

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: Evans

FORENAME(S): Joshua

1	Student Number	P067646
2	Title of Examination Paper	Advanced stress and FEA
3	Module Code	MSX00420
4	Date and Time of Examination	
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	13
3	11
Total	38

(Gweler yr ochr arall am y fersiwn Cymraeg)

63.3%



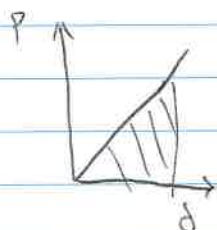
Q1

Strain energy is the energy used during the extension of a material due to strain. As a load is applied the material will get slightly longer hence $E = \frac{\delta}{ds}$.

$$b) E = \frac{\sigma}{\epsilon}, \quad E = \frac{P}{A} \div \frac{\delta}{ds}$$

$$E = \frac{P ds}{A \delta}$$

$$\delta = \frac{P ds}{AE}$$



area $\equiv U$

$$\frac{1}{2} \times b \times h$$

$$= \frac{1}{2} \times P \times \delta$$

$$= \frac{1}{2} \times P \times \frac{P ds}{AE}$$

section

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

Full bar

$$U = \int_0^L \frac{P^2 ds}{2AE} \quad \therefore U = \frac{P^2 L}{2AE}$$

d) Resilience is strain per unit volume.

The ability for a material to still absorb energy during deformation.

e)
$$\text{resilience} = \frac{\sigma^2}{2E}$$

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

$$\sigma = \frac{P}{A}$$

$$U = \frac{\sigma^2 AL}{2E}$$

$$P = \sigma A$$

$$P^2 = \sigma^2 A^2$$

$$V = AL, \quad \frac{U}{AL} = \frac{\sigma^2}{2E}$$

$\therefore$ strain per unit volume

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

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

$$E = 200 \times 10^9 \text{ Pa}$$

$$\sigma_P = 200 \times 10^6 \text{ Pa}$$

$$P = \sigma A$$

$$= 200 \times 10^6 \times 2.25 \times 10^{-4}$$

$$= 45 \times 10^3 \text{ N}$$

$$= 45 \text{ kN}$$

$$\text{Strain} = \frac{P^2 L}{2AE}$$

$$= \frac{(45 \times 10^3)^2 \times 1}{2 \times (2.25 \times 10^{-4}) \times 200 \times 10^9}$$

$$= 225 \text{ J}$$

g)

2

a) 1. A slag inclusion may have ^{opened} caused up

2.

2. A small crack may have formed A hole may not have been deburred and a stress concentration has developed

3. Accidental damage

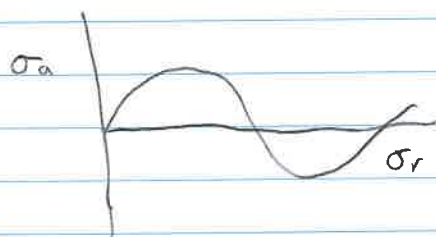
4. Sudden change in temperature conditions.

b) 1. the point of initiation - slag inclusion of bur | crack

2) Area of propagation - where the initial crack has slowly developed

3) Crystalline rupture - where the area of propagation has ~~caused~~ developed enough to cause part to shear.

c) Positive and negative stresses oscillate



e



$$2d) \quad \sigma_r^a N_f = k$$

$$a \log \sigma_r + \log N_f = \log k$$

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

$$a \log 100 \times 10^6 + \log 10^9 = \log k$$

$$8a + 9 = \log k \quad (1)$$

$$10^{17} = k$$

$$k \approx$$

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

$$a \log 200 \times 10^6 + \log 10^6 = \log k$$

$$8.304a + 6 = \log k \quad (2)$$

$$8a + 9 = \log k \quad (1)$$

$$8.304a + 6 = \log k \quad (2)$$

$$(2) - (1)$$

$$0.304a - 3 = 0$$

$$a = \frac{3}{0.3}$$

$$a = 10$$

$\therefore$ sub into (1)

$$8(10) + 9 = \log k$$

$$89 = \log k$$

$$k = 10^{89}$$

$$k = 1 \times 10^{89.7} = 10^{0.897} \times 10^{89} = 7.92 \times 10^{89}$$

$$a \log \sigma_r + \log N_f = \log k$$

$$\log N_f =$$

$$10 \log 150 \times 10^6 + \log N_f = \log(7.92 \times 10^{89})$$

$$81 + \log N_f = 89$$

$$\log N_f = 89 - 81$$

$$N_f = 10^8 \text{ cycles}$$

$\uparrow$ assumed to be error so 0.89 was used instead of 89.

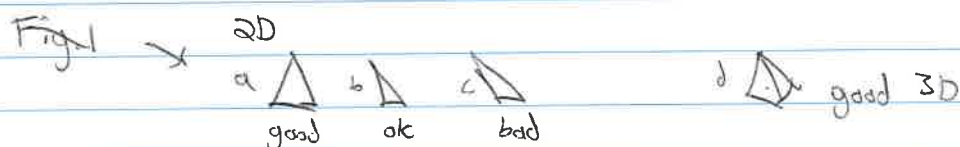
3 a) Skewness
Free edges
Quality
for

Meshing is vital in FEA as it is essentially breaking down a component into thousands of elements that are individually ^{values} computed • calculated for stiffness and stresses. These calculations are then all combined to recreate the component.

Hence ^{name} Finite Element Analysis.

The quality of mesh is vital and the following should be considered ^{checks}

Skewness - skewed elements signal a bad quality mesh. If Equilateral triangles are considered a good 2D mesh shape. (see drawing)



Aspect ratio = This ratio is given to the elements to determine if they are good or not. An aspect ratio of less than 3 is considered a high standard and would be given to an element with the same shape as a and d (See Drawing above). An aspect ratio of above 10 is bad and should be avoided as these element would likely look like drawing c) in the above drawing.

If elements are of a bad quality then the mesh size should be made smaller as it will should

result in a better mesh quality and be more accurate. This would take longer to compute however.

Free edges - These are edges of an element that are not completely fused to its surrounding element. this can occur when a part has been mirrored.



- Six nodes signalling elements are fused



- 8 nodes signalling elements are not fused. Initially may look like 6 nodes as the gap will be very small.

1st and 2nd order mesh

A first order mesh only consists of corner nodes



3D



= 4 nodes

A second order mesh consists of corner and mid/side nodes



3D



= 10 nodes

Each of these nodes can have up to 6 degrees of freedom. Seeing as a 2nd order element consists of 1.5 times more nodes, it will have a lot more degrees of freedom. Considering there are 100,000's of nodes in an FEA model, this will have a big effect on computation time.

3b Strain gauges

^{gauge}
~~Strain gauges~~ - testing the strain of a component and cross referencing with an FEA model will give an idea on the accuracy of the FEA model.

~~Vibration analysis~~ - This test can be carried out and cross referenced with frequency of FEA model.

2

3a continued ...

Check the model for any ^{areas} concentrated of high failure. See if these areas can be eliminated by changing the mesh size or adding a fillet to reduce stress concentration.

X

Question No.

Examiner O

Arholwr yn unig

iff y Cwestiwn

Question No.

Examiner Only

Question No.

Examiner On

Arholwr yn unig

Arif y Cwestiwn

Question No.

Examiner Only

Arholwr yn iunl

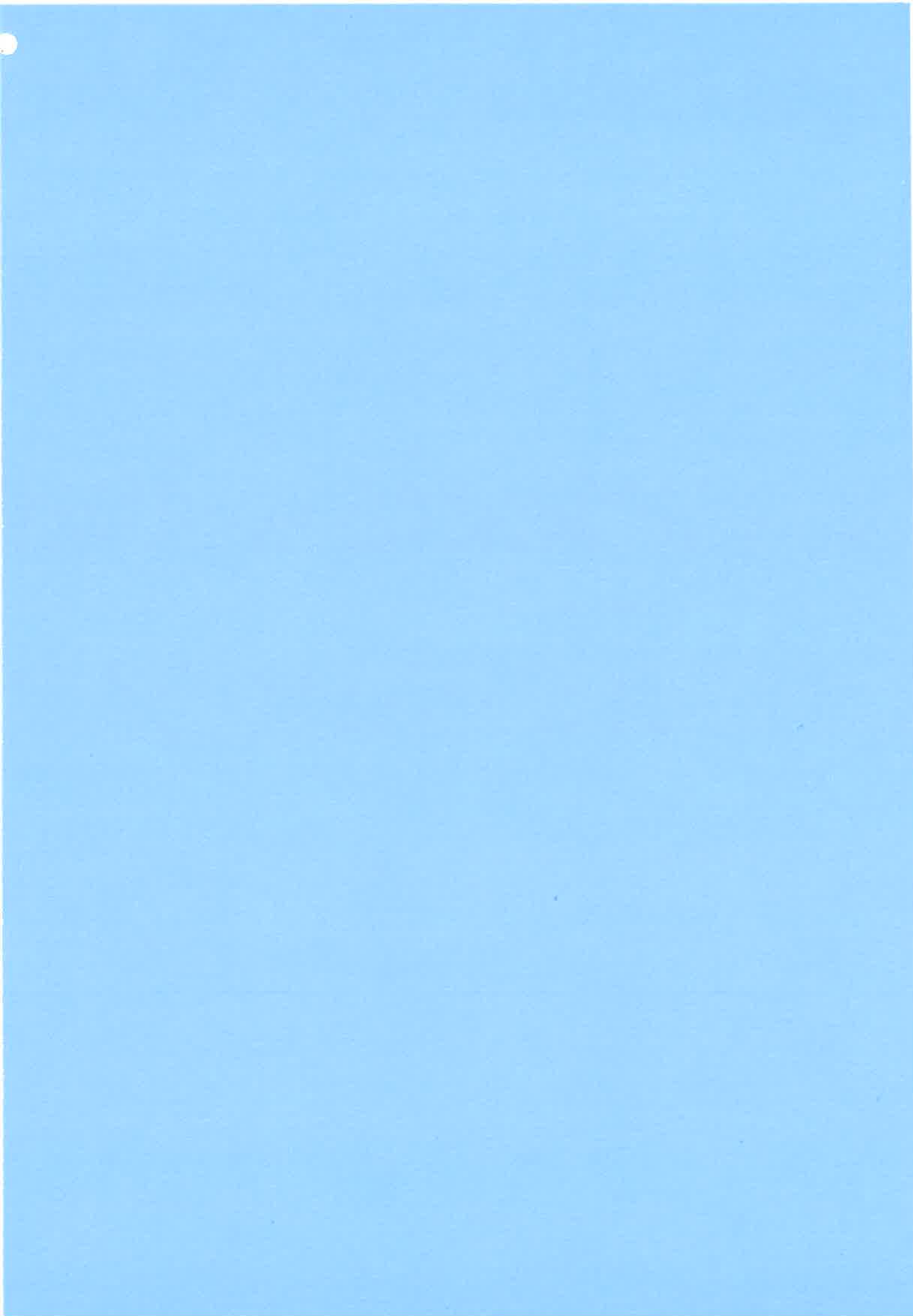
Rhif y Cwestiwn

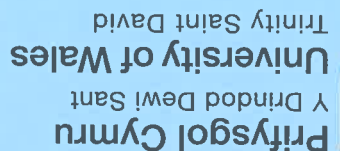
Question No.

Examiner On

Arholwr yn unig

hif y Cwestiwn





12 Tudalen

1. Rhwch yr holl wybodaeth y gofynnir amdani yn y blychau isod.
2. Rhwch eich enw yn lle a ddarparwyd ar y dde, plygwch 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 sgrïp annarllenadwy, neu drefnu iddi gael ei theipio 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 rhwgo 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 gwyllwyr/gwylwyr.

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

1	Rhif Myfyriwr	
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)

Лленвч, плгвч а селвч
(гвелер нodyn 2 isod)

CYFENW:

ENW(AU) CYNTAF:

ENW(AU) CYNTAF: