)/(V_B*T_B*P);
```

```
% Airframe Material
        C_FHA = (1.5994*C_A)/(1*10^6) + 3.4263;
        C_FCA = (1.9229*C_A)/(1*10^6) + 2.2504;
        CTM_AFM = (C_FHA*T_F + C_FCA)/(V_B*T_B*P);

% Engine-Labor
        K_FHE = (Engine_Num*(T_e/(1*10^3)))/(.82715*(T_e/(1*10^3) + 13.639));
        K_FCE = .20*Engine_Num;

        if Tech == 1
            CTM_EL = R_L*(K_FHE*T_F + K_FCE)/(V_B*T_B*P);
        elseif Tech == 0
            CTM_EL = (R_L*(K_FHE*T_F + K_FCE)/(V_B*T_B*P))*1.10;
        end

% Engine-Material
        C_FHE = Engine_Num*(28.2353*C_E/(1*10^6) - 6.5176);
        C_FCE = Engine_Num*(3.6698*C_E/(1*10^6) + 1.3685);

        if Tech == 1
            CTM_EM = (C_FHE*T_F + C_FCE)/(V_B*T_B*P);
        elseif Tech == 0
            CTM_EM = ((C_FHE*T_F + C_FCE)/(V_B*T_B*P))*1.10;
        end

% Total Maintenance - Burdened
        CTM_TM = (CTM_AFL + CTM_AFM + CTM_EL + CTM_EM)*2;

% Depreciation
        Da = 14; % Years to 10% Value
        CTM_DA = 1/(V_B*P)*(C_T + .06*(C_T - Engine_Num*C_E) +
.3*Engine_Num*C_E)/(Da*U);

% Total DOC

        DOC_Total = CTM_Crew + CTM_Fuel + CTM_Hull + CTM_TM + CTM_DA; % $/
Ton*Mile
        DOC_Passenger = DOC_Total*(P/PAX);

        DOC(i) = DOC_Passenger;

    end
    figure(1)
    hold on
    plot(AR,W_TO1,'LineWidth', 2);
end

legend('Sweep = 15 degs','Sweep = 20 degs','Sweep = 25 degs','Sweep = 30
degs','Sweep = 35 degs')
title('Takeoff Weight vs. Aspect Ratio for Conventional Aircraft')
    xlabel('Aspect Ratio (AR)')
    ylabel('Weight (lbs)')
    grid on
    hold off
```

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