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 MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-31 - APPLIED MECHANICS

TUESDAY, 16 OCTOBER 2018

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 examination centres:

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. In a set of sheer legs both front legs are 8 metres long and are fixed 5 metres apart on a horizontal base. The back stay of this concurrent non-coplanar force system is 15 metres long and is fixed on the same base at 8 metres measured linearly from the centre of the front legs shown in Fig Q1. The mass suspended by the system is 25 tonnes.

   (a) Determine the magnitude and nature of the force in EACH of the following;

      (i) the back stay; (8)

      (ii) each front leg; (6)

   (b) Define the term *concurrent non-coplanar force system.* (2)

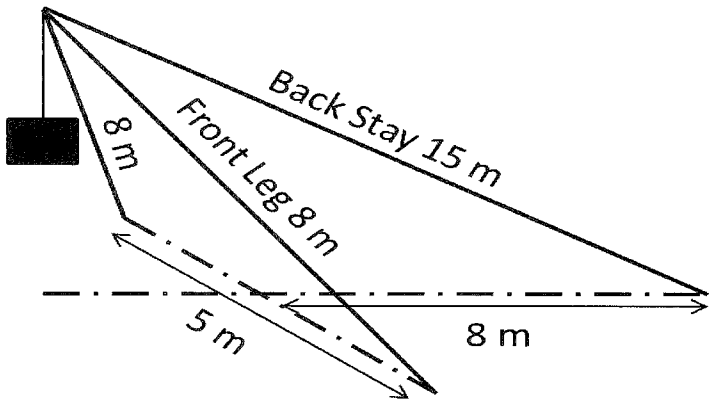

Fig Q1

2. A body of mass 100 kg is to be pulled along a horizontal plane, where the coefficient of friction between the contact surfaces has a constant value of 0.4.

   If a force is applied to the body at an angle of 45° above the horizontal plane:

   (a) sketch the force diagram indicating the interacting forces and the relevant angles; (4)

   (b) calculate EACH of the following:

      (i) the magnitude of the force that will slide the body at constant speed; (6)

      (ii) the magnitude and direction of the minimum force that will move the body. (6)

3. An engine crankshaft rotates at a constant speed of 1800 rpm driving a crank of radius 80 mm and a connecting rod 280 mm in length.

If the crank is rotating clockwise and is at a point 45° beyond top dead centre, determine EACH of the following:

(a) the instantaneous velocity of the piston; (8)

(b) the instantaneous velocity of a fixed point on the centre line of the connecting rod that is 100 mm from the centre of the crank pin; (4)

(c) the angular velocity of the connecting rod. (4)

4. A single-start worm rotates a 50-tooth worm-wheel in a simple lifting machine. The system is driven by an effort wheel that is 250 mm in diameter.

(a) If the effort required lifting a mass of 700 kg is 125 N with an overall efficiency of 35%, calculate EACH of the following;

(i) the mechanical advantage of the lifting machine; (2)

(ii) the velocity ratio of the lifting machine; (2)

(iii) the diameter of the load wheel; (4)

(iv) the time taken to raise the load 1.5 m if the effort wheel rotates at a constant speed of 50 rpm; (4)

(b) Sketch the arrangement. (4)

5. A piston reciprocates with simple harmonic motion when driven by an engine with a constant speed of 120 rpm. When the piston is 0.75 m from mid-stroke position it has an instantaneous velocity equivalent to 0.6 of its maximum velocity.

Calculate EACH of the following:

(a) the stroke of the engine; (8)

(b) the velocity of the piston when it is 0.7 m from top dead centre; (4)

(c) the maximum acceleration of the piston. (4)

6. A loaded truck of mass 5 tonnes is travelling on rails at 7 m/s and collides with an unloaded truck of mass 2 tonnes travelling at 3 m/s in the same direction. After collision the trucks move as a single body:

(a) Define the terms *elastic* and *inelastic collisions*; (2)

(b) Calculate EACH of the following:

(i) the velocity of the combined mass; (6)

(ii) the change in kinetic energy; (4)

(iii) the distance travelled by the trucks after the collision against a constant resistive force of 1400 N. (4)

7. A solid rectangular beam carries a uniformly distributed load of 10 kN/m over its entire span of 6 m which is simply supported at both ends, as shown in Fig Q7. The beam has a breadth 100 mm and a maximum bending stress of 70 MN/m^2.

Calculate EACH of the following:

(a) the magnitude and position of the maximum bending moment; (2)

(b) the minimum depth of the beam; (8)

(c) the minimum dimensions of a replacement solid square beam under these loading conditions. (6)

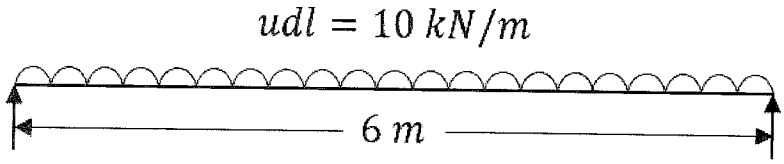

Fig Q7

8. A close coiled helical spring with mean coil diameter 40 mm is made from 5 mm diameter wire. The stress in the wire must not exceed 250 N/mm^2 at the maximum spring deflection of 20 mm.

Calculate EACH of the following:

(a) the number of coils in the spring; (8)

(b) the load which causes maximum deflection; (6)

(c) the energy stored within the spring at maximum deflection. (2)

Note: Modulus of Rigidity for wire = 88 kN/mm^2

9. A composite component consists of a steel rod, which is 250 mm long with diameter of 35 mm, which is firmly attached to an aluminium rod 625 mm in length as shown in Fig Q9. When the component has a tensile load of 32 kN applied to it the extension of the steel and aluminium sections are identical.

Calculate EACH of the following:

(a) the diameter of the aluminium rod; (8)

(b) the stress in each section of the component; (4)

(c) the total extension of the component. (4)

Note: *Modulus of Elasticity for steel = 200 GN/m²*
Modulus of Elasticity for aluminium = 70 GN/m²

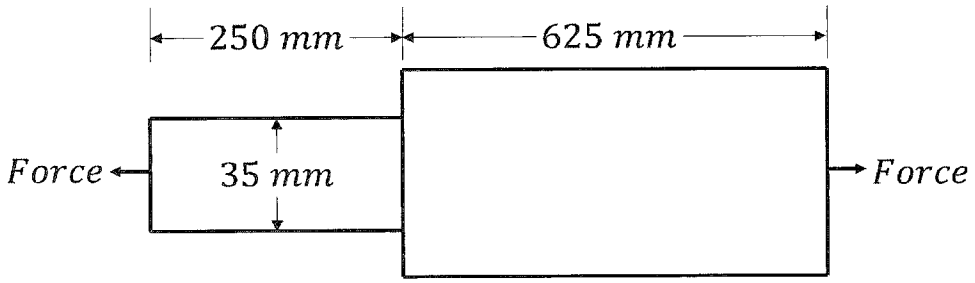

Fig Q9