# 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, 27 MARCH 2012**

**1315 - 1615 hrs**

Examination paper inserts:

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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 shaft consists of a bronze sleeve 390 mm outside diameter shrunk onto a solid steel shaft of 340 mm diameter. The shaft is to transmit a power of 4.8 MW at a speed of 120 rev/min.

   Calculate EACH of the following:

   (a) the torque transmitted by the bronze sleeve; (12)

   (b) the percentage of the total power which is transmitted by the steel. (4)

   *Note: Modulus of Rigidity for Bronze = 40 GN/m$^2$*
   *Modulus of Rigidity for Steel = 80 GN/m$^2$.*

2. A hollow brass tube, 24 mm outside diameter and 12 mm inside diameter is 260 mm long and at a temperature of 18°C. It is then heated to 180°C and then rigidly secured at each end to prevent any contraction.

   Calculate EACH of the following:

   (a) the length of the tube immediately after heating; (3)

   (b) the temperature to which the tube must be cooled so that the stress in the brass is 55 MN/m$^2$; (8)

   (c) the strain energy in the bar at this lower temperature. (5)

   *Note: Modulus of Elasticity for Brass = 80 GN/m$^2$*
   *Coefficient of linear expansion of Brass = 16 x 10$^{-6}$ / $^o$C.*

3. An electric motor is running at 1500 rev/min when the power is shut off. The total frictional resistance to motion is equivalent to a torque of 6 Nm, and forty seconds later the speed of the motor has fallen to 800 rev/min.

   Calculate EACH of the following:

   (a) the moment of inertia (I) of the motor; (8)

   (b) the total time taken to come to rest; (4)

   (c) the total number of revolutions made after the power is shut off before coming to rest. (4)

4. A steel beam is 5 m long and has a symmetrical cross section shown in Fig Q4 and is simply supported at each end. The weight of the beam itself is 480 N per metre length and the maximum allowable bending stress for the beam is 110 $MN/m^2$.

Calculate EACH of the following:

(a) the maximum additional uniformly distributed load which can be carried; (13)

(b) the least radius of curvature when carrying the load in Q4(a). (3)

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

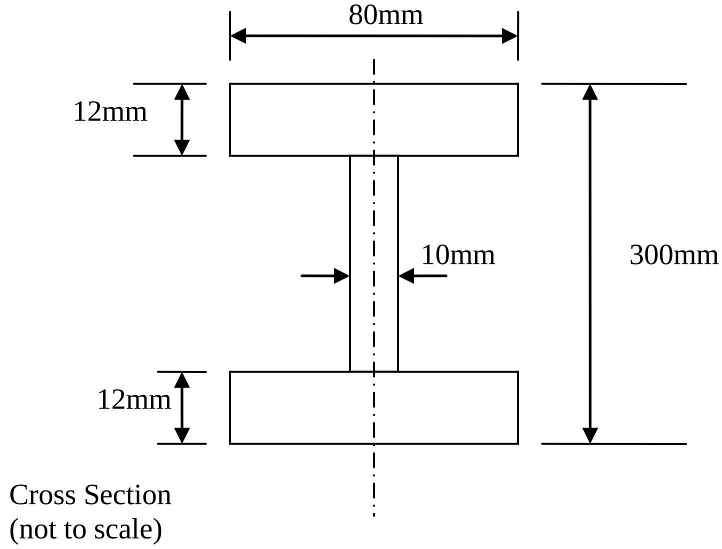


Fig Q4

5. A ship heading due South at 9 knots sights another ship dead ahead at a distance of 5 nautical miles. The second ship is heading in a direction 40° East of North at 20 knots.

Calculate EACH of the following:

(a) the relative velocity of the second ship to the first ship; (8)

(b) the distance of nearest approach of the two ships; (4)

(c) the time taken to reach the point of nearest approach. (4)

6. In a four-ram hydraulic steering gear the centre line of the rams is 1.2 m from the centreline of the rudder stock. The diameter of the rams is 280 mm and the diameter of the rudder stock is 420 mm.

Movement of the rudder is limited to 35° on either side and the maximum allowable shear stress in the rudder stock is 70 $MN/m^2$.

Calculate EACH of the following:

(a) the maximum allowable torque on the rudder stock; (6)

(b) the pressure to which the relief valves on the rams should be set. (10)

7. A pressurised spherical tank 12 m diameter is partly filled with liquefied gas. The pressure at the bottom of the tank is 820 $kN/m^2$ (gauge) whilst that in the gas space at the top of the tank is 780 $kN/m^2$ (gauge).

Calculate EACH of the following:

(a) the depth of liquid in the tank; (7)

(b) the weight of liquid in the tank. (9)

*Note:*

*Where r = radius of the sphere*
*h = depth of the segment*

*Relative density of liquefied gas = 0.52*

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8. Two bodies A and B are connected by a light cord over a frictionless pulley as shown in Fig Q8. The mass of A is 100 kg, its weight acts at its geometric centre and it stands on a rough inclined plane. Mass B is gradually increased until mass A overturns.

Calculate EACH of the following:

(a) the mass of B that will just cause A to overturn; (8)

(b) the minimum value of the coefficient of friction between the plane and body A to prevent sliding when A is about to overturn. (8)

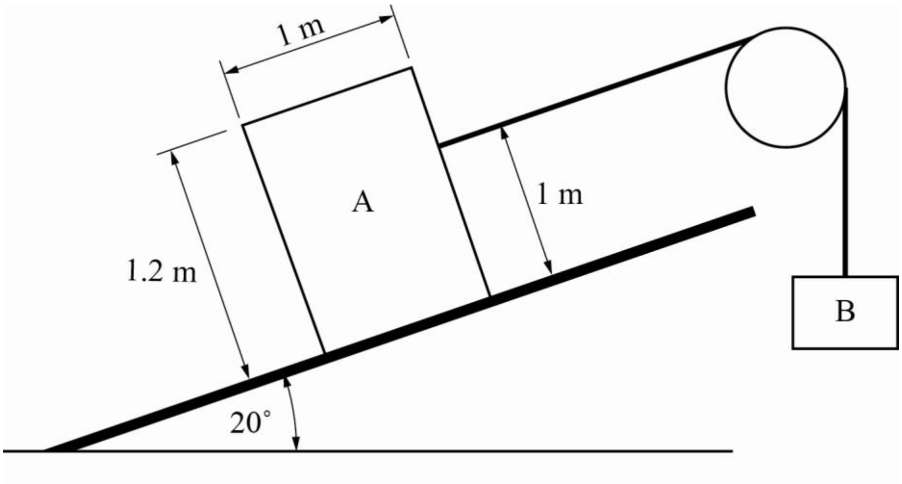


Fig Q8

9. A fire-fighting launch discharges three identical jets of sea water through 40 mm diameter nozzles, each jet being inclined upwards at 40° to the horizontal. The discharge velocity of the water is 42 m/s and the velocity at the suction side can be ignored.

Calculate EACH of the following:

(a) the vertical force created by the jets; (10)

(b) the increase in the immersed volume of the launch due to the operation of the jets. (6)

*Note: Density of Sea Water = 1025 kg/m*$^3$