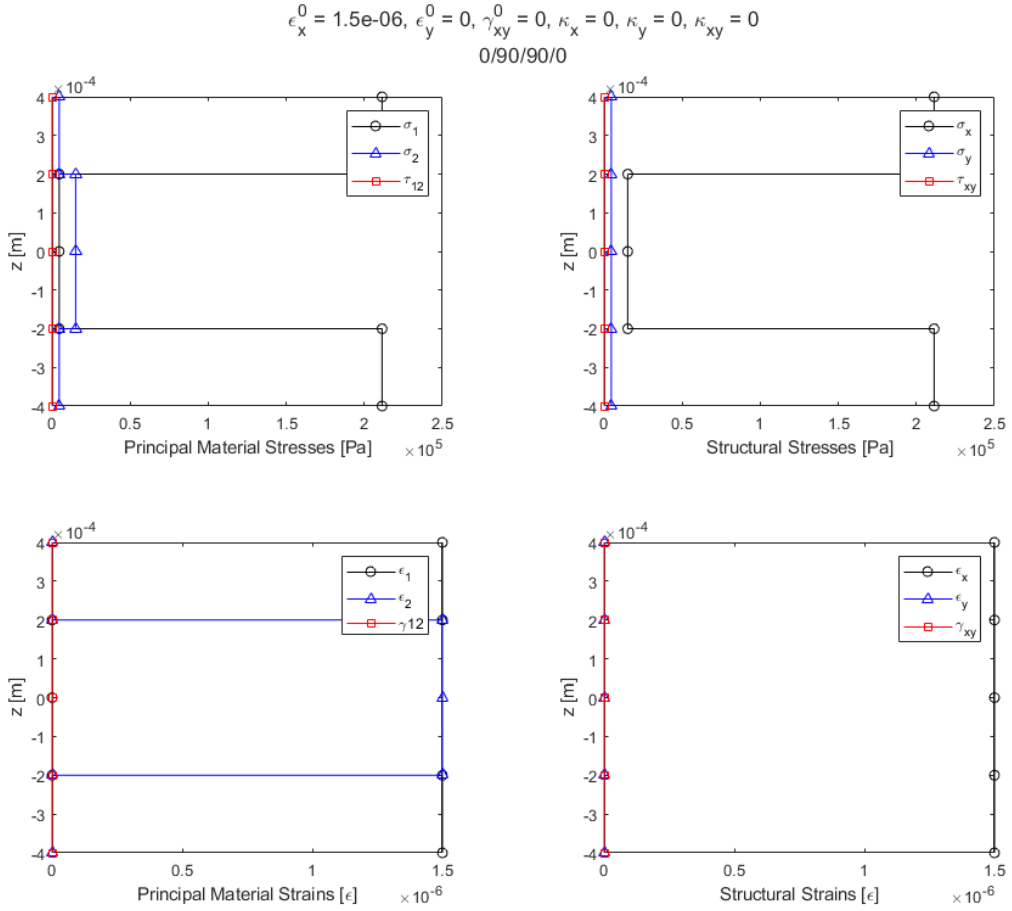
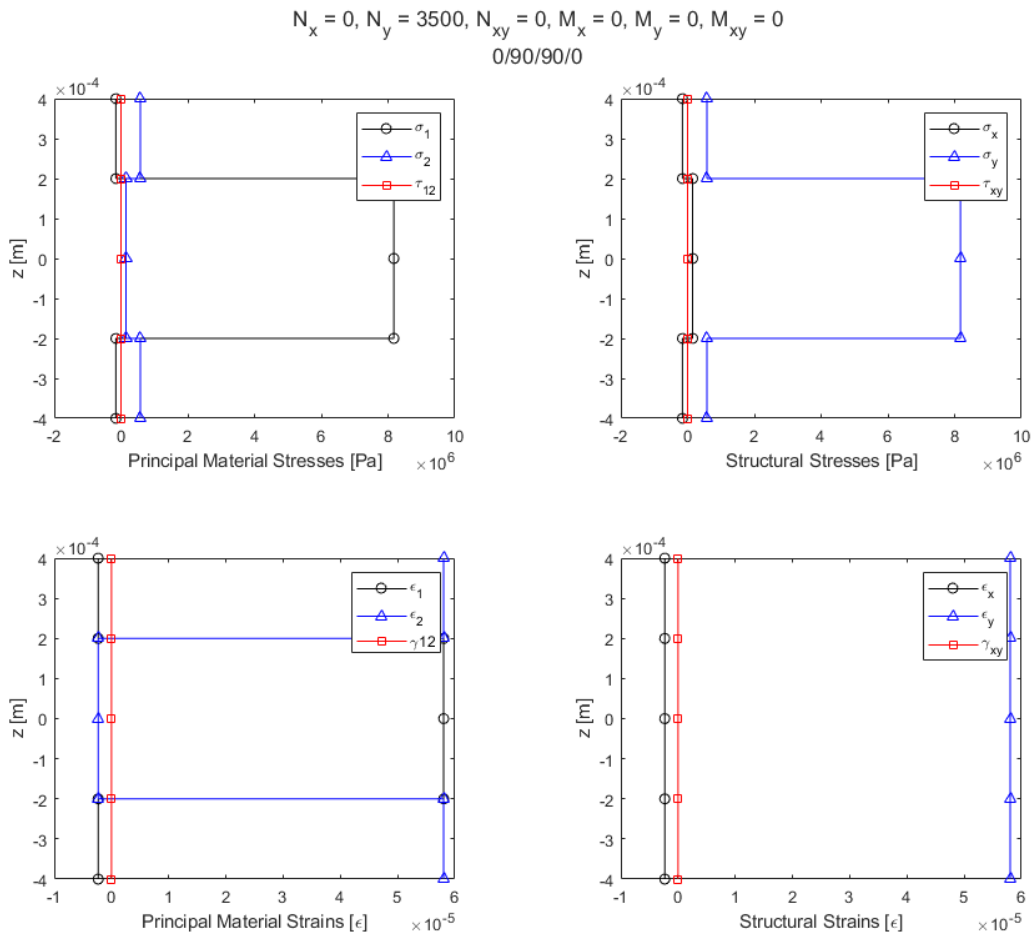
Part A:


ϵ_x^0 = 1.5e-06, ϵ_y^0 = 0, γ_{xy}^0 = 0, κ_x = 0, κ_y = 0, κ_{xy} = 0
0/90/90/0
Principal Material Stresses [Pa]
Structural Stresses [Pa]
Principal Material Strains [ϵ]
Structural Strains [ϵ]
z [m]

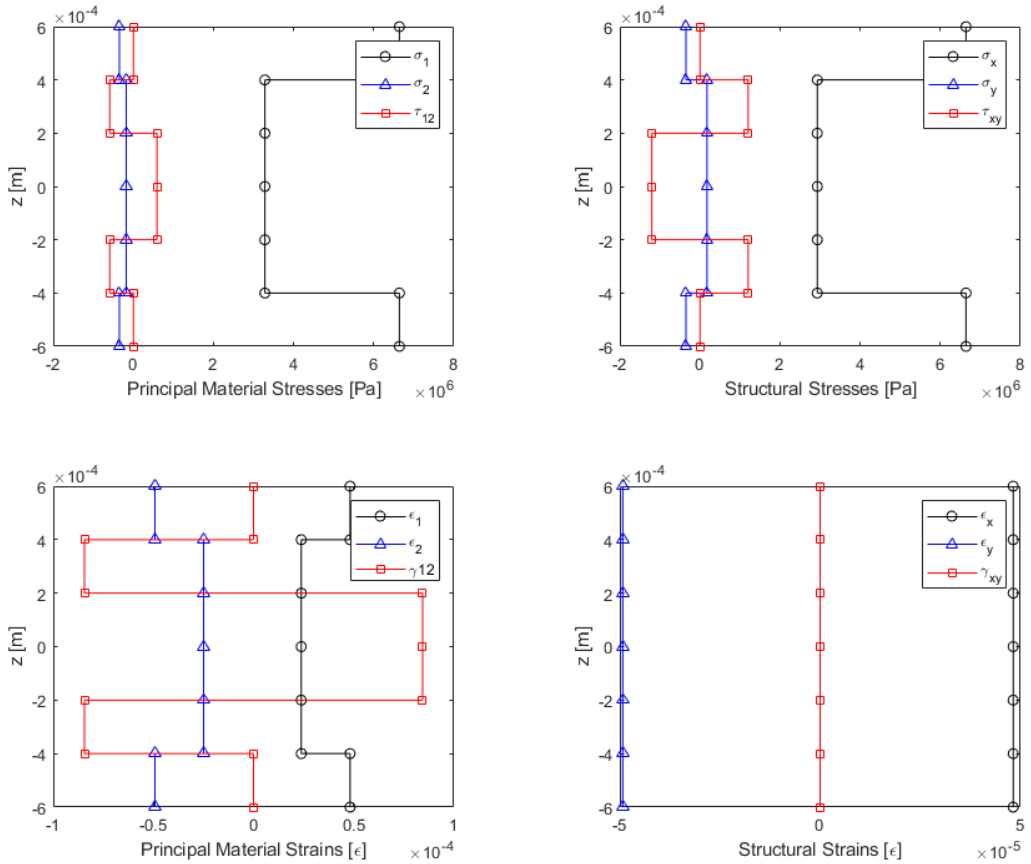
Part B:


$N_x = 0, N_y = 3500, N_{xy} = 0, M_x = 0, M_y = 0, M_{xy} = 0$
0/90/90/0
$\times 10^{-4}$
z [m]
σ_1
σ_2
τ_{12}
Principal Material Stresses [Pa]
$\times 10^{6}$
σ_x
σ_y
τ_{xy}
Structural Stresses [Pa]
ϵ_1
ϵ_2
γ_{12}
Principal Material Strains [ϵ]
$\times 10^{-5}$
ϵ_x
ϵ_y
γ_{xy}
Structural Strains [ϵ]

Part C:

$N_x = 5000$, $N_y = 0$, $N_{xy} = 0$, $M_x = 0$, $M_y = 0$, $M_{xy} = 0$

0/30/-30/-30/30/0



MAIN:

```
clc;clear;close all;

laminate = [140e9,10e9,7e9,0.3,0.0002,0;...
            140e9,10e9,7e9,0.3,0.0002,90;...
            140e9,10e9,7e9,0.3,0.0002,90;...
            140e9,10e9,7e9,0.3,0.0002,0];
%Part a
epsx0=1500e-9;
epsy0=0;
gammaxy0=0;
kx=0;
ky=0;
kxy=0;

midplaneStrainCurvature2StressStrainLaminate(epsx0,epsy0,gammaxy0,kx,ky,kxy,l
aminate);

%Part B
Nx=0;
Ny=3500;
Nxy=0;
Mx=0;
My=0;
Mxy=0;

forces2StressStrainLaminate(laminate,Nx,Ny,Nxy,Mx,My,Mxy);

%Part C
laminate = [140e9,10e9,7e9,0.3,0.0002,0;...
            140e9,10e9,7e9,0.3,0.0002,30;...
            140e9,10e9,7e9,0.3,0.0002,-30;...
            140e9,10e9,7e9,0.3,0.0002,-30;...
            140e9,10e9,7e9,0.3,0.0002,30;...
            140e9,10e9,7e9,0.3,0.0002,0];

Nx=5000;
Ny=0;

forces2StressStrainLaminate(laminate,Nx,Ny,Nxy,Mx,My,Mxy);
```

FUNCTIONS:

```
function
[sigmax,sigmay,tauxy,sigma1,sigma2,tau12,epsx,epsy,gammaxy,eps1,eps2,gamma12]
=midplaneStrainCurvature2StressStrainLaminate(epsx0,epsy0,gammaxy0,kx,ky,kxy,
