CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY - MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-31 - APPLIED MECHANICS

TUESDAY, 18 JULY 2017

1315 - 1615 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.
2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by colleges:

Candidate's examination workbook
Graph paper

APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A motor of mass 120 kg with a radius of gyration of 0.5 m is accelerated from rest to its full speed of 720 rev/min in 15 seconds. It is then clutched onto a stationary rotary pump of 50 kg mass with a radius of gyration of 0.38 m.

   Calculate EACH of the following:

   (a) the torque produced to accelerate the motor; (3)

   (b) the common speed in rev/min of the motor and pump after the clutch is engaged; (5)

   (c) the reduction in energy during the clutching operation; (4)

   (d) the time for the motor and pump to return from the speed calculated in Q1(b) to the running speed of 720 rev/min, if the torque remains as calculated in Q1(a). (4)

2. A coal wagon of mass 20 tonne runs down a smooth incline of 4°. As it does so it pulls an empty wagon of mass 3 tonne back up the same incline by means of a wire passed around a pulley of 2.5 m diameter. The pulley has a moment of inertia of 800 kgm^2. The friction torque in the pulley bearings is constant at 600 Nm.

   Calculate EACH of the following:

   (a) the acceleration of the wagons; (12)

   (b) the tensions in the wire at each wagon. (4)

3 A welded pressure vessel of circular cross section has an oblique welded seam at an angle of 50° to the circumferential joint. The internal diameter of the pressure vessel is 2 m, the shell plate thickness is 25 mm and the working pressure is 30 bar.

Calculate EACH of the following:

(a) the tensile stress normal to the circumferential seam; (3)

(b) the tensile stress normal to the oblique seam; (7)

(c) the percentage increase in the stress normal to the oblique seam if internal corrosion leads to a 8% reduction in shell thickness at the seam. (6)

4. A steel axle 150 mm in diameter and 2.4 m long is supported in symmetrically placed bearings 1.6 m apart. There is an upward load of 180 kN at each end of the axle.

(a) Sketch the Shear Force and Bending Moment diagrams. (6)

(b) Calculate EACH of the following:

(i) the maximum bending stress in the axle; (6)

(ii) the radius of curvature of the axle. (4)

Note: Modulus of Elasticity for steel = 208 GN/m²

5. A compound bar has a cross section of 100 mm by 120 mm. It consists of a rectangular piece of steel of cross section 100 mm by 40 mm fastened to a rectangular piece of copper of the same length and of cross section 100 mm by 80 mm. There are no stresses in either material at ambient temperature. The compound bar is then raised through a temperature change of 85°C.

Calculate EACH of the following:

(a) the stresses in both the steel and the copper after the temperature change, both magnitude and nature; (10)

(b) the change in length of the compound bar after heating if the length at ambient temperature is 1 metre. (6)

Note:

For steel	*Modulus of Elasticity*	$= 210\ GN/m^2$
	Coefficient of linear expansion	$= 12 \times 10^{-6}\ /°C$
For copper	*Modulus of Elasticity*	$= 100\ GN/m^2$
	Coefficient of linear expansion	$= 18 \times 10^{-6}\ /°C$

6. An intermediate propulsion shaft is fitted to an engine of power 8 MW operating at 120 rev/min. The shaft is solid, with a coupling flange at each end. On each flange there are 12 bolts, with a pitch circle diameter of 1.75 times the shaft diameter. The limiting torsional shear stress for the shaft material is 160 MN/m^2 and the limiting shear stress for the bolt material is 180 MN/m^2.

Calculate EACH of the following:

(a) the diameter of the shaft if a safety coefficient of two is required for the shaft material; (8)

(b) the diameter of the bolts if a safety coefficient of three is required for the bolt material. (8)

7. A cylinder cover of mass 2.2 tonne is hung from four vertical steel wires of diameter 12 mm. The cylinder cover is being lowered at a steady speed of 0.2 m/s when the brake is suddenly applied, halting the operation. Just before the brake is applied, all four wires have the same length of 32 m.

Calculate EACH of the following:

(a) the static stress in each wire when holding the cylinder cover; (3)

(b) the additional stress imposed on the wires due to the sudden stop; (10)

(c) the maximum extension of the wires due to the sudden stop. (3)

Note: Modulus of Elasticity for steel wires = 208 GN/m^2

8. A box whose mass is 60 kg is on a plane inclined at 30° to the horizontal, the coefficient of friction between the box and the plane is 0.4.

Calculate EACH of the following:

(a) the time taken for the box to slide down the plane a distance of 15 m from rest under the effect of gravity; (10)

(b) the force, applied parallel to the plane, to accelerate the box at 2 m/s^2 up the plane. (6)

9. A four-stroke single cylinder engine produces 750 kW at 720 rev/min. Fluctuation of energy is 20% of work done per cycle. A flywheel is to be fitted in order to stabilise the speed for power generation. The frequency must not fluctuate more than ± 0.2 Hz from the standard 60 Hz. Calculate the diameter of a 0.2 m thick solid flywheel. (16)

Note: The density of the flywheel material = 7800 kg/m^3