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, 19 JULY 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. A single cylinder, double acting vertical bilge pump operates at 50 rev/min against a discharge pressure of 1.8 bar. The flow rate is 18 m^3/hour of water and the piston has a diameter of 120 mm. The piston may be assumed to move with simple harmonic motion and the volume of the piston rod may be ignored. The pump is driven by a motor with an efficiency of 78%.

   At a given instant the piston is 90 mm away from the top of the stroke and the mass of the piston and entrapped water combined is 6 kg.

   Calculate EACH of the following, at the given instant:

   (a) the force required to move the piston; (12)

   (b) the input power to the motor. (4)

2. A mass of three tonne is being supported by two vertical 12 mm diameter wires, both equally loaded. One wire then suddenly fails, causing the other wire to carry the full load.

   Calculate EACH of the following:

   (a) the initial stress in each wire; (3)

   (b) the increase in stress in the remaining wire caused by the sudden failure; (10)

   (c) the maximum stress in the remaining wire at the time of failure. (3)

3. A compound shaft consists of a bronze sleeve 390 mm external diameter shrunk onto a solid steel shaft of 340 mm diameter. The compound shaft transmits a total power of 4 MW at 100 rev/min.

   Calculate EACH of the following:

   (a) the percentage of the total power transmitted by the bronze sleeve; (12)

   (b) the maximum shear stress set up in the steel shaft. (4)

   Note: for steel, Modulus of Rigidity = 80 GN/m^2
   for bronze Modulus of Rigidity = 40 GN/m^2

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4. A fan impeller has a total mass of 18 kg, a diameter of 0.8 m and has five equally spaced vanes. The fan rotates at 2400 rev/min.

Due to a fault in manufacture, the centre of gravity is found to be 6 mm from the centre of rotation as shown in Fig Q4. To achieve balance, it is decided to remove metal evenly from the full length of two of the 0.4 m long vanes.

Determine EACH of the following:

(a) the unbalanced force before the metal is removed; (3)

(b) the volume of metal to be removed evenly from each of the two vanes. (13)

Note: Density of impeller metal = 5800 kg/m^3

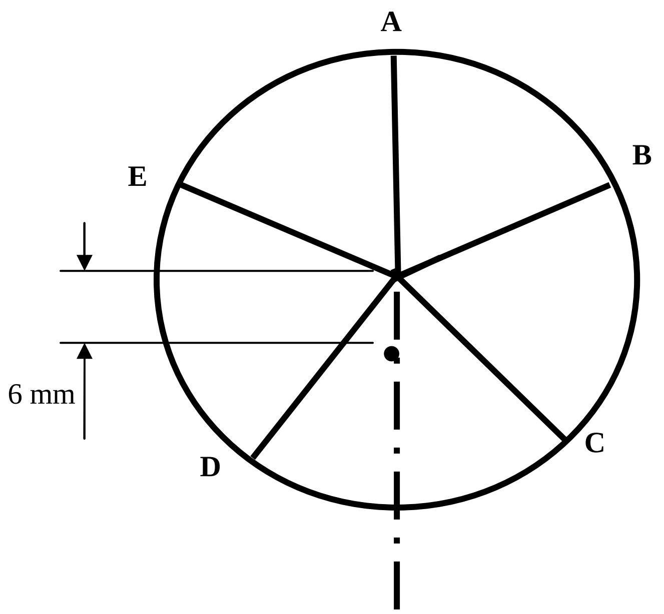

Fig Q4

5. A pontoon 12 m long and 2 m wide of negligible mass floats level in fresh water and carries two concentrated loads of 72 kN each as shown in Fig Q5.

(a) Sketch the shear force and bending moment diagrams along the length of the pontoon, showing the maximum and minimum values. (6)

(b) Calculate EACH of the following:

(i) the position of the points of contra flexure from each end; (6)

(ii) the increase in draught of the pontoon due to the two applied loads. (4)

