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, 10 DECEMBER 2013

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 coal truck with a total mass of 24 tonne has four wheels each of mass 400 kg, diameter 0.5 m and radius of gyration 0.2 m. It is travelling at 2 m/s when it starts to descend an incline of 4°. The incline is 180 m long and resistance to motion is constant at 900 N.

   Calculate EACH of the following:

   (a) the energy lost in descending the incline; (2)

   (b) the speed of the truck at the bottom of the incline. (14)

2. A vertical post and horizontal tie support a loaded jib as shown in Fig Q2. The load of 40 kN is suspended on a load wire which is allowed to oscillate through 60 degrees.

   Calculate EACH of the following:

   (a) the maximum force on the jib allowing for the centrifugal load; (10)

   (b) the tension in the load wire at the point of its nearest approach to the jib. (6)

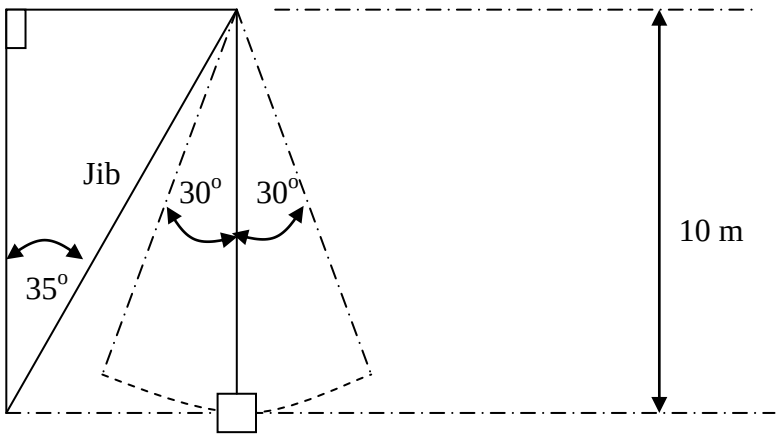

Fig Q2

3. When a two ram hydraulic steering gear has the rudder at an angle of 30°, the hydraulic oil pressure is 60 bar and the rudder is moving at 0.033 rad/sec. The rams are 220 mm diameter and the distance between the centreline of the rams and the centre of the rudder stock is 1.1 m.

Calculate EACH of the following:

(a) the power delivered to the rudder stock; (8)

(b) the bending moment in the tiller arm at a point 700 mm from the centre of the rudder stock. (8)

4. A centrifugal clutch is shown in Fig Q4 and has four shoes retained by springs. The shoes first contact the output drum at 9 rev/s, at which point the centre of gravity of each shoe is at a radius of 120 mm from the shaft axis. The internal radius of the output drum is 150 mm. When the drive shaft speed is then increased to 15 rev/s, the maximum power transmitted to the output shaft is 30 kW.

Calculate the mass of each shoe if the coefficient of friction between the shoes and the drum is 0.5. (16)

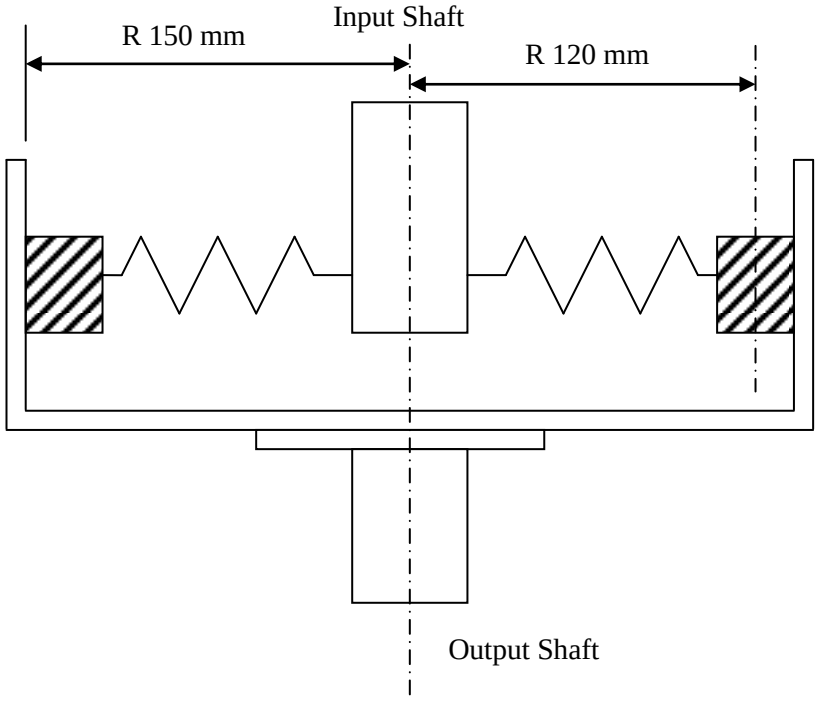

Fig Q4

5. A section of a hydraulic control system is shown in Fig Q5. The system is filled with an incompressible fluid. Movement of the input piston 'A' causes the output pistons 'B' and 'C' to move. Piston C moves against a spring of stiffness 50 kN/m. Piston B has no resistance to movement but reaches a rigid stop after 40 mm travel. Piston A has a diameter of 60 mm and pistons B and C are each 84 mm diameter.

Calculate the total movement "x" of the piston A, when a force of 1400 N is applied to it. (16)

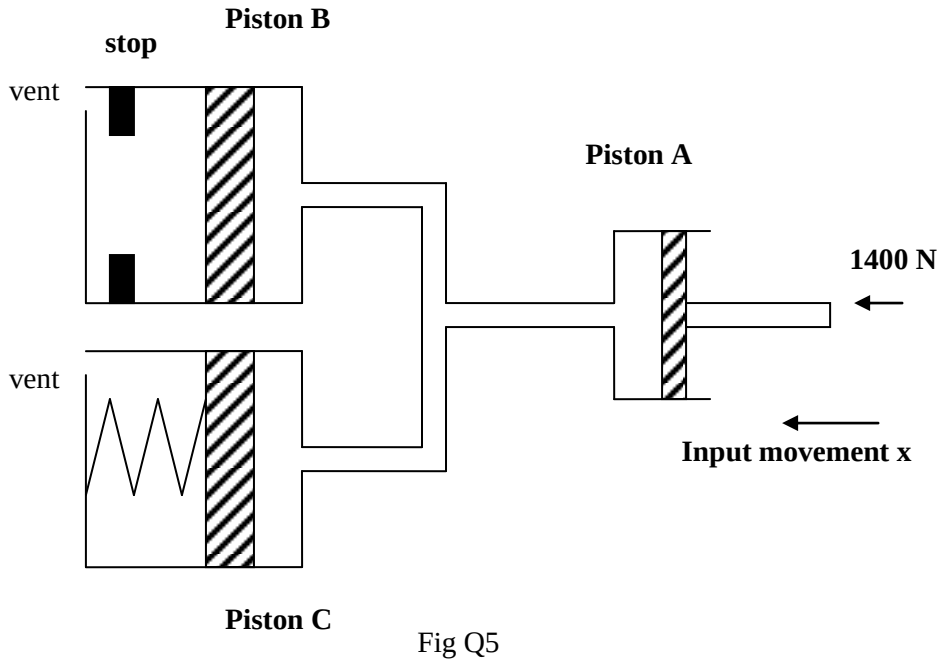

Fig Q5

6. A centrifugal pump delivers 900 tonne of sea water per hour. The impeller has an inlet width of 80 mm and an exit diameter of 440 mm. When running at 720 rev/min the radial flow velocity of the water is constant at 3.2 m/sec and the absolute velocity at exit is 9 m/sec.

Calculate EACH of the following:

(a) The impeller diameter at inlet; (4)

(c) The inlet angle of the impeller vanes for shock-less flow; (6)

(d) The exit angle of the impeller vanes for shock-less flow. (6)

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

7. A drive shaft comprises a solid steel shaft of 26 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 Q7. The torsional shear stress in the solid shaft is not to exceed 30 MN/m^2, whilst the pin material will shear at a stress of 70 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 Q7(a); (3)

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

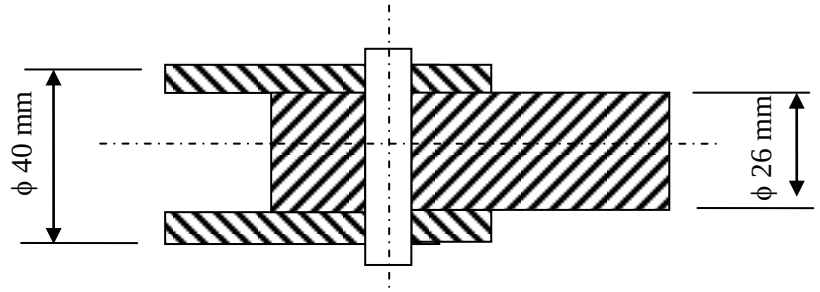

Fig Q7

8. A tank contains fresh water to a depth of 3 metres. Oil of depth 1.4 metres floats above the fresh water. The width of the vertical tank wall is 3 metres.

Calculate EACH of the following:

(a) the total hydrostatic force on the vertical tank wall; (4)

(b) the position of the resultant centre of pressure; (8)

(c) the equivalent depth of fresh water alone that would exert the same hydrostatic force as the two liquids combined. (4)

Note: Density of the oil = 800 kg/m^3

9. A short vertical hollow cylindrical column, 180 mm high and fixed at the base, is 90 mm outside diameter and 8 mm thick. It carries concentrated loads of 9 kN and 8 kN as shown in Fig Q9.

Calculate EACH of the following:

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

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

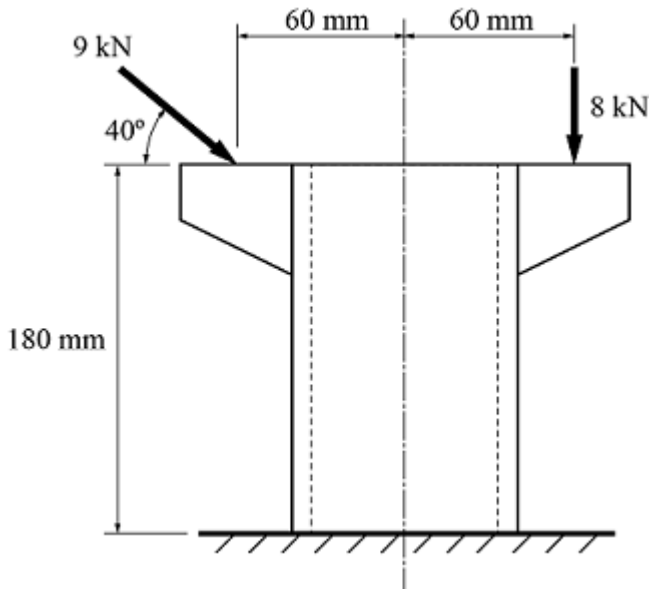

Fig Q9