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, 5 APRIL 2016

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 vessel travelling due West at 18 knots sights another vessel 8 nautical miles away in a direction 20^0 South of West. Thirty minutes later the second vessel is 3 nautical miles away in a direction 50^0 South of West.

   Determine EACH of the following:

   (a) the distance of nearest approach between the TWO vessels if they both maintain their present speed and course; (8)

   (b) the absolute course and speed of the second vessel. (8)

2. A lift of mass 700 kg is attached to a balance mass of 500 kg by a cable passing over a power driven drum of diameter 2.2 m and mass 200 kg. The drum has a radius of gyration of 0.8 m. At a certain instant the lift is ascending at 3 m/s but is decelerating at a rate of 0.2 m/s^2.

   (a) Sketch the arrangement showing all forces and torques present. (4)

   (b) Calculate the driving power required at the drum at this instant. (12)

3. A basic flapper/nozzle device is shown in Fig Q3 (not drawn to scale). The pnuematic signal for the input bellows unit is proportional to the measured temperature within the range 0-120^{0}C. The output signal range is to be 20–100 kN/m^2.

The characteristic of the input bellows is 5 μm/^{0}C, and the characteristic of the nozzle is 0.2 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 'y', the distance from the pivot to the nozzle, to achieve a gain of 0.5; (5)

(e) the output pressure at 75 ^{0}C with a gain of 0.5 if the output pressure was 40 kN/m^2 at a temperature of 30 ^{0}C. (5)

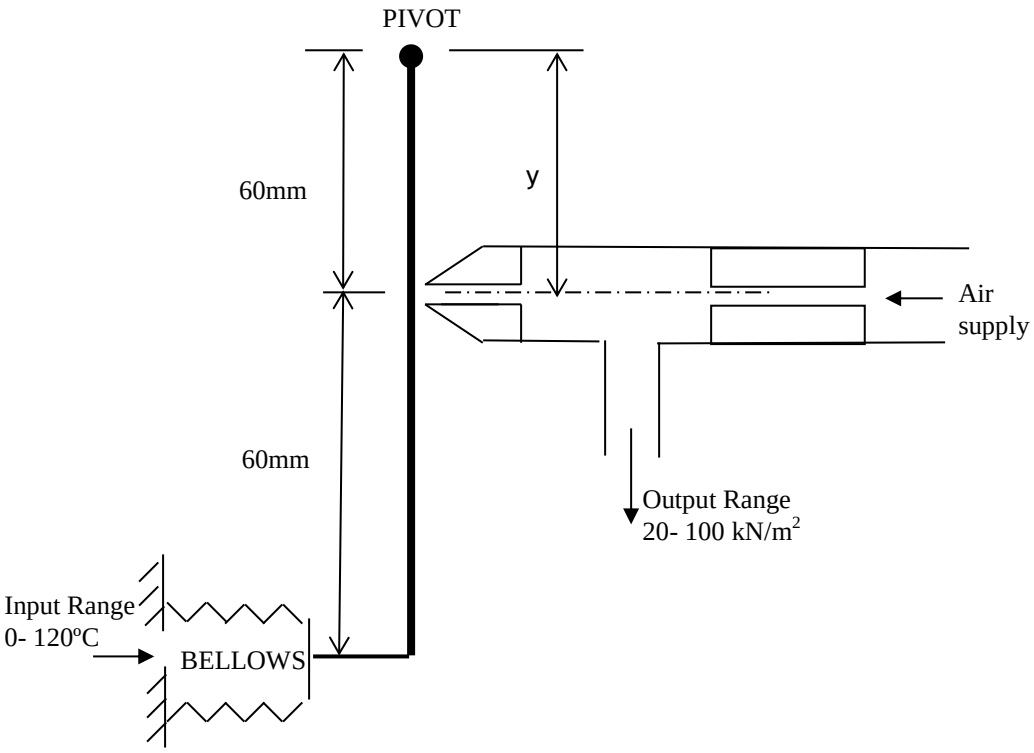

Fig Q3

4. A horizontal turbine rotor of mass 200 kg becomes unbalanced such that its centre of gravity is 0.2 mm from the centre of rotation. The rotor shaft is 750 mm long and is supported in bearings at each end. The weight of the rotor acts 300 mm from one end of the shaft.

Calculate EACH of the following:

(a) the maximum force at EACH bearing when the shaft speed is 2000 rev/min; (8)

(b) the speed at which the shaft would first lift from the bearings. (8)

5. A steel rod is 280 mm long with a diameter of 28 mm. It is firmly attached at one end to a copper rod of length 580 mm. When the combined assembly is subjected to a tensile pull of 40 kN, the extensions of the steel and copper are found to be equal.

Calculate EACH of the following:

(a) the diameter of the copper rod; (4)

(b) the stress in EACH rod; (4)

(c) the total extension; (4)

(d) the stored strain energy in the assembly when extended. (4)

Note: Modulus of Elasticity for steel = 210 GN/m^2
Modulus of Elasticity for copper = 90 GN/m^2

6. A short vertical hollow cylindrical column, 180 mm high and fixed at the base, is 80 mm outside diameter and 10 mm thick. It carries concentrated loads of 9 kN and 5 kN as shown in Fig Q6.

Calculate EACH of the following:

(a) the maximum compressive stress in the column; (8)

(b) the maximum tensile stress in the column. (8)

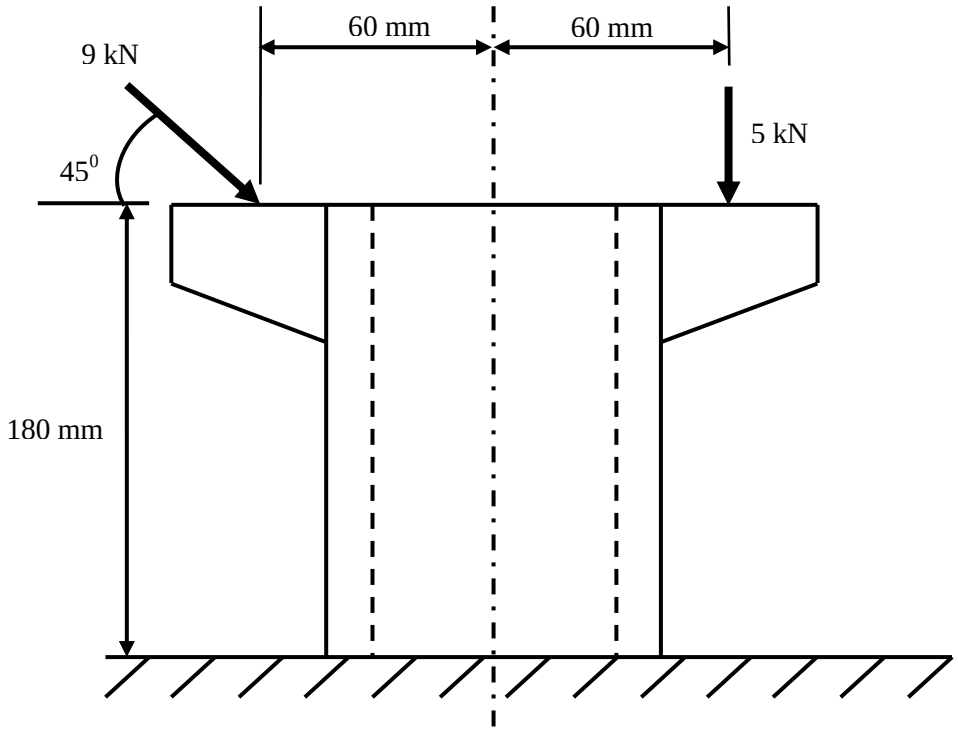

Fig Q6

7. A compound shaft consists of a 28 mm thick bronze sleeve fitted over a 380 mm diameter steel shaft. The compound shaft transmits 2.8 MW at 90 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

8. A regular cube of sides 100 mm floats vertically in a tank containing two non-mixing liquids of densities 700 and 1050 kg/m^3.
Calculate EACH of the following:

(a) the depth of the lighter liquid if 20 mm of the cube remains above the liquid surface; (8)

(b) the mass of steel which should be attached to the base of the cube to ensure that the cube is just submerged. (8)

Note: Density of cube material = 750 kg/m^3
Density of steel = 7800 kg/m^3

9. Sea water flows through a horizontal pipe at a rate of 80 m^3/hour. A bend in the pipe turns the sea water through 30° and the pipe is tapered from 90 mm diameter at the inlet to 40 mm diameter at the outlet. The outlet discharges to atmosphere and friction losses within the pipe can be neglected.

Determine EACH of the following:

(a) the velocity of the sea water at outlet from the bend; (4)

(b) the gauge pressure at inlet to the bend; (5)

(c) the force acting on the bend due to the change in velocity alone. (7)

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