



12 Pages

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

SURNAME: WOOHEAD

FORENAME(S):

BENJAMIN

ANDREW

1	Student Number	P151944
2	Title of Examination Paper	ADVANCED STRESS & FEA
3	Module Code	M6X00420
4	Date and Time of Examination	31-01-20 1.30PM
5	Examination Venue	1Q002
6	Seat Number	
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	14
2	8
3	15
Total	37

(Gweler yr ochr arall am y fersiwn Cymraeg)

61.7

1.

a) Strain energy is the energy built up inside a stressed part as an external force pulls at the bonds between atoms within the material. / 2

$$b) \quad \epsilon = \frac{\sigma}{E} \quad \epsilon = \frac{\Delta L}{L} \quad \therefore \frac{\Delta L}{L} = \frac{\sigma}{E} \quad \sigma = \frac{P}{A}$$

$$\therefore \epsilon = \frac{PL}{EA} \quad \therefore \Delta L = \frac{PL}{AE} \quad \therefore \delta = \frac{P\delta_s}{AE} \quad / 2$$

$$c) \quad u = \frac{1}{2} P \times d\theta \quad \text{also} \quad d\theta = \frac{P\delta_s}{AE}$$

$$\therefore u = \frac{1}{2} P \times \frac{P\delta_s}{AE} = \frac{P^2 \delta_s}{2AE}$$

Integrate between limits L & 0

$$U = \frac{P^2(L)}{2AE} - \frac{P^2(0)}{2AE} = \frac{P^2 L}{2AE} \quad / 2$$

d) Resilience is the capacity of a material to cope with strain energy per unit volume. Hence, a material with a higher resilience will be able to cope with higher stresses as it will be more resistant to the associated strain from loading. / 2

$$e) U = \frac{P^2 L}{2AE} \quad \text{also} \quad \sigma = \frac{P}{A} \therefore P = \sigma A$$

$$\therefore U = \frac{\sigma^2 L}{2AE} = \frac{\sigma^2 AL}{2E} \rightarrow AL = U$$

$$\therefore U = \frac{\sigma^2 U}{2E} \therefore \frac{U}{U} = \frac{\sigma^2}{2E} = \text{resilience}$$

$$f) A = 0.015 \times 0.015 = 2.25 \times 10^{-4} \text{ m}^2$$

$$L = 1 \text{ m}$$

$$\sigma = 200 \times 10^6 \text{ N/m}^2 \quad P = \sigma A$$

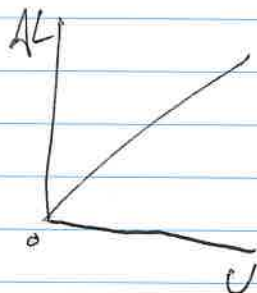
$$E = 200 \text{ GPa} \rightarrow \text{ASSUMED}$$

$$\epsilon = \frac{\sigma}{E} \therefore \epsilon = \frac{\sigma}{E} = \frac{200 \times 10^6}{200 \times 10^9} = 1 \times 10^{-3}$$

$$\epsilon = \frac{\Delta L}{L} \therefore \Delta L = \epsilon L = 1 \times 10^{-3} \times 1 = 1 \times 10^{-3} \text{ m}$$

$$U = \frac{P^2 L}{2AE} = \frac{(200 \times 10^6 \times 2.25 \times 10^{-4})^2 \times 1}{2 \times (2.25 \times 10^{-4}) \times (200 \times 10^9)} = 22.5 \text{ J}$$

g) Because strain energy is directly linked to potential energy (P.E = K.E = U) and potential energy = mgh + hf when extension is significant, the strain energy can increase greatly when under shock loading.



Designers must ensure part will not fail if load is suddenly applied.

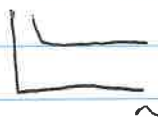
2. A crack could be caused by:

- machining defect
- loading above yield strength of material
- thermal expansion/contraction
- cyclic loading for more cycles than the lifespan of the part
- unexpected loads in multiple planes

b) 3 signs of fatigue failure -

- point of initiation
- area of propagation
- zone of crystalline failure

c) The machine would apply and remove a set load for a number of cycles, and this data could be used to plot stress against no. of cycles - on an S-N curve



$$d) \sigma_r^a N_f = k$$

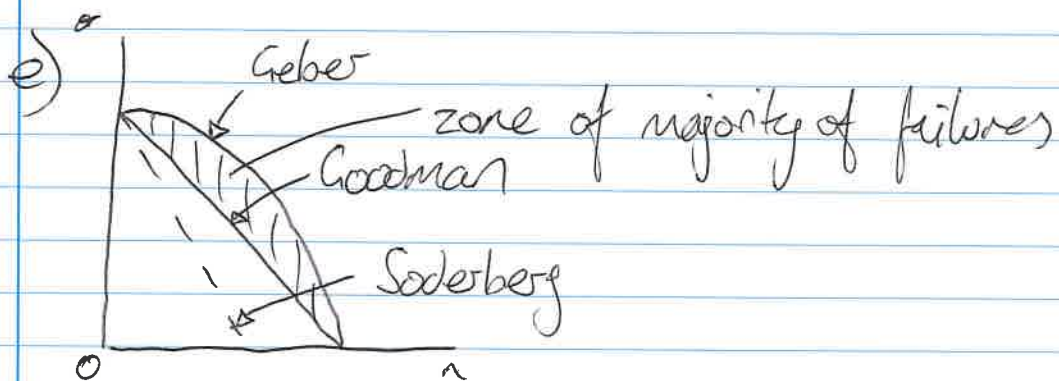
when $\sigma_r = 100 \text{ MPa}$, $N_f = 10^9$

