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, 8 APRIL 2014

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 shell is fired with a velocity of 420 m/sec at 40° above the horizontal from a point at the foot of a slope inclined at 12° above the horizontal.

   Calculate the range of the shell, as measured along the slope. (16)

2. A four stroke single cylinder engine produces 120 kW at 720 rev/min. The fluctuation of energy is 18% of the work done per cycle.

   In order to stabilise the speed for electrical generation purposes a 0.2 m thick flywheel is to be fitted. The frequency must not fluctuate more than +/- 0.2 Hz from the standard 60 Hz.

   Calculate the diameter of the solid flywheel. (16)

   Note: Density of flywheel material = 7800 kg/m^3

3. The piston of a reciprocating engine has a mass of 800 kg. The engine has a stroke of 2.4 m and a bore of 950 mm. At an engine speed of 90 rev/min the cylinder pressure just after TDC is 110 bar. The piston rod has a diameter of 340 mm. The piston may be assumed to move with simple harmonic motion.

   Calculate EACH of the following:

   (a) the velocity of the piston when 0.8 m from TDC; (3)

   (b) the maximum acceleration of the piston; (3)

   (c) the nature and magnitude of the stress in the piston rod just after TDC. (10)

4. A load of 3 tonne resting on tapered block A is to be raised using two identical wedges B and C as shown in Fig Q4.

The coefficient of friction between the wedges and block A is 0.3 and between the wedges and the ground is 0.4. The load on each wedge can be assumed to remain equal.

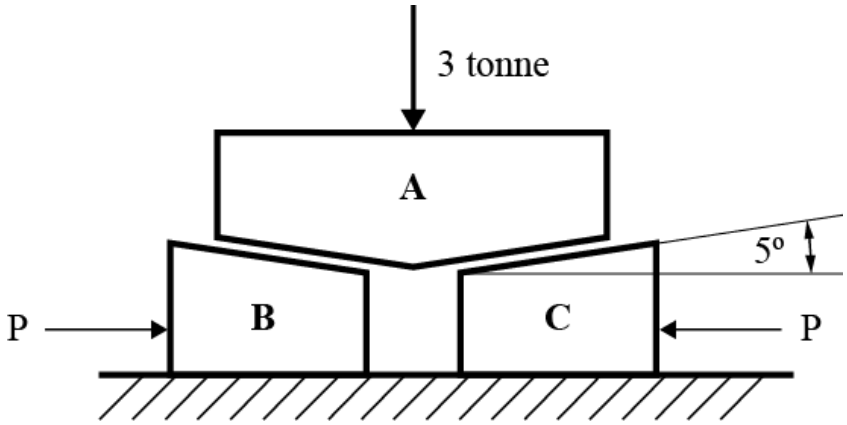

Fig Q4

Calculate the horizontal force 'P' required at each wedge (16)

5. A propeller shaft is designed to be solid with a diameter of 280 mm. It is then decided to replace this shaft with a hollow shaft of 350 mm outside diameter of the same material and length. Neither the maximum shear stress nor the angular twist per unit length of the original shaft is to be exceeded.

Calculate EACH of the following:

(a) the maximum permissible inside diameter of the hollow shaft; (12)

(b) the percentage reduction in weight. (4)

6. A horizontal cantilever beam is 2.8 m long. It carries a concentrated load of 2400 N at its free end and a uniformly distributed load of 360 N/m over its entire length. The beam has a hollow rectangular cross-section with outside dimensions of 100 mm wide by 150 mm deep and a constant thickness of 14 mm.

Calculate EACH of the following:

(a) the maximum bending stress in the beam; (10)

(b) the total deflection at the free end of the beam. (6)

Note: $\delta = \frac{WL^3}{3EI}$ *for a concentrated load where W = concentrated load (N)*

$\delta = \frac{wL^4}{8EI}$ *for a distributed load where w = distributed load (N/m)*

Modulus of Elasticity for beam material = 210 GN/m^2

7. A steel bar is 0.9 m long and 50 mm diameter. An axial hole 30 mm diameter is to be drilled from one end to such a depth that the extension of the drilled part is twice the extension of the solid part when an axial tensile load is applied.

Calculate EACH of the following:

(a) the required depth of the drilled hole; (8)

(b) the strain energy in the bar when an axial tensile load of 24 kN is applied. (8)

Note: Modulus of Elasticity for steel is 210 GN/m^2.

8. A tank, 4 m wide and 3 m deep is filled with fresh water. A pressure test is applied by filling the air vent pipe to give an additional head of 750 mm of water. A 380 mm diameter circular access door is fitted with its centre 600 mm from the tank floor. The access door is hinged at its top edge and secured by a single bolt at its lowest edge.

Calculate EACH of the following:

(a) the hydrostatic force on the access door; (3)

(b) the tension on the bolt; (6)

(c) the maximum permissible depth of water in the tank if the bolt tension is limited to 1.2 kN. (7)

9. A pump is required to draw fresh water from a depth of 4 m at the rate of 2.8 m^3/minute. The pressure in the pump suction line is not to fall below 24 kN/m^2. Barometric pressure may be taken as 750 mm mercury.

Calculate the required minimum diameter of the suction pipe. (16)

Note: The relative density of mercury is 13.6