



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:

HART

FORENAME(S):

MAXIMILIAN

1	Student Number	1700625
2	Title of Examination Paper	CAE & STRESS
3	Module Code	MSX02064
4	Date and Time of Examination	09-05-19 12:00
5	Examination Venue	310
6	Seat Number	6034
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
1	17
2	18
3	11
Total	46

(Gweler yr ochr arall am y fersiwn Cymraeg)

76.7%



1a $\uparrow$ Forces = $\downarrow$ Forces $\therefore$ Pressure Forces = Stress Forces.

Pressure Forces: Resolving Vertically.

$$F = \text{Pressure} \times \text{Projected Area} = P \times dL$$

Stress Forces:

$$F = \text{Stress} \times \text{Area} = 2\sigma_H \times Lt$$

$$\therefore PdL = 2\sigma_H Lt$$

$$\therefore \sigma_H = \frac{Pd}{2Lt}$$

b: $200 \times 10^6 = \frac{(P_{\max})(3.5)}{(2)(0.5 \times 10^{-3})} \therefore \frac{200 \times 10^6}{3.5} = P_{\max} = 57.14 \times 10^3 \text{ Pa} = 57.14 \text{ kPa}$

ii @ Sea level external pressure = 101 kPa

$$\therefore \text{min internal pressure} = 44 \text{ kPa} \quad \rightarrow 101 - 57 = 44$$

$$\therefore \text{Max Altitude} = 20,000 \text{ ft.}$$

@ 8000 ft internal pressure = 75.3 kPa

$$75.3 - 57 = 18.3 \text{ kPa which corresponds to } \underline{40,000 \text{ ft.}}$$

c. Pressurising plane cabins allows the difference in pressure to be much higher lower inside & outside the cabin, thus reducing the hoop stresses on the fuselage. Flying at higher altitude gives the aircraft better fuel economy.

d. PTO

d. $\uparrow F = \downarrow F \therefore \text{Pressure Forces} = \text{Stress Forces}$

Pressure Forces: Solved Vertically

$$F = \text{Pressure} \times \text{Projected Area} = P \times \frac{\pi d^2}{4}$$

Stress Forces:

$$F = \text{Stress} \times \text{Area} = \sigma_H \times \pi d t$$

$$\therefore \frac{P \pi d^2}{4} = \sigma_H \pi d t \quad \therefore \sigma_H = \frac{P d}{4 t}$$

e. It is clear from a cylinder's hoop stress $\left(\frac{P d}{2 t}\right)$ and a sphere's hoop stress $\left(\frac{P d}{4 t}\right)$ that that within a sphere is half the magnitude of a cylinder.

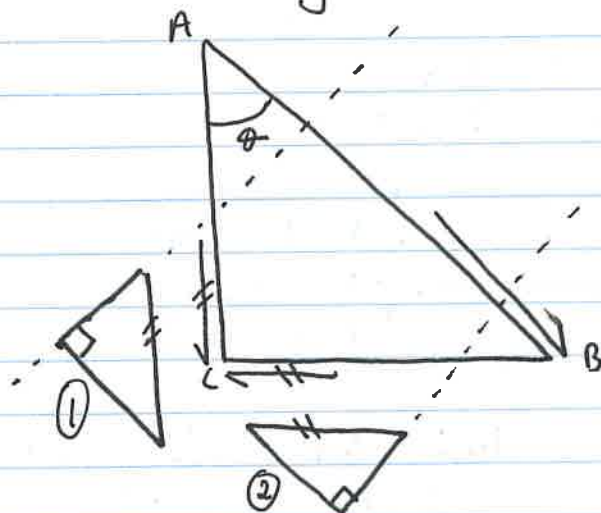
This means fluid inside can be stored at twice the pressure with the same hoop stress. This means more liquid can be stored with no extra risk.

A Spherical container also takes less space than a cylinder with the same volume.

2

b. ii

$$\tau_{\theta} = -\tau_{xy} \cos 2\theta$$



$$F = \sigma \cdot A$$

$$\therefore F = \sigma \cdot L \cdot W \rightarrow W = 1$$

$$\downarrow = AC \tau_{xy}$$

$$\leftarrow = BC \tau_{xy}$$

$$\searrow = AB \tau_{\theta}$$

$$\textcircled{1} = AC \tau_{xy} \cos \theta$$

$$\textcircled{2} = BC \tau_{xy} \sin \theta$$

$$\therefore AB \tau_{\theta} + AC \tau_{xy} \cos \theta = BC \tau_{xy} \sin \theta$$

$[\div AB] \qquad \qquad \qquad [\div AD]$

$$\sin \theta = \frac{O}{H} = \frac{BC}{AB}$$

$$\cos \theta = \frac{A}{H} = \frac{AC}{AB}$$

$$\therefore \tau_{\theta} = \sin^2 \theta \tau_{xy} - \cos^2 \theta \tau_{xy}$$

$$\therefore \tau_{\theta} = \frac{1}{2} (1 - \cos 2\theta) \tau_{xy} - \frac{1}{2} (1 + \cos 2\theta) \tau_{xy}$$

$$\therefore \tau_{\theta} = \left(\frac{1}{2} - \frac{1}{2} \cos 2\theta \right) \tau_{xy} - \left(\frac{1}{2} + \frac{1}{2} \cos 2\theta \right) \tau_{xy}$$

$$\therefore \tau_{\theta} = \cos 2\theta \tau_{xy} - 2 \cos 2\theta \tau_{xy} = -\cos 2\theta \tau_{xy}$$

$$\therefore \tau_{\theta} = -\tau_{xy} \cos 2\theta$$

$$\sin^2 \theta - \cos^2 \theta = -\cos 2\theta$$

$$\therefore \sin^2 \theta = \cos^2 \theta - \cos 2\theta$$

$$\therefore \sin^2 \theta = \frac{1}{2} (1 - \cos 2\theta)$$

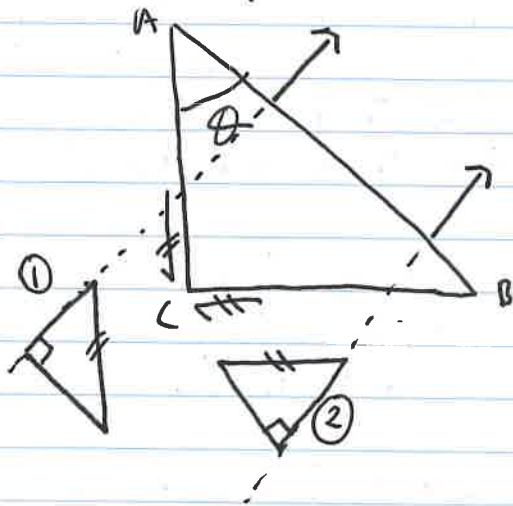
$$\therefore \cos^2 \theta = \frac{1}{2} (1 + \cos 2\theta)$$

↪

(5)

2 [b i]

$$\sigma_{\theta} = \tau_{xy} \sin 2\theta$$



$$F = \sigma \cdot A$$

$$\therefore F = \sigma \cdot l \cdot w \rightarrow w = 1$$

$$\therefore \downarrow = AC \tau_{xy}$$

$$\leftarrow = BC \tau_{xy}$$

$$\nearrow = AB \sigma_{\theta}$$

$$\textcircled{1} = AC \tau_{xy} \sin \theta$$

$$\textcircled{2} = BC \tau_{xy} \cos \theta$$

$$\therefore AB \sigma_{\theta} = AC \tau_{xy} \sin \theta + BC \tau_{xy} \cos \theta$$

$$[\div AB]$$

$$[\div AB]$$

$$\cos \theta = AC / AB$$

$$\sin \theta = BC / AB$$

$$\therefore \sigma_{\theta} = AC / AB \tau_{xy} \sin \theta + BC / AB \tau_{xy} \cos \theta$$

$$\therefore \sigma_{\theta} = \sin \theta \cos \theta \tau_{xy} + \sin \theta \cos \theta \tau_{xy}$$

$$\therefore \sigma_{\theta} = 2(\sin \theta \cos \theta) \tau_{xy} = 2 \left(\frac{1}{2} \sin 2\theta \right) \tau_{xy}$$

