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 78 as amended CHIEF ENGINEER REG. III/2 (UNLIMITED)

041-31 – APPLIED MECHANICS

TUESDAY, 12 JULY 2016

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 cam follower of mass 4 kg moves with simple harmonic motion. It is lifted upwards 60 mm and has a periodic time of 0.2 seconds.

   Calculate EACH of the following:

   (a) the velocity of the follower when 8 mm from the end of its upward travel; (5)

   (b) the maximum force between the follower and the cam; (3)

   (c) the time taken for the follower to move from a point 15 mm before mid-travel to the end of its travel. (8)

2. A centrifugal shoe clutch is shown in Fig Q2 and has four shoes retained by springs. The shoes first contact the output drum at 480 rev/min, at which point the centre of gravity of EACH shoe is at a radius of 125 mm from the shaft axis. The internal radius of the output drum 160 mm. When the drive shaft speed is increased to 840 rev/min, the power transmitted to the output shaft is 26 kW.

   Calculate the mass of EACH shoe if the coefficient of friction between the shoes and the output drum is 0.4. (16)

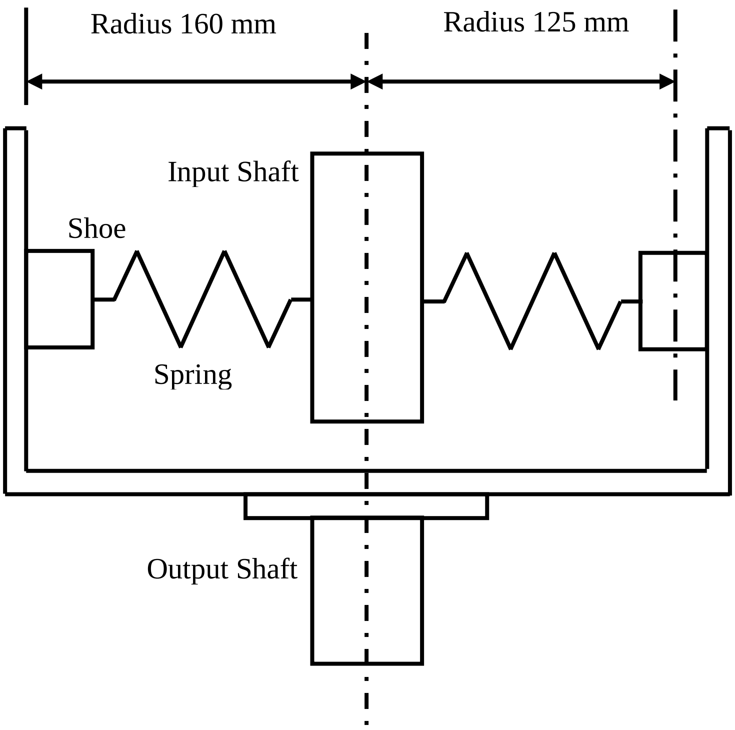

Fig Q2

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3. A ball is suspended by a fine, light wire 1 m long and when hanging vertically the point of suspension is 1.8 m above ground level. The ball is then rotated at a constant speed about a vertical axis forming a conical pendulum and the wire assumes an angle of 30^0 to the vertical.

Calculate EACH of the following:

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

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

4. A uniform 5 m long ramp has a mass of 1.2 tonne and is suspended at 15^0 to the horizontal by two 15 mm diameter cables as shown in Fig Q4. The cables are attached 1.5 m away from the free end of the ramp and are at angle of 50^0 above the ramp. The other end of the ramp is hinged using two pins EACH of 30 mm diameter and EACH is 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)

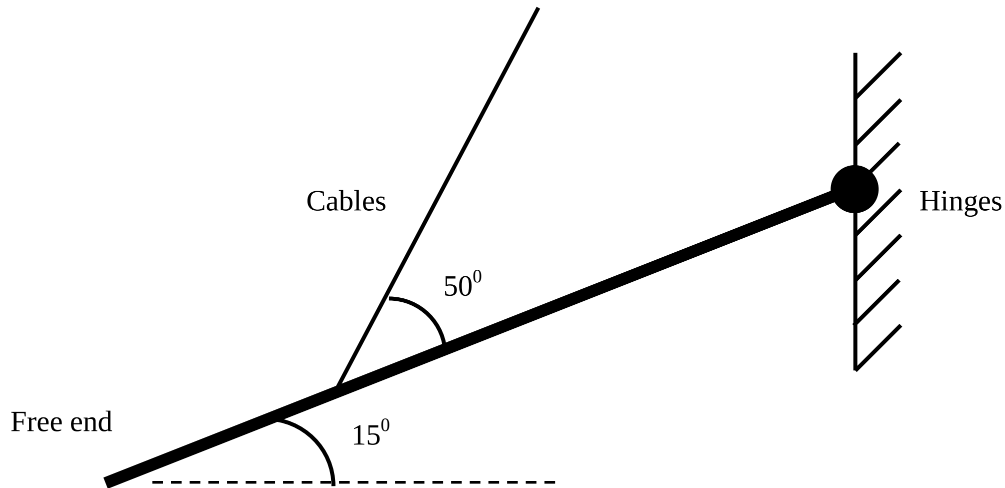

Fig Q4

5. A cast iron cylinder cover is secured by 12 steel bolts EACH of diameter 20 mm. The effective cross sectional area of the cover is 0.16 m^2. On assembly the bolts are tightened up so that the tensile stress in each bolt is 18 MN/m^2. The resulting stress in the cylinder cover is evenly distributed across its effective area.

Calculate EACH of the following:

(a) the initial stress in the cylinder cover; (6)

(b) the temperature rise at which the stress in the bolts and cover will become zero. (10)

Note: *For Cast Iron, Modulus of Elasticity* = *100 GN/m^2*
For Steel, Modulus of Elasticity = *200 GN/m^2*
For Cast Iron, Coefficient of Linear Expansion = *11 x 10^{-6} per ^0C*
For Steel, Coefficient of Linear Expansion = *12 x 10^{-6} per ^0C*

6. The cross section of 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 30 kN/m and a single concentrated load of 6 kN at mid-span.

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

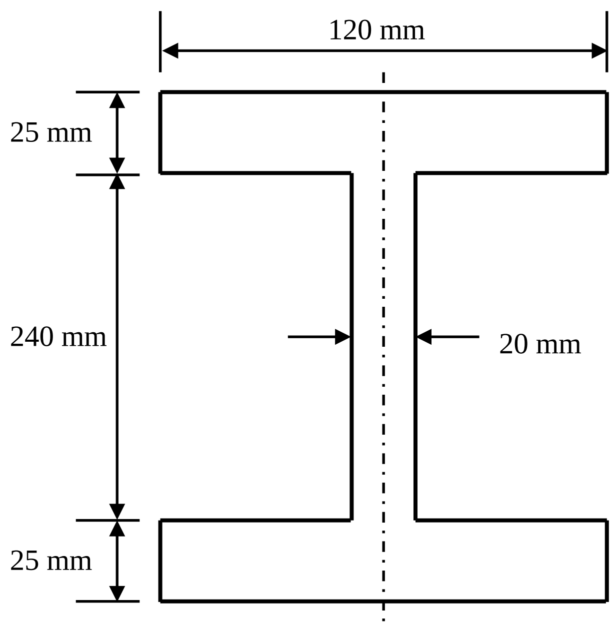

Fig Q6

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7. A container of mass 2 tonnes is being lowered onto the deck of a ship. It is supported by 4 steel wires each of 12 mm diameter. The container is being lowered at a constant speed of 0.2 m/s. When the length of the wires is 30 m the brake is suddenly applied.

Calculate EACH of the following:

(a) the static stress in EACH wire when supporting the weight of the container; (2)

(b) the additional stress imposed on the wires due to the sudden stop; (10)

(c) the maximum extension of the wires due to the sudden stop. (4)

Note: Modulus of Elasticity for steel = 200 GN/m^2

8. A conical buoy with a base diameter of 2.8 m and a vertical height of 3 m is placed in sea water with its apex downwards. The buoy floats at a draught of 1.6 m. When an anchor is suspended from the buoy, the draught increases to 2.4 m.

Calculate the tension in the chain which suspends the anchor from the buoy. (16)

Note: Density of sea water = 1025 kg/m^3
Volume of a cone = $\frac{1}{3}\pi r^2 h$

9. A centrifugal pump has an impeller with an inlet diameter of 240 mm and an outlet diameter of 600 mm. The impeller rotates at 600 rev/min and has a flow rate of 550 tonnes of fresh water per hour. Water flow at entry is radial and the radial velocity through the impeller is constant. The impeller width at entry is 55 mm and the vane exit angle is 40^0.

Calculate EACH of the following:

(a) the width of the impeller at the outlet; (3)

(b) the whirl velocity at outlet; (5)

(c) the angle of the outlet diffuser vanes for shockless entry to the diffuser; (2)

(d) the theoretical pump head; (3)

(e) the theoretical pump power. (3)