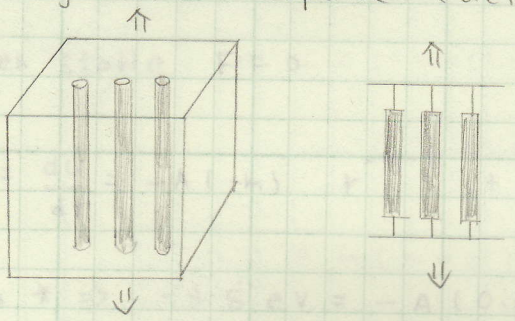
#1

carbon fiber reinforced epoxy composite

$V_f = 65\%$, $E_f = 200$ GPa & $E_m = 5$ GPa

(a) longitudinal response (action in parallel)



$$P_c = \sum_{i=1}^{n} P_i V_i$$

P - property
V - volume fraction
n - components

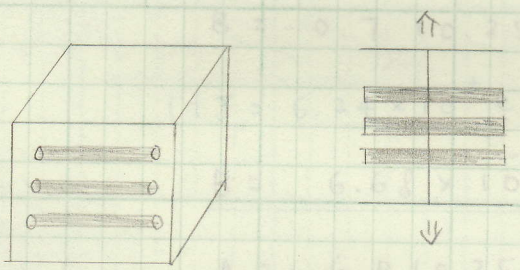
$$E_{cl} = E_f V_f + E_m (1 - V_f)$$

($V_f = 0.65$, $1 - V_f = 1 - 0.65$)

$$= 0.65 \times 200 + 0.35 \times 5 \text{ GPa}$$

$$= \underline{131.75 \text{ GPa}}$$

(b) transverse response (action in series)



$$\frac{1}{P_c} = \sum_{i=1}^{n} \frac{V_i}{P_i}$$

$$\frac{1}{E_c} = \frac{V_f}{E_f} + \frac{V_m}{E_m}$$

$$E_{ct} = \frac{E_f \cdot E_m}{E_f (1 - V_f) + E_m V_f}$$

$$= \frac{200 \times 5}{200 \times 0.35 + 5 \times 0.65}$$

$$= \underline{13.65 \text{ GPa}}$$

#2 (a) solve for A & B

$$U = \frac{-A}{r^m} + \frac{B}{r^n} \qquad m = 2,\ n = 12$$

$$U = -A r^{-m} + B r^{-n} \quad \text{—— (*)}$$

When stable $F = 0$

$$F = \frac{dU}{dr} = -A(-m)\, r^{-m-1} + B(-n) r^{-n-1} = 0 \quad \text{—— (**)}$$

from * $\Rightarrow$ $-3.5\ eV = -A(0.25)^{-2} + B(0.25)^{-12}$ —— (1)

from ** $\Rightarrow$ $2A(0.25)^{-3} - 12B(0.25)^{-13} = 0$

$\Rightarrow$ $A = 6B(0.25)^{-10}$ —— (2)

plug (2) into (1)

$$-3.5 = -6B(0.25)^{-12} + B(0.25)^{-12}$$

$$-3.5 = -5B(0.25)^{-12}$$

$$B = 0.7(0.25)^{12} = 4.17 \times 10^{-8}\ eV\ nm^{12}$$

$(1\ J = 6.24 \times 10^{18}\ eV)$

$$B = 6.68 \times 10^{-27}\ J\ nm^{12}$$

$$A = 6B(0.25)^{-10} = 6 \times 6.68 \times 10^{-27} \times (0.25)^{-10}$$

$$A = 4.20 \times 10^{-20}\ J \cdot nm^2$$

2

Critical separation which the molecule breaks:

$$F = \frac{du}{dr} = -A(-m)r^{-m-1} + B(-n)r^{-n-1}$$

$$\frac{d^2u}{dr^2} = 0 \Rightarrow -A(-m)(-m-1)r^{-m-2} + B(-n)(-n-1)r^{-n-2} = 0$$

$$-Amn(n+1)r^{-m-2} + Bn(n+1)r^{-n-2} = 0$$

$$Amn(n+1)r^{-m-2} = Bn(n+1)r^{-n-2}$$

$$2 \times 3(4.20 \times 10^{-20})r^{-4} = 12(13)(6.68 \times 10^{-27})r^{-14}$$

$$r^{10} = 4.14 \times 10^{-6} \text{ nm}^{10}$$

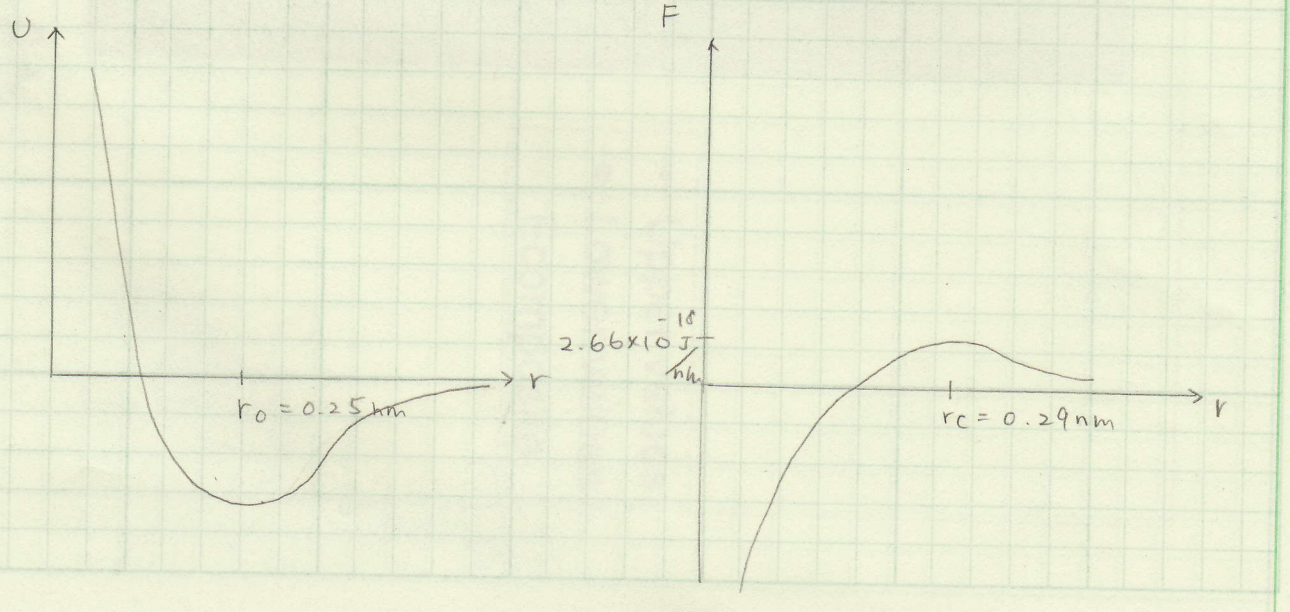
$$\underline{r = 0.290 \text{ nm}}$$

Force required to break the molecule:

$$F = -A(-m)r^{-m-1} + B(-n)r^{-n-1}$$

$$F = (4.20 \times 10^{-20})(2)(0.290)^{-3} + (6.68 \times 10^{-27})(-12)(0.290)^{-13}$$

$$F = \underline{2.66 \times 10^{-18} \text{ J/nm}}$$

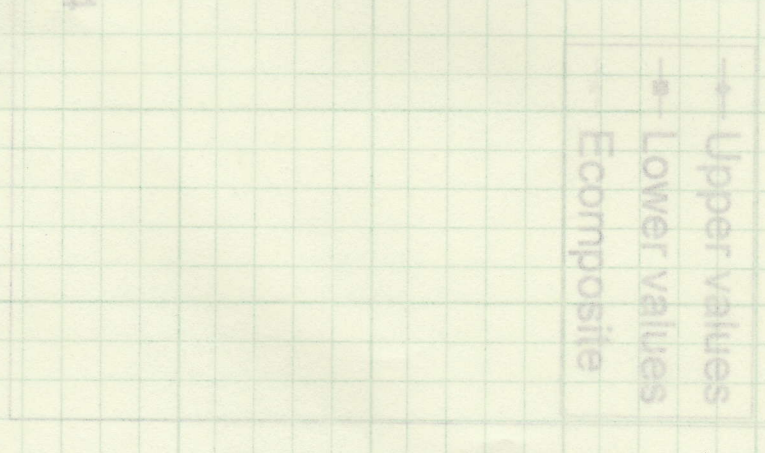


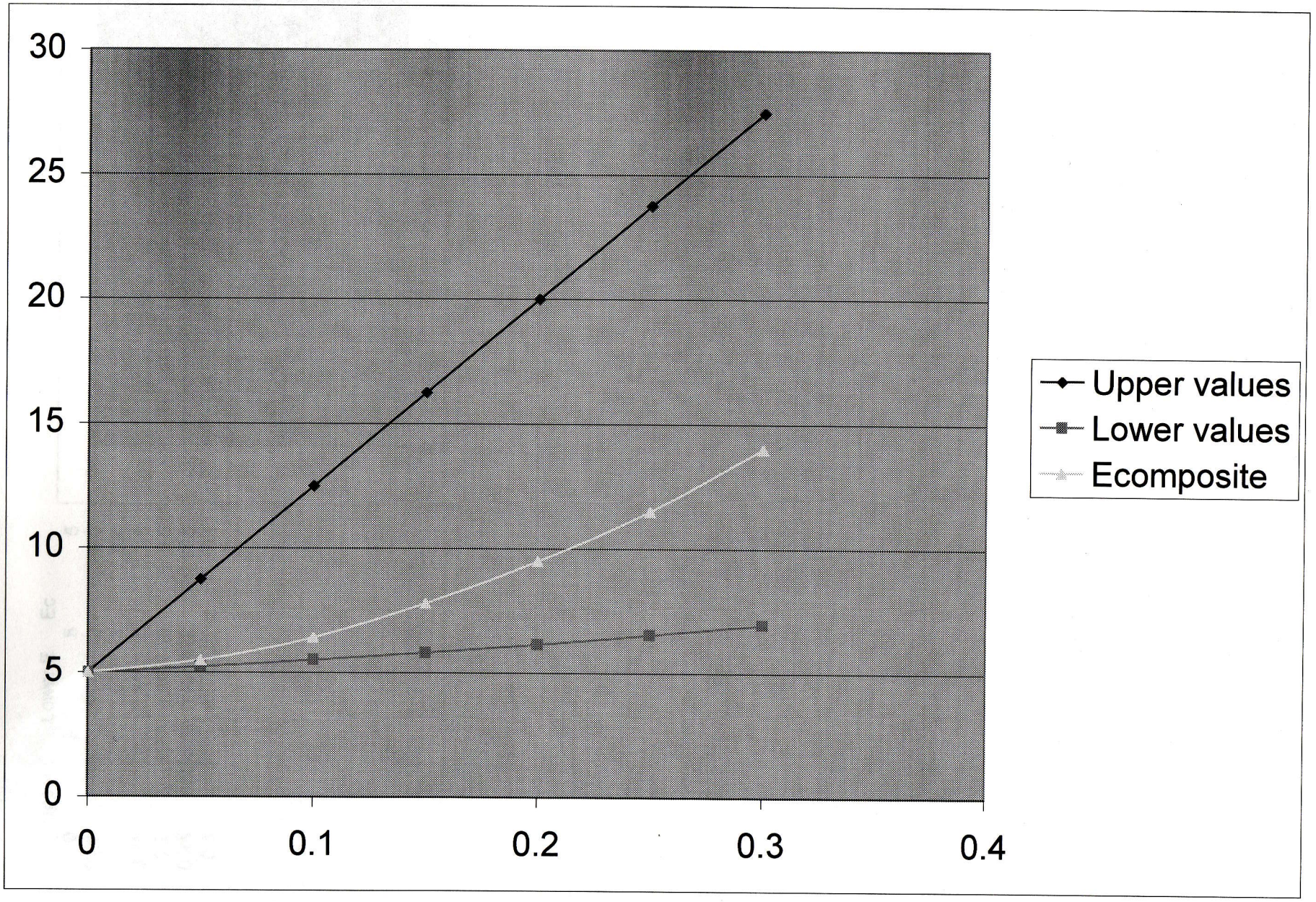
#3

Volume fraction of glass, V_f	$E_{composite}$ $GN\,m^{-2}$
0	5.0
0.05	5.5
0.10	6.4
0.15	7.8
0.20	9.5
0.25	11.5
0.30	14.0

The lower values better describes the results of E_{comp}. This implies that the composites are not in the direction of reinforcement. due to the randomly oriented glass particles.

A randomly chopped material does not have a continuous material property thus different young's modulus




30
25
20
15
10
5
0
0
0.1
0.2
0.3
0.4
Upper values
Lower values
Ecomposite

Vf	Upper E	Lower E	Ec
0	5	5	5
0.05	8.75	5.245902	5.5
0.1	12.5	5.517241	6.4
0.15	16.25	5.818182	7.8
0.2	20	6.153846	9.5
0.25	23.75	6.530612	11.5
0.3	27.5	6.956522	14