

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

**EXAMINATION PERIOD
MAY 2021**

**CYFNOD ARHOLIADAU
MAI 2021**

**MODULE CODE:
ACMA5010: Stress Analysis & Dynamics (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. The below figure shows a simply supported beam with a uniformly distributed load.

- i. Discuss the steps that you would take to prove from first principles, starting with the equation $EI \frac{d^2y}{dx^2} = M$, that the maximum deflection, $y_{\max}$ is given by

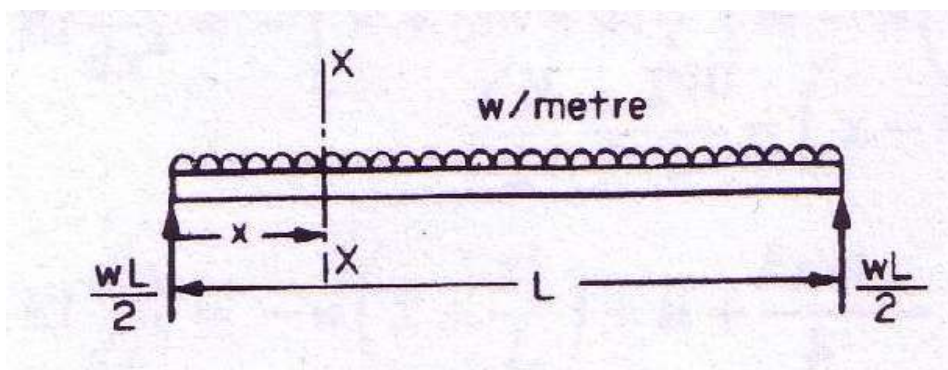
$$y_{\max} = \frac{-5WL^4}{384EI}$$

[8 Marks]

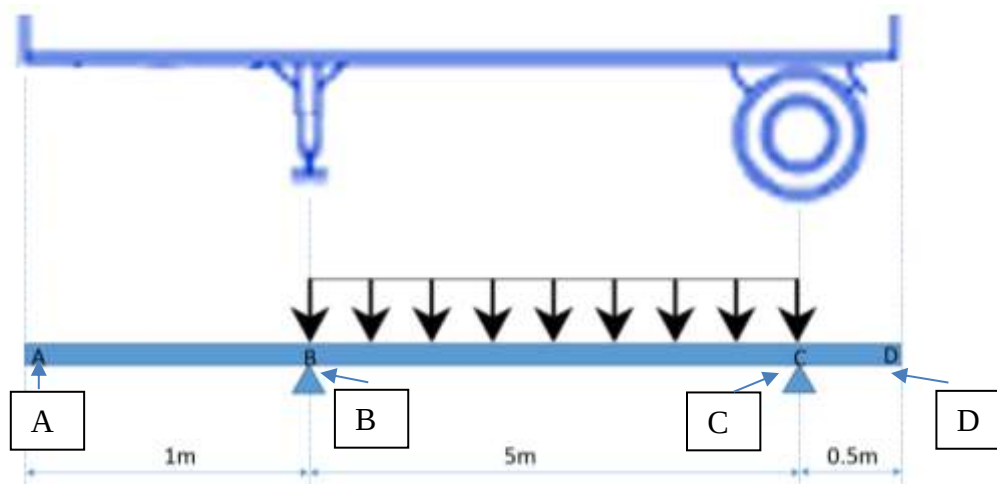
- ii. Hence, discuss how you would use part i to then go on to prove that the maximum slope is given by

$$\left(\frac{dy}{dx} \right)_{\max} = \pm \frac{WL^3}{24EI}$$

[2 Marks]



b.



- i. The above figure shows a HGV trailer that may be considered to be a simply supported beam with the rear axle at location C and a supporting leg at position B. The hitch to the cab is located at position A and the rear of the trailer is at location D. In order to allow the hitch to attach to the cab it must not deform upwards by more than 10mm. As such, by considering the required slope at B in order to get the maximum vertical deflection allowed at A, what flexural stiffness must the trailer supporting structure have to support a uniformly distributed mass of 5000kg between the supporting leg and the rear axle such that the trailer can still be coupled to the cab?

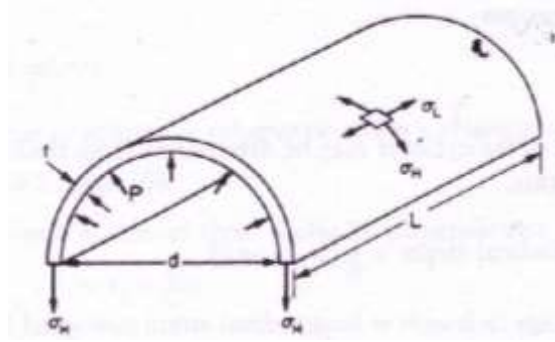
[5 Marks]

- ii. If the structural part of this trailer consists of an I beam that is loaded about the xx axis, using the table below, what would the mass of this I beam be if it was made from steel ($E=210\text{GPa}$) and it runs the length of the trailer?

[5 Marks]

Size D x B (mm)	Mass per metre (kg)	Thickness		I_{xx} (cm^4)	I_{yy} (cm^4)
		Web, t (mm)	Flange, T (mm)		
910.3 x 304.1	222	15.9	23.9	375924	11223
840.7 x 292.4	194	14.7	21.7	279450	9069
762 x 266.7	173	14.3	21.6	205177	6846
677.9 x 253.0	125	11.7	16.2	118003	4379
617.5 x 307.0	113	14.1	23.6	151631	11412
533.1 x 209.3	92	10.2	15.6	55353	2392
467.4 x 192.8	98	11.4	19.6	45717	2343
457.2 x 151.9	67	9.1	15	28577	878
402.3 x 142.4	46	6.9	11.2	15647	539
364 x 173.2	67	9.1	15.7	19522	1362
352.8 x 126.0	39	6.5	10.7	10087	357
310.9 x 166.8	54	7.7	13.7	11710	1061
312.7 x 102.4	33	6.6	10.8	6487	193
254 x 101.6	22	5.8	6.8	2867	120
203.2 x 133.4	25	5.8	7.8	2356	310

Question 2



a.

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

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

- b. An airplane 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. Given 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]

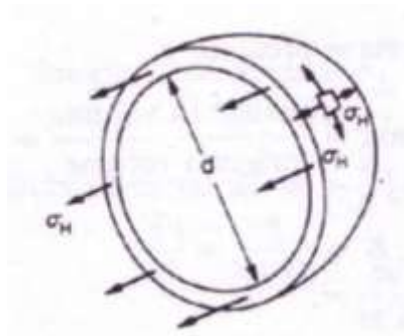
- ii. If the cabin is pressurized to an equivalent pressure of 8000ft

[3 Marks]

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

[2 Marks]

- d. Given the below structure which shows a freebody diagram of part of a sphere subjected to internal pressure discuss how you would show from first principles that the hoop stress (σ_H) is given by the following relationship. $\sigma_H = \frac{pd}{4t}$



[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 3

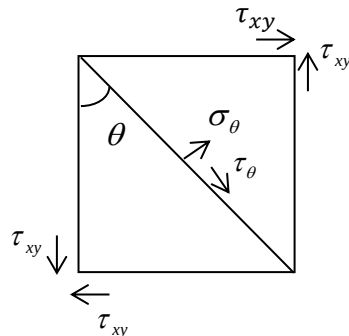
a.

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 only, τ_{xy} shown below;



If you were given that $\sin \theta \cos \theta = \frac{1}{2} \sin 2\theta$ and $\sin^2 \theta - \cos^2 \theta = -\cos 2\theta$, discuss how you would show from first principles 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.

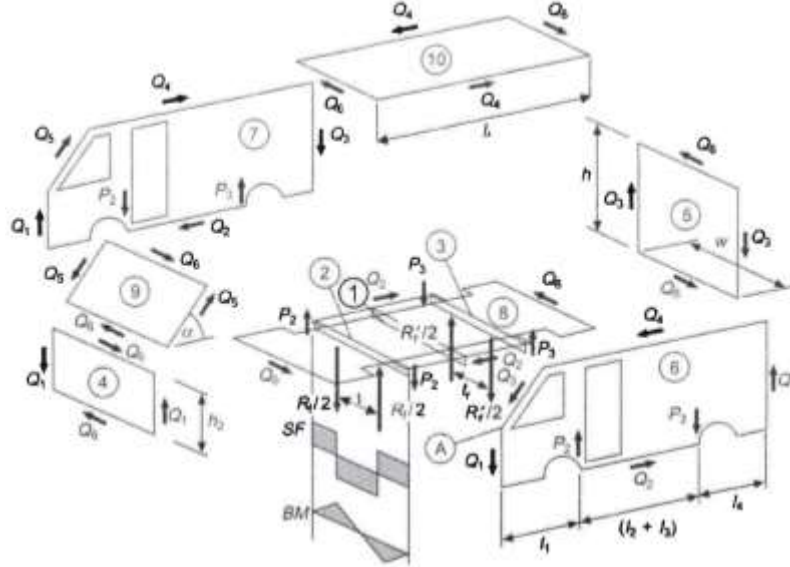
i

The figure below shows a representation of a simple van. It can be assumed that the roof acts as a shear panel (it is subjected to shear loads only).



How the loads propagate around the structure is shown in the below figure where the roof is represented by panel 10. The width of the panel where Q_6 is applied is 2m and the length

of the panel where Q_4 is applied is 3m. The panel is 2mm thick. Given that $Q_4=2250\text{N}$, $Q_6=1500\text{N}$ and the principal stresses are given by $\sigma_{1,2} = \frac{1}{2} \left[(\sigma_x + \sigma_y) \pm \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \right]$ calculate the maximum principal stress on the roof of the van.



[3 marks]

ii.

Given that $\tan \theta = \frac{\sigma_p - \sigma_x}{\tau_{xy}}$ calculate the plane that the maximum principal stress acts on.

[2 marks]

iii.

Comment on the answer obtained in part ii in terms of the location of the principal stresses relative to the shear stresses.

[2 marks]

Question 4

a.

Discuss 4 examples of data acquisition equipment that could be used to measure the loading that a component undergoes during an experiment.

[12 Marks]

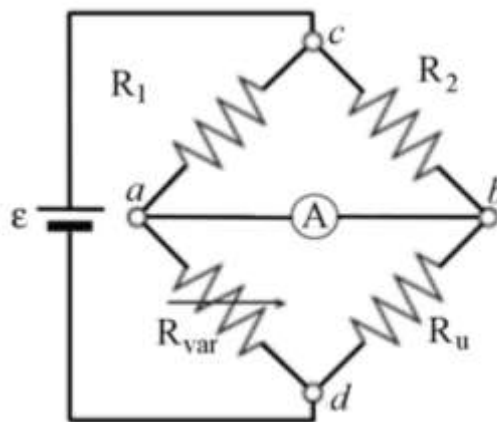
b.

When using an electrical resistance strain gauge, explain why a Wheatstone Bridge is generally used and the configurations that these may take.

[5 Marks]

c.

Given that $\frac{R_1}{R_{var}} = \frac{R_2}{R_u}$ and the below circuit which consists of two resistors with resistance $R_1=10\Omega$ and $R_2=5\Omega$, a variable resistor, the resistance R_{var} which can be adjusted, a resistor of unknown value R_u and a 9 volt battery. When R_{var} is adjusted to 8Ω , there is zero current through the ammeter. What is the unknown resistance R_u ?



[3 Marks]

Diwedd/End