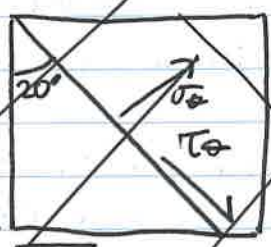
$$\therefore \sigma_{\theta} = \tau_{xy} \sin 2\theta$$

5

2 a The principal stress is the Maximum or minimum stress that can act upon an element within a given system, being acted upon by defined normal & sheer stresses, at a given angle. The principal plane is the plane on which the principal stress acts, the angle of which can be calculated from $\tan^{-1}\left(\frac{\sigma_y - \sigma_x}{\tau_{xy}}\right)$.

2 c

2 C PLEASE TURN 3 PAGES



$\tau_{xy} = 45 \text{ kN}$
 $= 5.63 \text{ kPa (kN/m}^2\text{)}$

Force = $\sigma \times A$

↑ Sorry!

$\therefore \sigma = F/A$

$\therefore \tau_{xy} = 45 \times 10^3 / 0.8$

$= 5.63 \text{ kN/m}^2$

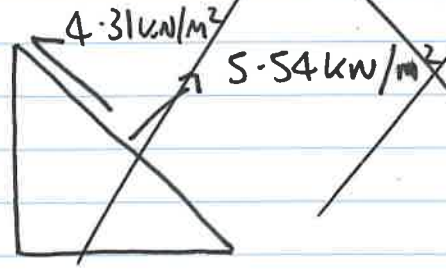
$\sigma_\theta = \tau_{xy} \sin 2\theta$

note

$\therefore \sigma_\theta = (5.63)(\sin 40) = 3.54 \times 10^3 \text{ Pa kN/m}^2$
 $= 3.54 \text{ kN/m}^2$

$\tau_\theta = -\tau_{xy} \cos 2\theta$

$\therefore \tau_\theta = (-5.63)(\cos 40) = -4.31 \times 10^3 \text{ N/m}^2$
 $= -4.31 \text{ kN/m}^2$



3a) A design problem is a vaguely defined problem with a variety of different possible solutions. As the problem solving progresses, the solution may change + be refined due to errors or impracticalities along the way.

An analysis problem is a problem with one clear solution that a certain process is likely to be followed to achieve. It will include little deviation from the original plan.

3

b) A design problem is solved in stages. As stated, there will be a variety of possible solutions and progress may be halted & restarted due to failure. This is an example of an iteration and each iteration combined will allow the user to learn and eventually solve the problem. ~~By this~~ This repetitive method cycles through each stage and thus is known as a cyclic process also.

The nature of an analysis problem, as stated, is such that the solution is often set at already and one must complete a set process to reach it, in a prescribed order. This defines a sequence for the user to follow, hence being known as a sequential process.

5

Engineering Design Process.

C.

5-Step Cycle of Design

- ① • Define Problem
 - Create a problem statement. Ensure you have a clear objective and the customer's needs are fully established.
 - ② • Gather Relevant Information
 - Establish a budget and timeframe for project. Research the market, is there an existing solution? What are the pros & cons of this solution? Research legislation surrounding the product and consider safety.
 - ③ • Generate Multiple Solutions.
 - Within the group, brainstorm. Do not be afraid to take risks within the design. Ensure specialist opinions are sought for specialist work. Create as many solutions as possible and don't discount any at this stage.
 - ④ • Analyse & Select
 - Taking into account practicality & budget, discount any solutions that may not be feasible. Discuss with co-workers and ensure solution chosen is the best option.
 - ⑤ • Test & Implement
 - Use contemporary testing techniques such as CFD, CAE (FEA) and 3D Modelling to test the solution virtually before going into production. If the selected solution fails, return to step 4 & re-select. If success, carry on to production. Consider Patent application.
- ADVANTAGES/DISADVANTAGES:
- | | | |
|-------|-------|---|
| +ve's | -ve's | ? |
|-------|-------|---|

