CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY MARINE ENGINEER OFFICER

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-31 - APPLIED MECHANICS

TUESDAY, 13 DECEMBER 2022

1315 - 1615 hrs

Materials to be supplied by centre

Candidate's examination workbook Graph paper

Examination paper inserts

Notes for the guidance of candidates:

1. Examinations administered by the SQA on behalf of the Maritime & Coastguard Agency.
2. Candidates should note that 96 marks are allocated to this paper. To pass, candidates must achieve 48 marks.
3. Non-programmable calculators may be used.
4. All formulae used must be stated and the method of working and all intermediate steps must be made clear in the answer.

Maritime & Coastguard Agency

SQA

APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A simply supported beam is loaded as shown in Fig Q1:

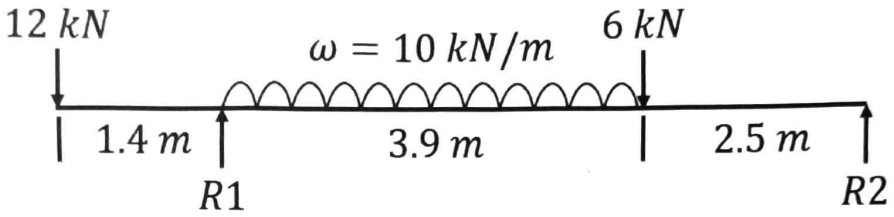

Fig Q1

Calculate the position of the point of contraflexure. (16)

2. Cylinder B is initially at rest on a smooth plane inclined 50° above the horizontal and is connected to mass A by a cable which passes over a frictionless pulley as shown in Fig Q2. Cylinder B weighs 100 N and mass A weighs 150 N. When the system is released mass A falls freely and cylinder B rolls without slipping on frictionless bearings.

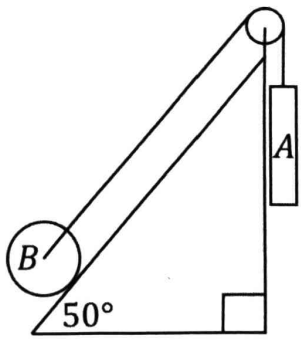

Fig Q2

Calculate the velocity of cylinder B when it has travelled 6 m up the plane. (16)

fuel after

3. A 350 kg block is held stationary on a plane inclined 30° above the horizontal by a force P which is applied parallel to the horizontal as shown in Fig Q3.

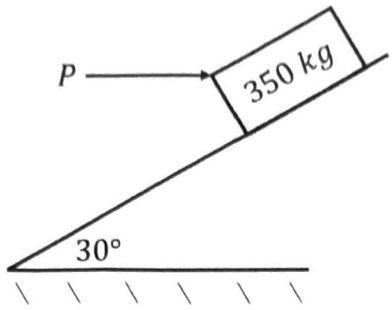

Fig Q3

The friction angle between the block and the plane is 15°.

Calculate the magnitude of the holding force P. (16)

4. A 3 m long steel shaft with an external diameter of 100 mm is secured at both ends. The shaft is solid for 1 m of its length and hollow for the remainder with an internal diameter of 50 mm. A torque of 30 kNm is applied to the shaft at the junction of the solid and hollow sections.

Calculate the percentage of the total torque transmitted to the solid section of the shaft. (16)

5. A homogeneous ladder of length 'L' m and weight of 'W' N Is supported as shown in Fig Q5. The coefficient of friction between all contact surfaces is 0.3.

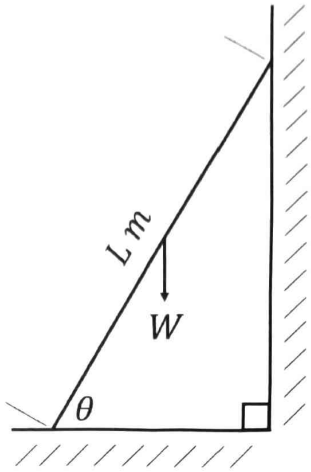

Fig Q5

Calculate the critical angle θ at which slip will occur. **(16)**

6. A 125 mm diameter solid steel bar acts as a strut supporting a 275 kN load. The line of action for the load is offset by 12 mm from the centre of the bar.

Calculate EACH of the following:

(a) the maximum stress within the bar; **(12)**

(b) the minimum change in length per metre of the steel bar. **(4)**

Note: Modulus of Elasticity for steel = 206 GN/m²

7. Blocks A, B and C are supported by a pair of identical massless, frictionless pulleys. The upper pulley is fixed to a horizontal surface and connects block C to the lower pulley with a fixed length cable. The unconstrained lower pulley supports blocks A and B with another fixed length cable as shown in Fig Q7. Blocks A, B and C have masses 1, 2 and 3 kg respectively and the system is initially at rest.

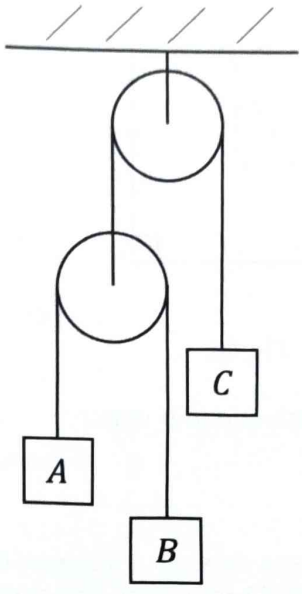

Fig Q7

Calculate the tension in the cable connecting blocks A and B when the system is released. **(16)**

8. TWO close coiled helical springs are compressed between TWO parallel plates by a load of 1 kN. The springs have a wire diameter of 10 mm and the radii of coils are 50 and 75 mm. EACH spring has 10 coils, is of the same initial length and both the springs are compressed by the same amount.

Calculate EACH of the following:

(a) the total deflection; **(12)**

(b) the maximum stress in each spring. **(4)**

Note: *Modulus of Rigidity for the spring material = 40 GN/m²*

9. A symmetrical steel bar is fabricated as shown in Fig Q9.

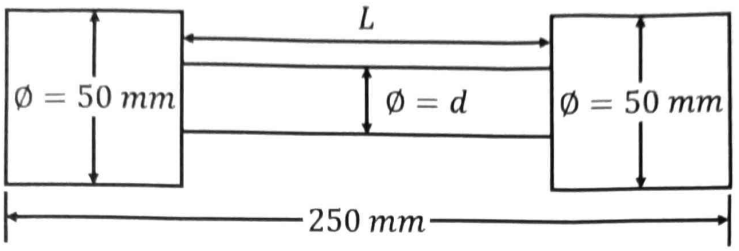

Fig Q9

During tensile testing the bar is subjected to a direct axial load of 150 kN which induces an overall elongation of 0.2mm and a tensile stress of 220 MN/m^2 in the central section.

Calculate the length of the central section of the stepped bar. (16)

Note: Modulus of Elasticity for steel = 207 GN/m^2