HYPERSONIC FLOWS

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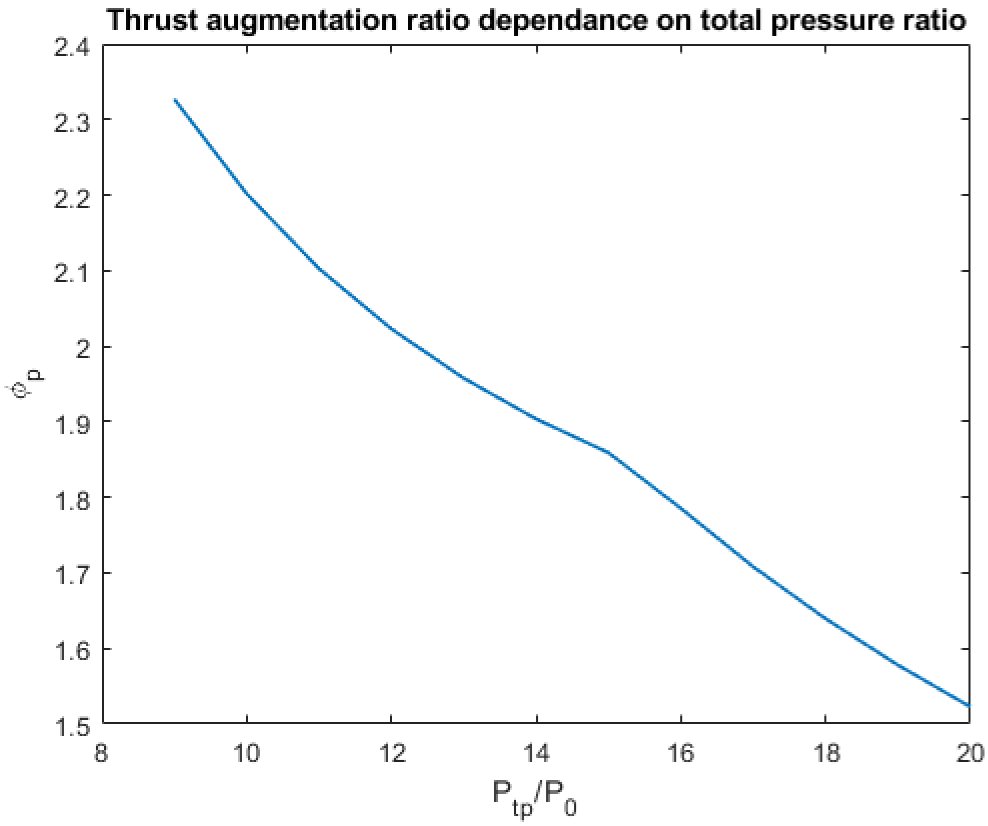
```
clear all
close all
```

Varying P_tp/P_0

```
M02=0;
%Primary flow
pp_p02=[9:1:20];  %pressure ratio
tp_t02=10;          %temperature ratio
a_ap2=12;           %area ratio
g=1.35;             %heat air coefficient
% Secondary flow
ps_p02=1.18;
ts_t02=1.044;
% Exhaust flow
p10_p02=1;
t10_tp2=1;
dp2=.0001;
pi_p02=zeros(10000);
pi_p02(1)=(2/(g+1))^(g/(g-1))+dp2;   %inlet plane static pressure
                                     %initial guess

for i=1:length(pp_p02)
    for j=1:10000
            %eq. 8.26
            mp2(i,j)=sqrt((2/(g-1))*((pp_p02(i)/pi_p02(j))^((g-1)/
g)-1));
            %eq. 8.27
            api_aps2(i,j)=(1/mp2(i,j))*((2/(g+1))*(1+((g-1)/2)*...
                mp2(i,j)^2))^((g+1)/(2*(g-1)));
            %eq. 8.28
            api_a2(i,j)=api_aps2(i,j)/a_ap2;
            %eq. 8.29
            asi_a2(i,j)=1-api_a2(i,j);
            %eq. 8.30
            msi2(i,j)=sqrt((2/(g-1))*((ps_p02/pi_p02(j))^((g-1)/
g)-1));
```

```
            %eq. 8.31 (bypass ratio eqn)
            alpha2(i,j)=ps_p02/pp_p02(i)*asi_a2(i,j)/api_a2(i,j)*...
                (msi2(i,j)/mp2(i,j))*sqrt(tp_t02/
ts_t02)*((1+((g-1)/2)...
                *mp2(i,j)^2)/(1+((g-1)/2)*msi2(i,j)^2))^((g+1)/
(2*(g-1)));
            %eq. 8.32
            te_tp2(i,j)=(2/(g+1))*((1+alpha2(i,j)*ts_t02/tp_t02)/...
                (1+alpha2(i,j)));
            %eq. 8.33
            pe_p02(i,j)=(1+alpha2(i,j))*pp_p02(i)/a_ap2*...
                sqrt(te_tp2(i,j))*(2/(g+1))^((g+1)/(2*(g-1)));
            %calculating the ratio at eqn 8.34
            nr2(i,j)=pe_p02(i,j)*(g+1);
            dr2(i,j)=pi_p02(j)*(api_a2(i,j)*(1+g*mp2(i,j)^2)+...
                asi_a2(i,j)*(1+g*msi2(i,j)^2));
            ratio2(i,j)=nr2(i,j)/dr2(i,j);
            %in order to obtain a correct result, the ratio must be
 equal
            %to 1 (or very close to it!). Hence, we are going to know
 that
            %our inlet pressure guess was correct.
            if (ratio2(i,j)-1)<10e-50
                pratio2(i)=pi_p02(j);
                %eqn 8.35
                pte_p02(i)=pe_p02(i,j)*((g+1)/2)^(g/(g-1));
                k2(i)=alpha2(i,j);
                %eq. 8.37
                mp02(i)=sqrt((2/(g-1))*(pp_p02(i)^((g-1)/g)-1));
                %eq. 8.38
                v0_vp02(i)=(M02/mp02(i))*(ts_t02/
tp_t02*((1+((g-1)/2)...
                    *mp02(i)^2)/(1+((g-1)/2)*M02^2)))^(1/2);
                %eq. 8.39
                m102(i)=sqrt((2/(g-1))*(pte_p02(i)^((g-1)/g)-1));
                %eq. 8.40
                v10_vp02(i)=(m102(i)/
mp02(i))*(t10_tp2*((1+((g-1)/2)*...
                    mp02(i)^2)/(1+((g-1)/2)*m102(i)^2)))^(1/2);
                %eq. 8.36
                phi2(i)=(1+k2(i))*v10_vp02(i)-k2(i)*v0_vp02(i);
                break
            else
                %incrementing of a small value our initial guess in
 case
                %our ratio did not satisfy the unity
                pi_p02(j+1)=pi_p02(j)+dp2;
            end
        end
end
%plotting
figure(2)
plot(pp_p02,phi2,'LineWidth',1.2)
title('Thrust augmentation ratio dependance on total pressure ratio')
```

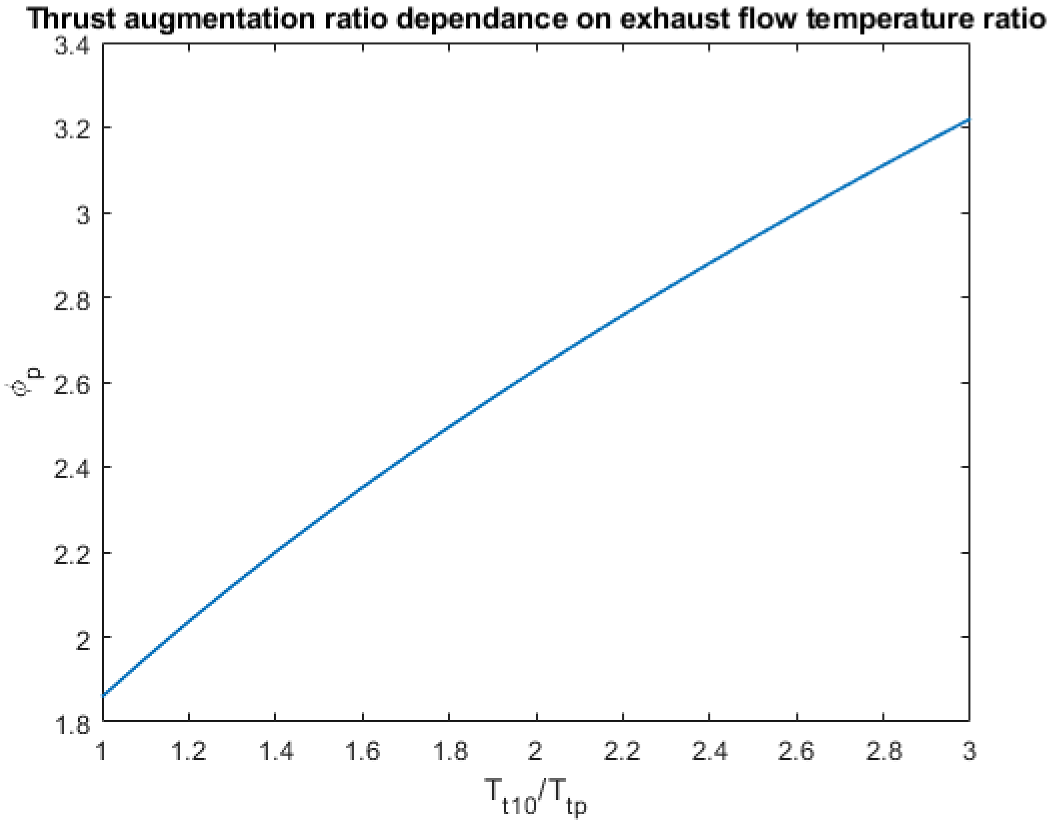
```
xlabel('{P_t_p}/{P_0}')
ylabel('\phi_p')
```



Varying T_t10/T_p

```
M0=0;              %mach numbers

% Primary flow
pp_p0=15;
tp_t0=10;
a_ap=12;
g=1.35;

% Secondary flow
ps_p0=1.18;
ts_t0=1.044;

% Exhaust flow
p10_p0=1;
t10_tp=[1:0.1:3];


dp=.0001;
pi_p0(1)=(2/(g+1))^(g/(g-1))+dp;
for i=1:10000
        mp(i)=sqrt((2/(g-1))*((pp_p0/pi_p0(i))^((g-1)/g)-1));
```

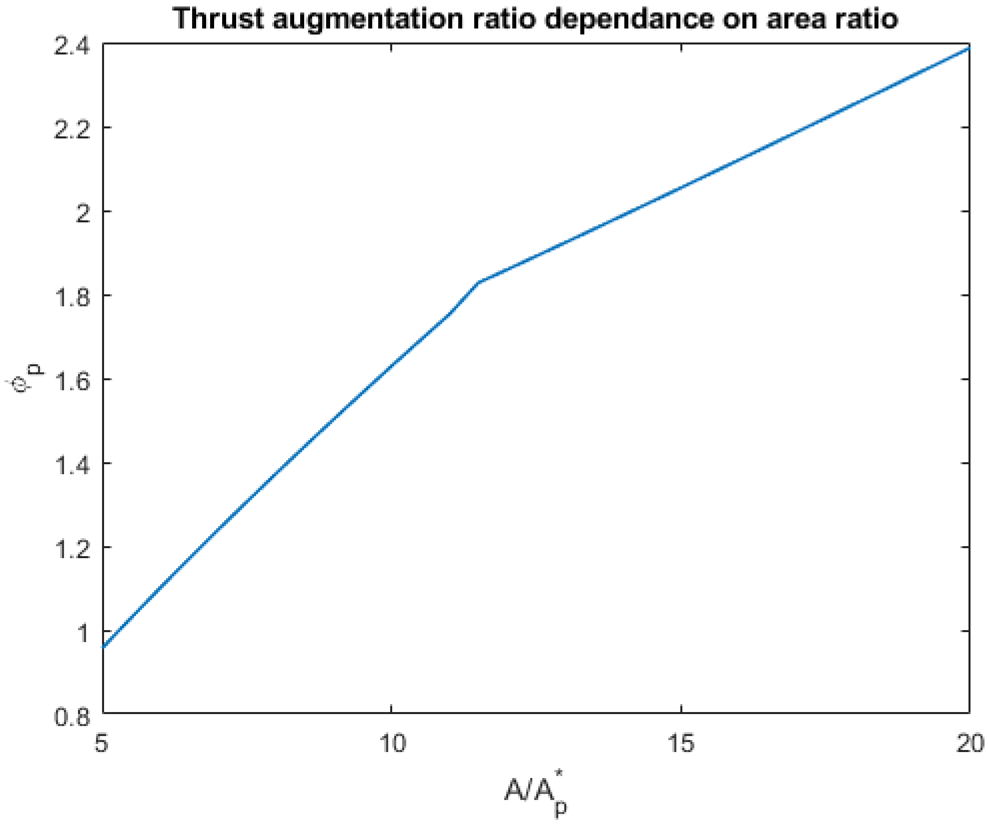
```
        api_aps(i)=(1/mp(i))*((2/(g+1))*(1+((g-1)/2)*...
            mp(i)^2))^((g+1)/(2*(g-1)));
        api_a(i)=api_aps(i)/a_ap;
        asi_a(i)=1-api_a(i);
        msi(i)=sqrt((2/(g-1))*((ps_p0/pi_p0(i))^((g-1)/g)-1));
        alpha(i)=ps_p0/pp_p0*asi_a(i)/api_a(i)*(msi(i)/mp(i))*...
            sqrt(tp_t0/ts_t0)*((1+((g-1)/2)*mp(i)^2)/(1+((g-1)/2)*...
            msi(i)^2))^((g+1)/(2*(g-1)));
        te_tp(i)=(2/(g+1))*((1+alpha(i)*ts_t0/tp_t0)/(1+alpha(i)));
        pe_p0(i)=(1+alpha(i))*pp_p0/a_ap*sqrt(te_tp(i))*(2/(g+1))...
            ^((g+1)/(2*(g-1)));
        nr(i)=pe_p0(i)*(g+1);

 dr(i)=pi_p0(i)*(api_a(i)*(1+g*mp(i)^2)+asi_a(i)*(1+g*msi(i)^2));
        ratio(i)=nr(i)/dr(i);
        if (ratio(i)-1)<10e-50
            pratio=pi_p0(i);
            pte_p0=pe_p0(i)*((g+1)/2)^(g/(g-1));
            k=alpha(i);
            break
        else
            pi_p0(i+1)=pi_p0(i)+dp;
        end
end

mp0=sqrt((2/(g-1))*(pp_p0^((g-1)/g)-1));
for i=1:length(t10_tp)
    v0_vp0(i)=(M0/mp0)*(ts_t0/tp_t0*((1+((g-1)/2)*mp0^2)/...
        (1+((g-1)/2)*M0^2)))^(1/2);
    m10=sqrt((2/(g-1))*(pte_p0^((g-1)/g)-1));
    v10_vp0=(m10/mp0)*(t10_tp(i)*((1+((g-1)/2)*mp0^2)/...
        (1+((g-1)/2)*m10^2)))^(1/2);
    phi(i)=(1+k)*v10_vp0-k*v0_vp0(i);
end
figure(1)
plot(t10_tp,phi,'LineWidth',1.2)
title('Thrust augmentation ratio dependance on exhaust flow
 temperature ratio')
xlabel('{T_t_1_0}/{T_t_p}')
ylabel('\phi_p')
```



Varying A/A_p

```
M03=0;
%Primary flow
pp_p03=15;
tp_t03=10;
a_ap3=[5:0.5:20];
g=1.35;
% Secondary flow
ps_p03=1.18;
ts_t03=1.044;
% Exhaust flow
p10_p03=1;
t10_tp3=1;
dp3=.0001;
pi_p03=zeros(10000);
pi_p03(:)=(2/(g+1))^(g/(g-1))+dp3;

for i=1:length(a_ap3)
    for j=1:10000
            mp3(i,j)=sqrt((2/(g-1))*((pp_p03/pi_p03(j))^((g-1)/g)-1));
            api_aps3(i,j)=(1/mp3(i,j))*((2/(g+1))*(1+((g-1)/2)...
                *mp3(i,j)^2))^((g+1)/(2*(g-1)));
            api_a3(i,j)=api_aps3(i,j)/a_ap3(i);
            asi_a3(i,j)=1-api_a3(i,j);
```

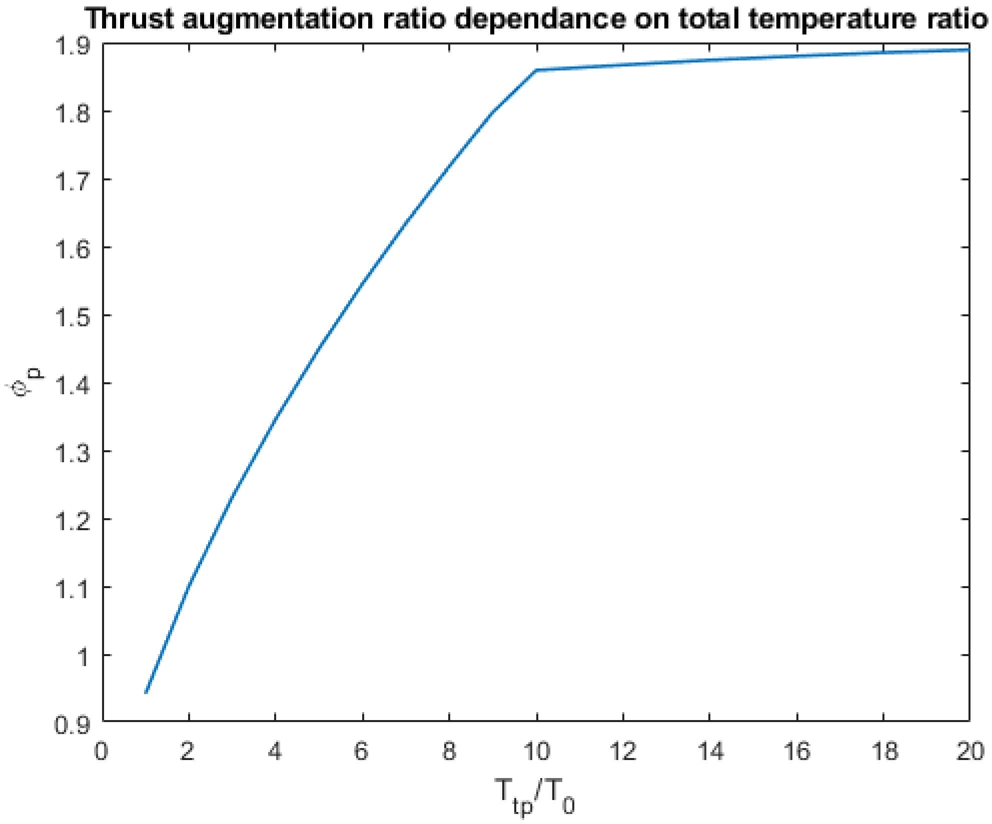
```
            msi3(i,j)=sqrt((2/(g-1))*((ps_p03/pi_p03(j))^((g-1)/
g)-1));
            alpha3(i,j)=ps_p03/pp_p03*asi_a3(i,j)/api_a3(i,j)*...
                (msi3(i,j)/mp3(i,j))*sqrt(tp_t03/ts_t03)*...
                ((1+((g-1)/2)*mp3(i,j)^2)/...
                (1+((g-1)/2)*msi3(i,j)^2))^((g+1)/(2*(g-1)));
            te_tp3(i,j)=(2/(g+1))*((1+alpha3(i,j)*ts_t03/...
                tp_t03)/(1+alpha3(i,j)));
            pe_p03(i,j)=(1+alpha3(i,j))*pp_p03/a_ap3(i)*...
                sqrt(te_tp3(i,j))*(2/(g+1))^((g+1)/(2*(g-1)));
            nr3(i,j)=pe_p03(i,j)*(g+1);
            dr3(i,j)=pi_p03(j)*(api_a3(i,j)*(1+g*mp3(i,j)^2)+...
                asi_a3(i,j)*(1+g*msi3(i,j)^2));
            ratio3(i,j)=nr3(i,j)/dr3(i,j);
            if (ratio3(i,j)-1)<10e-50
                pratio3(i)=pi_p03(j);
                pte_p03(i)=pe_p03(i,j)*((g+1)/2)^(g/(g-1));
                k3(i)=alpha3(i,j);
                mp03(i)=sqrt((2/(g-1))*(pp_p03^((g-1)/g)-1));
                v0_vp03(i)=(M03/mp03(i))*(ts_t03/
tp_t03*((1+((g-1)/2)...
                    *mp03(i)^2)/(1+((g-1)/2)*M03^2)))^(1/2);
                m103(i)=sqrt((2/(g-1))*(pte_p03(i)^((g-1)/g)-1));
                v10_vp03(i)=(m103(i)/
mp03(i))*(t10_tp3*((1+((g-1)/2)...
                    *mp03(i)^2)/(1+((g-1)/2)*m103(i)^2)))^(1/2);
                phi3(i)=(1+k3(i))*v10_vp03(i)-k3(i)*v0_vp03(i);
                break
            else
                pi_p03(j+1)=pi_p03(j)+dp3;
            end
    end
end
figure(3)
plot(a_ap3,phi3,'LineWidth',1.2)
title('Thrust augmentation ratio dependance on area ratio')
xlabel('{A}/{A^*_p}')
ylabel('\phi_p')
```



Varying T_tp/T_0

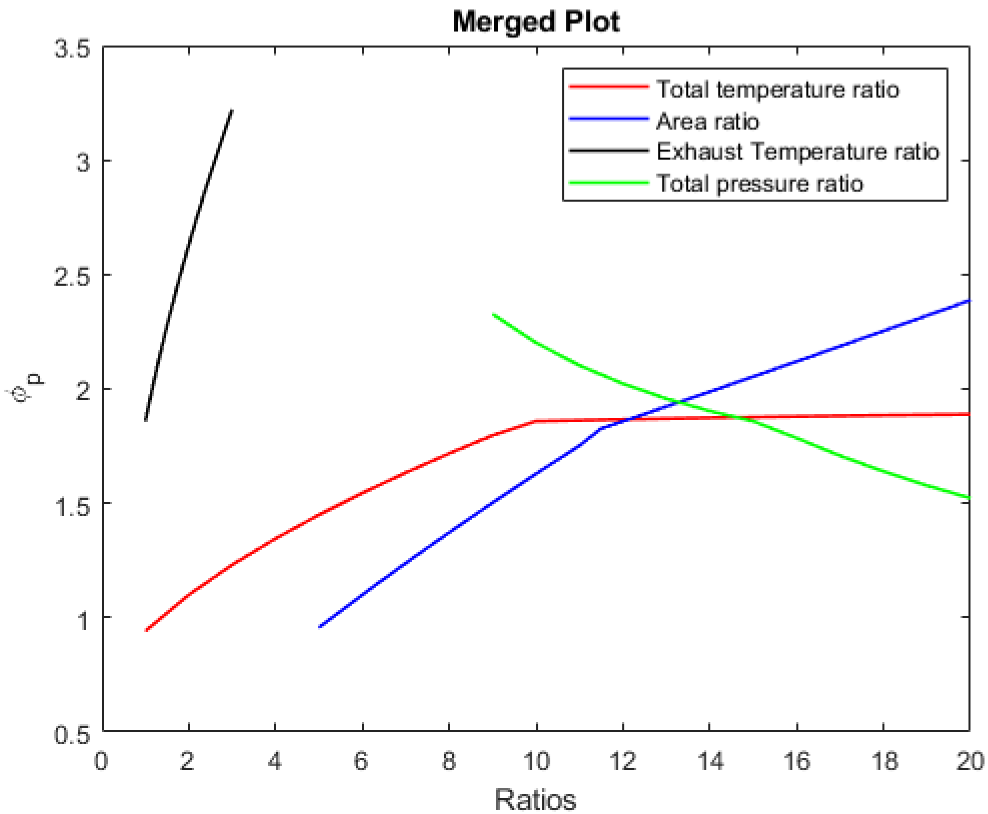
```
M04=0;
%Primary flow
pp_p04=15;
tp_t04=[1:1:20];
a_ap4=12;
g=1.35;
% Secondary flow
ps_p04=1.18;
ts_t04=1.044;
% Exhaust flow
p10_p04=1;
t10_tp4=1;
dp4=.0001;
pi_p04=zeros(10000);
pi_p04(:)=(2/(g+1))^(g/(g-1))+dp4;

for i=1:length(tp_t04)
    for j=1:10000
            mp4(i,j)=sqrt((2/(g-1))*((pp_p04/pi_p04(j))^((g-1)/g)-1));
            api_aps4(i,j)=(1/mp4(i,j))*((2/(g+1))*(1+((g-1)/2)...
                *mp4(i,j)^2))^((g+1)/(2*(g-1)));
            api_a4(i,j)=api_aps4(i,j)/a_ap4;
            asi_a4(i,j)=1-api_a4(i,j);
```

```
            msi4(i,j)=sqrt((2/(g-1))*((ps_p04/pi_p04(j))^((g-1)/
g)-1));
            alpha4(i,j)=ps_p04/pp_p04*asi_a4(i,j)/api_a4(i,j)*...
                (msi4(i,j)/mp4(i,j))*sqrt(tp_t04(i)/ts_t04)*...
                ((1+((g-1)/2)*mp4(i,j)^2)/...
                (1+((g-1)/2)*msi4(i,j)^2))^((g+1)/(2*(g-1)));
            te_tp4(i,j)=(2/(g+1))*((1+alpha4(i,j)*ts_t04/tp_t04(i))...
                /(1+alpha4(i,j)));
            pe_p04(i,j)=(1+alpha4(i,j))*pp_p04/
a_ap4*sqrt(te_tp4(i,j))*...
                (2/(g+1))^((g+1)/(2*(g-1)));
            nr4(i,j)=pe_p04(i,j)*(g+1);
            dr4(i,j)=pi_p04(j)*(api_a4(i,j)*(1+g*mp4(i,j)^2)+...
                asi_a4(i,j)*(1+g*msi4(i,j)^2));
            ratio4(i,j)=nr4(i,j)/dr4(i,j);
            if (ratio4(i,j)-1)<10e-50
                pratio4(i)=pi_p04(j);
                pte_p04(i)=pe_p04(i,j)*((g+1)/2)^(g/(g-1));
                k4(i)=alpha4(i,j);
                mp04(i)=sqrt((2/(g-1))*(pp_p04^((g-1)/g)-1));
                v0_vp04(i)=(M04/mp04(i))*(ts_t04/tp_t04(i)*...
                    ((1+((g-1)/2)*mp04(i)^2)/...
                    (1+((g-1)/2)*M04^2)))^(1/2);
                m104(i)=sqrt((2/(g-1))*(pte_p04(i)^((g-1)/g)-1));
                v10_vp04(i)=(m104(i)/
mp04(i))*(t10_tp4*((1+((g-1)/2)...
                    *mp04(i)^2)/(1+((g-1)/2)*m104(i)^2)))^(1/2);
                phi4(i)=(1+k4(i))*v10_vp04(i)-k4(i)*v0_vp04(i);
                break
            else
                pi_p04(j+1)=pi_p04(j)+dp4;
            end
    end
end
figure(4)
plot(tp_t04,phi4,'LineWidth',1.2)
title('Thrust augmentation ratio dependance on total temperature
 ratio')
xlabel('{T_t_p}/{T_0}')
ylabel('\phi_p')
```



Final Plot

```
figure(5)
plot(tp_t04,phi4,'-r','LineWidth',1.2)
hold on
plot(a_ap3,phi3,'-b','LineWidth',1.2)
hold on
plot(t10_tp,phi,'-k','LineWidth',1.2)
hold on
plot(pp_p02,phi2,'-g','LineWidth',1.2)
hold on
legend('Total temperature ratio','Area ratio','Exhaust Temperature
 ratio','Total pressure ratio')
xlabel('Ratios')
ylabel('\phi_p')
title('Merged Plot')
```



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