

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:

MAY

FORENAME(S):

CORNELIUS

List the numbers of the questions you have attempted	Office Use
1	20
2	12
3	11
Total	43

(Gweler yr ochr arall am y fersiwn Cymraeg)

7172



Since structure is in equilibrium:

1 a Forces due to hoop stress = Forces due to internal pressure

$$\text{Forces due to hoop stress } (\sigma_H) = \sigma_H \times L \times 2t$$

Pressure = Force $\times$ surface area
 $\therefore \text{Force} = \frac{\text{Pressure}}{\text{surface area}}$ Considering only the forces in the same direction as σ_H
 $\therefore F = \frac{P}{Ld}$

Force = Pressure $\times$ surface area Consider only forces in same direction as σ_H

$$\therefore F = P \times L \times d$$

Forces are equal

$$\therefore P \cdot L \cdot d = \sigma_H \cdot L \cdot 2t \quad \text{divide } L$$

$$\therefore Pd = \sigma_H \cdot 2t$$

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

b $\sigma_{H \max} = 200 \text{ MPa} = 200 \times 10^6 \text{ Pa}$

$$d = 3.5 \text{ m}$$

$$t = 0.5 \text{ mm} = 0.5 \times 10^{-3} \text{ m}$$

$$P = \rho gh$$

$$\sigma_H = \frac{Pd}{2t} \quad \therefore P = \frac{\sigma_H 2t}{d} = \frac{(200 \times 10^6) \cdot (2 \times 0.5 \times 10^{-3})}{3.5}$$

$$\therefore P = \underline{57142.86 \text{ N/m}^2} \quad \text{max allowed pressure difference}$$

b i At sea level ambient Pressure = 101 kPa
 $= 101 \times 10^3 \text{ Pa}$

Max pressure difference = $57.142 \times 10^3 \text{ Pa}$

$(101 \times 10^3) - (57.142 \times 10^3) = 43.857 \times 10^3 \text{ Pa}$
 $= \text{Minimum outside pressure allowed}$

$\therefore$ Max altitude is 20,000 feet.

b ii At 8000 ft ambient Pressure = $75.3 \text{ kPa} = 75.3 \times 10^3 \text{ Pa}$

$(75.3 \times 10^3) - (57.14 \times 10^3) = 18.157 \text{ kPa}$

$\therefore$ Max altitude is 40,000 ft

c Pressurizing the plane cabin allows the plane to safely fly at higher altitudes, where air density & therefore drag are lower, reducing the amount of fuel required.

d Forces due to hoop stress = Forces due to Pressure

Forces due to hoop stress = $\sigma_H \times t \cdot \pi d$

Forces due to pressure = $P \cdot \frac{\pi d^2}{4}$

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

$\pi r^2 = \frac{\pi d^2}{4}$

$\frac{\pi (d+t)^2}{4} - \frac{\pi d^2}{4}$

$\frac{\pi}{4} (d^2 + t^2 + 2dt - d^2)$

$\frac{\pi}{4} (d^2 + t^2 + 2dt - d^2)$

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

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

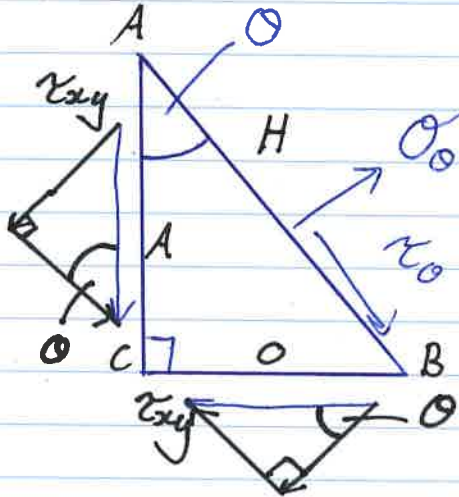
e The equations show that ~~sph~~ spherical containers can cope with 2x the pressure before failing compared to cylindrical containers.

However the volume to footprint ratio of a sphere compared to a cylinder means, cylinders are more efficient for storage.

- 2 a Principle stress, is the stress within a structure, caused by the surface stresses & strains. It acts at 90° to the Principal plane & the principle strain.

(2)

b



SOH CAH TOA

$$AB = H, AC = A, BC = O$$

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

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

$$\tan \theta = \frac{BC}{AC}$$

- i Using components of τ_{xy} parallel to σ_θ :

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

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

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

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

$$\text{given that } \sin \theta \cos \theta = \frac{1}{2} \sin 2\theta$$

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

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

(5)

ii Using components of τ_{xy} parallel to τ_θ :

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

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

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

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

$$= \tau_{xy} (-\cos^2 \theta + \sin^2 \theta) = \tau_{xy} (\sin^2 \theta - \cos^2 \theta)$$

$$\text{given that } \sin^2 \theta - \cos^2 \theta = -\cos 2\theta$$

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

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

C  $\frac{\pi d^2}{4} = 800 \text{ mm}^2$

$$\therefore d = 31.92 \text{ mm}$$

$$\tau_\theta = -45 \cos(2 \times 20) = \underline{\underline{-34.5 \text{ kN}}}$$

$$\sigma_\theta = 45 \sin(2 \times 20) = \underline{\underline{-28.93 \text{ kN}}}$$

- 3 a A design problem is one where multiple possible solutions exist, to suit a set of criteria, whilst an analysis problem has 1 ideal solution.

A design problem is solved in iterations, each one getting closer to a possible solution. An analysis problem follows a single flow from problem to solution.

- b A design problem tends to be iterative as a result of its definition. The design flows in a way that a design is created from experience & then tested against the criteria. At each iteration mistakes are made & the design process loops until a solution is that matches all criteria is found. This is a cyclic process.

Analysis is sequential as you look at all the criteria together & work to solve them together, evaluating as you go. This means that no repeating of steps or "iterations" are required.

CAE/FEA

C ~~Not~~ The first process uses no CAD. This results in a process that loops from CAD to tooling to testing & repeats. This process has the benefit that no specialised CAE software or training is required. However, this process relies heavily on the experience & knowledge of designers. This also means that more testing & manufacture of prototypes is needed which is more expensive than software & training for CAE in most cases.

The next process involves CAE partway through the design process. FEA is used to evaluate designs before testing on prototypes. This reduces the amount spent on tooling & testing, ~~as~~ however requires money to be spent on software & training. The time taken for the design process is slightly reduced.

In this process, design is initially carried out using FEA, to optimally design the part for the situation. No money is spent on prototyping & the experience required does not effect the model created. The ~~all~~ only prototype required is to correlate FEA models & for legislative testing. Training on FEA software is required & ~~the~~ money must be spent on software.

This final process is an idealised version of the previous one, where absolutely no prototyping is required & all testing takes place through FEA. This has the shortest design time, however testing ~~is~~ is needed for legislative requirements & for FEA correlation.

Question No.

Examiner Only

Arholwr yn unig

Arif y Cwestiwn

Question No.

Examiner Only

Question No.

Examiner Only

Arholwr yn unig

Prif y Cwestiwn

Question No.

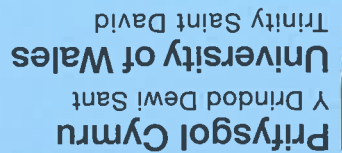
Examiner Only

Question No.

Examiner Only

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 selio i lawr (gan ddefnyddio'r label a ddarparwyd) i guddio'ch enw.

3. Rhaid i'r atebion fod mewn llawysgriflen ddarlennadwy. Gall yr Arholwyr naill ai anwybyddu sgrifft 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 drwyddyn.

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 gwylwlr/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 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	Tittl y Papur Arholiad	
1	Rhif Myfyriwr	

[illegible]

(See the other side for English version)

Llenwch, plygwch a seliwch
(gweler nodyn 2 isod)

CYFENN:

ENW(AU) CYNTAF:

ENW(AU) CYNTAF: