



EXAMINATIONS 2011 / 2012 **AHOLIADAU 2011 / 2012**

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: September 2012

EXAMINATION TIMES:

START TIME: 12 pm

FINISH TIME: 2pm

TIME ALLOWED: 2 hours

INSTRUCTIONS TO CANDIDATES:

Answer 3 from 4 questions.

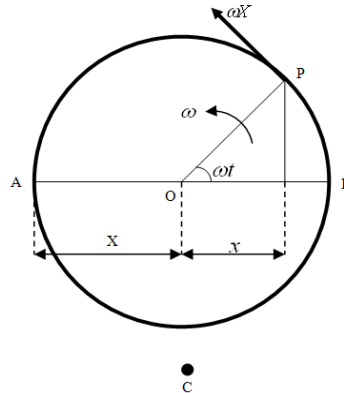
Assume acceleration due to gravity, $g = 9.81 \text{ ms}^{-2}$

Attach any graph paper used to your answer booklet

1.

- a. 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?

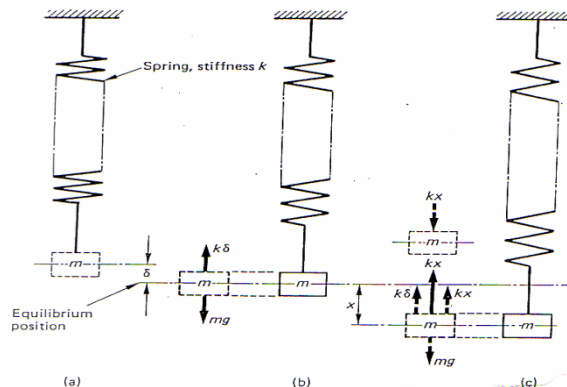
[5 Marks]



- b. Consider a mass on a spring as shown below, show that the natural frequency is given by

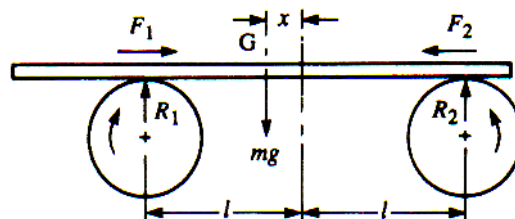
$$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$

[5 Marks]



- c. A thin uniform bar of mass, m , is placed on two identical discs which rotate with equal but opposite speeds as shown below. Show that if the centre of gravity of the bar is displaced from the mid position by a distance x , that the bar will oscillate with a periodic time given by $T = 2\pi \sqrt{\left(\frac{l}{\mu g}\right)}$ where μ is the coefficient of friction between the discs and the bar and $2l$ is the distance between the centres of the two discs.

[10 Marks]



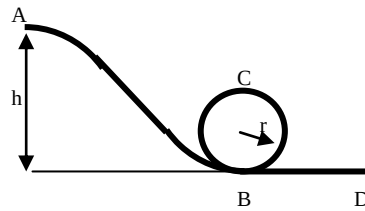
2.

- a. Attached to this exam paper is a 'line diagram' of a mechanism (figure Q2a), which has been drawn to scale. The crank OA rotates in a clockwise direction at 102 rev/min, the block B moves along the axis XX which is 30° to the vertical. The block D moves along the horizontal axis YY. AB and CD are connected by a pin-joint at C. $AB = 210\text{mm}$, $AC = 80\text{mm}$ and $CD = 240\text{mm}$.

In the space on the right side of the worksheet, construct the velocity diagram for the mechanism at the instant shown, and hence determine the magnitude and sense of the instantaneous velocity of the sliders B and D. A scale of $1\text{cm} = 0.1\text{m/s}$ should be used, and point O has been located, from where your construction should begin. Make sure any lengths or angles measured during construction are clearly marked.

[10 Marks]

- b. A roller coaster, shown below, consists of a sloping section AB, a circular loop-the-loop section BC of radius r , and a straight horizontal section BD;



- i) By considering the transfer of energy, determine the least height, in terms of r , of A above B, from which the car can start from rest without falling off of the track at C.

[5 marks]

- ii) Discuss the assumptions that you have made in your answer to part (i)

[5 marks]

3.

a.

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

[3 marks]

b.

At a given section a shaft is subjected to a bending stress of 20MPa and a shear stress of 40MPa.

i) Draw a Mohrs circle to represent the above condition. [5 marks]

Hence determine;

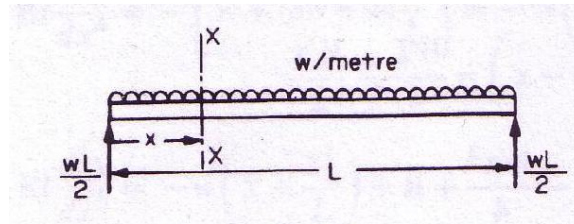
ii) The principal stresses and the planes on which these act. [4 marks]

iii) The maximum shear stress and the plane on which this acts [2 marks]

iv) Determine the tensile stress, which acting alone would produce the same maximum shear stress. [3 marks]

v) Determine the shear stress, which acting alone would produce the same maximum tensile principal stress. [3 marks]

4.



a) Given the above diagram, and using the relationship, $M = EI \frac{d^2y}{dx^2}$, show that the deflection, y , at any point on the beam is given by;

$$y = \frac{1}{EI} \left[\frac{WLx^3}{12} - \frac{Wx^4}{24} - \frac{WL^3x}{24} \right]$$

[10 marks]

b)

i)

A 5m long simply supported beam carries a uniformly distributed load of 0.2 kN/m. What is the minimum flexural stiffness required to limit the central deflection to 2mm neglecting the weight of the beam?