laminate)
    [E1s,E2s,G12s,v12s,thicknesses,thetas] = laminateReader(laminate);

    [epsx,epsy,gammaxy] =
strainLaminateStructural(epsx0,epsy0,gammaxy0,kx,ky,kxy,thicknesses);
    [eps1,eps2,gamma12] = strainLaminatePrincipal(epsx,epsy,gammaxy,thetas);

[sigmax,sigmay,tauxy]=strain2stressStructural(epsx,epsy,gammaxy,thetas,E1s,E2
s,G12s,v12s);

[sigma1,sigma2,tau12]=stressLaminatePrincipal(sigmax,sigmay,tauxy,thetas);


    distances=laminateDistances(thicknesses);
    figure
    plots = tiledlayout(2,2);
    nexttile
    plot(sigma1,distances,'k-o',sigma2,distances,'b-^',tau12,distances,'r-
square')
    xlabel('Principal Material Stresses [Pa]')
    ylabel('z [m]')
    legend('\sigma_{1}','\sigma_{2}','\tau_{12}')
    nexttile
    plot(sigmax,distances,'k-o',sigmay,distances,'b-^',tauxy,distances,'r-
square')
    xlabel('Structural Stresses [Pa]')
    ylabel('z [m]')
    legend('\sigma_{x}','\sigma_{y}','\tau_{xy}')
    nexttile
    plot(eps1,distances,'k-o',eps2,distances,'b-^',gamma12,distances,'r-
square')
    xlabel('Principal Material Strains [\epsilon]')
    ylabel('z [m]')
    legend('\epsilon_{1}','\epsilon_{2}','\gamma{12}')
    nexttile
    plot(epsx,distances,'k-o',epsy,distances,'b-^',gammaxy,distances,'r-
square')
    xlabel('Structural Strains [\epsilon]')
    ylabel('z [m]')
    legend('\epsilon_{x}','\epsilon_{y}','\gamma_{xy}')
    set(gcf,'position',[90,90,1000,800])

    titleLine1=['\epsilon_{x}^{0} = ',num2str(epsx0),', \epsilon_{y}^{0} =
',num2str(epsy0),', \gamma_{xy}^{0} = ',num2str(gammaxy0),', \kappa_{x} =
',num2str(kx),', \kappa_{y} = ',num2str(ky),', \kappa_{xy} = ',num2str(kxy)];
    titleLine2=num2str(thetas(1));
    for i=2:length(thetas)
        titleLine2=[titleLine2,'/',num2str(thetas(i))];
    end
    title(plots,{titleLine1,titleLine2})
end
```

```
function
[sigmax,sigmay,tauxy,sigma1,sigma2,tau12,epsx,epsy,gammaxy,eps1,eps2,gamma12]
=forces2StressStrainLaminate(laminate,Nx,Ny,Nxy,Mx,My,Mxy)
    [E1s,E2s,G12s,v12s,thicknesses,thetas] = laminateReader(laminate);
    [epsx0,epsy0,gammaxy0,kx,ky,kxy] =
midPlaneStrainsCurvature(Nx,Ny,Nxy,Mx,My,Mxy,thicknesses,thetas,E1s,E2s,G12s,
v12s);
    [epsx,epsy,gammaxy] =
strainLaminateStructural(epsx0,epsy0,gammaxy0,kx,ky,kxy,thicknesses);
    [eps1,eps2,gamma12] = strainLaminatePrincipal(epsx,epsy,gammaxy,thetas);

[sigmax,sigmay,tauxy]=strain2stressStructural(epsx,epsy,gammaxy,thetas,E1s,E2
s,G12s,v12s);

[sigma1,sigma2,tau12]=stressLaminatePrincipal(sigmax,sigmay,tauxy,thetas);



    distances=laminateDistances(thicknesses);
    figure
    plots = tiledlayout(2,2);
    nexttile
    plot(sigma1,distances,'k-o',sigma2,distances,'b-^',tau12,distances,'r-
square')
    xlabel('Principal Material Stresses [Pa]')
    ylabel('z [m]')
    legend('\sigma_{1}','\sigma_{2}','\tau_{12}')
    nexttile
    plot(sigmax,distances,'k-o',sigmay,distances,'b-^',tauxy,distances,'r-
square')
    xlabel('Structural Stresses [Pa]')
    ylabel('z [m]')
    legend('\sigma_{x}','\sigma_{y}','\tau_{xy}')
    nexttile
    plot(eps1,distances,'k-o',eps2,distances,'b-^',gamma12,distances,'r-
square')
    xlabel('Principal Material Strains [\epsilon]')
    ylabel('z [m]')
    legend('\epsilon_{1}','\epsilon_{2}','\gamma{12}')
    nexttile
    plot(epsx,distances,'k-o',epsy,distances,'b-^',gammaxy,distances,'r-
square')
    xlabel('Structural Strains [\epsilon]')
    ylabel('z [m]')
    legend('\epsilon_{x}','\epsilon_{y}','\gamma_{xy}')
    set(gcf,'position',[90,90,1000,800])

    titleLine1=['N_{x} = ',num2str(Nx),', N_{y} = ',num2str(Ny),', N_{xy} =
',num2str(Nxy),', M_{x} = ',num2str(Mx),', M_{y} = ',num2str(My),', M_{xy} =
',num2str(Mxy)];
    titleLine2=num2str(thetas(1));
    for i=2:length(thetas)
        titleLine2=[titleLine2,'/',num2str(thetas(i))];
    end
    title(plots,{titleLine1,titleLine2})
end
```

```
function [E1s,E2s,G12s,v12s,thicknesses,thetas] = laminateReader(laminate)
    % Creates vectors of elastic properties of laminate where each row is a
    layer
    % and the laminate matrix is:
    %           E1    E2    G12    v12    thickness    theta
    % Layer 1   X     X      X      X         X          X
    % Layer 2   X     X      X      X         X          X
    %   .       X     X      X      X         X          X
    %   .       X     X      X      X         X          X
    %   .       X     X      X      X         X          X
    % Layer N   X     X      X      X         X          X

    E1s=laminate(:,1);
    E2s=laminate(:,2);
    G12s=laminate(:,3);
    v12s=laminate(:,4);
    thicknesses=laminate(:,5);
    thetas=laminate(:,6);
end
```

```
function [epsx0,epsy0,gammaxy0,kx,ky,kxy] =
midPlaneStrainsCurvature(Nx,Ny,Nxy,Mx,My,Mxy,thicknesses,thetas,E1s,E2s,G12s,
v12s)
    ABDmatrixINV =
laminateStiffnessMatrixINV(thicknesses,thetas,E1s,E2s,G12s,v12s);
    epsk=ABDmatrixINV*[Nx;Ny;Nxy;Mx;My;Mxy];
    epsx0=epsk(1);
    epsy0=epsk(2);
    gammaxy0=epsk(3);
    kx=epsk(4);
    ky=epsk(5);
    kxy=epsk(6);
end
```

```
function [epsx,epsy,gammaxy] =
strainLaminateStructural(epsx0,epsy0,gammaxy0,kx,ky,kxy,thicknesses)
    distances=laminateDistances(thicknesses);
    N=length(distances);
    epsx=zeros(1,N);
    epsy=zeros(1,N);
    gammaxy=zeros(1,N);
    for i=1:N
        epsx(i)=epsx0+(distances(N)*kx);