when $\sigma_r = 200 \text{ MPa}$, $N_f = 10^6$

$$(100 \times 10^6)^a \cdot 10^9 = k$$

$$a = \frac{\log k}{100 \times 10^6 \cdot 10^9}$$

Assuming linear correlation, $N_f = 10^{7.5}$ at $\sigma_r = 150 \text{ MPa}$



Where mean stress is non-zero, the higher the mean stress the lower a stress amplitude a material is able to cope with before failure

3. Factors that influence quality of mesh:

- Element size; the smaller the elements, the more accurate the results. However ~~they~~ smaller elements greatly increase run time.
- Element quality; if the elements are distorted in order to fit part geometry, they will provide less accurate results.
- Order type; first-order elements have less nodes than second order so will take less time to compute, at the cost of accuracy.
- Free faces; undefined faces, typically where 2D elements meet 3D. These will not behave as the real world part would and cause spurious results.
- Duplicate nodes; where two nodes occupy the same space but are not actually linked. This will cause them to not transfer stresses and cause 'breaks' in the stress analysis.
- Element normalisation; if certain elements are not aligned similarly to the rest they will cause errors in calculations as their stresses will be 'reversed'.

In order to prevent these issues, an analyst should check the element geometry to ensure no elements in key areas have been distorted (jagged?). Also most meshes will have a duplicates locator which detects any ~~like~~ non-linked nodes within a certain distance of

each other. This should be used to remove any duplicates that have resulted from modelling errors, symmetry issues etc. Any free faces should have a stiffness associated with their pivot point to prevent unreasonable displacement.

15

- b) FEA analysis should be compared to real-world experimental results such as loading tests, shock loading, fatigue failure tests etc. If these correlate well it inspires confidence that the model is accurate for use on conditions that are harder to test in a lab setting - environmental, long-term fatigue etc.

0

Question No.

Examiner Only

Arholwr yn uni

Rhif y Cwestiwn

Question No.

Examiner On

Arholwr yn unig

nif y Cwestiwn

Question No.

Examiner On

Arholwr yn unig

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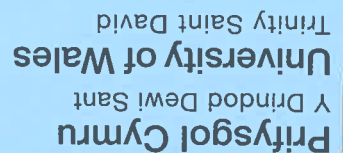
Question No.

Examiner On

Arholwr yn unig

hif y Cwestiwn





12 Tüdalen

1. Rhwch yr holl wybodaeth y gofynnir amdani yn y blychau isod.
2. Rhwch eich enw yn y lle a ddarparwyd ar y dde, plynwch ef a'i seilio i lawr (gan ddefnyddio'r label a ddarparwyd) i guddio'ch enw.

3. Rhaid i'r atebion fod mewn llawysgrifen ddarllenadwy. Gall yr Arholwyr naill ai anwybyddu sgrïpt annarllenadwy, neu drefnu iddi! gael ei threipio a chael yr ymgeisydd i dalu.

4. Ysgriennwch eich atebion mewn inc.

5. Dechreuwch bob ateb ar dudalen newydd. Gwnewch unrhyw fras nodiadau yn y llyfr atebion a thynnu llinell drwyddynt.

6. Ni ddylid rhwygo unrhyw ran o'r llyfr hwn; rhaid ei gyflwyno yn gyfan.

7. Os defnyddir mwy nag un llyfr, rhwymwch hwy gyda'i gilydd gan ddefnyddio'r tagiau sydd ar gael oddi wrth y gwylwyr/gwylwyr.

8. Rhaid dychwelyd pob llyfr. Ni chanafeir mynd â llyfrau atebion, wedi eu defnyddio neu heb eu defnyddio, allan o'r lleoliad arholi o dan unfryw amgylchiadau.

1	Rhif Myfyrwr	
2	Teitl y Papur Arholiad	
3	Cod y Modwl	
4	Dyddiad ac Amser yr Archoliad	
5	Lleoliad yr Arholiad	
6	Rhif Sedd	
7	Nifer y Llyfrau Atebion a gyflwynwyd	

[illegible]

(See the other side for English version)

Lienwch, plygwch a seliwch
(gweler nodyn 2 isod)

CYFENN:

ENW(AU) CYNTAF:

ENW(AU) CYNTAF: