



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: DOYLE

FORENAME(S): NATHAN LOUIS

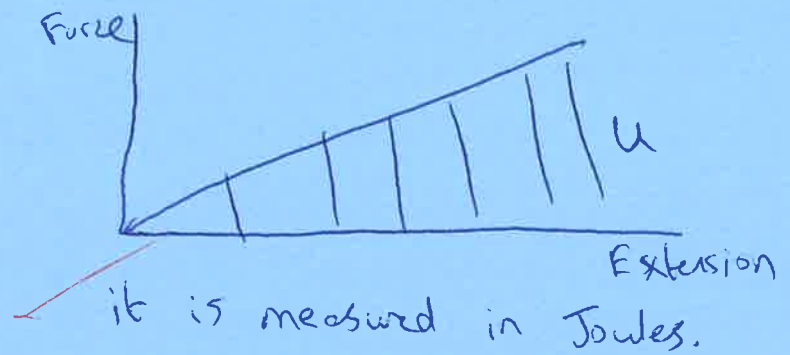
1	Student Number	P151450
2	Title of Examination Paper	ADVANCED STRESS AND FEA
3	Module Code	M6X00420
4	Date and Time of Examination	31/01/20 1:30
5	Examination Venue	IQ002
6	Seat Number	
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
1	13
2	14
3	16
Total	43

(Gweler yr ochr arall am y fersiwn Cymraeg)

71.7%

strain energy
is give by $\frac{1}{2} P d$
and is displayed in the
area under the graph



1. a.) Strain = $\frac{\delta}{L} \left(\frac{\Delta L}{L} \right)$ and is a force exerted by two forces acting opposite to each other on a component. The energy is created by the forces. Examiner Only



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

$$E = \frac{P}{A} \div \frac{\delta}{L}$$

$$E = \frac{PL}{A\delta} \rightarrow \delta = \frac{PL}{AE} \rightarrow \boxed{\delta = \frac{P\delta s}{AE}}$$

As required
2

c.) $U = \frac{1}{2} \frac{P\delta s}{AE}$

$$U = \int_0^L \frac{P^2 \delta s}{2AE} \rightarrow \boxed{U = \frac{P^2 L}{2AE}} \quad \text{As required.}$$

2

d.) Resilience is strain per unit volume and is the ability of a component to resist stress

1

e.) $U = \frac{P^2 L}{2AE}$

$$U = \frac{\sigma^2 A^2 L}{2AE}$$

$$U = \frac{\sigma^2 A L}{2E}$$

$$U = \frac{\sigma^2 V}{2E} \rightarrow \frac{U}{V} = \boxed{\frac{\sigma^2}{2E}} \quad \text{As required}$$

2

$$F.) \quad A = 15 \times 10^{-3} \times 15 \times 10^{-3} \quad E = 200 \times 10^9$$

$$A = 225 \times 10^{-6} \text{ m}^2$$

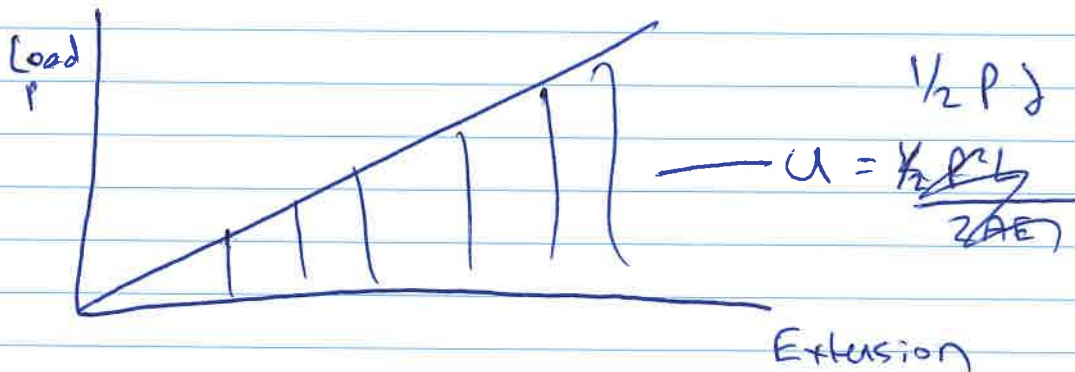
$$\begin{aligned} \text{Force} &= \text{stress} \times \text{Area} \\ &= 200 \times 10^6 \times 225 \times 10^{-6} \\ &= 45 \text{ kN} \end{aligned}$$

$$U = \frac{P^2 L}{2AE}$$

$$U = \frac{(45 \times 10^3)^2 \times 1}{2 \times 225 \times 10^{-6} \times 200 \times 10^9}$$

$$U = 22.5 \text{ Joules}$$

G.)



