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STRUCTURAL MECHANICS ACDA 6009

①

a) Thin walled cylinders — Analysed by calculating the cross section area of a rolled out cylinder. Thick walled cylinders are not rolled out, but analysed using the internal and external pressures.

b) A thick cylinder is a cylinder whose wall thickness is greater than $1/20$ times ^{of} its internal diameter.

$$c) \sigma_r = \frac{PD}{2t} \quad t = \frac{PD}{\sigma \times 2} = \frac{12000000 \times 0.1}{36000000 \times 2} \\ = 1.6 \text{ cm}$$

②

a) Critical Damping $C_c = \sqrt{4MK}$

$$\text{Natural Frequency } \omega_n = \sqrt{\frac{K}{M}}$$

§ Damping ratio is defined as the number of oscillations in a system that can decay after an ~~is~~ interruption.

$$\frac{\text{Damping coefficient}}{\text{Critical Damping Coefficient}} \left(\frac{c}{C_c} \right)$$

②

b)

$$1) \text{ Frequency in rads/s} = 4.7746 \times 6.28$$

$$= 29.98 \text{ rad/s}$$

$$2) \text{ Natural freq} = \omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{10000}{5}}$$

$$= 44.72 \text{ rad/s}$$

$$3) \text{ Critical Damping} = c_c = \sqrt{4mk}$$

$$= \sqrt{4 \times 5 \times 10000} = 447.21 \text{ Ns/m}$$

$$4) \text{ Damping ratio} = \frac{c}{c_c} = \frac{150}{447.21}$$

$$= 0.335$$

5)

$$A^2 = \frac{\frac{F}{k}}{\sqrt{\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right]^2 + \left[2\zeta\left(\frac{\omega}{\omega_n}\right)\right]^2}}$$

$$A = \frac{\frac{40}{10000}}{\sqrt{\left[1 - \left(\frac{29.98}{44.72}\right)^2\right]^2 + \left[2 \times 0.335 \left(\frac{29.98}{44.72}\right)\right]^2}}$$

$$= \frac{4 \times 10^{-3}}{0.30313 + 0.2017}$$

$$= 7.92 \times 10^{-3} \text{ m}$$

$$6) \tan \theta = \frac{2\zeta\omega\omega_n}{\omega_n^2 - \omega^2} = \frac{2 \times 0.335 \times 29.98 \times 44.72}{44.72^2 - 29.98^2}$$

$$= \frac{898.27}{1101.078} = 0.815^\circ$$

③ a) See graph attached

a) ~~2~~

0.1% Carbon Steel

1) yield point - 5500 N

2) yield extension - 0.8 mm

3) yield stress = $\frac{F}{A} = \frac{5500}{0.00002} = 275 \text{ MPa}$

4) Ultimate Tensile Load - 8000 N

5) Ultimate Tensile Stress = $\frac{F}{A} = \frac{8000}{0.00002} = 400 \text{ MPa}$

6) % elongation

$$= \frac{\text{elongation}}{\text{original length}} \times 100 = \frac{9.2 - 0.8}{25} \times 100$$

$$= 33.6\%$$

7) Elasticity - 0.8 mm

0.3% Carbon Steel

1) yield point - 5000 N

2) yield extension - 0.75 mm

3) yield stress = $\frac{F}{A} = \frac{5000}{0.00002} = 250 \text{ MPa}$

4) Ultimate Tensile Load - 10100 N

5) Ultimate Tensile Stress = $\frac{F}{A} = \frac{10100}{0.00002} = 505 \text{ MPa}$

6) % elongation = $\frac{5 - 0.75}{25} \times 100 = 17\%$

7) Elasticity - 0.75 mm

③ b) Increasing the carbon content in steel increases the strength and hardness of the material. However, it makes the material less ductile and increases brittleness.

c) Mild steel - 0.15 - 0.45% carbon content
Medium Carbon steel - 0.45 - 0.8% carbon
High Carbon steel - 0.8 - 1.5% carbon

④ Normalising - For this process metal is heated to just above its upper critical temperature. When the new grain structure forms it is removed from the heat and cooled in air. As it cools, new grains will form which will be smaller and more evenly spaced. This process is used to relieve stresses and restore grain structure to normal.

Annealing - Similar to normalising except the metal is cooled very slowly (usually kept to ~~cool~~ cool down in the furnace). This process leaves the metal in a soft state and is used to increase ductility prior to cold working or machining.

Hardening - Steel requires heating to its upper critical temperature and then quenched, which keeps the grains in a solid state solution. The rate of cooling affects the hardness, the faster the cooling the harder the result.

Tempering - This is the process for reducing hardness and brittleness. It involves reheating the previously hardened steel. During this heating small flakes of carbon appear which reduces hardness and brittleness. The higher the tempering temperature, the less hard will be the resulting steel.

b) **Thermoplastic** - Solid materials at room temperature but become viscous liquids when heated to a few hundred degrees.

Thermosetting - Unlike thermoplastics, these cannot tolerate repeated heating cycles. When ~~not~~ initially heated they can be molded as they soften but high temperatures can also cause a chemical reaction that hardens the material into a solid.

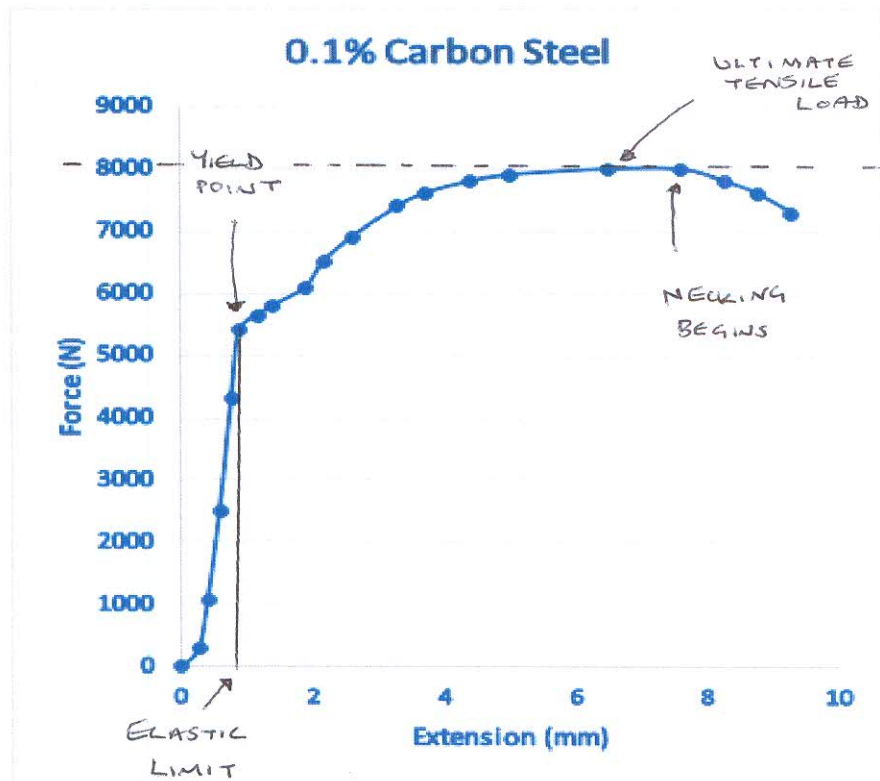
Elastomers - these are rubber materials that have extreme elasticity when subjected to low mechanical stress. They have different properties to thermoset plastics but do have a similar molecular structure.

THIS PAGE MUST BE SUBMITTED WITH YOUR ANSWER BOOK

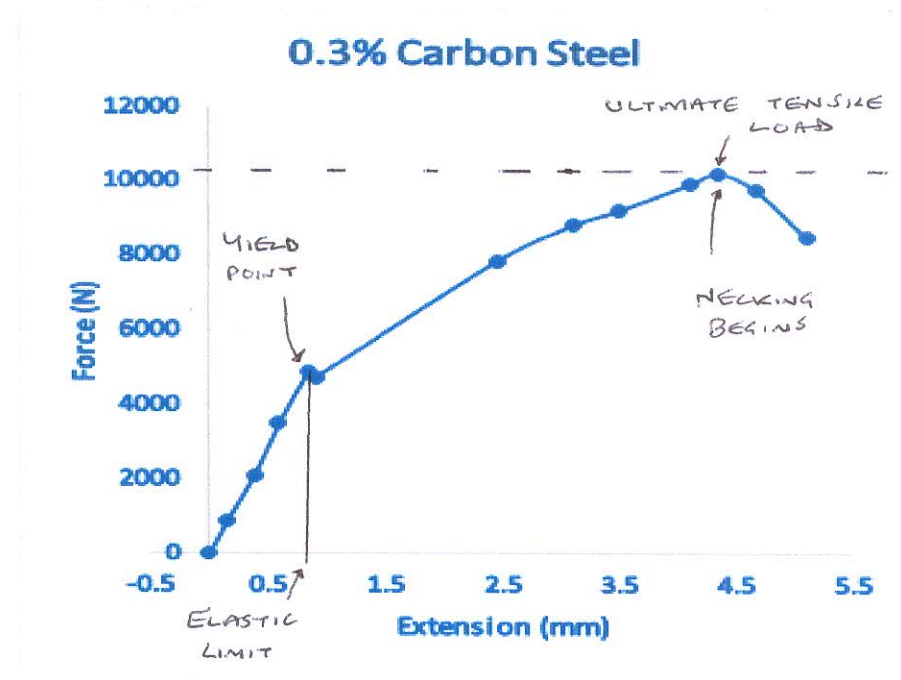
YOUR NAME:

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Graphs for question 3



Load (N)	Ext (mm)
0	0
300	0.28
1080	0.42
2500	0.6
4300	0.78
5400	0.9
5650	1.19
5800	1.4
6100	1.9
6500	2.17
6900	2.6
7400	3.3
7600	3.7
7800	4.4
7900	5
8000	6.5
8000	7.6
7800	8.3
7600	8.8
7300	9.3



Load (N)	Ext (mm)
0	0
900	0.15
2100	0.38
3500	0.59
4900	0.85
4750	0.9
7850	2.45
8800	3.1
9200	3.5
9900	4.1
10200	4.35
9750	4.67
8500	5.1

END OF EXAMINATION PAPER