[5 marks]

ii)

If the beam were to be made out of Aluminium ($E=69\text{GPa}$) what would the minimum second moment of area be?

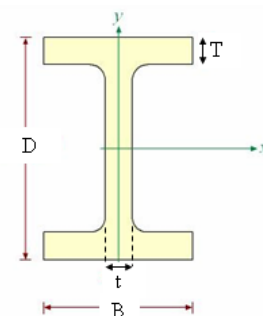
[1 mark]

iii)

Hence choose the lightest suitable beam from the below table assuming the beam is loaded about the x axis. What would the weight of this beam be over the length required?

[4 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



FORMULA SHEET

Free Vibrations;

$$v = \omega \sqrt{(X^2 - x^2)}$$

$$a = \omega^2 x$$

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

Dynamics

Assume $g = 9.81 \text{ms}^{-2}$ in all calculations

$$\text{Centripetal Force} = \frac{mv^2}{r}$$

Momentum = Mass x Velocity

Force = Mass x Acceleration

$$T = I\alpha$$

$$I = mk^2$$

$$\text{Kinetic Energy} = \frac{1}{2} mv^2$$

Linear acceleration

$$v = u + at$$

$$s = ut + \frac{1}{2} at^2$$

$$v^2 = u^2 + 2as$$

Slope and deflection of beam theory;

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

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

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

Graph paper for question 3b

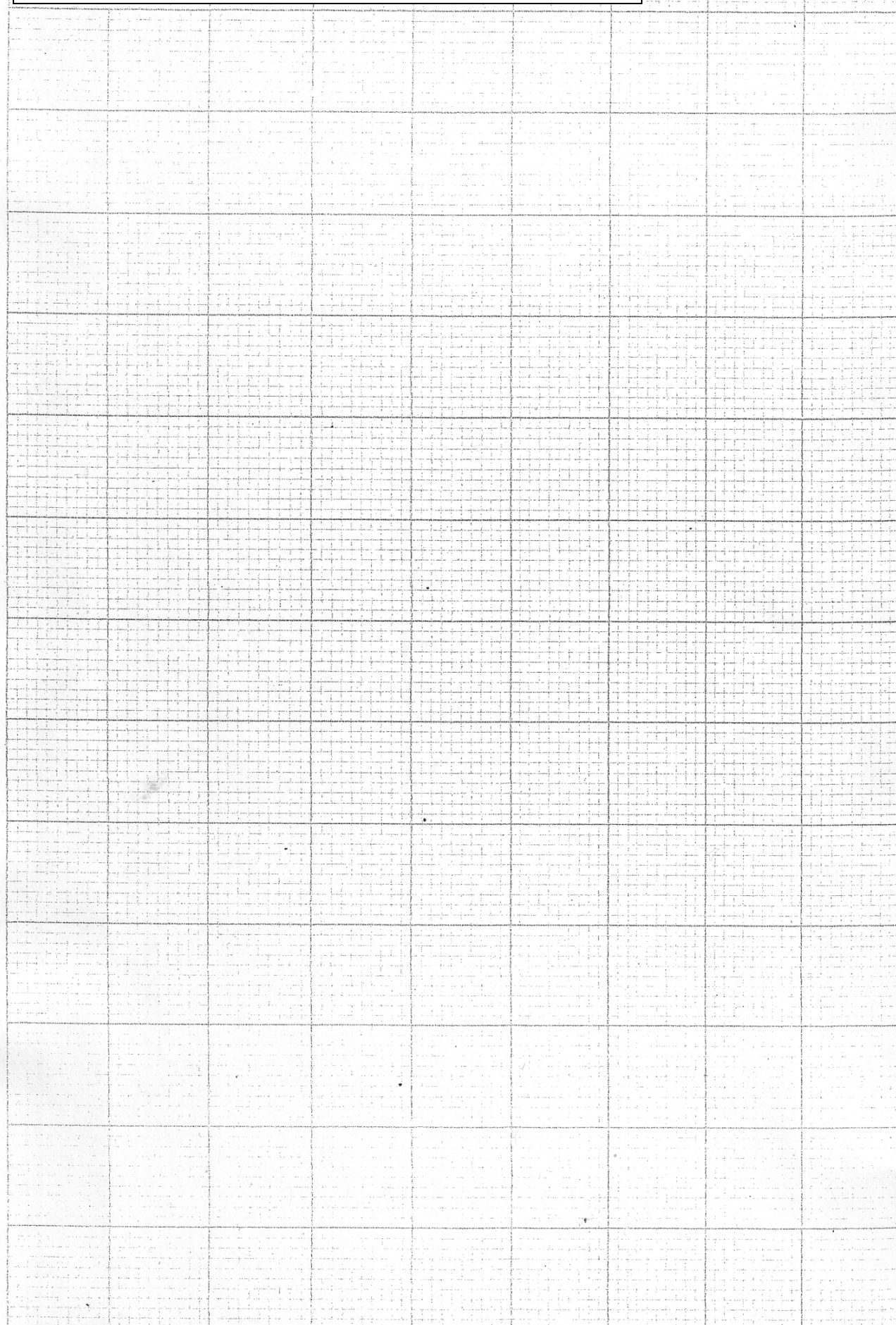


Figure Q2a

