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 22 JULY 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 Hartnell governor has two flyweights each of mass 0.5 kg. The flyweight arm length is 60 mm and the sleeve arm length is 25 mm. At a governor speed of 1600 rev/min and rising, the radius of the flyweights is 30 mm. A speed increase of 2% causes the central sleeve to move by 1.2 mm. Friction in the governor is equivalent to a force of 40 N at the sleeve.

   Calculate the spring stiffness. (16)

2. A crane lifting wire of 22 mm diameter is found to extend by 1.2 mm per metre length when subjected to a tensile load of 70 kN.

   The crane wire is attached to a spare piston ready for lifting. Whilst the crane wire is still slack the piston becomes dislodged from its storage mounting and falls a distance of 30 mm before taking up the slack in the crane wire. The crane wire is 3.8 m long and the instantaneous extension due to the falling piston is 2.8 mm.

   Calculate EACH of the following:

   (a) the modulus of elasticity for the crane wire material; (3)

   (b) the mass of the piston. (13)

3. A winch motor drives a pinion with 320 teeth, and friction at the motor bearings is constant at 18 Nm. The pinion then meshes with a gear wheel having 960 teeth which drives a shaft of 140 mm diameter. This shaft is supported in bearings having a coefficient of friction of 0.1 and drives a winch drum of diameter 380 mm.

   Calculate EACH of the following:

   (a) the driving torque required by the motor when raising a mass of 2 tonnes at steady speed; (10)

   (b) the input power required by the motor when raising the load in Q3(a) at a steady speed of 0.2 m/s if the motor efficiency is 88%. (6)

4. A basic flapper/nozzle device is shown in Fig Q4. The pneumatic signal for the input bellows unit is proportional to the measured temperature within the range 0 - 500°. The output signal range is to be 20 - 100 kN/m^2.

The characteristic of the input bellows is 3 μm/°C, and the characteristic of the nozzle is 0.1 kN/m^2 per μm of flapper movement.

$$\text{The gain of the device} = \frac{\%\ \text{change in output}}{\%\ \text{change in input}}$$

Calculate EACH of the following:

(a) the flapper movement at the nozzle for 100% input change; (2)

(b) the resulting change in output; (2)

(c) the gain of the device; (2)

(d) the new setting of *x*, the distance from the pivot to the nozzle, to achieve a gain of magnitude 0.7; (5)

(e) the output pressure at 450°C with a gain of magnitude 0.7 if the output pressure was 50 kN/m^2 at a temperature of 430°C. (5)

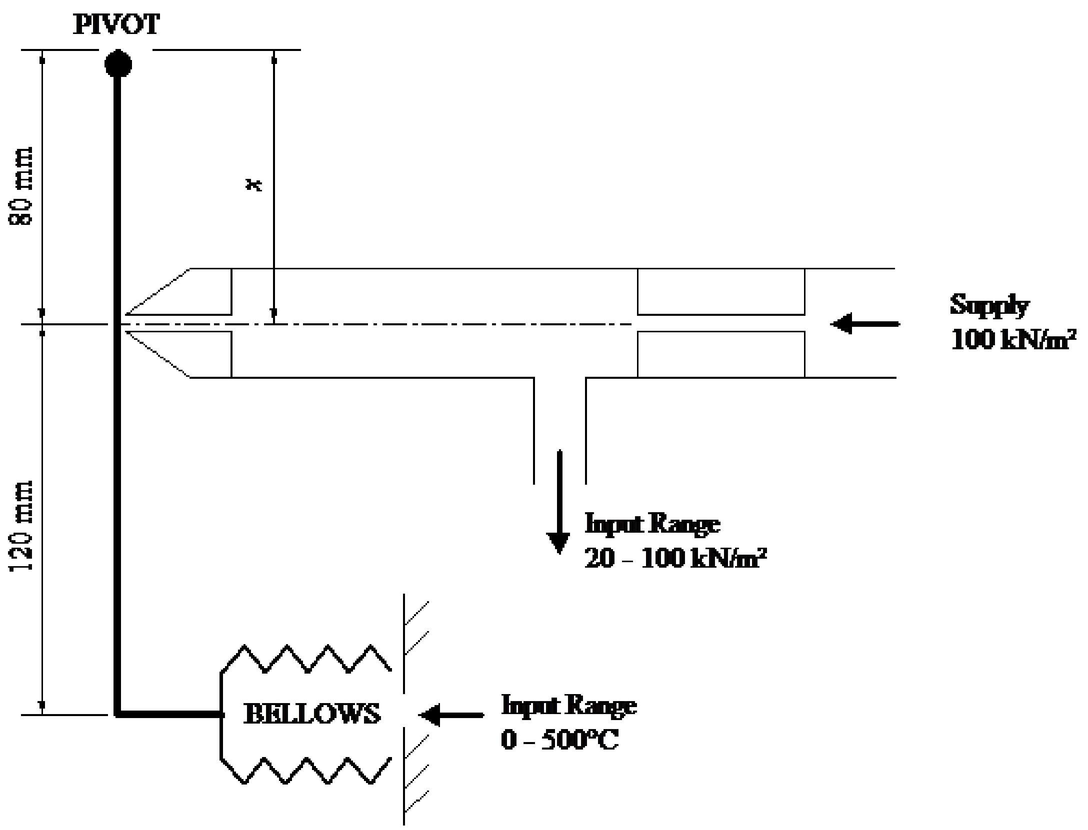

Fig Q4

5. A compound shaft consists of a 25 mm thick bronze sleeve fitted over a 375 mm diameter steel shaft. The compound shaft transmits 2.9 MW at 92 rev/min.

Calculate EACH of the following:

(a) the torque transmitted by the bronze sleeve; (6)

(b) the torque transmitted by the steel shaft; (6)

(c) the maximum shear stress in the bronze sleeve; (2)

(d) the maximum shear stress in the steel shaft. (2)

Note: Modulus of Rigidity of the steel = 80 GN/m^2
Modulus of Rigidity of the bronze = 45 GN/m^2

6. A cable consists of one steel wire 6 mm diameter and eight brass wires each 3 mm diameter. The stress in the brass wires is not to exceed 50 MN/m^2.

Calculate EACH of the following:

(a) the maximum load the cable can carry; (10)

(b) the equivalent modulus of elasticity for the cable. (6)

Note: Modulus of Elasticity for Steel = 210 GN/m^2
Modulus of Elasticity for Brass = 80 GN/m^2

7. A pump delivers fresh water at the rate of 30 tonne/hour. The discharge pipe is 75 mm bore and delivers water to the bottom of a tank located 11 m above the pump. The suction lift of the pump is 1.6 m. The discharge pipe is 28 m long with a friction coefficient for Darcy's equation of 0.01. Friction losses in the suction pipe may be neglected.

Calculate the output power of the pump when the water level in the tank has risen to 3 m. (16)

8. A vertical pipe 6 m long is 80 mm diameter at the bottom and 120 mm diameter at the top. Sea water flows upwards through the pipe and the pressure at the top is 0.6 bar less than the pressure at the bottom. Friction head loss in the pipe is 0.4 m.

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

Note: Density of sea water = 1025 kg/m^3

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9. A steel beam of symmetrical I section is shown in Fig Q9. The beam has a mass of 30 kg per metre run and is 9 m long. The beam is simply supported at each end and the maximum bending stress is not to exceed 140 MN/m^2 at any point.

Calculate EACH of the following:

(a) the maximum uniformly distributed load that can be carried; (12)

(b) the minimum radius of curvature when this maximum uniformly distributed load is carried. (4)

Note: Modulus of elasticity for steel = 210 GN/m^2

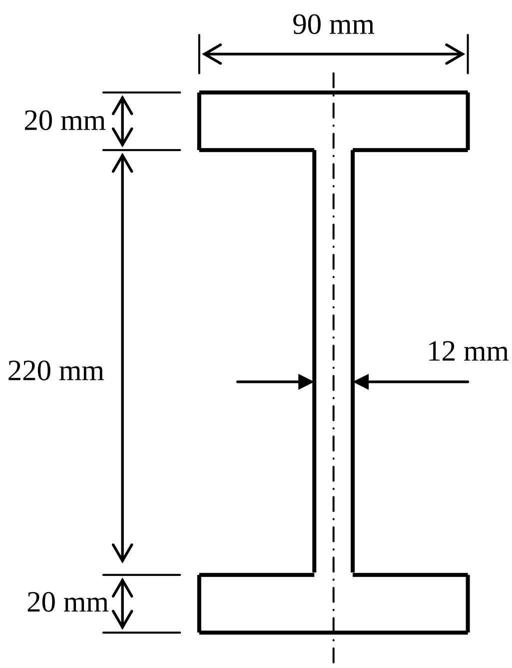

Fig Q9