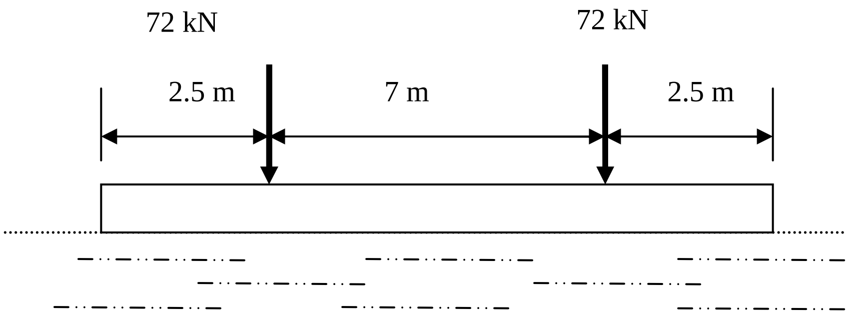

Fig Q5

6. The round steel bar shown in Fig Q6 has a total elongation of 0.4 mm when subjected to an axial load.

Calculate EACH of the following:

(a) the magnitude of the applied load; (12)

(b) the strain energy stored in the bar. (4)

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

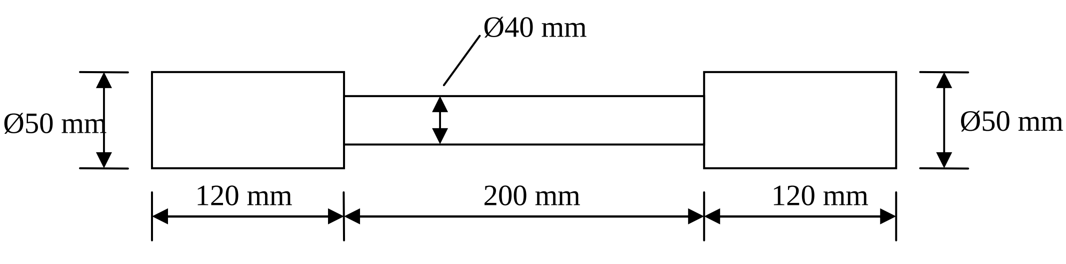

Fig Q6

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7. A flywheel has a mass of 250 kg and a radius of gyration of 380 mm. It is driven by a four cylinder, four stroke engine. The work done in every power stroke of each cylinder is 700 J and 70% of this work is used when accelerating the flywheel from 120 rev/min to 360 rev/min.

Calculate EACH of the following:

(a) the energy gained by the flywheel during the accelerating period; (8)

(b) the number of revolutions necessary to increase the speed of the engine from 120 rev/min to 360 rev/min. (8)

8. The lock gate shown in Fig Q8 is supported by two hinges at A and B at one side, and by a single catch at C on the opposite side. The fresh water in the lock is at a level of 5 m upstream of the gate and at a level of 3 m downstream of the gate.

Calculate EACH of the following:

(a) the resultant hydrostatic force on the gate; (4)

(b) the reaction at the catch; (4)

(c) the reaction at each of the hinges. (8)

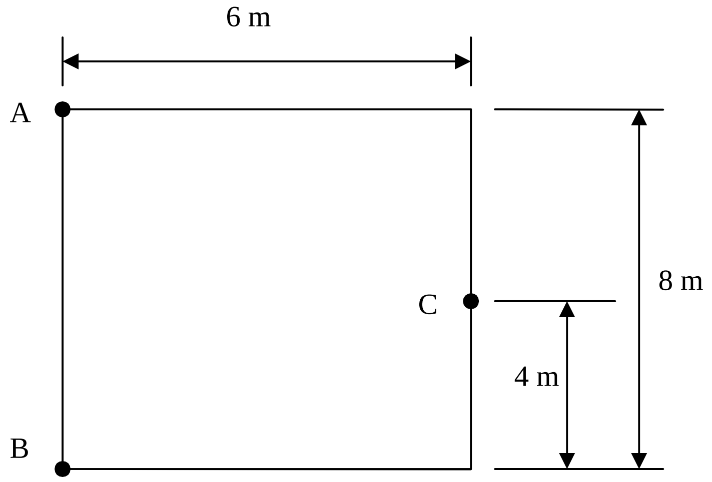

Fig Q8

9. A venturi-meter having an inlet diameter of 40 mm and a throat diameter of 20 mm is used to measure the flow of fresh water in a vertical pipeline. The throat is 150 mm above the inlet and a differential pressure gauge connected between these points gives a reading of 180 mm of water. The meter coefficient for the venturi is 0.95.

Calculate the hourly mass flow rate of the water. (16)