



ZIMBABWE

MINISTRY OF HIGHER AND TERTIARY EDUCATION

**HIGHER EDUCATION EXAMINATIONS COUNCIL
(HEXCO)**

HIGHER NATIONAL DIPLOMA

IN

MECHANICAL ENGINEERING

SUBJECT: Engineering Mechanics

PAPER NO: 713/S02

OCTOBER/NOVEMBER 2013 EXAMINATION

REQUIREMENTS

Formulae booklet, A3 drawing paper and non-programmable scientific calculator.

INSTRUCTIONS TO CANDIDATE

1. Answer any five (5) questions.
2. Each question carries 20 marks.
3. Start each question on a fresh page.
4. Take $g = 9.81\text{m/s}^2$

This paper consists of 5 printed pages.

QUESTION 1

The turbine rotor of a ship has a mass of 30 tonnes a radius of gyration of 600mm, and rotates at 2400rpm in a clockwise direction when viewed from left. The ship pitches through a total angle of 15° , $7\frac{1}{2}^\circ$ above and $7\frac{1}{2}^\circ$ below the horizontal, the motion being simple harmonic and having a period of 12 seconds. Determine the maximum gyroscopic couple on the holding down bolts on the turbine and the direction of you as the bow rises. (20 marks)

QUESTION 2

An electric motor running at 2250rpm drives a centrifugal pump running at 650rpm through a simple stage gear reduction. The motor armature has a moment of inertial of 32kgm^2 and the pump impeller one of 84kgm^2 . The shaft from the pump to the gears is 90mm diameter and 3.6m long and that from the motor to the gear is 0.6m long. What should be the diameter of shaft from the rotor to the gears to ensure that the node for natural torsional vibrations is at the gears? Determine the frequency of these vibrations and the amplitude of the impeller vibrations for an amplitude of one degree at the motor. The inertia of the shafts and the gears may be neglected. The modulus of rigidity of the steel shafts is 80GN/m^2 . (20 marks)

QUESTION 3

A thin vertical strut 1m long and initially straight is pinned at each end and carries an axial load (P). A spring of stiffness $4,5\text{kN/M}$ is attached at the centre with its axis horizontally and when the strut is straight, the spring is stretched 30mm. Find the central deflection when P is one quarter of the Euler crippling load and EI is 30Nm^2 . (20 marks)

QUESTION 4

An 80mm×80mm angle as shown in figure Q4a is used as a freely supported beam with one leg vertical. $I_{xx} = I_{yy} = 0.8736 \times 10^{-6} \text{ m}^4$.

When a bending moment is applied in the vertical plane YY. The mid section of the beam deflects in the direction AA at $30^\circ 15'$ to the vertical. Calculate the second moments of area of the section about its principal axes. Find also the bending stress at the corner B if the bending moment is 2kNm. (20 marks)

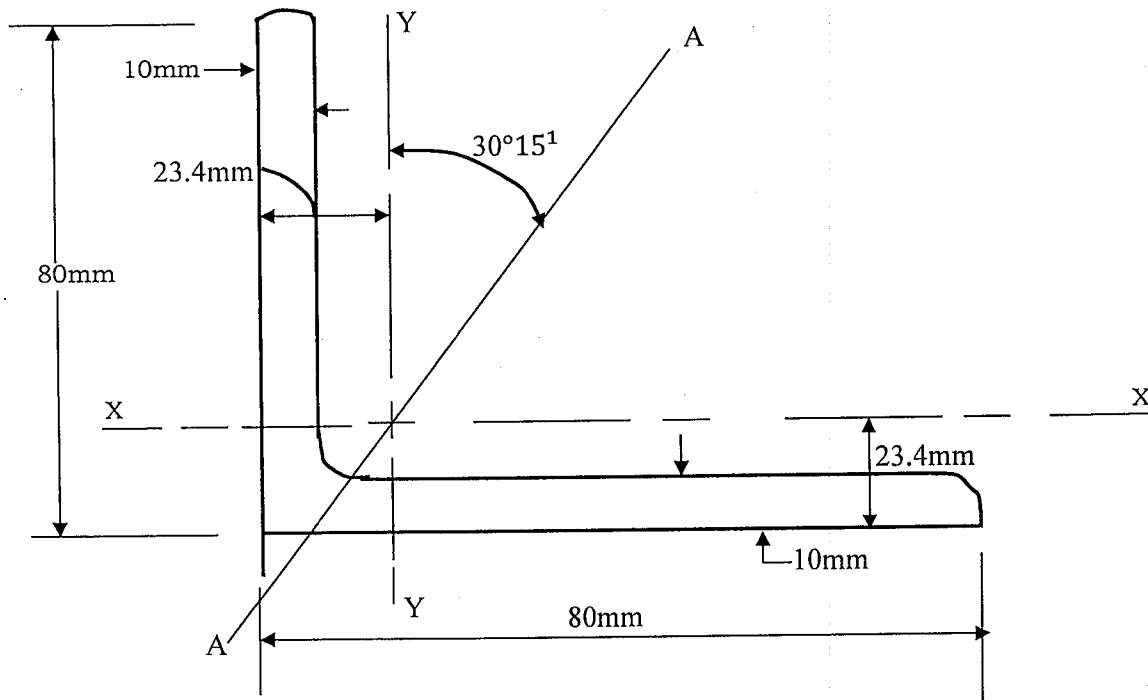


Fig Q4a

QUESTION 5

(a) Briefly explain the following terms as used in engineering mechanics.

- | | |
|---------------------------------|-----------|
| (i) rotation about a fixed axis | (2 marks) |
| (ii) rectilinear translation | (2 marks) |
| (iii) curvilinear translation | (2 marks) |
| (iv) kinematics | (2 marks) |
| (v) kinetics | (2 marks) |

- (b) A radial arm weed saw has an operating speed of 150rpm. When the saw is turned off a magnetic brake brings the blade to rest in one minute.
- (i) If the braking deceleration is assumed to be constant, through how many revolutions does the blade rotate before coming to rest? (5 marks)
- (ii) In a certain operation the blade jams in a piece of material and comes to rest in $\frac{3}{4}$ revolutions. Find the value of deceleration. (5 marks)

QUESTION 6

A thick cylinder of 100mm internal radius and 150mm external radius is subjected to an internal pressure of 60MN/m² and an external pressure of 30MN/m². Determine the hoop and radial stresses at the inside and outside of the cylinder together with longitudinal stress if the cylinder is assumed to have closed ends. (20 marks)

QUESTION 7

Some particulars of a five –cylinder air compressor are given below. Cylinders 2 and 4 (which are the high pressure cylinders) are to have their cranks at 180°. Determine a crank arrangement to satisfy the following conditions.

- (a) primary forces balanced
- (b) primary couples to have the least value compatible with condition (a).

For this arrangement find the magnitude of the unbalanced primary and secondary couples about No.3 cylinder line. Speed 250rev/mm, crank radius 0.3m, connecting rod 1.5m, axial spacing cylinders 0,825m.

Cylinder No.	Reciprocating mass (kg)	Crank angle
1	250	
2	125	0°
3	150	
4	125	180°
5	200	

(20 marks)

QUESTION 8

A cylinder has an internal diameter of 230mm, has walls 5mm thick and 1m long. It is found to change in internal volume by $12 \times 10^{-6} m^3$ when filled with a liquid at a pressure (p). If $E = 200GN/m^2$ and $\nu = 0,25$ and assuming rigid end plates, determine

- (a) Value of hoop and longitudinal stresses. (8 marks)
- (b) The modification of these values if joint efficiencies of 45% (hoop) and 85% (longitudinal) are assumed. (8 marks)
- (c) The necessary change in pressure (p) to produce a further increase in internal volume of 15%. The liquid may be assumed incompressible. (4 marks)

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