



Prifysgol Cymru  
Y Drindod Dewi Sant  
University of Wales  
Trinity Saint David

## Examination Answer Books

12 Pages

### Instructions to Candidates

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.

Complete, fold and seal  
(see note 2 below)

SURNAME: PRITCHARD

FORENAME(S): AARON

|   |                                  |                       |
|---|----------------------------------|-----------------------|
| 1 | Student Number                   | PS1481                |
| 2 | Title of Examination Paper       | Advanced Stress & FEA |
| 3 | Module Code                      | MGX00420              |
| 4 | Date and Time of Examination     | Jan 31 2020<br>13:30  |
| 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 |
|------------------------------------------------------|------------|
| 2                                                    | 9          |
| 3                                                    | 6          |
| 4                                                    | 11         |
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| Total                                                | 26         |

(Gweler yr ochr arall am y fersiwn Cymraeg)

43.3%



Answered Q 2, 3 and 4.

Question No.

Examiner Only

i)  
a) Strain energy is a force applied to an object which deforms the object to compress one side and extend the opposite. the ~~middle~~<sup>centre</sup> axis remains the same length. but the compressive shortens and opposite side extends.

b)  $E = \frac{\sigma}{\epsilon}$   ~~$P = \frac{F}{A}$~~   $\sigma = \frac{P}{A} \rightarrow P = \sigma A$   $E = \frac{\Delta ds}{ds}$

$$\delta = \frac{\sigma A ds}{A \frac{\sigma}{\epsilon}}$$

$$E = \sigma \div \frac{\Delta ds}{ds}$$

$$ds = \frac{\Delta ds}{\sigma}$$

c)  $U = \frac{1}{2} \times P \times \delta$

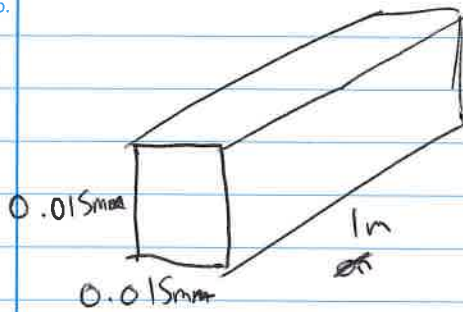
$$U = \frac{1}{2} \times P \delta^2$$



d) resilience is the amount of strain per volume.

X

f)



$$\sigma = 200 \times 10^3 \text{ Nm}^2$$

$$\epsilon = ?$$

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

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

$$\therefore F = \sigma \times A \\ = 200 \times 10^3 \times 2.25 \times 10^{-4}$$

$$F = 45 \text{ N}$$



2a) cyclic loading

weakness in the material structure

weathered, corrosion etc damage to material

exceeding the materials yield strength to past its elasticity point and causing separation/cracks in the material due to failure.

2

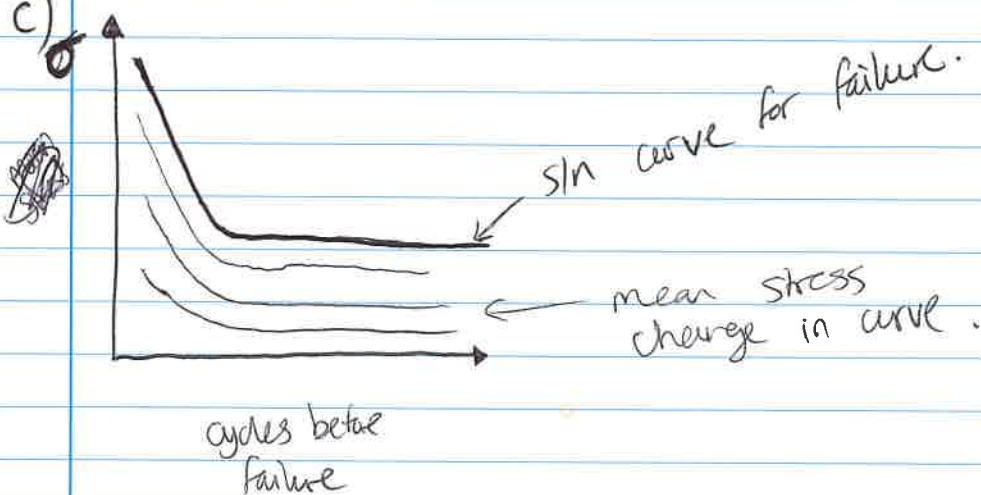
b) point of initiation

point of propagation

crystalline area of failure.

3

c)



X

d)  $N_f$   $\sigma_r$  ( $\sigma_{R_0}$ )

$$\frac{10 \times 10^9}{10 \times 10^6} ?$$

$$\frac{100 \times 10^3}{200 \times 10^3} \frac{150 \times 10^3}{150 \times 10^3}$$

$$\frac{n_1}{n_1} + \frac{n_2}{n_2} + \frac{n_3}{n_3} = 1$$

$$\frac{100 \times 10^3}{10 \times 10^9} + \frac{200 \times 10^3}{10 \times 10^6} + \frac{150 \times 10^3}{X} = 1$$

$= 1 \times 10^{-4}$   $2 \times 10^{-2}$

$$1 - \left( \frac{100 \times 10^3}{10 \times 10^9} \right) - \left( \frac{200 \times 10^3}{10 \times 10^6} \right) = \frac{150 \times 10^3}{X}$$

$$1 - 1 \times 10^{-4} - 0.02 = \frac{150 \times 10^3}{X}$$

$$X = \frac{150 \times 10^3}{(1 - 1 \times 10^{-4} - 0.02)} = 187.52 \times 10^3 \text{ cycles}$$

Answer X

~~1000~~ ~~5~~

$$\frac{10 \times 10^9}{100 \times 10^3} = \frac{10 \times 10^6}{200 \times 10^3} + \frac{150 \times 10^3}{X} = 1$$

$$1 - \left( \frac{10 \times 10^9}{100 \times 10^3} \right) - \left( \frac{10 \times 10^6}{200 \times 10^3} \right) = \frac{150 \times 10^3}{X}$$

$$1 - 100 - 50 = \frac{150 \times 10^3}{X}$$

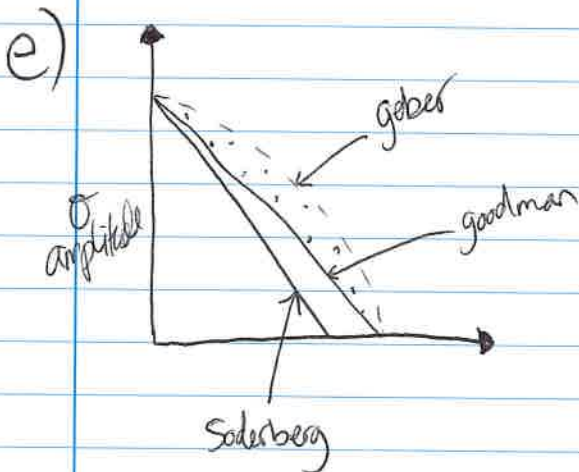
$$-149 = \frac{150 \times 10^3}{X}$$

$$X = \frac{150 \times 10^3}{-149} = -1006.71 \times 10^3$$

d)

$$100 \times 10^3 \times 10^9 = 1 \times 10^{14}$$

$$20000 \times 10^6 = 2 \times 10^{11}$$

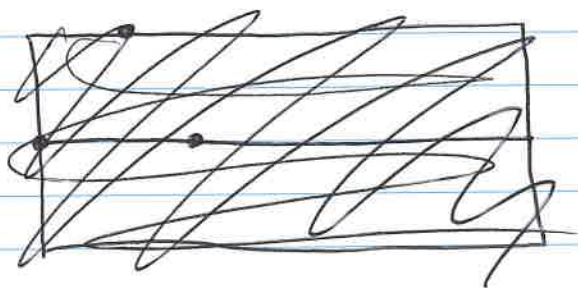


Soderberg is most conservative so is widely used to be safer/cautious. Most likely failure occurs ~~between~~ in area between gerber and goodman.

3)

- a) Meshing a part in the pre-processing stage determines the degree of accuracy your results predict.

i.e. large mesh

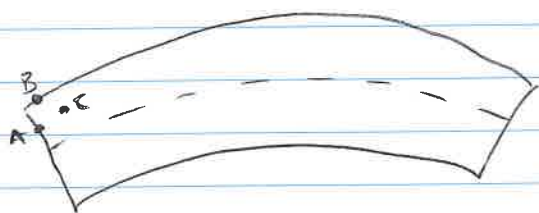


with a large mesh that covers from the side in extension all the way to the centre ~~the~~ axis; the nodes A + C will have a value of 0. Therefore lowering the average sum of nodes A, B + C down further, i.e.

$$\left. \begin{array}{l} A = 0 \\ B = 10 \\ C = 0 \end{array} \right\} \begin{array}{l} 0 + 10 + 0 = 10 \\ \frac{10}{3} = 3.33 \text{ average} \end{array}$$

So with a larger mesh the average stress experienced in that element is 3.33.

If the mesh was  $\frac{1}{2}$  as small, i.e.



$$\begin{array}{l} \text{where } A = 5 \\ B = 10 \\ C = 5 \end{array}$$

$$\text{average} = \frac{20}{3} = 6.67$$

The degree of accuracy has increased with

a smaller mesh, resulting in a more accurate representation of the stress experienced in the part. Determining the appropriate mesh size is often a balance between degree of accuracy/reliability and the processing speed of the test.

More elements, i.e. a smaller mesh, will increase the length of time needed to run an FEA test.

Furthermore, software packages will check for any gaps between ~~the~~ elements, ~~where~~ an overlapping of nodes will occur and may incorrectly misinterpret the results from the FEA test.

By reducing the element size, the ~~area~~ area of higher stress concentrations will be more precisely identified. This allows design changes to be made to increase the strength of those areas or reduce the stress experienced in them.

Without an accurate mesh size, excess stress can occur causing failure over time, which may be increased by other fatigue factors.

- b) FEA analysis software will allow stresses to be placed on objects to test their limits and determine areas of weakness. Material properties can be taken into account in order to accurately predict if a material choice is sufficient. Cyclic loading, max stress, deflection of part and deformation can be determined by Computer software. Objects can be fixed on a particular part while forces are applied, resulting in possible need for a change in design, along with the possibility of reducing the size and weight of the object in testing to save further weight and cost implications.

X  
D

Question No.

Examiner On

Arholwr yn unig

Arif y Cwestiwn

#### 4a) Pre-processing

Mesh sizing, material properties, forces in play, design specification can all be established pre process stage.

#### Processing

Max stress that can be assessed can be calculated to ensure a factor of safety is there compared to the actual stresses expected. material reduction for cost and weight benefits can be tested for ~~to~~ by running multiple cycles lowering the volume of material gradually. Max deflection can be tested for which may be crucial in objects such as struts and bridges. Natural frequency and other implications from moving objects attached when all assembled together which can amplify the deflection on any object and increase the rate of wear.

#### Post processing

Is the part sufficient.

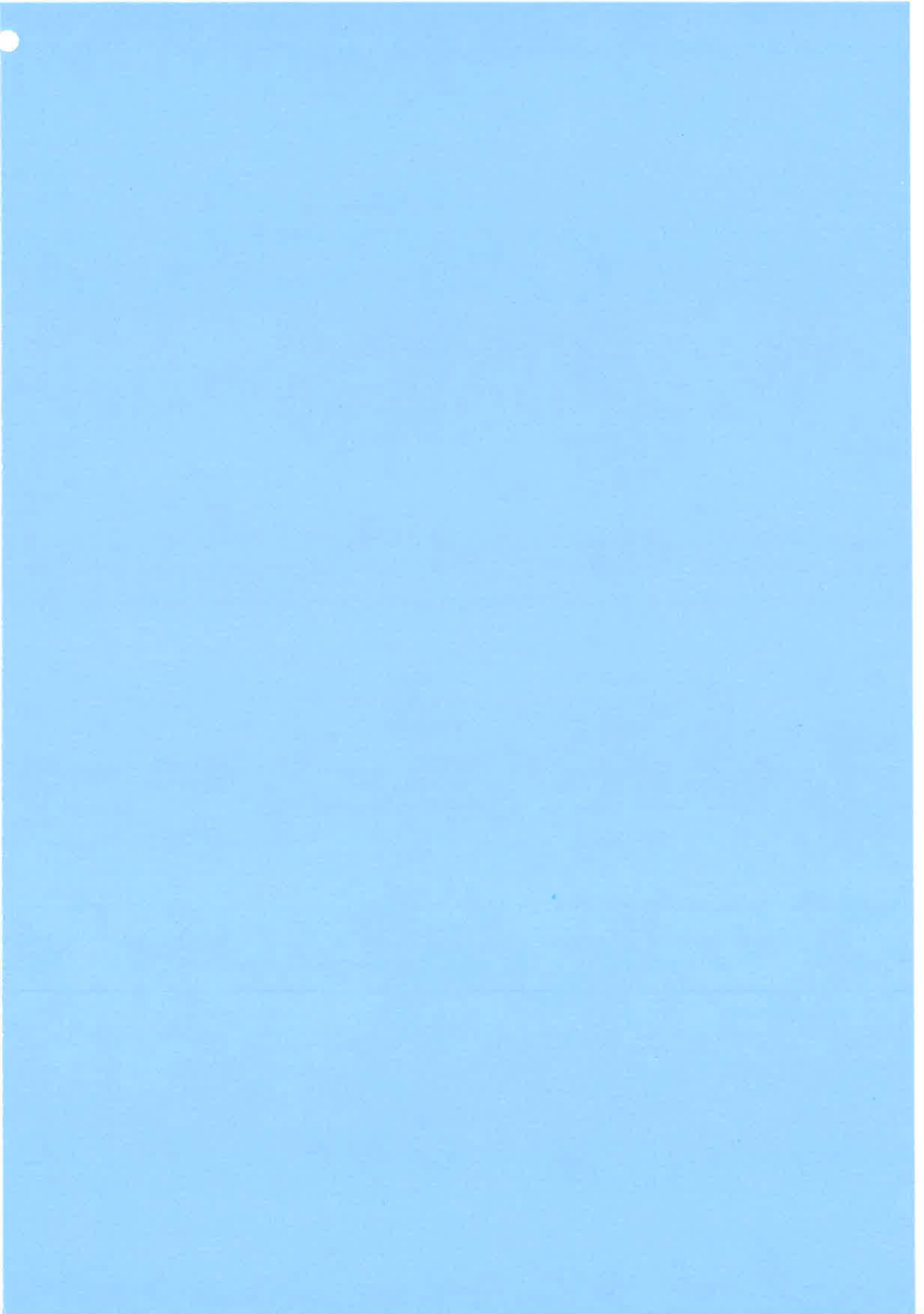
Can ~~the~~ final design based on material reduction be altered.

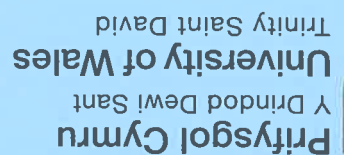
Benefits to possibly altering the material choice

4b) Automatic meshing may make assumptions that are incorrect. Areas of a large object may still have smaller sections that experience increased stress levels and therefore a smaller mesh is advised to focus on those areas. Processing speed is important so a larger automatic mesh may initially provide feedback needed quickly, to enable engineers to determine what level of detail is required when considering element sizing. However as a final result, an automatic mesher may be acceptable for a non-safety crucial part such as the shaft of a pen, but not reliable enough for the forces experienced on a helicopter rotor where failure could be catastrophic.

Increased computer capacity speeds up the test results but the computer can't identify or predict what final specification you need & for the object.

~~Larger~~ Automatic mesher may benefit static objects where the forces ~~placed~~ experienced on the part do not change and are constant, but more finer and specific meshing techniques are required for objects experiencing multiple levels of forces at different times to establish if an increase in force will have an effect on ~~larger~~ areas of higher stress concentrations.





## 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, pigwch ef a'i seio i lawr (gan ddefnyddio'r label a ddarparwyd) i guddio'ch enw.

3. Rhaid i'r atebion fod mewn llawysgriften ddarlennadwy. Gall yr Arholwyr naill ai anwybyddu sgript annarllennadwy, neu drefnu iddi gael ei theipio a chael yr ymgeisydd i dalu.
4. Ysgrifennwch 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 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)

Llenwch, plygwrch a seliwrch  
(gweler nodyn 2 isod)

**CYFENN:**

ENW(AU) CYNTAF:

ENW(AU) CYNTAF: