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, 18 OCTOBER 2011

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. The flow of air through a duct is controlled by a diaphragm actuated valve. The pressure P (kN/m^2) on the diaphragm is given by:

$$P = K_1 - K_2 (x/A)$$

Whilst the volumetric flow rate of air through the duct Q (m^3/h) is given by:

Where:

x is the valve displacement from the closed position (mm)
A is the area of the diaphragm (mm^2)
K_1 and K_2 are constants

When the valve is 38 mm from the closed position, the diaphragm pressure is 15 kN/m^2.
When the valve is 75 mm from the closed position, the diaphragm pressure is 4 kN/m^2.
The effective diameter of the diaphragm is 110 mm.

Calculate EACH of the following:

(a) the numerical value of the constants K_1 and K_2; (8)

(b) the valve displacement from the closed position when the flow rate of air through the duct is 55 m^3/h. (8)

2. A short vertical tubular column of 180 mm outside diameter and 140 mm inside diameter is used to support a lighting fixture which is to be offset from the centreline of the column. The lighting fixture consists of a circular cap of mass 4 kg, which sits concentrically above the column, and an offset lighting fixture of mass 0.9 kg supported by an arm of negligible mass.

Calculate the greatest allowable offset of the lighting fixture from the centre-line of the column, if no part of the column is to be placed in tension. (16)

3. A 1 tonne load is suspended from the end of a hoist cable. The cable is wound round a drum of effective diameter 0.6 m.

Calculate EACH of the following:

(a) the acceleration of the load when being raised if the tension in the cable is 8.5 kN; (6)

(b) the acceleration of the load when being lowered at 9 m/s if the tension in the cable is 9.81 kN; (3)

(c) the acceleration of the load when being lowered if the tension in the cable is 11 kN; (3)

(d) the driving power required at the drum when raising the load at 4 m/s and causing an upwards acceleration of 0.3 m/s^2. (4)

4. A drive shaft comprises a solid steel shaft of 28 mm diameter which is a sliding fit in a hollow shaft of outside diameter 40 mm. The two shafts are connected by a shear pin as shown in Fig Q4. The torsional shear stress in the solid shaft is not to exceed 24 MN/m^2, whilst the pin material will shear at a stress of 80 MN/m^2.

Calculate EACH of the following:

(a) the maximum torque that can be transmitted by the solid shaft; (6)

(b) the maximum shear stress in the hollow shaft when transmitting the torque calculated in Q4(a); (3)

(c) the diameter of the shear pin so that it will protect the solid shaft from excessive stress. (7)

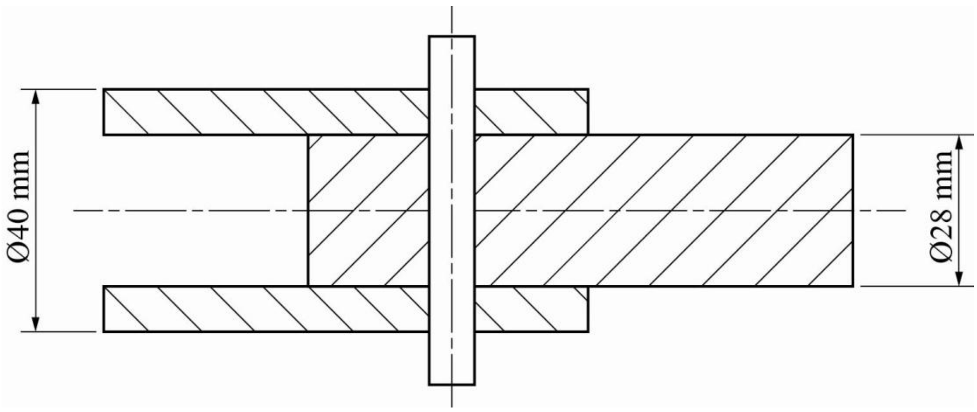

Fig Q4

5. A casting of mass 20 kg is attached to the face-plate of a lathe. The centre of gravity of the casting is 120 mm from the axis of rotation. In order to achieve dynamic balance, two balance masses are attached to the face-plate. The first has a mass of 12 kg and is fitted 150^o clockwise from the casting and 90 mm from the axis of rotation, whilst the second is to be located 100 mm from the axis of rotation.

Calculate EACH of the following:

(a) the unbalanced force before the balance masses are fitted, if the lathe is run at a speed of 120 rev/min; (4)

(b) the required magnitude of the second balance mass; (8)

(c) the required angular position of the second balance mass. (4)

6. A horizontal tubular beam is 5 m long, has an outside diameter of 180 mm, an inside diameter of 150 mm and is simply supported at each end. The beam carries a uniformly distributed load over its entire length and the maximum deflection of the beam due to this load is 4.5 mm.

Calculate the maximum bending stress in the beam. (16)

Note: Modulus of Elasticity of beam material = 210 GN/m^2

where W is the total load carried by the beam.

7. A crankcase relief door is 240 mm diameter and has a mass of 0.6 kg. The door operates along a horizontal axis and is kept closed by a helical spring made from 8 mm diameter wire. The spring has six coils of mean diameter 60 mm and is compressed by 18 mm on assembly.

Calculate EACH of the following:

(a) the minimum gas pressure in the crankcase that will cause the door to open; (8)

(b) the time taken for the door to open 60 mm, assuming an effective pressure of 0.3 bar above atmospheric pressure acts on the door throughout the opening period. (8)

Note: Modulus of Rigidity for spring material = 70 GN/m^2

8. An oil-water mixture consists of 80% oil and 20% seawater by volume. The mixture is pumped into a flat-bottomed 4 m square section tank. The depth of the mixture in the tank is 5 m.

Calculate the hydrostatic force on a vertical side of the tank for EACH of the following:

(a) when the oil and water are still thoroughly mixed together; (6)

(b) when the oil and the water have completely settled out. (10)

Note: Relative Density of Sea Water = 1.025
Relative Density of Oil = 0.8

9. A vertical venturi-meter having an inlet diameter of 200 mm and a throat diameter of 80 mm is used to measure the flow of fresh water in a vertical pipeline. The throat is 180 mm above the inlet and the flow rate is 50 tonnes/hour.

Calculate the differential pressure in millimetres of water between the inlet and the throat of the venturi-meter. (16)