- ① Problem not always definable straight away, sometimes vague: -ve
Gives a clear starting point, able to work towards clear goal: +ve
- ② Not always able to gather info you need at start / don't know what need: -ve
Reduces chances of mistake / failure: +ve
- ③ If you make too many you may get lost in them all: -ve
Gives a broad range of ideas: +ve
- ④ Could discount good ideas: -ve / Helps discount bad ideas: +ve
- ⑤ Testing with CAE & FEA should happen earlier in design process: -ve
Testing, even this late, reduces chance of failure: +ve.

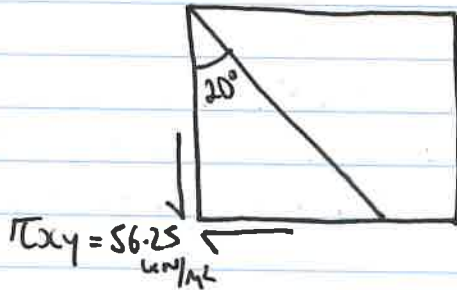
/ 3

2 C

$$\text{Area} = 800 \text{ mm}^2 = 800 \times 10^{-3} \text{ m}^2 \quad \text{Force} = 45 \text{ kN} = 45 \times 10^3 \text{ N}$$

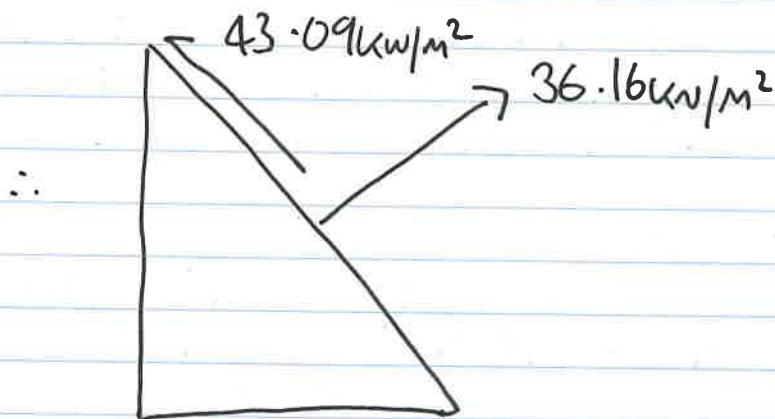
$$F = \sigma \times A \quad \therefore \sigma = F/A = \frac{45 \times 10^3}{800 \times 10^{-3}}$$

$$\therefore \sigma = 56250 \text{ N/m}^2 = 56.25 \text{ kN/m}^2 \quad \text{UNITS}$$



$$\therefore \sigma_{\theta} = (56250)(\sin 40) = 36156.8 \text{ N/m}^2 = 36.16 \text{ kN/m}^2 \quad \times$$

$$\therefore \tau_{\theta} = -(56250)(\cos 40) = -43089.9 \text{ N/m}^2 = -43.09 \text{ kN/m}^2 \quad \times$$



(5)

$$\begin{aligned} \sin^2 \theta + \cos^2 \theta &= 1 \\ \sin^2 \theta &= 1 - \cos^2 \theta \end{aligned}$$

Question No.

