Answer All Questions. **Total Marks: 20** Date/Time: 13-02-2018 / 9.30-10.30 AM

- This is a question cum answer booklet. Answer need to be provided within the space given.
- Read the questions carefully and Answer all questions.
- If any data found incomplete that could be assumed suitably and justification shall be furnished.

1. a) Sketch a Bar-Chart of room temperature strength (ie., tensile strength) values for various metals, ceramics, polymers and composite materials. (1 1/2 Marks)

Tensile Strength:

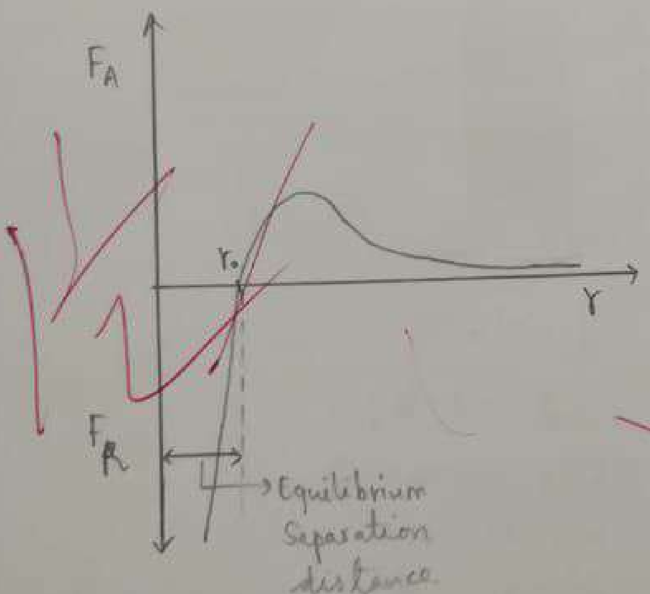
Metals > Ceramics > Polymers > Composite Materials.

b) List the following construction materials in the descending order of density. (1/2 Mark)

A. Water
B. Brick
C. Concrete
D. Steel

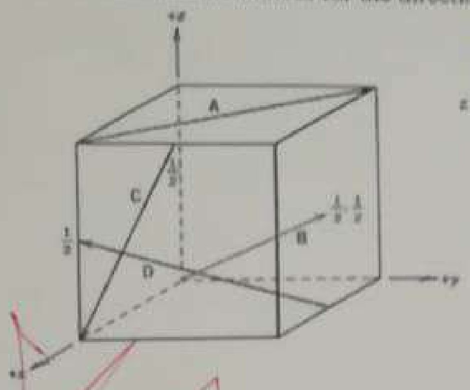
Your Answer: Steel > Concrete > Brick > Water.

2. Sketch the relationship between inter-atomic forces vs separation distance and mark how the Young's modulus is being calculated. (2 Marks)



$$E = \int_R^{\infty} F_A \, dr + \int_R^{\infty} F_R \, dr$$

3. Determine the indices for the directions shown in the following cubic unit cell. (2 Marks)



A $\{[101] - [011]\}$

$= A\,[1\,\bar{1}\,0]$

B $[\frac{1}{2}, 1, \frac{1}{2}]$

$= B\,[2, 1, 2]$

C $\{-[1,0,0] + [1, \frac{1}{2}, 1]\}$

$= \{[0, -\frac{1}{2}, -1]\}$

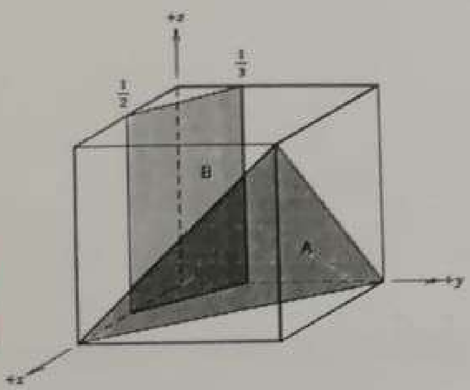
$= \{[0, \bar{1}, \bar{2}]\}$

D $\{[\frac{1}{2}, 1, 0] - [1, 0, \frac{1}{2}]\}$

$= \{[-\frac{1}{2}, 1, -\frac{1}{2}]\}$

$= \{[\bar{1}, 2, \bar{1}]\}$

4. Determine the Miller indices for the planes shown below (2 Marks)



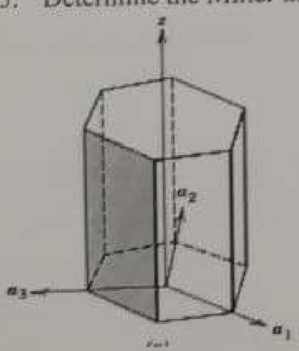
A: $\frac{1}{1}, \frac{1}{1}, \infty$

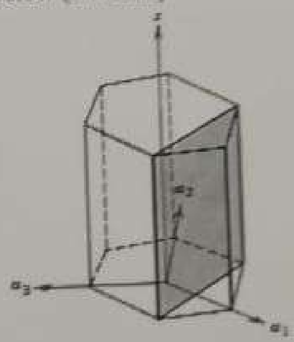
$\Rightarrow (1, 1, 0)$

B: $\frac{1}{2}, \frac{1}{3}, \infty$

$\Rightarrow (2, 3, 0)$

5. Determine the Miller indices for the planes shown below (2 Marks)





$\infty, -1, \infty$

$\Rightarrow (0, -1, 0)$

$h' = 0 \quad h = 0$

$k' = -1 \quad k = -1$

$l' = 0 \quad i = -(-1+0)$

$= 1$

$l = 0$

$\therefore$ Miller indices: $(0, \bar{1}, 1, 0)$

$\frac{1}{2}, -1, \infty$

$\Rightarrow (2, -1, 0)$

$h' = 2 \quad h = 2$

$k' = -1 \quad k = -1$

$l' = 0 \quad i = -(2+(-1)) = -1$

$l = 0$

Miller indices: $(2\,\bar{1}\,\bar{1}\,0)$

6. a) Write the basic expression for the Modulus of Resilience (1/2 Marks)

$U_r = \frac{\sigma^2}{2E}$; $U_r \rightarrow$ modulus of resilience
$\sigma \rightarrow$ true stress
$E \rightarrow$ Young's Modulus

b) The tensile σ-ε data for a few hypothetical materials (metals) are presented in the following table.

Material	Yield Strength (MPa)	Tensile Strength (MPa)	Strain at Fracture	Fracture Strength (MPa)	Elastic Modulus (GPa)
A	310	340	0.23	265	210
B	100	120	0.40	105	150
C	415	550	0.15	500	310
D	700	850	0.14	720	210
E	Fractures before yielding			650	350

Of these metals, a) which will experience the greatest percent reduction in area, b) Which is the strongest and c) Which is the stiffest (1 ½ Marks)

a) • B → experiences greatest percent reduction in area
• lowest yield strength (i.e 100 MPa)
• Lowest Tensile strength (i.e 120 MPa)

b) D is the strongest as it has the highest value of 'Tensile strength' (i.e, 850 MPa)

c) * E is the stiffest
* Has greatest value of 'Elastic Modulus'
* Elastic Modulus = 350 GPa.

7. A cylindrical rod of steel (E=207 GPa) having a yield strength of 310 MPa is to be subjected to a load of 11100N. If the length of the rod is 500mm, what must be the diameter to allow an elongation of 0.38mm. (2 Marks)

$E = 207\ GPa$ $\quad \sigma_y = 310\ MPa$ $\quad P = 11100\ N$ $\quad l = 500\ mm.$ $\quad dl = 0.38\ mm$

$$\Delta l = \frac{Pl}{AE} = \frac{Pl}{\frac{\pi d^2}{4} E} \Rightarrow d = \sqrt{\frac{4Pl}{\pi \Delta l E}}$$

$$\Rightarrow d = \sqrt{\frac{4 \times 11100 \times 500}{3.14 \times (0.38)(207 \times 10^9)}} = \sqrt{89.881 \times 10^{-6}}$$

$$d = 9.4 \times 10^{-3}\ m$$

$$d = 9.4\ mm$$

8. A specimen of magnesium having a rectangular cross section of dimensions 3.2 x 19.1 mm is deformed in tension and the load-elongation data is presented in the following table. (6 Marks)

	Load N	Length mm
1	0	63.50
2	1380	63.53
3	2780	63.56
4	5630	63.62
5	7430	63.70
6	8140	63.75
7	9870	64.14
8	12,850	65.41
9	14,100	66.68
10	14,340	67.95
11	13,830	69.22
12	12,500	70.49
	Fracture	

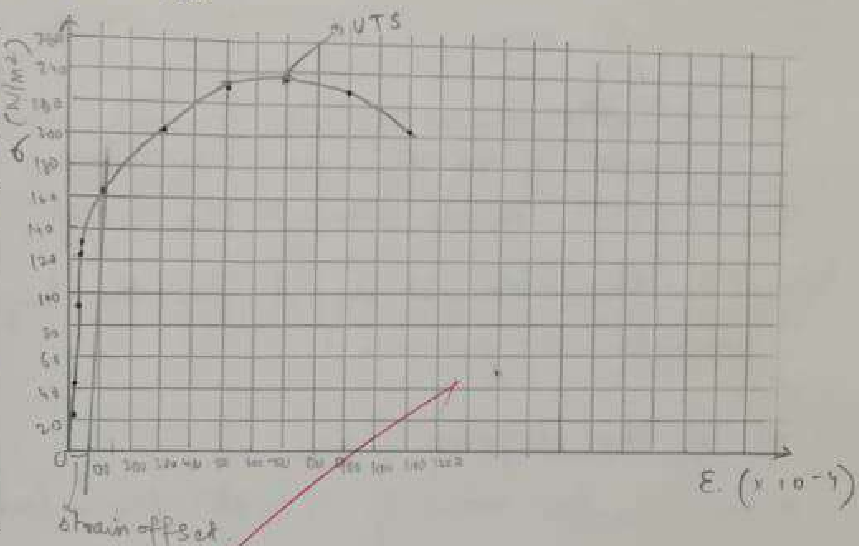
a) Plot the data as engineering stress vs engineering strain (2 ½ Marks)
b) Compute 'E' (1/2 Mark)
c) Determine yield strength at strain offset, 0.002 (1/2 Mark)
d) Determine the tensile strength, (1/2 Mark)
e) Compute modulus of resilience, (1/2 Mark)
f) What is ductility, in percent elongation?, (1/2 Mark)
g) Compute true stress for a particular value of engineering stress (1/2 Mark)
h) Compute true strain for a particular value of engineering strain (1/2 Mark)

$CS_A = (3.2 \times 19.1) \times 10^{-6}\ m^2 = 61.12 \times 10^{-6}\ m^2$.

$\sigma = P/A_0$.

a)

	σ ($\times 10^6$) (MPa)	ε
1	0.	~~63.50~~ 0.
2	22.57	4.72×10^{-4}
3	45.48	9.44×10^{-4}
4	92.11	18.89×10^{-4}
5	121.56	31.49×10^{-4}
6	133.18	39.37×10^{-4}
7	161.48	100.7×10^{-4}
8	210.24	300.7×10^{-4}
9	230.69	500.7×10^{-4}
10	234.62	700.7×10^{-4}
11	226.27	900.7×10^{-4}
12	204.51	1100.7×10^{-4}



b) $E = \dfrac{\sigma}{\varepsilon} = \dfrac{2780 - 1380}{61.12 \times 10^{-6}} \times \dfrac{63.53}{0.03} = 48506 \times 10^6\ Pa = 48.5 \times 10^9\ Pa$
$= 48.5\ GPa$

e) $U_r = \dfrac{\sigma^2}{2E} = \dfrac{(2780 - 1380)^2}{2(61.12\times10^{-6})^2 \times 48.5\times10^9} = 5.4 \times 10^3\ Pa = 5.4\ kPa$

f) Ductility $= \left| \dfrac{l_f - l_0}{l_0} \right| \times 100 = \left| \dfrac{70.49 - 63.5}{63.5} \right| \times 100 = 11\ \%$

g) $\sigma_T = \sigma(1+\varepsilon)$: $\sigma_{T,12} = \sigma_{12}(1+\varepsilon_{12})$ (12 → reading from table)
$= \cancel{(22.57)(1+4.72\times10^{-4})}$
$= (204.51)(1 + 0.11) = 227.0061\ MPa$

6

h) $\varepsilon_T = \ln(1+\varepsilon)$: $\varepsilon_{T,12} = \ln(1+\varepsilon_{12}) = \ln(1+0.11)$
$= 0.104$

d) Tensile strength = 251.04 MPa.
($\sigma_T = \sigma(1+\varepsilon) = 234.62(1+0.07)$
$= 251.04\ MPa$