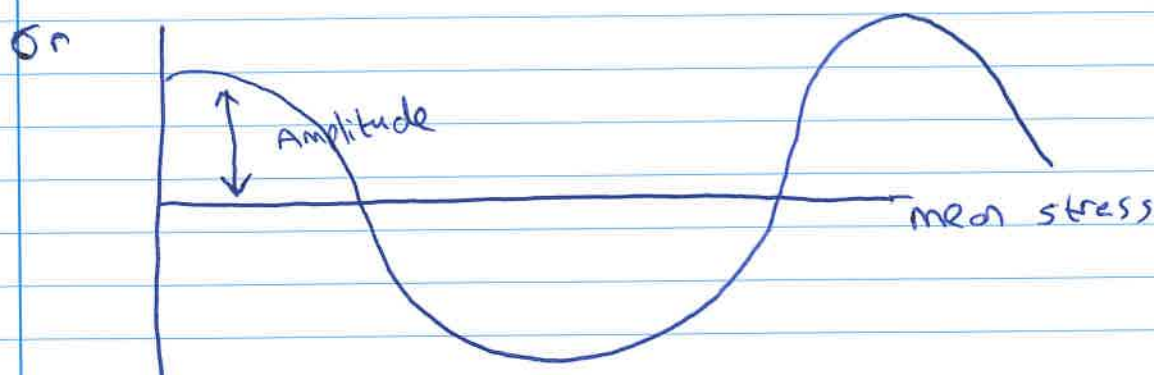
Great care must be given to sudden applied loads as the graph shows that the greater the load the greater the extension. To reduce the extension with increased loads, designers should look to include features such as fillets, chamfers and holes or even redesign the part entirely. The graph shows that the area under the graphs becomes greater, the more load is applied.

Question 2

a.) One ~~reason~~ ^{one} is material defects such ~~as~~ as porosity ~~at~~ ~~we~~ which significantly ~~wedens~~ weakens a material. Reasons such as increased stress concentrations by heavy loads as well as corrosion can also begin the crack defect. Other factors such as bad material design, human error ~~by~~ ~~as well as~~ and fatigue can also start a crack. 3

b.) The first area is the point of ~~initiation~~ which is then followed by 'arrest lines' created by the crack propagating. The last area shows a crystalline area of rupture. 3

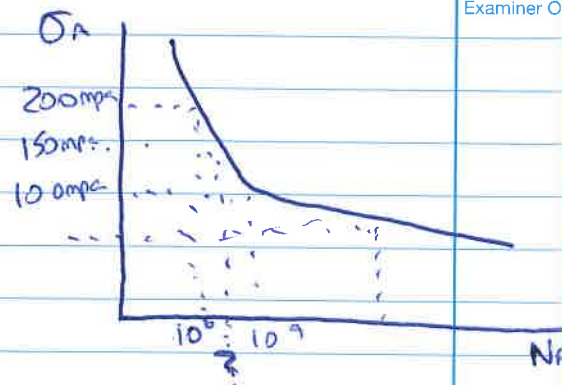
c.) The test shows a bar material that has a weight held at one end. The bar is then rotated. The bar will experience compression and tension at opposite sides as it rotates. The compression and tension creates a ~~cos~~ sin curve below. The stress amplitude can then be placed into an SN curve. X



