Sample: Atomic Physics - Physics Assignment

1. 1) A) Upper-bound modulus
   We can use the rule of mixtures.
   In general, for some material property E (often the elastic modulus), the rule of mixtures states that the overall property in the direction parallel to the fibers may be as high as
   $E = fE_f + (1-f)E_M$,
   Where the
   $f = \frac{V_f}{V_f + V_m}$ is the fraction of fiber,
   $E_f = 355GPa$ is the Young modulus of fiber
   $E_m = 2GPa$ is the Young modulus of matrix.
   Whence, we get $f = \frac{E - E_M}{E_f - E_M} = \frac{85GPa - 2GPa}{355GPa - 2GPa} = 0.235 = 23.5\%$

   B) Here we use such assumption: composite material load parallel to the fibers

   2) The lower-bound modulus
   In this case $E = \left(\frac{f}{E_f} + \frac{1-f}{E_m}\right)^{-1}$
   Whence, we get
   $$\left(\frac{f}{E_f} - \frac{f}{E_m}\right) = \frac{1}{E} - \frac{1}{E_m}$$
   $$f = \left(\frac{1}{E} - \frac{1}{E_m}\right)\left(\frac{1}{E_f} - \frac{1}{E_m}\right)^{-1} = \frac{E - E_m}{E_f - E_m}\frac{E_f}{E}$$
   $$f = \frac{E - E_m}{E_f - E_m}\frac{E_f}{E}$$
   $$f = \frac{(85-2)GPa}{(355-2)GPa}\frac{355GPa}{85GPa} = 0.982 = 98.2\%$$
   Here we use such assumption: composite material load perpendicular to the fibers
   Answer:
   In case of upper-bound modulus we have the minimum volume fraction of fibers
   $f = 23.5\%$

2. Using the definition of elastic modulus we get that the

$$l' = l + \Delta l = 401mm$$
$$l = 400mm$$
$$d = 12mm$$
$$b = 25mm$$
$$S = d \times b = 12mm \times 25mm = 300mm^2$$
$$\Delta l = l' - l = 401mm - 400mm = 1mm$$
$$E = 72GPa$$

$$E = \frac{Fl}{S\Delta l} \Rightarrow$$

$$F = \frac{ES\Delta l}{l} = \frac{7.2 \cdot 10^{10} \frac{N}{m^2} \cdot 10^{-3} m \cdot 300 \cdot 10^{-6} m^2}{0.4m} = 54kN$$

3. We get from the figure that if the vectors have the coordinates (in terms of unit of cubic cell)

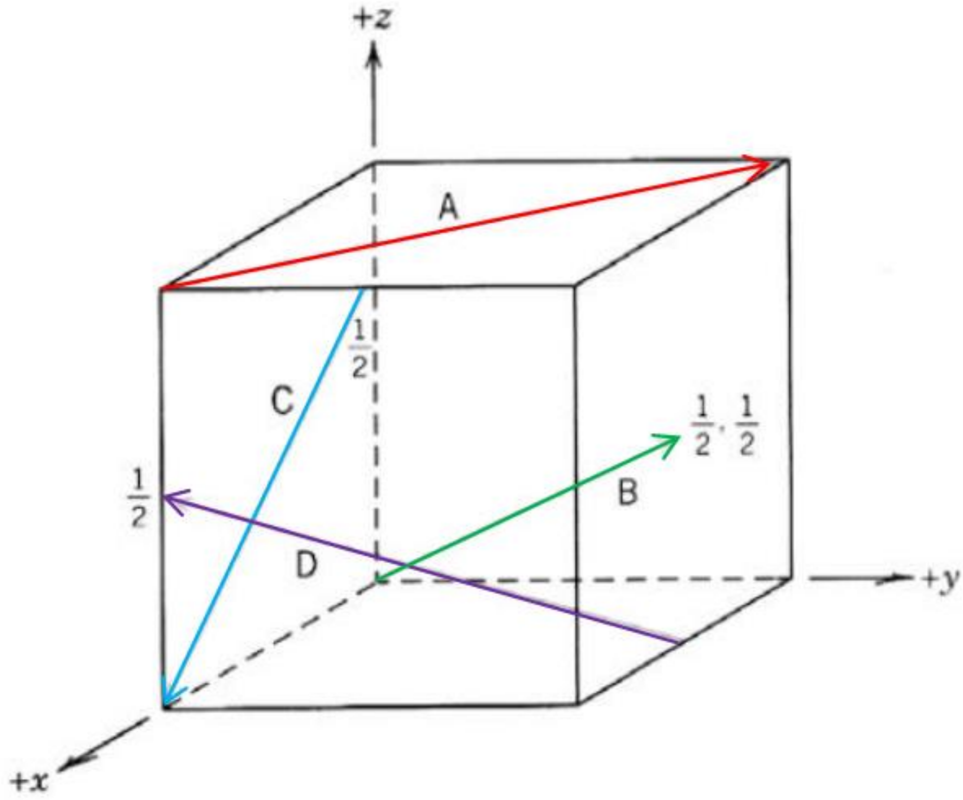
$$A = \begin{pmatrix} -1 & 1 & 0 \end{pmatrix}$$
$$B = \begin{pmatrix} 0 & \frac{1}{2} & \frac{1}{2} \end{pmatrix}$$
$$C = \begin{pmatrix} 0 & -\frac{1}{2} & -1 \end{pmatrix}$$
$$D = \begin{pmatrix} \frac{1}{2} & -1 & \frac{1}{2} \end{pmatrix}$$

Reducing to integers we get

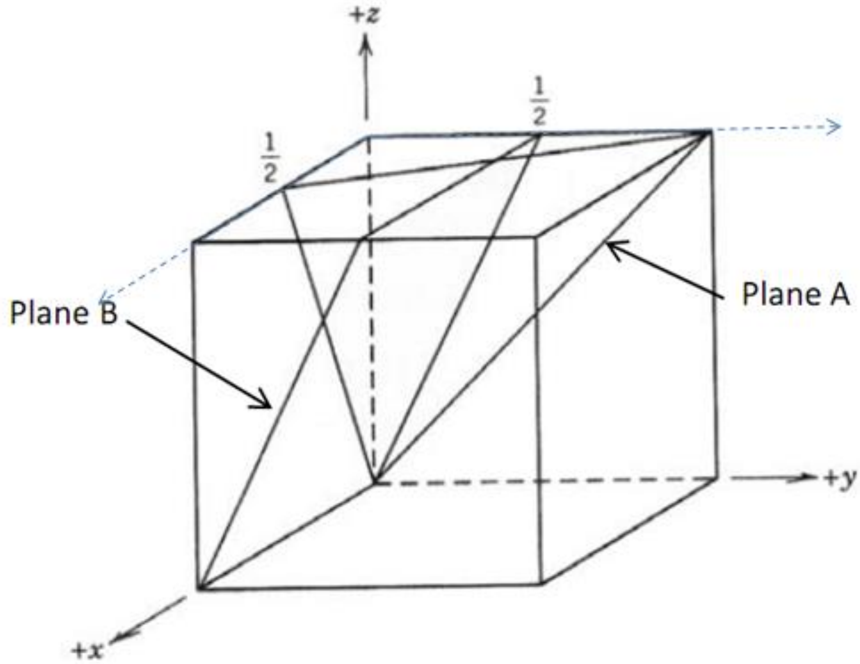
$$A = \begin{pmatrix} -1 & 1 & 0 \end{pmatrix}$$
$$B = \begin{pmatrix} 0 & 1 & 1 \end{pmatrix}$$
$$C = \begin{pmatrix} 0 & -1 & -2 \end{pmatrix}$$
$$D = \begin{pmatrix} 1 & -2 & 1 \end{pmatrix}$$

In traditional in crystallography notation we get

$$A = \begin{pmatrix} \bar{1} & 1 & 0 \end{pmatrix}$$
$$B = \begin{pmatrix} 0 & 1 & 1 \end{pmatrix}$$
$$C = \begin{pmatrix} 0 & \bar{1} & \bar{2} \end{pmatrix}$$
$$D = \begin{pmatrix} 1 & \bar{2} & 1 \end{pmatrix}$$



4. We get from the definition of Miller indices (please see, for example http://en.wikipedia.org/wiki/Miller_index)
   1) Plane A intercepts the x-axis in point ½ , the y-axis in point 1, z-axis in point -1.
      Whence, its Miller indices are (2,1,-1), or, in traditional terms $(2 \quad 1 \quad \bar{1})$
   2) Plane b intercepts the x-axis in point ∞ (it is parallel to x-axis), y-axis in point ½, z-axis in point 1.
      Whence, its Miller indices are (0,2,1) .



5. We get from the method of three point bending flexural test that the

$$E_f = \frac{L^3 m}{4bd^3}$$

in these formulas the following parameters are used:

- E_f = flexural Modulus of elasticity,(MPa)
- F = load at a given point on the load deflection curve, (N)
- $L = 160mm$ = Support span, (mm)
- $b = 15mm$ = Width of test beam, (mm)
- $d = 5mm$ = Depth of tested beam, (mm)
- m = The gradient (i.e., slope) of the initial straight-line portion of the load deflection

Curve (N/mm)

We know that the $m = \frac{\Delta F}{\Delta \delta}$.

We have the values of force and deflection

Applied Force, F (N)	Measured Deflection, δ (mm)
64.5	0.065
128.5	0.130
193.0	0.195
257.5	0.260
382.5	0.380 (fracture)

Whence, we can find the gradient of the initial straight-line portion of the load deflection

Δδ mm	***ΔF, N***	***m, N/mm***
0.065mm	***64N***	***984,6***
0.065mm	***64.5N***	***992,3***
0.065mm	***64.5N***	***992,3***
0.120	***125N***	***1041.7***

Whence, we can use ***m=992.3N/mm.***

$$E_f = \frac{L^3 m}{4bd^3} = \frac{(160mm)^3 992.3N/mm}{4 \cdot 15mm \cdot (5mm)^3} = 541930MPA = 541.93GPa$$

If we use the average value of ***m=1002.7 N/mm***

We get $E_f = 547.61GPa$

b) From the data of m, we can see that the m is not decreasing. If the material is brittle, the m is decreasing.

Whence, the material is ductile.