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, 11 DECEMBER 2012

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 flat plate in a boiler is supported by bar stays. Each stay is 40 mm diameter, 0.8 m long and supports a plate area of 0.4 m^2. The internal pressure is 6 bar.

   Calculate EACH of the following:

   (a) the stress in each stay; (4)

   (b) the strain energy in each stay; (6)

   (c) the strain energy in a hollow stay of the same length and external diameter but an internal diameter of 18 mm. (6)

   Note: Modulus of Elasticity for stay material = 190 GN/m^2.

2. A set of shear legs arranged as shown in Fig Q2 is used to lift a load of 200 kg.

   Determine EACH of the following:

   (a) the load in each front leg; (12)

   (b) the load in the back-stay, stating whether this is compressive or tensile. (4)

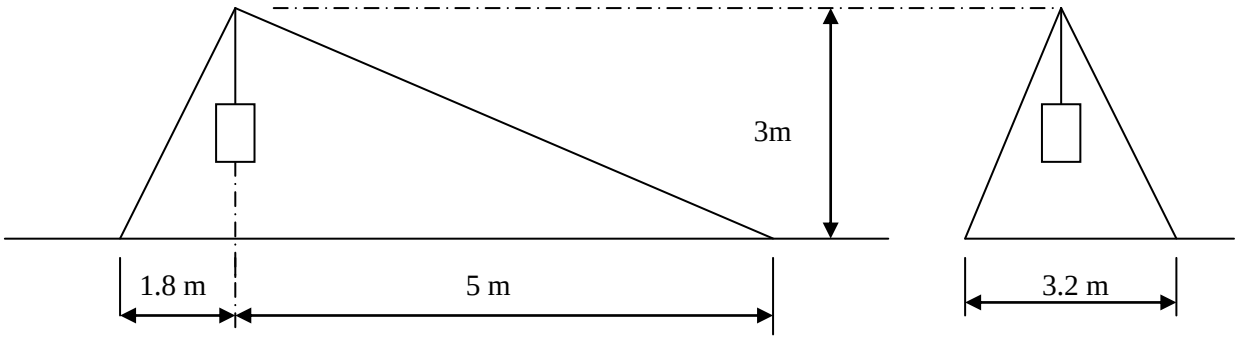

Fig Q2

3. A welded pressure vessel of circular cross section has an oblique welded seam at an angle of 60° to the longitudinal joint. The internal diameter of the pressure vessel is 1.9 m, the shell plate thickness is 32 mm and the working pressure is 28 bar.

(a) Sketch the Forces normal and tangential to the longitudinal joint and the Forces normal and tangential to the oblique seam. (4)

(b) Calculate EACH of the following:

(i) the tensile stress normal to the circumferential seam; (2)

(ii) the tensile stress normal to the oblique seam; (5)

(iii) the percentage increase in the stress normal to the oblique seam if corrosion leads to a 10% reduction in shell thickness at the seam. (5)

4. An intermediate shaft is fitted to an engine of power 14 MW operating at 100 rev/min. The shaft is to be solid, with a coupling flange at each end with 12 bolt holes on a pitch circle diameter of 1.6 times the shaft diameter. The limiting shear stress is 190 MN/m^2 for the shaft material and 170 MN/m^2 for the bolt material.

Calculate EACH of the following:

(a) the diameter of the shaft for a safety coefficient (factor of safety) of two; (8)

(b) the diameter of the bolts for a safety coefficient (factor of safety) of two. (8)

5. A vehicle travels around a bend on a banked track at a constant speed of 25 m/s and at an effective radius of 100 m. The vehicle has a wheel base width of 1.6 metres and a centre of gravity 1.4 metres above the track surface.

Calculate EACH of the following:

(a) the minimum angle of banking required to prevent the vehicle from overturning; (10)

(b) the minimum coefficient of friction between the track and the vehicle to prevent the vehicle sliding when the track is banked at the angle calculated in Q5(a). (6)

6. A Porter governor has arms of equal length 320 mm and two rotating masses of 0.8 kg each. At the mean speed of 120 rev/min, with the speed falling, both sets of arms are at 30 degrees to the vertical. Friction at the central sleeve is constant at 20N.

Calculate EACH of the following:

(a) the central sleeve mass; (8)

(b) the speed that would cause the sleeve to rise 20 mm from the mean speed position given; (5)

(c) the speed that would cause the sleeve to fall 20 mm from the mean speed position given. (3)

7. An engine fuel injector is operated by fuel oil pressure acting on the underside of a needle valve. Movement of the needle valve is opposed by a spring with 14 coils of outside diameter 22 mm and wire diameter 6 mm. Fuel oil pressure acts on an effective area of 34 mm^2 on the underside of the needle valve. Fuel injection should not commence until the fuel pressure has risen to 26 MN/m^2. Valve lift is limited to 0.8 mm.

Calculate EACH of the following:

(a) the required initial axial compression of the spring; (8)

(b) the maximum force on the spring; (4)

(c) the maximum torsional stress in the spring. (4)

Note: Modulus of Rigidity for spring material = 80 GN/m^2

8. A regular cube of sides 100 mm floats vertically in a tank containing two immiscible liquids of densities 800 kg/m^3 and 1000 kg/m^3.

Calculate EACH of the following:

(a) the depth of the lighter liquid if 10 mm of the cube remains above the liquid surface; (10)

(b) the mass of steel which should be attached to the base of the cube to ensure that the cube is just submerged. (6)

Note: Density of Cube material = 850 kg/m^3
Density of Steel = 7800 kg/m^3

9. A pump has a suction lift of 0.5 m and delivers 24 tonnes per hour of fresh water to a tank whose water level is 16 m above the pump. The delivery pipe is 28 m long and 90 mm bore, with a friction coefficient of 0.02.

Calculate EACH of the following:

(a) the power output of the pump; (10)

(b) the pump discharge pressure. (6)

Note: Assume the friction loss in the suction pipeline is negligible.