$$d) \quad O_r^a N_f = K$$

$$\log O_r^a + \log N_f = \log K$$

$$a \log O_r + \log N_f = \log K$$



$$a) \quad \log 100 \times 10^9$$

$$\textcircled{1} \quad a \log(100 \times 10^6) + \log(10^9) = \log K$$

$$a \log 8 + 9 = \log K$$

$$\textcircled{2} \quad a \log(200 \times 10^6) + \log(10^6) = \log K$$

$$a \log 8.30103 + 6 = \log K$$

$$\textcircled{2} - \textcircled{1} \quad 8.30103a + 6 = \log K$$

$$\textcircled{1} \quad 8a + 9 = \log K$$

$$30103a - 3 = 0$$

$$30103a = 3$$

$$a = \frac{3}{30103}$$

$$a = 0.0000997 \text{ or } 99.658 \times 10^{-6}$$

From $\textcircled{1}$

$$8a + 9 = \log K$$

$$8 \times 99.658 \times 10^{-6} + 9 = \log K$$

$$9.0008 = \log K$$

$$K = 10^{9.0008}$$

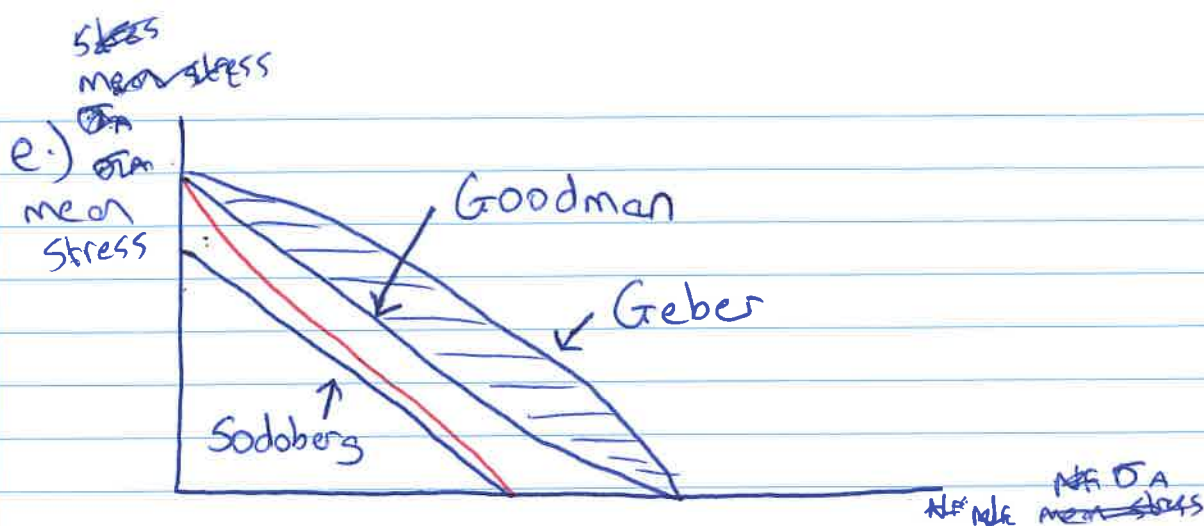
$$K = 1001843766$$

From $O_r^a N_f = K$

$$(150 \times 10^6)^{0.0000997} \times N_f = 1001843766$$

$$N_f = \frac{1001843766}{1.001878729}$$

$$N_f = 999.97 \times 10^6 \text{ at } 150 \text{ MPa}$$



These are the three theories that help link the mean stress and the amplitude stress. Most results are located within the shaded region however, most designers use Soderberg as this provides a safety margin. The graph shows how mean stress ~~can~~ increase relates to the mean Amplitude.

3

- a.) In an FEA study, meshing is extremely important, as it allows the software to give an approximation of the stress concentrations along a component under a certain load and boundary conditions. Below are certain checks and aspects of the mesh that need to be considered.

Element shapes- The component is either represented in 1D, 2D and 3D. In 1D, the physical properties need to be determined such as the second moment of Area, Polar second moment of Area and the area. In 2D, the element thickness needs to be determined. This is very similar in 3D elements also.

Element Quality- A bad mesh quality will result in a bad correlation of stress throughout the component. In terms of 3D elements, a perfect shape is a tetrahedron and a perfect mesh will contain these in every element throughout the part. Checks such as the aspect ratio and Jacobian, can be done to identify elements how far away elements are from their perfect shape. The aspect ratio for example, divides the largest element side by the smallest to give a value. Any value under 5, is seen as good. Other checks such as volumetric skew, and tet collapse, and internal angles should also be considered. Depending on the level of accuracy required, 1st or 2nd order elements can be used. 2nd order elements ~~are~~ significantly give more accurate results however, the time taken is usually longer. The Differences are shown below.



