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, 17 OCTOBER 2023

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 tubular mast has an external diameter of 240 mm and an internal diameter of 200 mm. The mast is held vertical by a stay wire secured at a point 4 m above horizontal ground. The stay wire is tensioned to 100 kN at an angle of 30° to the vertical and is offset by 150 mm from the centre of the mast as shown in Fig Q1.

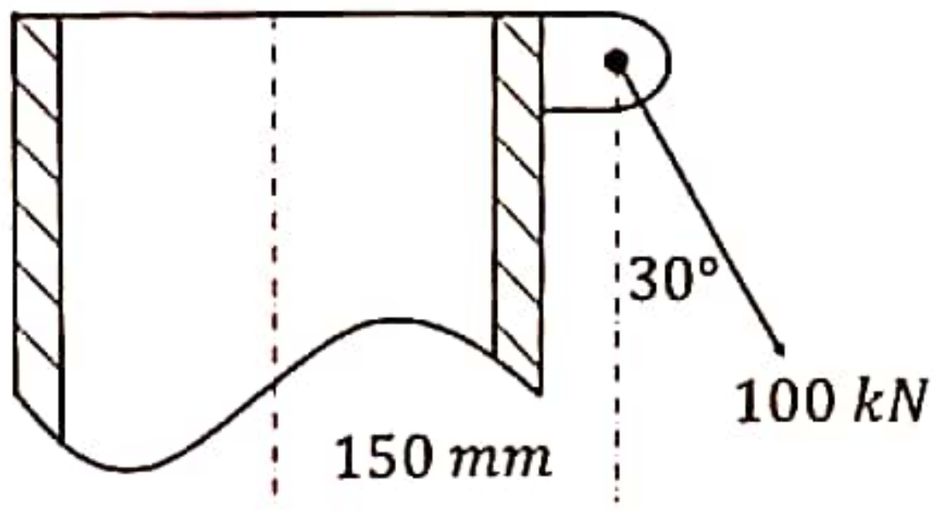

Fig Q1

Calculate EACH of the following:

(a) the maximum compressive stress in the mast; (14)

(b) the maximum tensile stress in the mast. (2)

2. A 250 mm diameter solid shaft with a mass of 600 kg is held at rest on a smooth plane inclined above the horizontal. When the shaft is released it rolls down the incline without slipping taking 3.2 seconds to reach a velocity of 4.8 m/s.

Calculate the angle at which the plane is inclined above the horizontal. (16)

3. A crankcase relief door has a diameter of 200 mm, a mass of 0.7 kg and is held closed by a close-coiled helical spring made from 6 mm diameter wire.

The spring has a mean diameter of 52 mm, 8 coils and is compressed by 20 mm during assembly. The relief door operates at a maximum pressure of 0.3 bar above atmospheric pressure and oscillates horizontally with simple harmonic motion during operation.

Calculate EACH of the following:

(a) the minimum gas pressure in the crank case that will cause the door to open; (5)

(b) the distance to mid-stroke at which time the net force on the door is zero; (6)

(c) the time taken for the door to open 50 mm. (5)

Note: Modulus of Rigidity for the spring material = 70 GN/m²

4. A projectile is fired at an angle of 30° above the horizontal from a position 150 m above sea-level. The projectile hits the water at a range of 25 km.

Calculate the magnitude and direction of the projectile's impact velocity. (16)

5. A solid 700 N cylinder with a diameter of 30 cm rolls without slipping down a plane inclined at an angle of 25° above the horizontal.

Calculate EACH of the following:

(a) the linear acceleration of the mass centre of the cylinder; (14)

(b) the force of friction between contact surfaces; (2)

6. A 10 kg block is at rest upon a smooth inclined plane that is free to rotate around the y-axis. It is connected to the axis of rotation by a cable that is 2 m in length as shown in Fig Q6.

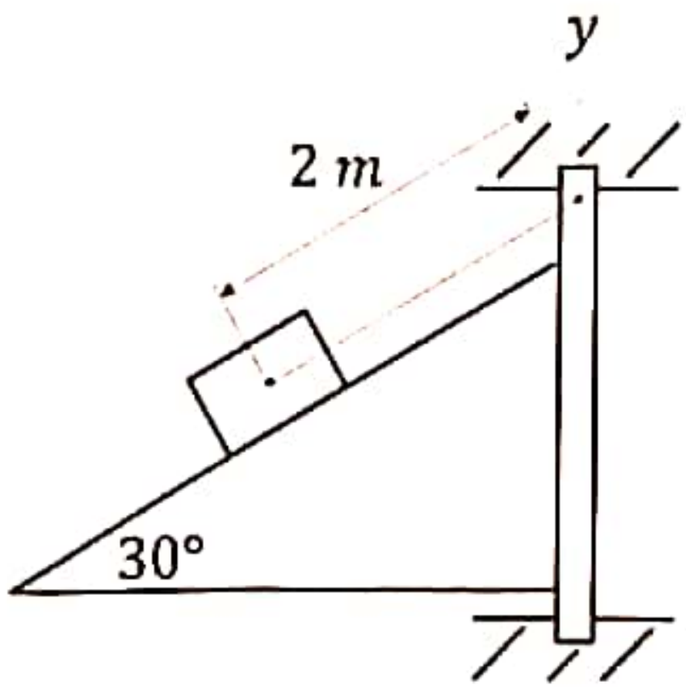

Fig Q6

The common angular speed of the block and the plane is 10 revolutions per minute.

Calculate the tension in the cable. (16)

7. A ship leaves port travelling 20° North of East at 12 knots. 2.5 hours later a second ship leaves the same port 10° West of South at 10 knots.

Determine how long after the second ship leaves port that the ships will be 150 nautical miles apart to the nearest second. (16)

8. A 1500 kg shearing machine flywheel has a 720 mm radius of gyration. During a 180 mm cutting stroke the speed of the flywheel falls from a maximum speed of 210 rpm to 175 rpm.

Calculate EACH of the following:

(a) the average force applied by the shearing machine during the cutting process; (11)

(b) the angular impulse transmitted to the flywheel when returning to 210 rpm in 6 seconds. (5)

9. A 200 mm solid steel shaft has a 20 mm thick brass liner shrunk over its entire length. The shaft transmits a mean torque of 185 kNm and the ratio of maximum to mean torque is 1.2 to 1.

Calculate the difference between the maximum shearing stresses induced in the shaft and the liner as a percentage of the total. (16)

Note: Modulus of Rigidity for steel = 80 GN/m²
Modulus of Rigidity for brass = 40 GN/m²