



EXAMINATIONS 2012 / 2013 **AHOLIADAU 2012 / 2013**

Semester 2

FACULTY OF: Applied Design & Engineering

NAME OF COURSE/PROGRAMME: BEng Manufacturing Systems Engineering
BEng Mechanical & Manufacturing Engineering

YEAR OR LEVEL: Year 2

NAME OF MODULE/UNIT/EXAM PAPER: Stress Analysis and Dynamics

MODULE NO:

DATE OF EXAMINATION: ??

EXAMINATION TIMES:

START TIME: ?? pm

FINISH TIME: ?? pm

TIME ALLOWED: 2 hours

INSTRUCTIONS TO CANDIDATES:

Answer 3 from 4 questions.

Assume acceleration due to gravity, $g = 9.81 \text{ ms}^{-2}$

Attach any graph paper used to your answer booklet

Question 1

- a. A 7m long simply supported beam that is supported at either end has a vertical downwards load of 20kN 2m from the left hand end and another vertical downwards load of 40kN 4.5m from the left hand end. Using Macaulays method calculate the minimum flexural stiffness required to limit the central deflection to 8mm neglecting the weight of the beam.

[15 Marks]

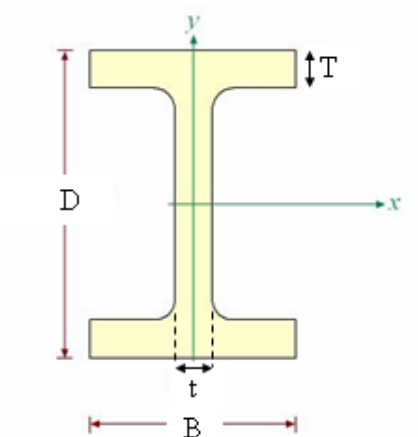
- b. Assuming the beam is made of steel ($E = 200\text{GPa}$), what would the minimum second moment of area be?

[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?

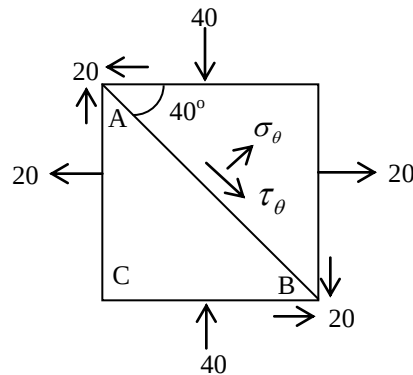
[3 Marks]

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



Question 2

- a. Consider the stressed element shown below. 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 is the maximum principal plane ?
[2 Marks]
- f. Comment on the results from a-c when compared to those obtained in d.
[1 Marks]

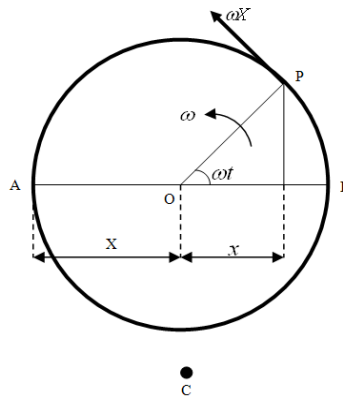
(Make sure you attach your graph paper to your answer booklet)

Question 3

a. i.

Consider point P rotating about point O at a constant angular velocity, ω , as shown in the below figure. When viewed from position C point P appears to move with simple harmonic motion. Prove that the velocity, v , of P, when viewed from C, is given by $v = \omega\sqrt{(X^2 - x^2)}$. When would P appear to have its greatest velocity when viewed from position C.

[5 Marks]



ii.

If the frequency of a body oscillating with simple harmonic motion is 3Hz and the amplitude of the motion is 60mm, determine the velocity and acceleration of the body when it is at a point midway between the maximum displacement and the mean position

[5 Marks]

b.

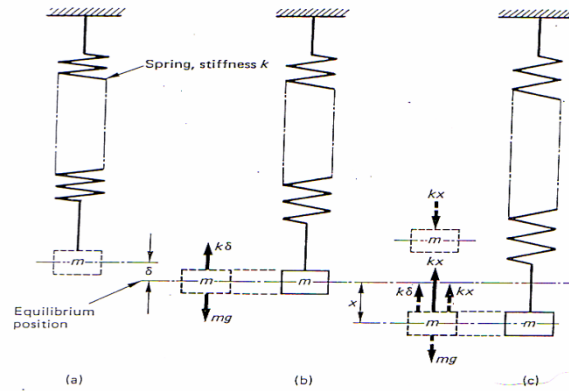
i.

Consider a mass on a spring as shown below, show that the natural frequency

is given by

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

[5 Marks]



ii.

A structure when loaded statically with a weight of 100g deflects 5mm. Determine the periodic time of this structure if this oscillates with simple harmonic motion due to a mass of 250g being hung from the structure.

[5 Marks]

Question 4

- a. i.
Explain why it is often necessary to determine the velocity and acceleration of points in a mechanism.

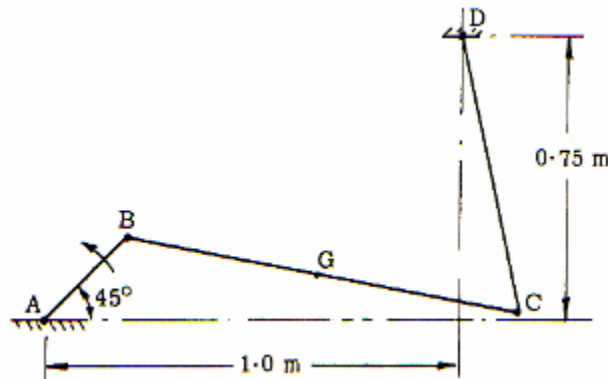
[2 marks]

- ii.
When constructing a velocity diagram explain what assumptions you make in order to construct the diagram.

[4 marks]

- b.
Attached to this exam paper is a 'line diagram' of the below mechanism, which has been drawn to scale. The diagram shows a mechanism in which the crank AB rotates anticlockwise about A at 70 rev/min. The link CD swings about D and is connected to the crankpin B by the link BC. The lengths are; AB, 0.25m, BC, 1.0m, CD, 0.75m. Draw the velocity diagram and hence find the velocity of C relative to D.

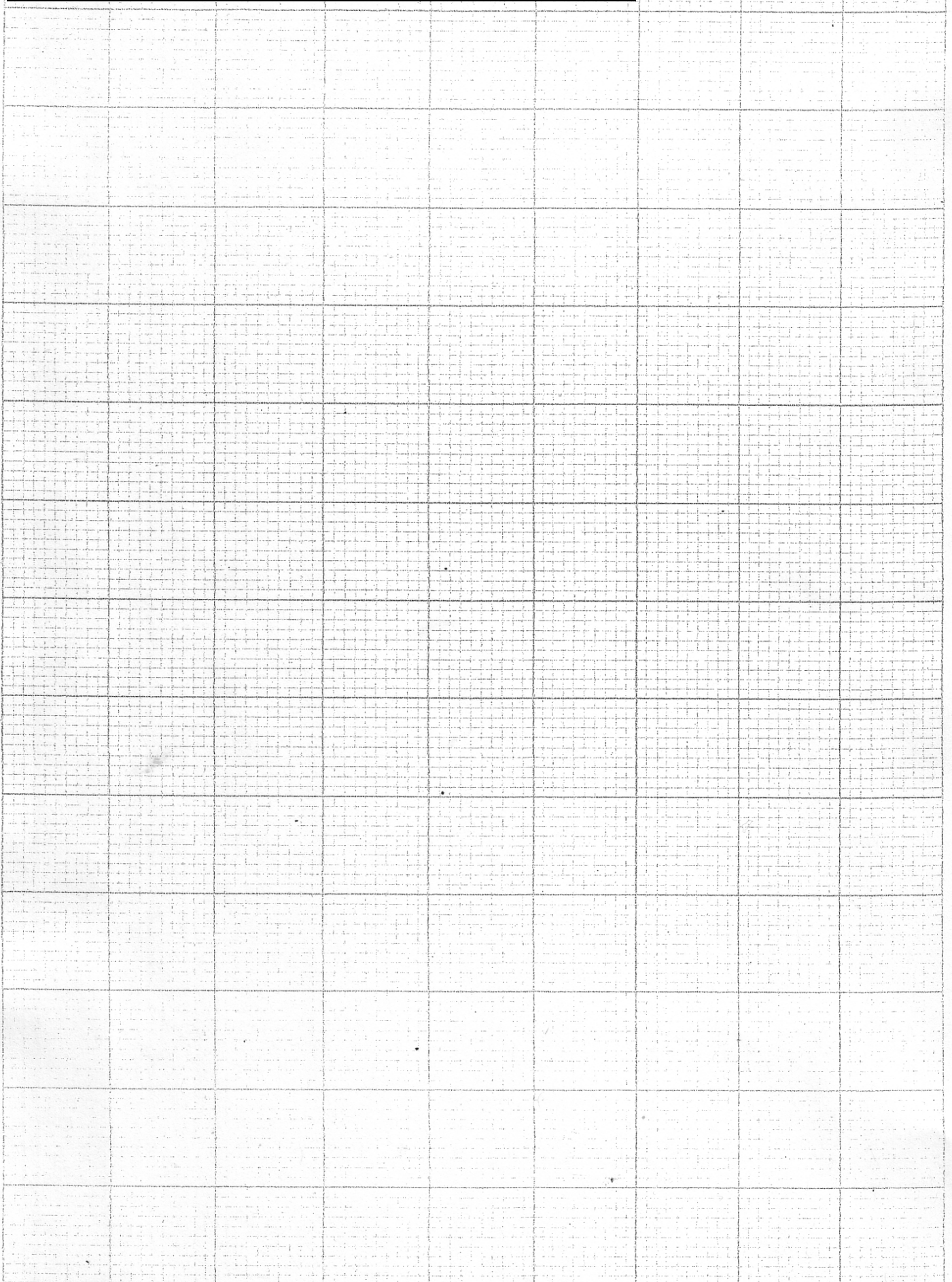
[10 marks]



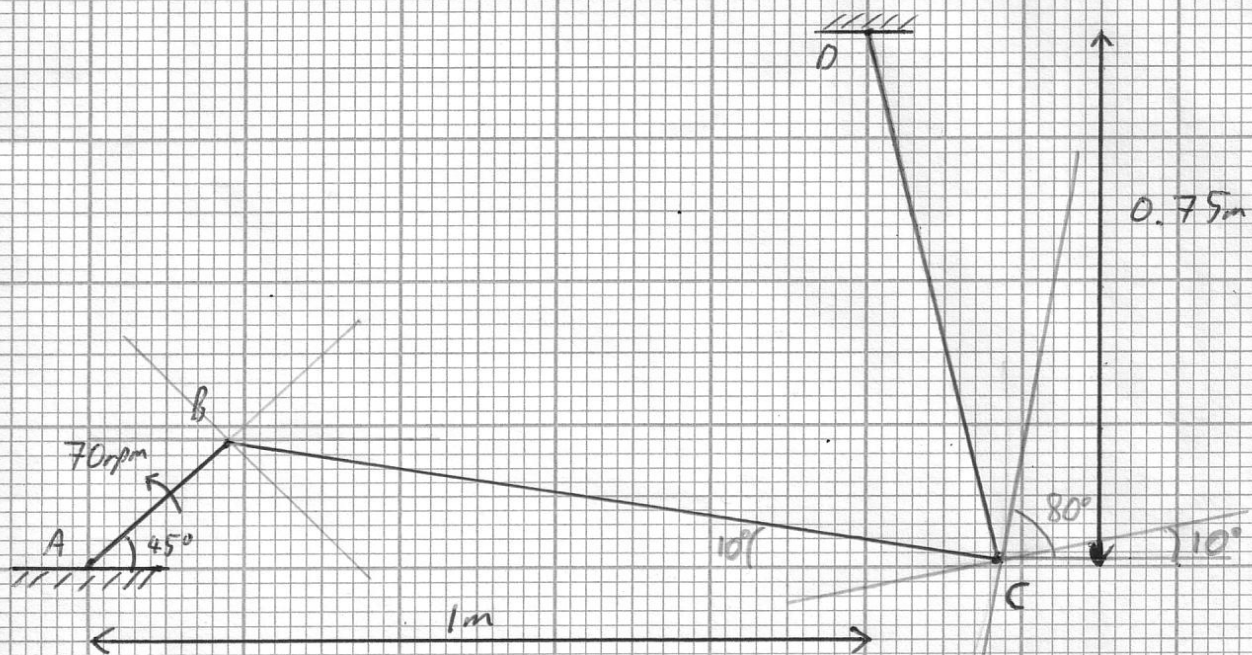
- c.
Briefly discuss why, when constructing an acceleration diagram, the acceleration of one point relative to another potentially has two components.

[4 marks]

Graph Paper for question 2 d



Line diagram for question 4 b



Graph Paper for question 4 b
(Scale 1m/s=5cm)

ad

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;

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

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

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

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

Simple Harmonic Motion

$$a = \omega^2 x$$

$$T = \frac{2\pi}{\omega}$$

$$f = \frac{1}{T} = \frac{\omega}{2\pi}$$