

LOCATION: SA1 CAMPUS

LLEOLIAD: SA1 CAMPWS

LEVEL 6

LEFEL 6

EXAMINATION PERIOD

CYFNOD ARHOLIADAU

MARCH 2022

MAWRTH 2022

MODULE CODE: ACDA6009

Structural Mechanics

EXAMINATION

TIME: 2.5 HOURS

ANSWER ALL FOUR QUESTIONS

TOTAL MARKS = 100

NUMBER OF PAGES = 6

Equipment or materials required

- *Calculators are permitted.*
- *Standard formula sheet provided.*

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- *Caniateir ddefnyddio cyfrifiannell.*
- *Ddarperir taflen fformiwla safonol.*

Question 1

- (a) What is the main difference in the analysis between thick and thin cylinders?
(5 marks)
- (b) What is the value of the ratio of wall thickness to internal diameter for a cylinder to be classified as a thick cylinder?
(5 marks)
- (c) Design calculations are needed for a gun barrel to establish that the barrel will not fail catastrophically when subjected to abnormal internal gas pressures. It has been determined that the design maximum internal pressure is 12 MPa. The internal diameter of the barrel is 100 mm. Determine the wall thickness to limit the tensile stress to 36 MPa.
(15 marks)

Total marks for question = 25

Question 2

A bespoke munition carrier can be characterised as a mass (m), spring (k) and damper (c). The carrier is designed to minimise the vibration the munitions are subjected to when being transported.

The force equation is given by: $F \sin(\omega t) = m\ddot{x} + c\dot{x} + kx$

The characteristic solution is: $F \sin(\omega t) = \ddot{x} + 2\zeta\omega_n\dot{x} + \omega_n^2x$

- (a) Define the terms *critical damping* C_c , ω_n and ξ .
(6 marks)
- (b) The system can be considered as a mass of 5 kg, the carrier has a spring stiffness of 10,000 N/m and damper 150 Ns/m. From field measurements taken during trials involving a helicopter, the forcing function input to the carrier is 40N at a frequency of 4.7746 Hz

Calculate:

- 1) The forcing frequency in rad/s (2 marks)
- 2) Natural frequency (3 marks)
- 3) Critical damping (3 marks)
- 4) Damping ratio (3 marks)
- 5) Amplitude of displacement of the munition (4 marks)
- 6) Phase angle of the munition's motion to the forcing frequency (4 marks)

Total marks for question = 25

Question 3

A tensile test was conducted on two carbon steels of 0.1% carbon and 0.3% carbon, which are being considered for an ordnance application. The samples tested had a cross sectional area of 20 mm² and original length of 25 mm. The data obtained has been plotted on the final page of the examination paper (write your name on the page in the space indicated and hand this final page in with your answer book).

- a) Mark on the graphs: (4 marks)
 - 1) yield point
 - 2) Ultimate tensile load
 - 3) Elastic limit
 - 4) Point at which “necking” starts

- a) For each material determine: (14 marks)
 - 1) Yield load
 - 2) Yield extension
 - 3) Yield stress
 - 4) Ultimate tensile load
 - 5) Ultimate tensile stress
 - 6) % Elongation
 - 7) Elasticity

- b) What is the effect of increasing the carbon in steel on strength, hardness and ductility? (4 marks)

- c) What would be the typical carbon content of (3 marks)
 - 1) mild steel,
 - 2) medium carbon steel
 - 3) high carbon steel

Total marks for question = 25

Question 4

During the manufacture of a shell casing, a number of heat treatments are performed. These heat treatments are required to change the properties of the material such that the required processes in the manufacturing sequence can be performed.

- (a) Describe the following heat treatments of steels by stating how it is performed and the desired properties as a result of the process:
 - 1) Normalising
 - 2) Annealing
 - 3) Hardening
 - 4) Tempering

(5 marks for each process)

Polymers have either a glassy or crystalline structure or a mixture of both. They have a wide range of properties. Choosing the right polymer for an application requires a good knowledge of the characteristics.

- (b) Polymers are classified as either “THERMOPLASTIC”, THERMOSET” or ELASTOMER”. Describe the main characteristics of each of these classifications.