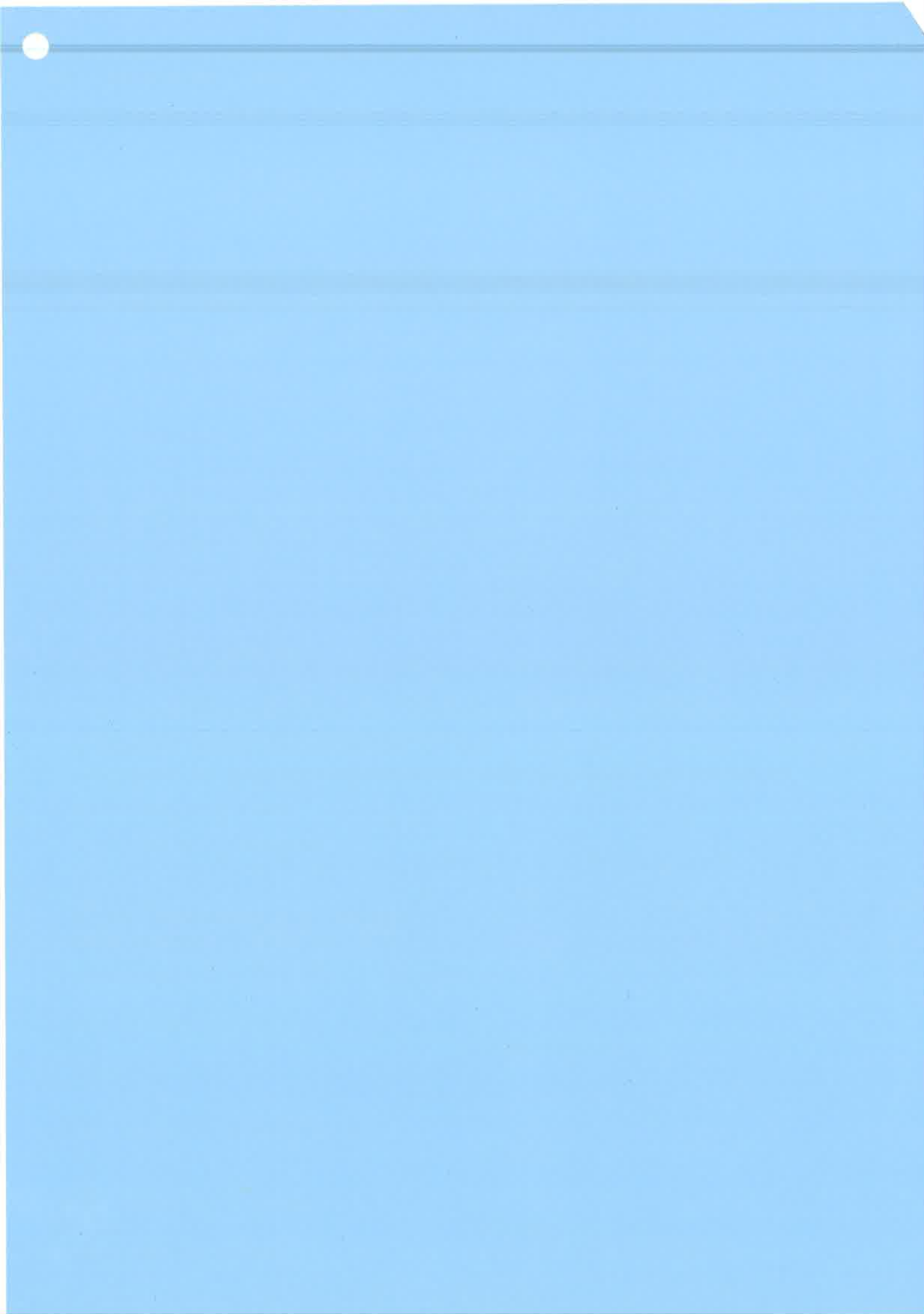
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Cyfarwyddiadau i Ymgeiswyr

4. Ysgrifennwch eich atebion mewn inc.

arholi o dan unrhwy amgylchiadau.

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)

CYFENW:

ENW(AU) CYNTAF: