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, 13 DECEMBER 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 person is working on a ladder inclined at 30° to a smooth vertical wall. The ladder is of uniform cross section and has a mass of 20 kg. The person has a mass of 80 kg and is working two thirds of the way up the ladder, which stands on rough horizontal ground.

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

   (b) Calculate the minimum coefficient of friction between the ground and the ladder if the ladder is not to slip. (8)

   (c) If the minimum coefficient of friction calculated in Q1(b) is reduced by 20%, calculate the magnitude of an additional mass which could be placed on the ground at the foot of the ladder to just prevent slipping. Assume the coefficient of friction for the mass is the same as for the ladder. (4)

2. Ship X is travelling at 7 knots in a direction 30° North of West when it sights ship Y dead ahead at a distance of 4 nautical miles, travelling on a true course due East at 12 knots.

   Determine EACH of the following:

   (a) the velocity of ship Y relative to ship X, in both magnitude and direction; (6)

   (b) the nearest distance of approach of the two ships to each other; (6)

   (c) the time taken for the ships to lose sight of each other, after the time of nearest approach, if the limit of visibility remains at 4 nautical miles. (4)

3. A turbine rotor has 60 equally spaced blades and rotates at 12000 rev/min. Due to damage, material is lost from 3 consecutive blades as follows:

   4 grams is lost from the first blade at an effective radius of 102 mm
   3 grams is lost from the next blade at an effective radius of 103 mm
   2 grams is lost from the third blade at an effective radius of 104 mm

   Calculate the magnitude and position of the resultant out of balance force on the rotor. (16)

4. A Porter governor has arms of equal length, 3 flyweights each of mass 4 kg and a central mass of 21 kg. Friction at the sleeve is constant at 24 N.

   Calculate the maximum and minimum speeds for a governor height of 110 mm. (16)

5. A symmetrical I-shaped beam has a flange width of 100 mm and flange thickness of 20 mm. The overall height is 300 mm and the web thickness is 18 mm. The beam is simply supported at both ends and carries a uniformly distributed load of 20 kN/m along its whole length. There is also a single concentrated load of 8 kN at mid-span.

   Calculate EACH of the following:

   (a) the support reactions in terms of the length L of the beam; (2)

   (b) the maximum bending moment in the beam in terms of the length L of the beam; (6)

   (c) the maximum permissible length L of the beam if the bending stress in the beam is not to exceed 120 MN/m^2. (8)

6. A hollow steel propeller shaft is 7 m long with an outside diameter of 450 mm and is to transmit a maximum torque of 1700 kNm. The torsional shear stress in the shaft is not to exceed 100 MN/m^2. At full power the propeller efficiency is 80%, the shaft speed is 90 rev/min and the speed of the ship is 16 knots.

   Calculate EACH of the following:

   (a) the maximum permissible inside diameter of the shaft; (6)

   (b) the angle of twist, in degrees, in the shaft when transmitting maximum torque; (4)

   (c) the force resisting the motion of the ship at full power. (6)

   Note: *Modulus of Rigidity for steel* = *80* GN/m^2
   One nautical mile = *1852 m*

7. A welded pressure vessel of circular cross section has an oblique welded seam at an angle of 30° to the circumferential joint. The internal diameter of the pressure vessel is 1.8 m, the shell plate thickness is 30 mm and the working pressure is 28 bar.

Calculate EACH of the following:

(a) the tensile stress normal to the circumferential seam; (3)

(b) the tensile stress normal to the oblique seam; (7)

(c) the percentage increase in the stress normal to the oblique seam if corrosion on the outside of the vessel leads to a 10% reduction in shell thickness at the seam. (6)

8. A pump delivers oil of density 980 kg/m^3 at the rate of 40 tonne/hour through a discharge pipe of 150 mm bore. The outlet of this pipe is 10 m higher than the inlet. The pipe is 1000 m long with a friction factor coefficient of 0.006.

Calculate EACH of the following:

(a) the friction head loss in the pipe; (6)

(b) the minimum gauge pressure required at the inlet to the pipe to ensure that the gauge pressure at the outlet is not less than 60 kN/m^2. (10)

9. A circular life-buoy has a cross sectional area of 120 cm^2 and floats in sea water. It is being tested and with a 12 kg steel mass attached to the lower side of the buoy, one quarter of the volume of the buoy remains above the surface.

Calculate EACH of the following:

(a) the mean diameter of the buoy; (12)

(b) the time taken for the mass to reach the sea bed if the steel mass becomes detached and falls to the sea bed 8 m below. (4)

Note: *Density of sea water* = *1025* kg/m^3
Density of buoy = *240* kg/m^3
Density of steel = *7840* kg/m^3