

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

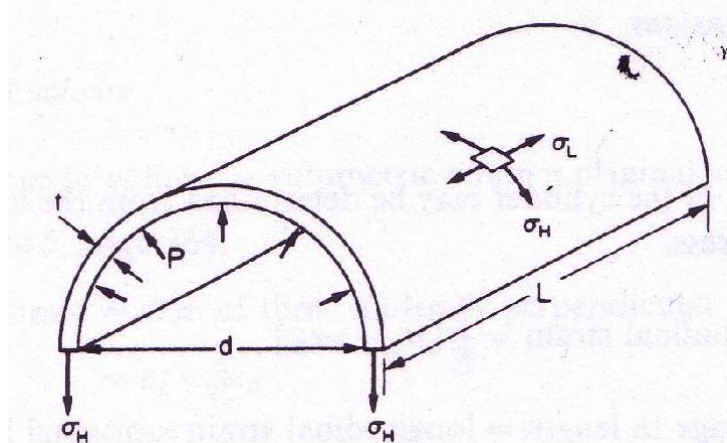
Adnoddau neu ddefnyddiau sydd eu hangen – Dim

A formula sheet is provided for reference.

University approved calculators are permitted.

Assume 'g' = 9.81 m/s².

Question 1



a.

Given the above structure which shows a freebody diagram of part of a thin cylinder subjected to internal pressure show that the hoop stress (σ_H) is given by the following relationship.

$$\sigma_H = \frac{Pd}{2t} \quad [4 \text{ marks}]$$

- b. A plane fuselage which is circular in cross section, is made from Alu7075 and the hoop stress must not exceed 200MPa. The fuselage is 3.5m in diameter and has a skin thickness of 0.5mm. Give that $P = \rho gh$ using table 1 determine to the nearest 5000ft the maximum altitude that this aircraft can fly at.

- i. If the cabin is sealed at sea level

[4 marks]

- ii. If the cabin is pressurized to an equivalent pressure of 8000ft

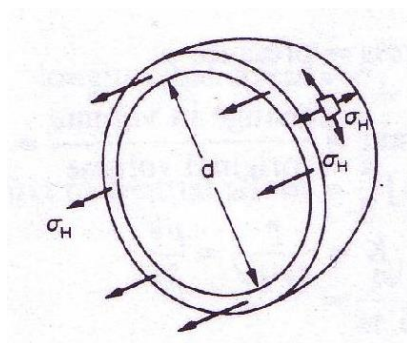
[3 Marks]

- c. In terms of the plane structure, using your answer to part b comment on the advantage of pressurizing plane cabins.

[2 Marks]

- d. Given the below structure which shows a freebody diagram of part of a sphere subjected to internal pressure show that the hoop stress (σ_H) is given by the following relationship.

$$\therefore \sigma_H = \frac{pd}{4t}$$



[4 Marks]

- e. Based on the equations derived in parts a and d, discuss why in oil storage facilities some fluids are stored in spherical tanks whilst others are stored in cylindrical containers.

[3 Marks]

Table 1

Altitude Above Sea Level		Absolute Barometer		Absolute Atmospheric Pressure		
feet	meters	inches Hg	mm Hg	psia	kg/cm ²	kPa
-5000	-1524	35.7	908	17.5	1.23	121
-4500	-1372	35.1	892	17.2	1.21	119
-4000	-1219	34.5	876	16.9	1.19	117
-3500	-1067	33.9	861	16.6	1.17	115
-3000	-914	33.3	846	16.4	1.15	113
-2500	-762	32.7	831	16.1	1.13	111
-2000	-610	32.1	816	15.8	1.11	109
-1500	-457	31.6	802	15.5	1.09	107
-1000	-305	31.0	788	15.2	1.07	105
-500	-152	30.5	774	15.0	1.05	103
0 ¹⁾	0	29.9	760	14.7	1.03	101
500	152	29.4	746	14.4	1.01	99.5
1000	305	28.9	733	14.2	0.997	97.7
1500	457	28.3	720	13.9	0.979	96.0
2000	610	27.8	707	13.7	0.961	94.2
2500	762	27.3	694	13.4	0.943	92.5
3000	914	26.8	681	13.2	0.926	90.8
3500	1067	26.3	669	12.9	0.909	89.1
4000	1219	25.8	656	12.7	0.893	87.5
4500	1372	25.4	644	12.5	0.876	85.9
5000	1524	24.9	632	12.2	0.860	84.3
6000	1829	24.0	609	11.8	0.828	81.2
7000	2134	23.1	586	11.3	0.797	78.2
8000	2438	22.2	564	10.9	0.768	75.3
9000	2743	21.4	543	10.5	0.739	72.4
10000	3048	20.6	523	10.1	0.711	69.7
15000	4572	16.9	429	8.29	0.583	57.2
20000	6096	13.8	349	6.75	0.475	46.6
25000	7620	11.1	282	5.45	0.384	37.6
30000	9144	8.89	226	4.36	0.307	30.1
35000	10668	7.04	179	3.46	0.243	23.8
40000	12192	5.52	140	2.71	0.191	18.7
45000	13716	4.28	109	2.10	0.148	14.5
50000	15240	3.27	83	1.61	0.113	11.1

Question 2

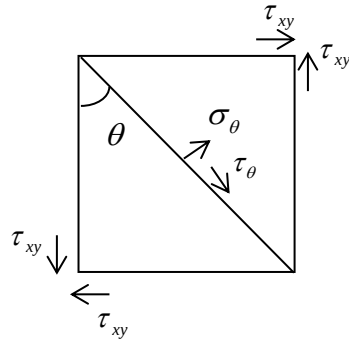
a.

In the context of complex stress, explain what is meant by the terms 'Principal Stress' and 'Principal Plane'.

[3 marks]

b.

Consider the stressed element subjected to shear stress, τ_{xy} shown below;



Given that $\sin \theta \cos \theta = \frac{1}{2} \sin 2\theta$ and $\sin^2 \theta - \cos^2 \theta = -\cos 2\theta$, show from first principals that;

- i. the normal stress on a plane inclined at an angle θ is given by;

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

[5 marks]

- ii. the shear stress on the same plane is given by;

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

[5 marks]

c.

A bar of cross sectional area 800mm^2 is acted upon by tensile forces of 45kN applied at each end of the bar. Determine the normal and shearing stresses on a plane inclined at 20° to the direction of loading.

[7 marks]

Question 3

a.

Discuss the difference between a Design problem and an Analysis problem.

[3 Marks]

b.

Hence discuss why a design problem is usually an iterative process, whereas an analysis problem is primarily sequential.

[5 Marks]

c.

There are numerous descriptive theories and models that have been developed to understand, describe and prescribe how the design process should be carried out. Discuss four of these, stating an advantage and a disadvantage of each.

[12 Marks]

Question 4

a.

Optimisation is a powerful tool that can be used within CAE. Many tools within this discipline use 'gradient' based optimisation. With the aid of a diagram discuss the major limitation of 'gradient' based optimisation.

[10 Marks]

b.

Discuss one way in which the major limitation of gradient based optimisation can be overcome. Discuss the disadvantage of doing this.

[4 Marks]

c.

In the context of Finite Element Analysis, discuss three types of Optimisation

[6 Marks]

Formula Sheet

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

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