        epsy(i)=epsy0+(distances(N)*ky);
        gammaxy(i)=gammaxy0+(distances(N)*kxy);
    end
end
```

```
function [eps1,eps2,gamma12] =
strainLaminatePrincipal(epsx,epsy,gammaxy,thetas)
    N=length(epsx);
    eps1=zeros(1,N);
    eps2=zeros(1,N);
    gamma12=zeros(1,N);
    for i=2:2:N
        strainTrans=strainTransformationMatrix(thetas(i/2));
        principleStrains=strainTrans*[epsx(i);epsy(i);gammaxy(i)];
        eps1(i)=principleStrains(1);
        eps1(i-1)=eps1(i);
        eps2(i)=principleStrains(2);
        eps2(i-1)=eps2(i);
        gamma12(i)=principleStrains(3);
        gamma12(i-1)=gamma12(i);
    end
end


function
[sigmax,sigmay,tauxy]=strain2stressStructural(epsx,epsy,gammaxy,thetas,E1s,E2
s,G12s,v12s)
    N=length(epsx);
    sigmax=zeros(1,N);
    sigmay=zeros(1,N);
    tauxy=zeros(1,N);
    for i=2:2:N
        Qbar =
transReducedStiffnessMatrix(E1s(i/2),E2s(i/2),G12s(i/2),v12s(i/2),thetas(i/2));
        stress=Qbar*[epsx(i);epsy(i);gammaxy(i)];
        sigmax(i)=stress(1);
        sigmax(i-1)=stress(1);
        sigmay(i)=stress(2);
        sigmay(i-1)=stress(2);
        tauxy(i)=stress(3);
        tauxy(i-1)=stress(3);
    end
end


function
[sigma1,sigma2,tau12]=stressLaminatePrincipal(sigmax,sigmay,tauxy,thetas)
    N=length(sigmax);
    sigma1=zeros(1,N);
    sigma2=zeros(1,N);
    tau12=zeros(1,N);
    for i=2:2:N
        stressTrans = stressTransformationMatrix(thetas(i/2));
        principalStresses = stressTrans*[sigmax(i);sigmay(i);tauxy(i)];
        sigma1(i)=principalStresses(1);
        sigma1(i-1)=principalStresses(1);
        sigma2(i)=principalStresses(2);
        sigma2(i-1)=principalStresses(2);
        tau12(i)=principalStresses(3);
        tau12(i-1)=principalStresses(3);
    end
end
```