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```
clear all; clc; close all
```

Question 1

Part a

```
vf = [0.6-0.05, 0.6+0.05];
vm = ones(1, length(vf)) - vf;

Em = 2.4e9;
Ef = 120e9;
nuM = 0.35;
nuF = 0.32;
Gm = Em/(2*(1 + 0.35));
Gf = Ef/(2*(1 + 0.32));

Ex = (vf*Ef + vm*Em)*1e-9
Ey = (1./(1/Ef * vf + 1/Em * vm))*1e-9
vxy = nuF*vf + nuM*vm
Gxy = (1./(1/Gf * vf + 1/Gm * vm))*1e-9
```

Part b

```
Exavg = mean(Ex)
Exstd = std(Ex)

Eyavg = mean(Ey)
Eystd = std(Ey)

vxyavg = mean(vxy)
vxystd = std(vxy)
```

```
Gxyavg = mean(Gxy)
Gxystd = std(Gxy)


Ex =

   67.0800   78.8400


Ey =

    5.2061    6.6116


vxy =

    0.3335    0.3305


Gxy =

    1.9292    2.4507


Exavg =

   72.9600


Exstd =

    8.3156


Eyavg =

    5.9088


Eystd =

    0.9938


vxyavg =

    0.3320


vxystd =

    0.0021
```

```
Gxyavg =

    2.1899


Gxystd =

    0.3687
```

Question 2

```
Ex = 181;
Ey = 10.3;
vxy = 0.28;
Gxy = 7.17;

c = 1/(1 - vxy^2 * Ey/Ex);

Q11bar = c*Ex;
Q22bar = c*Ey;
Q12bar = c*vxy*Ey;
Q66bar = Gxy;

theta = linspace(0, pi/2, 101);
m = cos(theta);
n = sin(theta);
Q11 = m.^4*Q11bar + n.^4*Q22bar + 2*m.^2 .* n.^2*Q12bar + 4*m.^2 .*
 n.^2*Q66bar;

figure(1), clf, hold on, grid on;
plot(rad2deg(theta), Q11, 'LineWidth',2);
xlabel('$\theta$ (deg)', 'Interpreter','latex')
ylabel('In-plane longitudinal stiffness (GPa)','Interpreter','latex')
```

Part a

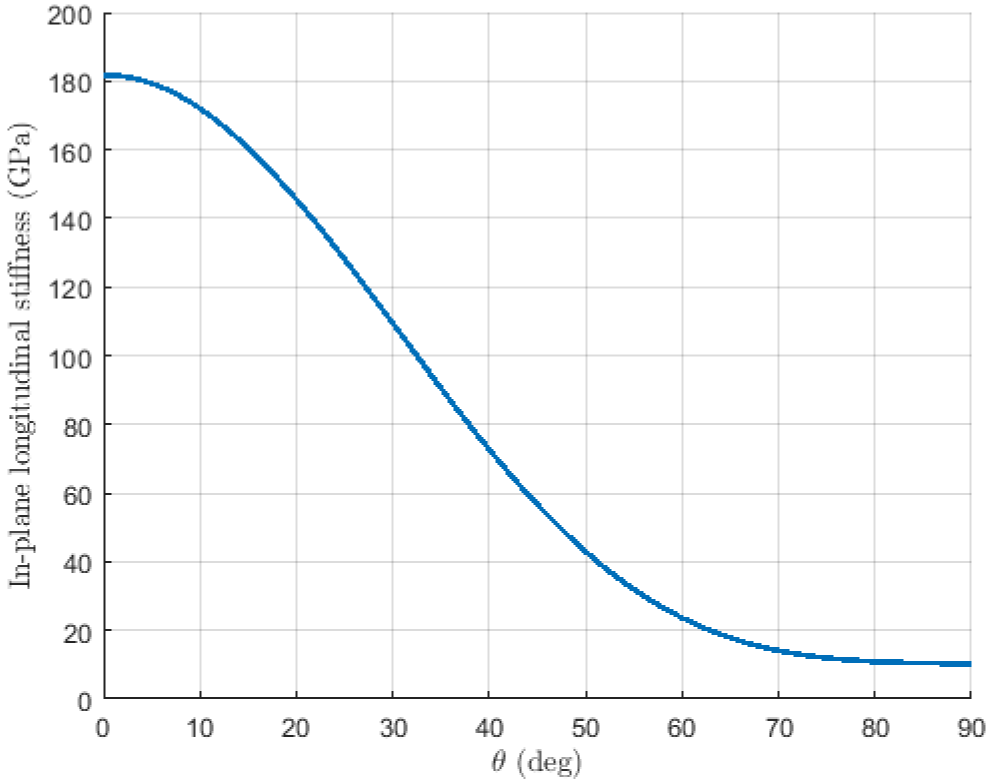
```
thetaA = rad2deg(theta(40)) % One-half
thetaB = rad2deg(theta(50)) % One-third
```

Part b

```
thetaC = rad2deg(theta(16)) % 10% drop
```

```
thetaA =

   35.1000


thetaB =
```

```
    44.1000

thetaC =

    13.5000
```



Question 3

```
Q16 = m.^3 .* n * Q11bar - m .* n.^3 * Q22bar + (m .* n.^3 - m.^3 .* n)*Q12bar
 + 2*(m .* n.^3 - m.^3 .* n)*Q66bar;

theta3 = rad2deg(theta(Q16 == max(Q16)))
```

Part a

Yes, $Q_{16,max}$ is a function of the material's consitutive properties, since the equation for Q_{16} is coupled (shear strain appears in axial stress and vice versa).

Part b

Q_{16} and Q_{26} represent the coupling between the shear and extension, only seen in anistropic materials.

Part c

No, they do not appear in isotropic constitutive relations, since there is symmetry along the material axes (no coupling between shear and extension)

```
theta3 =

   30.6000
```

Question 4

```
Ex = 38.6e9;
Ey = 8.27e9;
vxy = 0.26;
Gxy = 4.14e9;

X = 1062e6;
Xp = 610e6;
Y = 31e6;
Yp = 118e6;
S = 72e6;

F1bar = 1/X - 1/Xp;
F2bar = 1/Y - 1/Yp;

F11bar = 1/(X*Xp);
F22bar = 1/(Y*Yp);
F12bar = -1/2 * sqrt(F11bar * F22bar);
F66bar = 1/S^2;

theta = deg2rad(15);
m = cos(theta);
n = sin(theta);

F1 = m^2*F1bar + n^2*F2bar;
F11 = m^4*F11bar + n^4*F22bar + 2*m^2*n^2*F12bar + 4*m^2*n^2*F66bar;

z = roots([F11, F1, -1]);

sigma_compress = z(sign(z) == -1)*1e-6
sigma_tensile = z(sign(z) == 1)*1e-6
```

```
sigma_compress =

 -151.9499


sigma_tensile =

  132.9200
```

Question 5

No. Since the constraint was derived assuming incompressibility for istropic materials and the definition of bulk modulus. Since composites are comprised of more than one material, the bounds do not hold.

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