(5 marks)

Total marks for question = 25

END OF QUESTIONS

Appendix 1 Formula Sheet

$$\sigma = \frac{f}{a}$$

$$\sigma_h = a + \frac{b}{r^2}$$

$$\sigma_r = a - \frac{b}{r^2}$$

$$\epsilon = \frac{\Delta L}{L}$$

$$E = \frac{\sigma}{\epsilon}$$

$$F_m = Ma = M\ddot{x}$$

$$F_d = C\dot{v} = C\dot{x}$$

$$F_s = Kx$$

$$F \sin(\omega t) = \ddot{x} + 2\zeta\omega_n\dot{x} + \omega_n^2 x$$

$$f = \frac{1}{\tau}$$

$$\omega_n = \sqrt{\frac{K}{M}}$$

$$C_c = \sqrt{4MK}$$

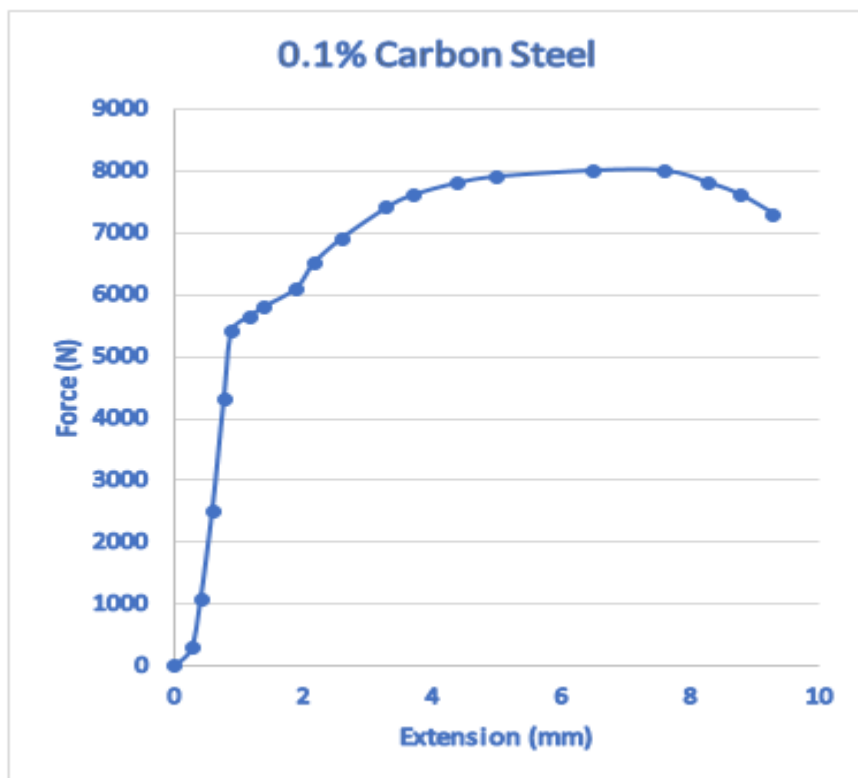
$$A^2 = \left(\frac{F}{M}\right)^2 \left[\frac{1}{(\omega_n^2 - \omega^2) + (2\zeta\omega\omega_n)^2} \right]$$

$$\tan \theta = \frac{2\zeta\omega\omega_n}{\omega_n^2 - \omega^2}$$

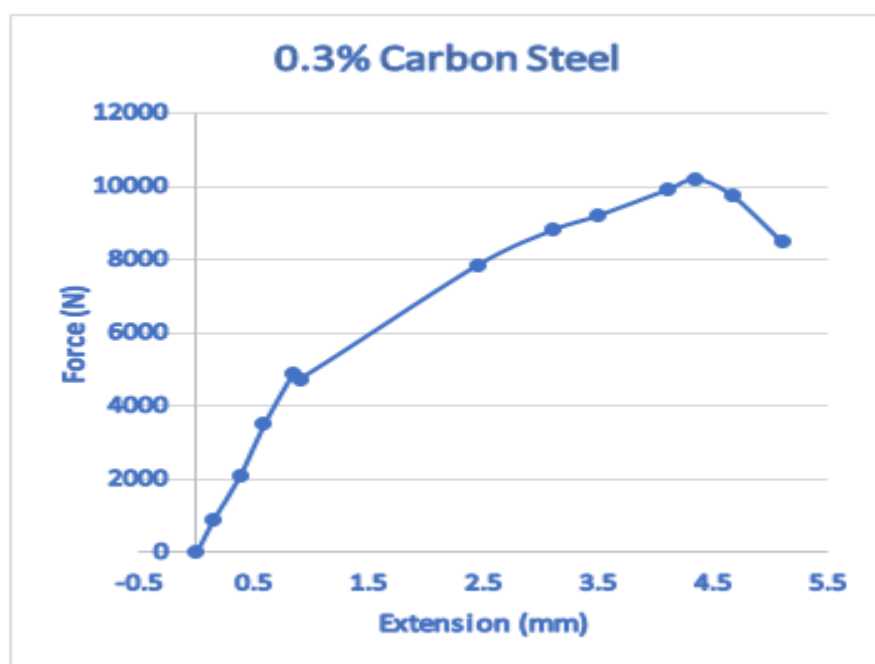
THIS PAGE MUST BE SUBMITTED WITH YOUR ANSWER BOOK

YOUR NAME:

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