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 OCTOBER 2010

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 plate friction clutch with both sides effective is to be used to transmit 7kW at 720 rev/min. The outer diameter of the clutch plate is 600mm and the inner diameter is 180mm. The effective coefficient of friction is 0.4. The axial load for the clutch is provided by four springs each of stiffness 3kN/m.

   Calculate EACH of the following:

   (a) the spring compression required when the clutch is new; (8)

   (b) the percentage reduction in the maximum power which can be transmitted if 3mm of plate wear occurs. (8)

   Note: *For constant pressure* $$T = \frac{2\mu n W\left(r_1^3 - r_2^3\right)}{3\left(r_1^2 - r_2^2\right)}$$

   For constant wear $$T = \frac{\mu n W\left(r_1 + r_2\right)}{2}$$

   where n = No. of surfaces in contact.

2. A short column of solid circular section is to carry an axial compressive load.

   (a) Determine, as a ratio of the diameter of the column, the greatest distance from the centre line of the column that the line of action of the load can have without any part of the column being in tension. (8)

   (b) A 200mm diameter short solid column carries an axial compressive load of 400kN placed at half the maximum eccentricity determined above.

   Calculate the greatest compressive stress in the column. (8)

3. A uniform 5m long ramp has a mass of 1.2 tonne and is suspended at 15° to the horizontal by two 15mm diameter cables as shown in Fig Q3. The cables are attached 1.5m away from the free end of the ramp and are at an angle of 50° above the ramp. One end of the ramp is hinged using two pins each of 30mm diameter and each in double shear.

Calculate EACH of the following:

(a) the tensile stress in each cable when supporting the ramp; (8)

(b) the shear stress in each of the hinge pins. (8)

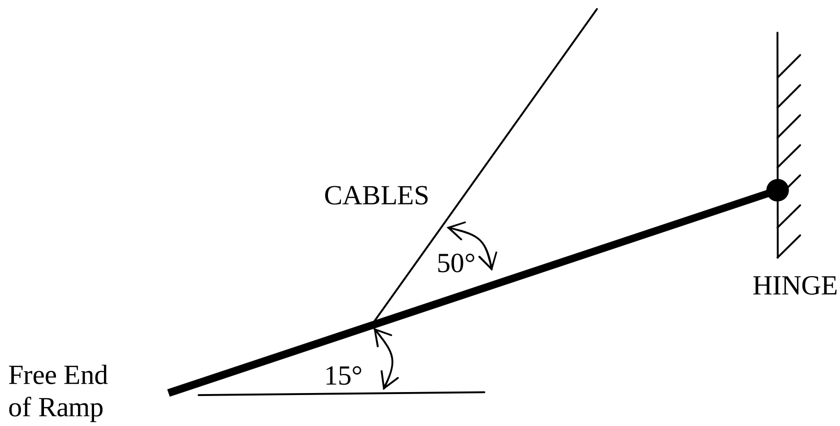

Fig Q3

4. A compound bar consists of a round copper bar of 28mm diameter tightly encased in a steel tube 40mm diameter and of the same length.

A tensile load of 100kN is applied.

Calculate EACH of the following:

(a) the stress in the copper bar; (8)

(b) the stress in the steel. (8)

Note: *For steel, Modulus of Elasticity* $= 210\ GN/m^2$
For copper, Modulus of Elasticity $= 90\ GN/m^2$

5. A ball is suspended by a fine wire 0.8m long from a point 2m above ground level. The ball is rotated at a constant speed about a vertical axis forming a conical pendulum and the wire assumes an angle of 30° to the vertical.

Calculate EACH of the following:

(a) the angular velocity of the ball; (6)

(b) the horizontal distance that the ball will travel before hitting the ground if the wire suddenly breaks. (10)

6. A symmetrical I-shaped beam is shown in Fig Q6. The beam is simply supported at both ends and carries a uniformly distributed load of 30kN per metre length and a single concentrated load of 6kN at mid-span.

Calculate the maximum permissible length of the beam if the bending stress in the beam is not to exceed $140MN/m^2$. (16)

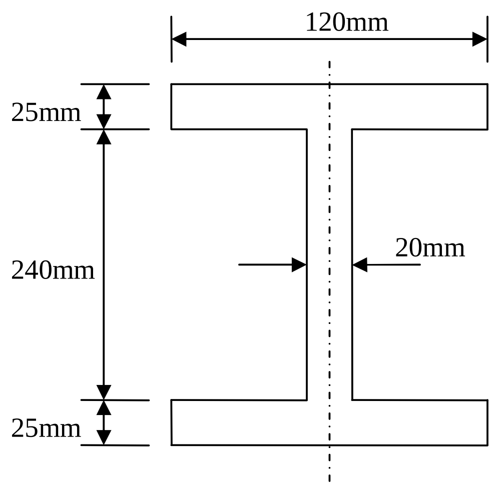

Fig Q6

7. A vessel is to be re-engined and the shafting changed so that a 20 percent higher maximum power is transmitted at a 10 percent reduction in maximum speed.

The original shaft was made of steel of UTS $500 MN/m^2$ and was solid with a diameter of 450mm. The replacement shaft is to have the same outside diameter as the original but be made of steel of UTS $800 MN/m^2$ and be hollow. The original safety coefficient (factor of safety) of eight is to be maintained for the replacement shaft.

Calculate EACH of the following:

(a) the maximum torque that the original shaft can transmit; (8)

(b) the maximum permissible internal diameter of the replacement shaft. (8)

8. A centrifugal pump has an impeller with an inlet diameter of 120mm and an outlet diameter of 320mm. The impeller rotates at 720 rev/min and has a flow rate of 300 tonnes of sea water per hour. Water flow at entry is radial and the radial velocity through the impeller can be assumed constant at 3m/s. The impeller vane exit angle is 35°.

Calculate EACH of the following:

(a) the impeller vane inlet angle for shockless flow; (5)

(b) the width of the impeller at inlet and exit; (5)

(c) the absolute velocity of the water at exit. (6)

Note: Density of Seawater = 1025 kg/m^3.

9. A concrete reservoir dam, 12m long and 24m high is shown in Fig Q9. When the dam is full of fresh water, the water level is 3m below the top of the dam as shown.

Calculate EACH of the following:

(a) the weight of the concrete; (2)

(b) the magnitude and direction of the resultant thrust on the base of the dam when the reservoir is full; (7)

(c) the distance, measured from the front wall of the base of the dam, at which the line of action of the resultant force acts when the reservoir is full. (7)

Note: Relative Density of concrete = 2.4

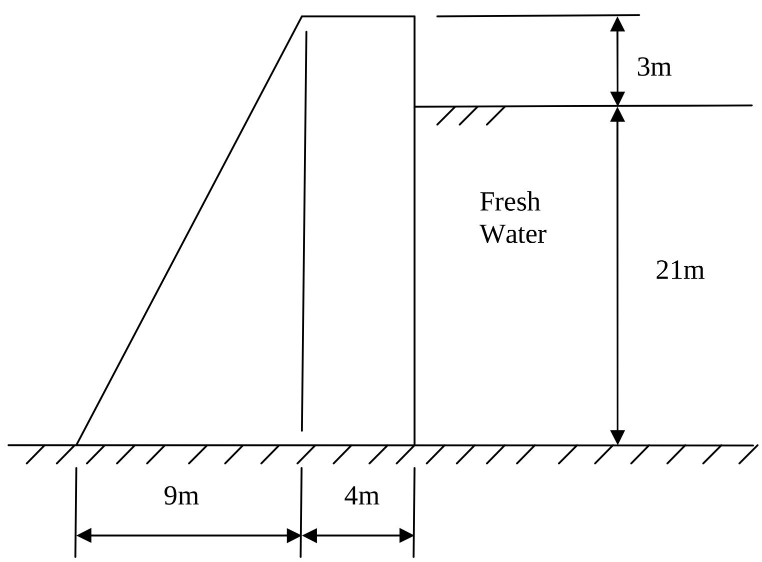

Fig Q9