4 nodes

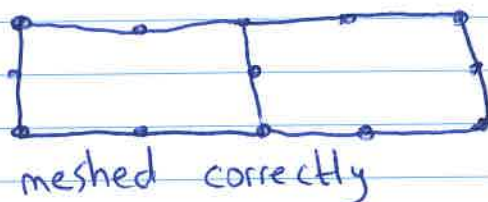
first order element



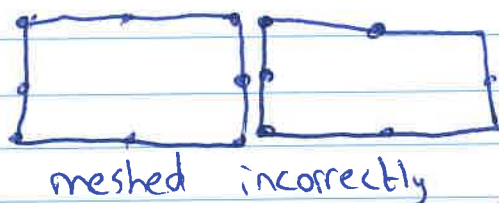
10 nodes

second order elements

Element Free edges - During an FEA analysis, it is common for ~~two elements~~ neighbouring elements to have not mesh correctly, which the FEA software will assume they ~~are~~ are not together. Instead This can be created by the CAD drawing of a component, therefore, the part should be simplified where possible. ~~This is~~ The problem of free edges, is illustrated below



This can give a bad stress correlation across the job.



Element duplicates - If a component has been reflected, or ~~the~~ been sketched badly, meshing duplicates can occur. This involves two elements placed on top of each other that will increase the components stiffness, ~~giving~~ indicating the incorrect stress figures

Element Normals - Each element should have normals perpendicular to the part, however, it is possible to have elements flipped to show incorrect normals. This can have a significant effect from Node to Node.

b.) After an FEA has occurred, the designer will usually carry out physical tests to gain confidence and verify the FEA study.

A simple test that usually occurs is using a DTI Gauge along the components surface to detect movement. Another tool that can be used is a strain gauge which detects strain along the part under certain conditions.

~~If the component is~~ It isn't uncommon for manufacturers to use tools that allow for photo Elastic techniques, and possible. If the part needs to be straight and level for example, instance, many companies use tools such as Accelerometers and even spirit levels. Even though, FEA software carries out mathematical equations to produce results, these can be wrong depending on the data that was entered (Garbage in = Garbage out). As a result, many organisations use hand calculations to investigate if the results and compare the results to the FEA software.

4

Question No.

Examiner Only

Arholwr yn unig

Rhif y Cwestiwn

Question No.

Examiner On

Arholwr yn unig

Ynif y Cwestiwn

Question No.

Examiner Only

Arholwr yn unig

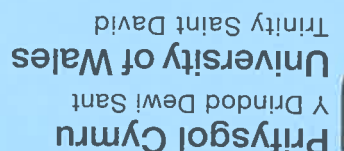
Rhif y Cwestiwn

Question No.

Examiner On

Arholwr yn unig

hff y Cwestiwn



12 Tudalen

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

1. Rhaid i'r atebion fod mewn llawysgrifen ddarllenadwy. Gall yr Arholwyr naill ai anwybyddu sgript annarllenadwy, neu drefnu iddi gael ei theipio a chael yr ymgeisydd i dalu.
2. Ysgrifennwch eich atebion mewn inc.
3. Dechreuwch bob ateb ar dudalen newydd. Gwnewch unrhyw fras nodiadau yn y llyfr atebion a thynnu llinell drwyddynt.
4. Ni ddylid rhwgo unrhyw ran o'r llyfr hwn; rhaid ei gyflwyno yn gyfan.
5. Os defnyddir mwy nag un llyfr, rhwymwch hwy gyda'i gilydd gan ddefnyddio'r tagiau sydd ar gael oddi wrth y gwyllyw/gwylwyr.
6. Rhaid dychwelyd pob llyfr. Ni chaniateir mynd â llyfrau atebion, wedi eu defnyddio neu heb eu defnyddio, allan o'r lleoliad arholi o dan unrhyw amgylchadau.

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

[illegible]

(See the other side for English version)

Lenwch, plygwh a selwch
(gweler nodyn 2 isod)

CYFENW:

ENW(AU) CYNTAF:

ENW(AU) CYNTAF: