

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
MAY 2016

CYFNOD ARHOLIADAU
MAI 2016

MODULE CODE:
CAE & Stress Analysis

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.

Calculators are permitted.

Assume 'g' = 9.81 m/s².

ONE

- a. A 8m long simply supported beam that is supported at either end has a vertical downwards load of 15kN 1.75m from the left hand end and another vertical downwards load of 30kN 5m from the left hand end. Using Macaulays method calculate the minimum flexural stiffness required to limit the central deflection to 7.5mm neglecting the weight of the beam.

[15 Marks]

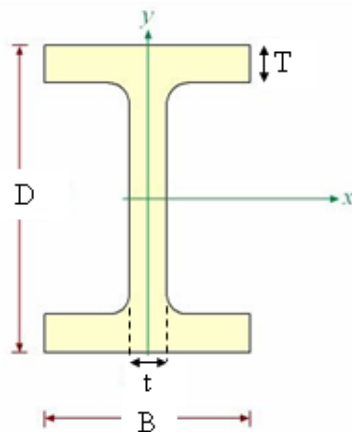
- b. Assuming the beam is made of steel ($E = 200\text{GPa}$), what would the minimum second moment of area be?

[2 Marks]

- c. Hence choose the lightest suitable beam from below assuming the beam is loaded about XX. What would the mass of this beam be over the span required?

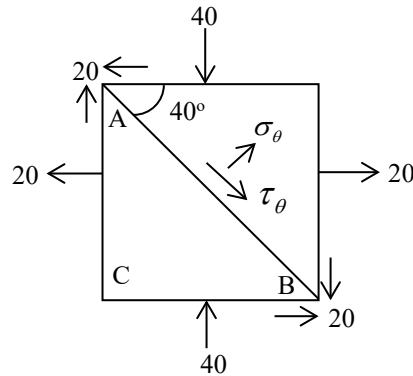
[3 Marks]

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



TWO

- a. Consider the below stressed element. Determine what the normal and shear stresses on plane AB are using analytical methods.



All stresses are in MN/m^2

[5 Marks]

- b. What is the maximum principal stress on the above element?
[2 Marks]
- c. What is the maximum shear stress on the above element?
[2 Marks]
- d. Confirm your answers to a-c above using graphical methods on the graph paper attached to this exam paper. Make sure to mark clearly on the diagram any measurements that you take.
[8 Marks]
- e. Using graphical methods, at what angle when measured anti-clockwise from plane BC does the maximum principal plane act?
[2 Marks]
- f. Comment on the results from a-c when compared to those obtained in d.
[1 Mark]

THREE

By adopting a recognised design process, such as British Standard BS7000 Part2 (2015), it may be possible to ensure that a manufactured product is 'fit for purpose' and is successfully marketable.

- (a) Briefly explain the core sequential phases employed in most design processes, how these relate to one another, and the importance of an iterative approach when undertaking a design problem. Also discuss the advantages in employing Computer Aided Engineering (CAE) tools within a design problem, when considering a manufactured product.

[14 marks]

- (b) Discuss how a formulated Design for Manufacturing (DfM) activity will aid a design team in reducing the cost and difficulty of manufacturing a product.

[6 marks]

FOUR

A widely used method for determining stress analysis data for a loaded component is applying computational numerical methods in the form of the Finite Element Method (FEM). This CAE tool is used where analytical solutions cannot be obtained.

