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 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-31 – APPLIED MECHANICS

TUESDAY, 16 JULY 2013

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. Two close coiled helical springs are used in parallel for an engine valve assembly. The springs have the following dimensions:

	Mean coil diameter	Wire diameter	No. of coils
Outer spring	70 mm	10 mm	12
Inner spring	50 mm	8 mm	14

During the fitting of the valve to the springs, the outer spring is compressed 8 mm more than the inner spring. The final force on the spring assembly is 700 N.

Calculate EACH of the following:

(a) the compression of the inner spring when the valve is closed; (8)

(b) the maximum shear stress in each spring when the valve is opened vertically downwards by 30 mm. (8)

Note: Modulus of Rigidity of Spring Material = 70 GN/m^2

2. Three masses are attached to a disc and rotate in the same plane . Mass A is 5.5 kg at 0.8 m radius, mass B is 6.2 kg at 1.2 m radius and mass C is 3.8 kg at 0.8 m radius. Masses B and C are at 140° and 210° respectively, clockwise from mass A.

Determine EACH of the following:

(a) the magnitude and direction of the out of balance force when the disc rotates at 60 rev/min; (12)

(b) the radius and angular position at which a 5 kg mass should be placed in order to balance the system. (4)

3. A box of mass 400 kg is pulled at constant speed up a ramp inclined at 20° above the horizontal by the application of a horizontal force of 2750 N.

Calculate EACH of the following:

(a) the coefficient of friction between the box and the ramp; (8)

(b) the minimum force that could be used to move the box, and its line of action. (8)

4. A cast iron cylinder cover is secured by twelve steel bolts, each of 18 mm diameter. The effective cross sectional area of the cylinder cover is 0.15 m^2. On assembly the bolts are tightened up so that the tensile stress in each bolt is 20 MN/m^2. The resulting stress in the cylinder cover is evenly distributed across its effective area.

Calculate the temperature rise at which the stress in the bolts will be zero. (16)

Note: *For Cast Iron modulus of Elasticity = 100 GN/m^2*
For Steel modulus of Elasticity = 200 GN/m^2
For Cast Iron coefficient of linear expansion = 11 x 10^{-6} per° C
For Steel coefficient of linear expansion = 12 x 10^{-6} per°C

5. A simple pendulum consists of a mass of 0.3 kg on the end of a wire. The pendulum performs 60 oscillations in 120 seconds, the angular amplitude of each being 8 degrees and can be assumed to move with simple harmonic motion.

Calculate EACH of the following:

(a) the maximum linear acceleration of the mass; (4)

(b) the length of the pendulum; (4)

(c) the maximum velocity of the mass; (2)

(d) the maximum tension in the wire. (6)

6. An “I”section beam is loaded as shown in Fig Q6.

Calculate EACH of the following:

(a) the maximum stress due to shear in the beam; (5)

(b) the maximum bending moment on the beam; (5)

(c) the point of contraflexure. (6)

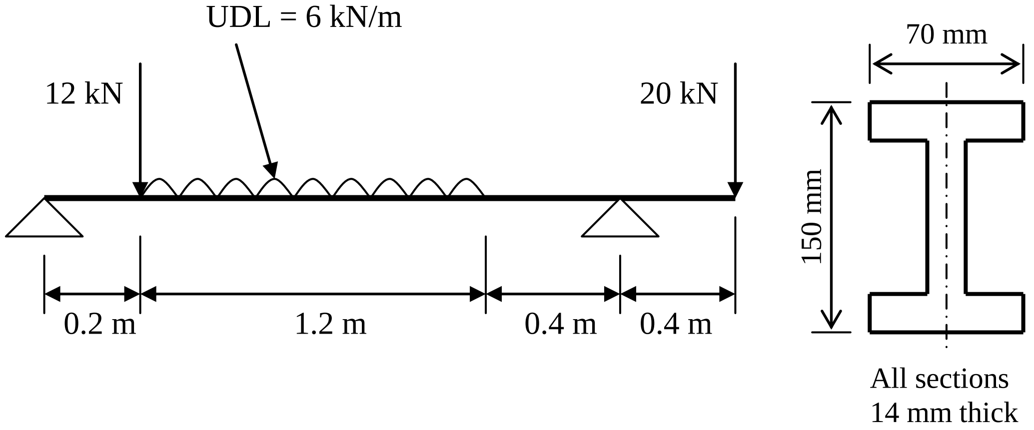

Fig Q6

7. A hollow steel shaft transmits a torque of 30 kNm. The outside diameter is 1.5 times the inside diameter and the angle of twist is one degree over a length equal to 18 times the outside diameter.

Calculate EACH of the following:

(a) the inside diameter of the shaft; (8)

(b) the maximum shear stress in the shaft; (4)

(c) the diameter of a solid shaft of the same material which could transmit the same torque without exceeding the maximum shear stress calculated in Q7(b). (4)

Note: For steel, Modulus of Rigidity = 80 GN/m^2

8. A circular life-buoy has a cross-sectional area of 140 cm^2 and floats in sea water. With a 15 kg steel mass attached to the lower side of the buoy, one quarter of the volume of the buoy remains above the surface.

(a) Calculate the mean diameter of the buoy. (12)

(b) If the steel mass becomes detached and falls to the sea bed 8 m below, calculate the time taken for the mass to reach the sea bed. (4)

Note: *Density of seawater* $= 1025 \ kg/m^3$
Density of Buoy $= 240 \ kg/m^3$
Density of steel $= 7840 \ kg/m^3$

9. Sea water flows through a 50 mm diameter hose and discharges from a nozzle with an outlet diameter of 12.5 mm. The nozzle is horizontal, and is 1.2 m above ground level. The discharge rate is 38 tonne/hour.

Calculate EACH of the following:

(a) the magnitude and direction of the reaction force at the nozzle; (10)

(b) the horizontal range of the jet of water before it first strikes the ground; (6)

Note: Density of seawater $= 1025 \ kg/m^3$