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, 14 OCTOBER 2014

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 packing case rests on an inclined plane of 14°. A force of 1400 N acting parallel to and up the plane is applied and just moves the packing case up the incline.

   When a force of 1510 N is applied to the same packing case but now horizontal and acting into the plane, the packing case also just moves up the incline.

   Determine EACH of the following:

   (a) the coefficient of friction between the packing case and the plane; (11)

   (b) the mass of the packing case. (5)

2. A helicopter is 300 nautical miles due South of a ship. The absolute speed of the ship is 18 knots in a direction 30° South of East. The speed of the helicopter is 120 knots.

   Determine EACH of the following:

   (a) the course to be taken by the helicopter to meet the ship as quickly as possible; (12)

   (b) the time taken by the helicopter to meet the ship. (4)

3. A winch motor drives a pinion which has 320 teeth. Friction in the motor bearings is constant at 20 Nm. The pinion meshes with a gear wheel having 640 teeth and this gear wheel drives a winch drum of diameter 340 mm. The winch drum raises an anchor of mass 2 tonne at a steady speed of 0.3 m/s. Assume the efficiency of the gearing is 100%.

   Calculate EACH of the following:

   (a) the total torque to be supplied at the output from the winch motor; (8)

   (b) the input power required by the winch motor if the motor efficiency is 85%. (8)

4. A single plate clutch with both sides effective has an outside diameter of 380 mm and an inside diameter of 140 mm. The clutch is designed to transmit 12 kW at 600 rev/min. The axial thrust on the clutch faces is provided by six identical springs, each with a stiffness of 8 kN/m. The coefficient of friction at the clutch surfaces is 0.6.

Calculate EACH of the following:

(a) the required compression of each spring to deliver the designed power when the clutch is new; (8)

(b) the power transmitted when a total of 2 mm of plate wear occurs and the clutch is worn. (8)

Note:

$$\text{For constant pressure, } T = \frac{2\mu n W(r_o^3 - r_i^3)}{3(r_o^2 - r_i^2)}$$

$$\text{For constant wear, } T = \frac{\mu n W(r_o + r_i)}{2}$$

n = number of pairs of contact surfaces.

5. A short vertical column consists of a hollow steel tube of 48 mm outside diameter and 40 mm inside diameter with a solid brass rod of 34 mm diameter within it. The steel tube is 380 mm long and the brass rod is 1 mm shorter. The brass rod is supported on a raised boss so that the top of the tube and the top of the rod are level.

Calculate the maximum load that can be applied to the column so that the compressive stress in the brass rod does not exceed 50 MN/m^2. (16)

Note: For steel, Modulus of Elasticity = 210 GN/m^2
For brass, Modulus of Elasticity = 80 GN/m^2

6. When a four ram hydraulic steering gear has the rudder at an angle of 30°, the hydraulic oil pressure is 60 bar and the rudder is moving at 0.033 rad/s. The rams are 250 mm diameter and the distance between the centreline of the rams and the centre of the rudder stock is 1.2 m.

Calculate EACH of the following:

(a) the power delivered to the rudder stock; (10)

(b) the bending moment on the tiller arm at a point 800 mm from the centre of the rudder stock. (6)

7. A hollow square section beam of external dimension 100 mm and thickness 5 mm is loaded as shown in Fig Q7.

Calculate EACH of the following:

(a) the maximum stress due to shear in the beam; (8)

(b) the position of the point of contraflexure from the left hand side of the beam. (8)

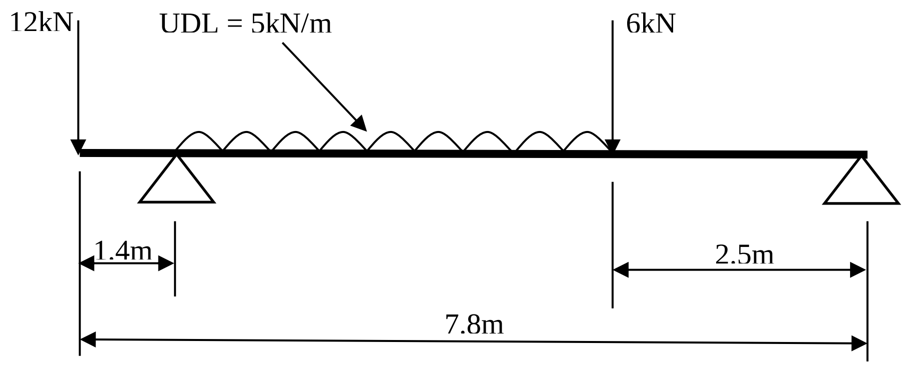

Fig Q7

8. A tank is 4 m deep and filled with fresh water. A 400 mm diameter circular access door is fitted into one side of the tank and its centre is 600 mm from the tank floor. The access door is vertical and is hinged at its top edge and is secured by a single bolt at its lowest edge.

A pressure test is applied to the tank by filling the air vent pipe to give an additional head of 800 mm of fresh water.

Calculate EACH of the following:

(a) the hydrostatic force on the access door; (3)

(b) the position of the centre of pressure of the hydrostatic force below the centroid of the door; (6)

(c) the tensile force in the bolt. (7)

9. A vertical pipe is 8 m long. It is 100 mm diameter at the bottom and 140 mm diameter at the top. Sea water flows upwards through the pipe and the pressure at the top is 0.7 bar less than the pressure at the bottom. Friction head loss in the pipe is found to be 0.5 m.

Calculate the sea water flow rate in tonne/hour. (16)

Note: Density of sea water is 1025 kg/m³.