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, 24 MARCH 2015

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 2 m long uniform ladder of mass 15 kg rests against a smooth vertical wall. The ladder stands on an inclined plane, which rises at 10° away from the wall.

   (a) Sketch the ladder arrangement showing all forces acting. (4)

   (b) Calculate the largest angle possible between the ladder and the wall for the ladder to be stable and not slide away from the wall. (12)

   Note: Coefficient of friction between the ladder and the inclined plane is 0.24

2. An engine room lift cage has a mass of 1 tonne. The hoist wire is wound around a motor driven drum, with the lift cage on one end and a balance mass of 0.8 tonne suspended from the other end. The drum is 1.4 m diameter with a mass of 250 kg and radius of gyration of 450 mm.

   The maximum tension in the hoist wire is not to exceed 12 kN.

   Calculate EACH of the following:

   (a) the maximum allowable acceleration of the lift cage when being raised; (3)

   (b) the driving torque required at the drum to achieve the acceleration found in part Q2(a); (8)

   (c) the motor output power when the lift is moving upwards with a constant velocity of 3 m/s. (5)

3. A Hartnell governor has two rotating flyweights each of mass 0.8 kg. The pivot arms are vertical and the flyweights are at an orbital radius of 100 mm at a mean speed of 720 rev/min.

The length of the flyweight arms is 120 mm and the length of the sleeve arms is 80 mm. The spring stiffness is 30 kN/m and friction in the governor is equivalent to a force of 12 N at the sleeve if the governor speed increases or decreases.

Calculate EACH of the following:

(a) the spring force when the governor is running at its mean speed, assuming friction is not present; (6)

(b) the vertical movement of the sleeve for a speed decrease of 20 rev/min, including the effect of friction. (10)

4. A single acting vertical bilge pump operates at 40 rev/min against a constant discharge pressure of 2.8 bar. The pump delivers 10 m^3/hour of fresh water for the single 120 mm diameter piston. The combined mass of the piston and entrapped water is 18 kg and the piston can be assumed to move with simple harmonic motion.

The piston is moving upwards and is 80 mm away from the top of the stroke.

Calculate EACH of the following:

(a) the force required to move the piston; (12)

(b) the input power to the pump motor at the given instant if the motor efficiency is 80%. (4)

5. A piece of steel is tested in compression and when the compressive yield stress is applied to a test specimen of 100 mm length, the compression is measured to be 0.16 mm.

A strut is to be made from the same type of steel and it is to be a solid, square section column of 450 mm^2 cross-section and 2 m long. It will be fixed at both ends.

Calculate EACH of the following:

(a) the Modulus of Elasticity for the steel being used; (4)

(b) the critical load for the strut using Euler's equation; (8)

(c) the ratio of compressive yield stress to critical stress for the strut. (4)

Note: Compressive Yield Stress for the steel = 320 MN/m^2

For a fixed end strut, $F_C = \frac{4\pi^2 EI}{L^2}$

6. An intermediate propeller shaft is fitted to an engine of power output 16 MW running at 110 rev/min. The shaft is solid with a coupling flange at each end. Each flange has 12 bolts on a pitch circle diameter of 1.5 times the shaft diameter. The limiting shear stress is 180 MN/m^2 for the shaft material and 160 MN/m^2 for the bolt material.

Calculate EACH of the following:

(a) the diameter of the shaft for a safety coefficient (factor of safety) of 2; (8)

(b) the diameter of the bolts for a safety coefficient (factor of safety) of 2. (8)

7. A steel bar is 1.1 m long and 60 mm diameter. An axial hole 38 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 force 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 20 kN is applied. (8)

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

8. Two oil tanks are separated by a vertical bulkhead fitted with a circular inspection door, 800 mm diameter. The door is hinged at its top edge, which is 2.8 m above the bottom of the tank. Both tanks contain oil of density 900 kg/m^3, in one tank to a depth of 2.8 m and in the other to a depth of 3.1 m.

Calculate EACH of the following:

(a) the hydrostatic forces produced by the oil on each side of the door; (6)

(b) the horizontal force required at the bottom edge of the door to open it against the resultant hydrostatic force. (10)

9. A pump delivers fresh water at the rate of 32 tonne/hour. The delivery pipe is 90 mm bore. Suction is from a tank which is 0.9 m below the pump and delivery is to a tank which is 19.5 m above the pump. The discharge pipe has a total length of 25 m and a friction factor coefficient of 0.01 for use in D'Arcy's equation. Friction losses and velocity in the suction pipe can be neglected.

Calculate EACH of the following:

(a) the total manometric head in the system; (12)

(b) the input power of the pump required if its efficiency is 75%. (4)