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, 13 OCTOBER 2015

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 light cord passing over a light, smooth pulley has masses of 2 kg and 4 kg respectively attached to its ends. The pulley has a diameter of 300 mm. The 4 kg mass is held 3 m above ground level, with tension in the cord, and then released.

   Calculate EACH of the following:

   (a) the time taken for the 4 kg mass to reach ground level; (10)

   (b) the time the cord remains slack after the 4 kg mass reaches ground level if the 4 kg mass does not bounce. (6)

2. A winch motor drives a pinion with 320 teeth. Friction at the motor bearings is constant at 20 Nm. The pinion then meshes with a gear wheel having 640 teeth which drives a shaft of 120 mm diameter. This shaft is supported in bearings having a coefficient of friction of 0.12 and drives a winch drum of diameter 340 mm.

   Calculate EACH of the following:

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

   (b) the input power required by the motor when raising the mass of 2 tonnes at a steady speed of 0.3 m/s if the motor efficiency is 90%. (6)

3. An extending ladder has two sections, each of length 4 m and mass 20 kg. It stands on rough, horizontal ground and leans against a smooth wall at an angle of 30° to the wall. The coefficient of friction between the ladder and the ground is 0.2. A person of mass 80 kg is working half way (2 m) up the lower section.

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

(b) Calculate the minimum overlap of the two sections if the ladder is not to slide away from the wall. (12)

4. A freefall lifeboat is released from rest on an incline of 30° to the horizontal. The lifeboat takes 2.4 seconds to travel 10 m along the incline, at which point it starts to freefall under the effect of gravity alone.

Calculate EACH of the following:

(a) the acceleration of the lifeboat as it travels down the incline; (2)

(b) the velocity at which the lifeboat leaves the incline; (2)

(c) the horizontal distance the lifeboat will travel after leaving the incline when the vertical distance to the water at this point is 40 m; (7)

(d) the velocity and angle at which the lifeboat enters the water. (5)

5. A hammer of mass 1.5 kg moves vertically downwards with a velocity of 10 m/s to drive a steel pin of mass 40 gramme into a horizontal floor to a depth of 28 mm.

Calculate EACH of the following:

(a) the common velocity of the hammer and pin immediately after impact; (3)

(b) the percentage reduction of energy at impact; (6)

(c) the average resisting force offered by the floor. (7)

6. A cable consists of one steel wire 4 mm diameter and eight brass wires each 2 mm diameter. The stress in the brass wires is not to exceed 60 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. The stepped steel shaft shown in Fig Q7 is to transmit a torque. The larger diameter section of the shaft is to have a hole drilled in it to a depth of 100 mm.

Calculate EACH of the following:

(a) the diameter of the drilled hole '*d*' that would make the maximum stress in the hollow part of the shaft equal to the maximum stress in the 34 mm diameter section; (6)

(b) the length of the 34 mm section if the total angle of twist for the shaft is to be 0.02 rad when a torque of 400 Nm is applied. (10)

Note: *Modulus of Rigidity for shaft material = 80 GN/m^2*

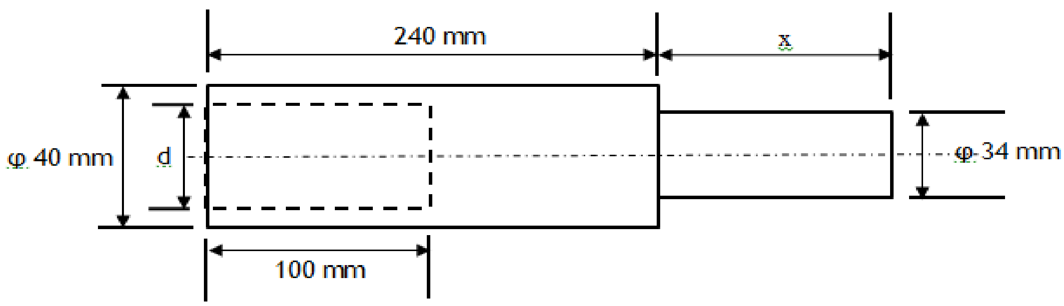

Fig Q7

8. A canal of width 7 m is sealed by a hinged lock gate as shown in Fig Q8. The fresh water is 4.2 m deep on one side of the gate and 1.5 m deep on the other side.

Calculate EACH of the following:

(a) the resultant hydrostatic force on the gate; (6)

(b) the reaction force R between the lock gate and the canal wall when closed; (4)

(c) the minimum force which could be applied to the lock gate to just open it. (6)

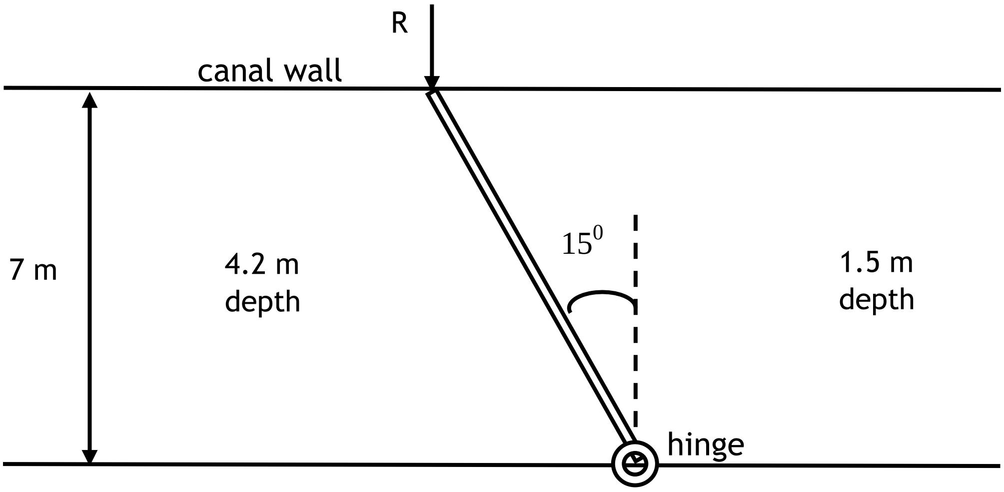

Fig Q8

9. A tank containing lubrication oil of density 850 kg/m^3 has two sharp edged outlet orifices on one side of the tank. The upper orifice is 15 mm diameter and has its centre 1.3 m below the oil surface. The lower orifice is 20 mm diameter and has its centre 2.8 m below the oil surface. Oil is supplied to the tank at 1.8 kg/s to maintain a constant oil level in the tank.

Calculate EACH of the following:

(a) the mass flow rate of oil from the 15 mm diameter orifice; (8)

(b) the coefficient of velocity for the 20 mm diameter orifice. (8)

Note: *For 15 mm diameter orifice,* *Coefficient of Velocity = 0.97*
Coefficient of Contraction = 0.68
For 20 mm diameter orifice, *Coefficient of Contraction = 0.72*