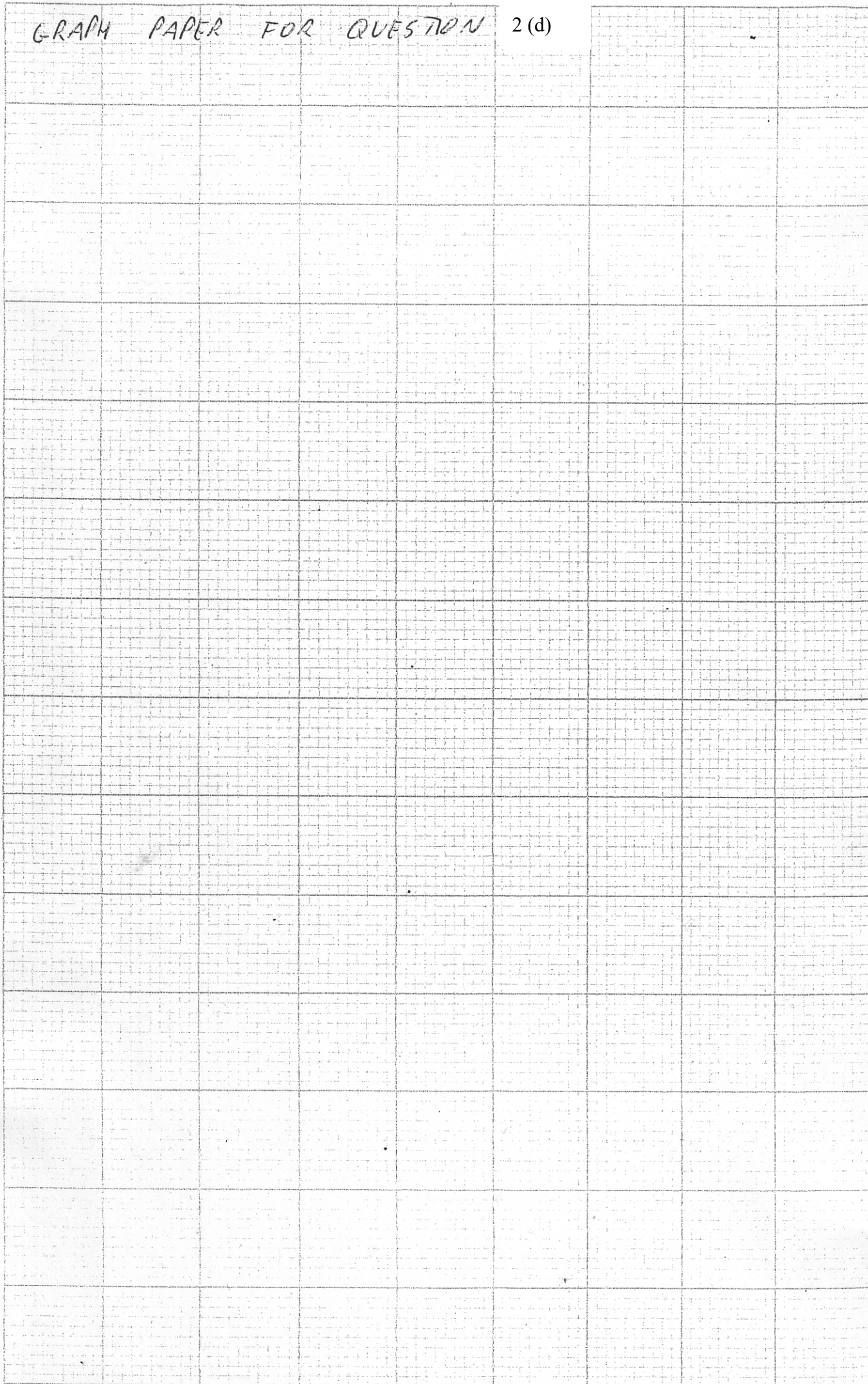
- (a) Discuss the fundamental principles of FEM, covering such concepts as; governing equations, boundary conditions, stiffness matrix, and the general three stage procedure for Finite Element Analysis (FEA). Also mention any disadvantages / limitations of this method.

[12 marks]

- (b) FEM may be applied to numerical analysis of engineering problems other than stress analysis. State two other physical quantities that can be analysed using FEM, as well as the associated 'actions', 'property', and 'behaviour' determined by the appropriate set of simultaneous algebraic equations.

[8 marks]

GRAPH PAPER FOR QUESTION 2(d)



Formula Sheet

Slope and deflection of beam theory;

$$EI \frac{d^2 y}{dx^2} = M \quad \text{Bending moment.}$$

$$Q = EI \frac{d^3 y}{dx^3} \quad \text{Shear Force}$$

$$w = EI \frac{d^4 y}{dx^4} \quad \text{Load}$$

Complex stress;

$$\sigma_{\theta} = \frac{1}{2}(\sigma_x + \sigma_y) + \frac{1}{2}(\sigma_x - \sigma_y)\cos 2\theta + \tau_{xy} \sin 2\theta \quad \text{Stress normal to a plane.}$$

$$\tau_{\theta} = \frac{1}{2}(\sigma_x - \sigma_y)\sin 2\theta - \tau_{xy} \cos 2\theta \quad \text{Shear stress on a plane.}$$

$$\sigma_{1,2} = \frac{1}{2} \left[(\sigma_x + \sigma_y) \pm \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \right] \quad \text{Principal stresses}$$

$$\tau_{\max} = \frac{1}{2} \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \quad \text{Maximum shear stress}$$

Diwedd/End