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 14 JULY 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. The pulley system shown in Fig Q1 has a mass of 40 kg and radius of gyration of 0.4 m. Friction in the pulley bearings is constant at 20 Nm.

   Calculate EACH of the following:

   (a) the angular acceleration of the pulley when released from rest; (10)

   (b) the tension in each rope during the acceleration. (6)

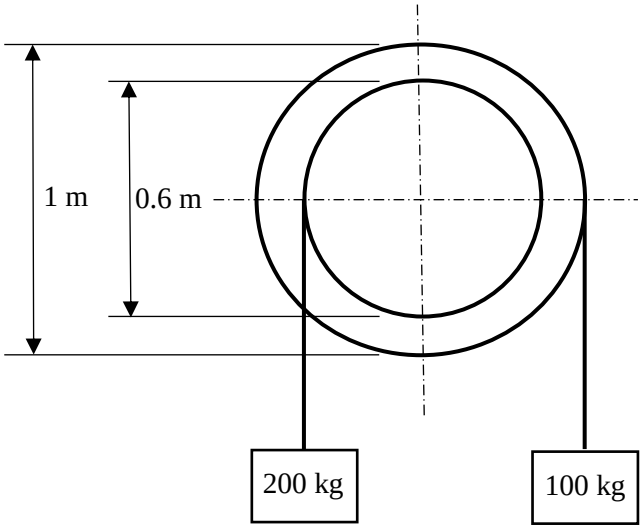

Fig Q1

2. For one cylinder of a vertical diesel engine, the mass of the piston and other reciprocating parts is 40 kg. The engine stroke is 400 mm and the engine speed is 480 rev/min. The motion of the piston may be assumed to be simple harmonic.

   Calculate EACH of the following:

   (a) the maximum velocity of the piston; (4)

   (b) the velocity of the piston when it is 50 mm from top dead centre and travelling downwards; (5)

   (c) the piston rod force, in both magnitude and direction, acting on the piston at the position given in part (b) if the gas force above the piston is 25 kN at this instant. Assume the piston rod is vertical. (7)

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3. A ship's fire hose is being tested and the elevation of the hose is 45°. The jet of water is fired over the side of the ship at a speed of 20 m/s as shown in Fig Q3. The horizontal range of the water jet is 65 m.

Calculate EACH of the following:

(a) the maximum height above the deck of the ship that the jet of water achieves; (4)

(b) the total time of flight; (2)

(c) the height of the deck above sea level. (10)

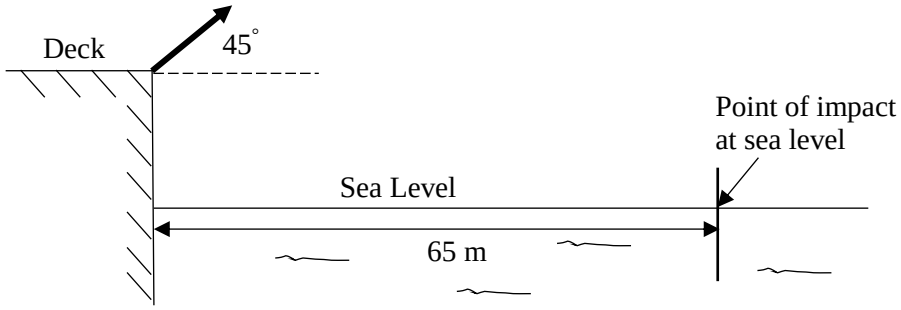

Fig Q3

4. A pile driver has a mass of 600 kg and drops 5 m vertically onto a pile with a mass of 2000 kg. The pile is driven 110 mm into the ground before coming to rest.

Calculate EACH of the following:

(a) the common velocity of the pile driver and pile immediately after impact assuming no rebound; (4)

(b) the average resisting force of the ground on the pile; (8)

(c) the reduction of kinetic energy during the impact. (4)

5. A load of 2.1 kN is suspended from three identical vertical wires each of 10 mm diameter. One of the wires has a sudden failure causing the other two wires to carry the full load equally between them.

Calculate EACH of the following:

(a) the initial stress in EACH of the three wires before the sudden failure assuming each wire carries an equal share of the load; (3)

(b) the maximum sudden increase in stress in the remaining two wires caused by the sudden failure; (5)

(c) the maximum instantaneous stress produced in each of the two remaining wires; (5)

(d) the final stress in each of the two remaining wires after the load has come to rest. (3)

6. An engine bedplate is secured by steel holding down bolts 20 mm diameter and 180 mm long. Each bolt is tightened onto a steel sleeve of 25 mm inside diameter, 50 mm outside diameter and 100 mm long. After tightening the tensile force in the bolt is 4 kN.

Calculate EACH of the following:

(a) the stress in each bolt; (2)

(b) the strain energy stored in the bolt material; (5)

(c) the stress in the sleeve; (4)

(d) the change in length of the sleeve. (5)

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

7. A horizontal cantilever beam is 3 m long. It carries a concentrated load of 2000 N at its free end and a uniformly distributed load of 350 N/m along 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 15 mm.

Calculate EACH of the following:

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

(b) the total deflection of the beam at its free end caused by the loading. (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 the beam material = 210 GN/m²

8. A cylindrical buoy of length 2 m and mass 600 kg floats vertically upright whilst partly immersed in two non-mixing liquids (immiscible). The upper liquid is oil of depth 0.6 m, whilst the lower liquid is fresh water.

The buoy has a diameter of 1 m and is ballasted by a 250 kg steel mass attached below it.

Calculate EACH of the following:

(a) the initial total immersed depth of the buoy; (7)

(b) the total immersed depth if the steel mass becomes detached, assuming the buoy remains upright; (4)

(c) the time taken for the steel mass to fall a depth of 200 m in the fresh water. (5)

Note: Density of oil = 880 kg/m³
Density of steel = 7800 kg/m³

9. Sea water flows through a hosepipe of 50 mm diameter and discharges to atmosphere through a nozzle of outlet diameter 12.5 mm. The nozzle is horizontal and is 1 m above ground level. The discharge rate is 40 tonne/hour.

Calculate EACH of the following:

(a) the magnitude and direction of the reaction force at the nozzle; (10)

(b) the horizontal range of the jet of water before it strikes the ground. (6)

Note: Density of sea water = 1025 kg/m^3