



Prifysgol Cymru
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LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
MAY 2019

CYFNOD ARHOLIADAU
MAI 2019

MODULE CODE:
M5X02064: CAE & Stress analysis (FULL TIME)

TIME: 2 HOURS

ANSWER THREE OUT OF FOUR QUESTIONS

Equipment or materials required – None

Adnoddau neu ddefnyddiau sydd eu hangen – Dim

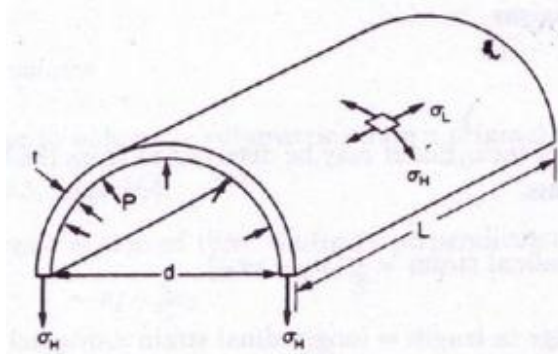
A formula sheet is provided for reference.

University approved calculators are permitted.

Assume 'g' = 9.81 m/s².

Question 1

a)



Resolve vertically:

$$\begin{aligned} \text{Upwards Force, } F &= P \times A \\ &= P \times dL \end{aligned}$$

$$\text{Downwards Force, } F = 2 \sigma_H \times tL$$

$$\therefore 2 \sigma_H tL = PdL$$

$$2 \sigma_H t = Pd$$

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

[4 Marks]

b)

From part a)

$$P_{Max} = \frac{2\sigma_H t}{d} = \frac{2 \times 200 \times 10^6 \times 0.5 \times 10^{-3}}{3.5} = 57kPa$$

If sealed at sea pressure the pressure inside would be, from the table

$$P = 101 \text{ kPa}$$

Thus the min outside pressure is

$$P = 101 - 57 = 44 \text{ kPa}$$

In this situation, the pressure difference would be 57 kPa.

From the table the plane can fly no higher than **20,000** feet. At this point the pressure is above 44 kPa, at 46.6 kPa.

[4 Marks]

bii)

If sealed at a pressure equivalent to 8000ft the pressure inside would be, from the table

$$P = 75 \text{ kPa}$$

Thus the min outside pressure is

$$P = 75 - 57 = 18 \text{ kPa}$$

In this situation, the pressure difference would be 57 kPa.

From the table the plane can now fly at **40,000** feet. At this point the pressure is above 18 kPa, at 18.7 kPa.

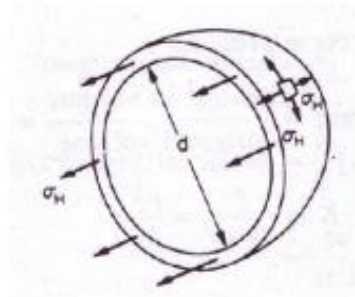
[3 Marks]

c)

At 40,000 feet the air is thinner which is obviously better for fuel economy.

[2 Marks]

d)



Force on the sphere from the internal pressure;

$$\begin{aligned} F &= P \times A \\ &= P \times \frac{\pi d^2}{4} \end{aligned}$$

The resisting force;

$$F = \sigma_H \pi d t$$

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

$$\therefore \sigma_H = \frac{p d}{4 t}$$

[4 Marks]

e)

In terms of footprint v storage capacity, cylindrical containers are more cost effective, however the Hoop stresses are halved by storing fluids in spheres meaning these fluids can be stored at higher pressures which you may want to do to change their state from gas to liquid etc.

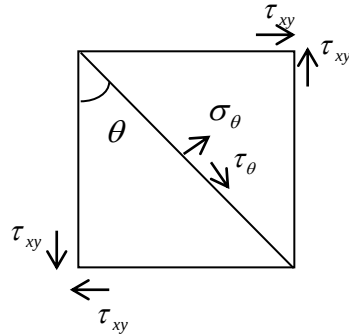
[3 Marks]

Question 2

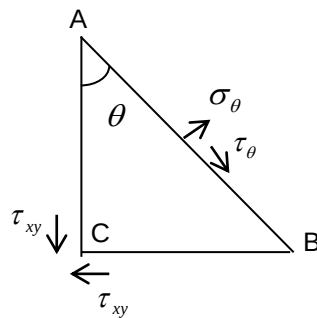
a.

The PRINCIPAL STRESS is the MAXIMUM OR MINIMUM stress that the component would see and these would act on PRINCIPAL PLANES.

bi.



Consider the free body diagram



Σ FORCES perpendicular to AB are zero,

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

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

Now;

$$\frac{AC}{AB} = \cos\theta \text{ and } \frac{BC}{AB} = \sin\theta$$

$$\begin{aligned} \therefore \sigma_{\theta} &= \tau_{xy}\sin\theta\cos\theta + \tau_{xy}\sin\theta\cos\theta \\ &= 2\tau_{xy}\sin\theta\cos\theta \end{aligned}$$

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

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

bii.

Σ FORCES parallel to AB are zero,

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

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

Now;

$$\frac{AC}{AB} = \cos\theta \text{ and } \frac{BC}{AB} = \sin\theta$$

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

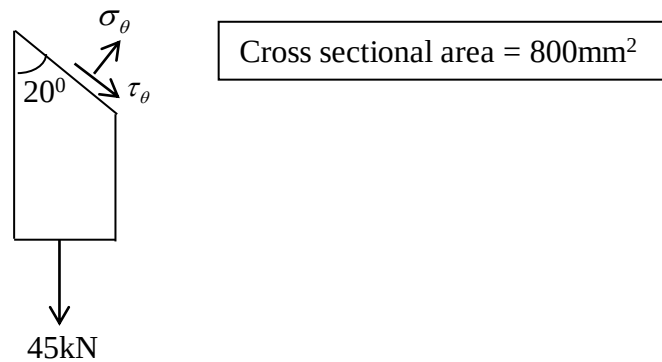
$$\tau_{\theta} = \tau_{xy}\sin^2\theta - \tau_{xy}\cos^2\theta$$

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

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

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

c.



$$\sigma_y = \frac{P}{A} = \frac{45 \times 10^3}{800 \times 10^{-6}} = 56.3 \text{ MPa}$$

$$\sigma_{\theta} = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y)\cos 2\theta$$

$$= \frac{1}{2}(0 + 56.3 \times 10^6) + \frac{1}{2}(0 - 56.3 \times 10^6)\cos 40$$

$$= 49.7 \text{ MPa}$$

$$\tau_{\theta} = \frac{1}{2}(\sigma_x - \sigma_y)\sin 2\theta$$

$$= \frac{1}{2}(0 - 56.3 \times 10^6)\sin 40$$

$$= -18.1 \text{ MPa}$$

Question 3

a.

It should be noted that design problems are usually more vaguely defined than analysis problems. Analysis problems have only one answer, whereas the solution to a design problem is a system having specified properties, i.e. the ability to meet a specific need; there may be many possible devices to meet the need.

[3 Marks]

b.

Solving a design problem is usually an iterative process; as the solution to a design problem evolves, there may be continual refinement of the design. It may be the case that while implementing the solution to a design problem, the solution developed is found to be unsafe, too expensive, or will not work. Hence, design activity is cyclic or iterative in nature, whereas analysis problem solving is primarily sequential.

[5 Marks]

c.

Discussion could include theories such as;

Pahl and Beitz (1996)

Strengths: Procedural approach, with emphasis on concept design stage. Plan for functional involvement of humans before concept design stage.

Limitations: Evaluation of human interaction with product was after concept design phase, which could prove costly and time consuming if re-design was required at this later stage.

British Standard BS7000 Part2 (2015)

Strengths: Procedural approach based on Pahl and Beitz (1996). Stated that ergonomics was a performance necessity of a product.

Limitations: No prescription of how ergonomics could be integrated into the design process.

French (1985)

Strengths: Procedural approach focused on conceptual design.

Limitations: No mention of analysing, designing or evaluating product for human user.

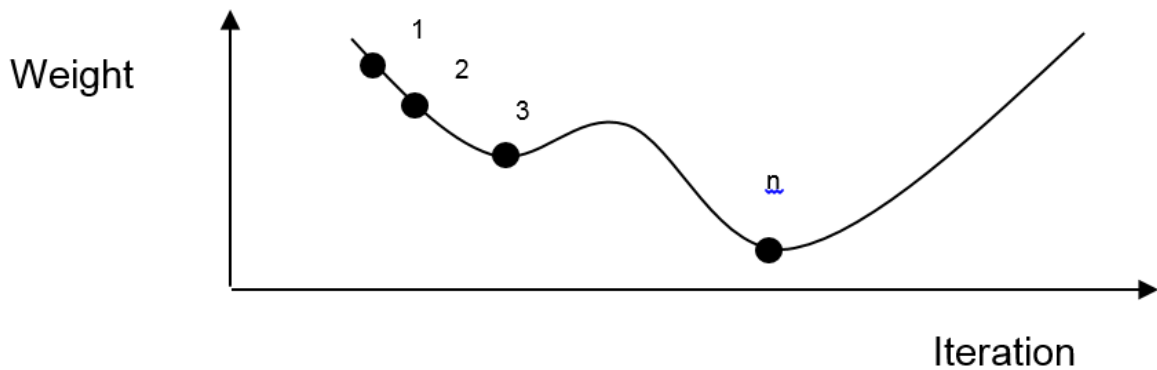
Etc

[12 Marks]

Question 4

a.

The major limitation of gradient based optimisation, is that this may result in a LOCAL MINIMUM as defined below. A function (such as weight) can be monitored for each iteration. If the change in gradient is monitored from one iteration to the next then a local minimum could be found (such as shown by iteration 3 in the diagram) hence the software would assume that convergence has been achieved, despite the fact that the GLOBAL MINIMUM (at iteration n) has yet to be found.



[10 Marks]

b.

An easy way to overcome the problem discussed in part a is to run several sets of analysis where the variables have been changed such that the analysis starts in several places. Whilst this minimises the chance of a local minimum being calculated as the global minimum, it does not eliminate this. Obviously, doing this is computationally expensive.

[4 Marks]

c.

Discussion could include the following;

Topology Optimisation

Where the major loadpaths are established which connect non-designable space.

Topometry Optimisation

Used to define the size necessary in the physical property of an element. For example, the shell thickness of a 2D element.

Shape Optimisation

Once the major loadpaths for design space are established using topology optimisation, shape optimisation can be used to establish the size of these loadpaths.

[6 Marks]

Diwedd/End