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, 14 JULY 2020

1315 - 1615 hrs

Materials to be supplied by examination centres

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

All formulae used must be stated and the method of working and all intermediate steps must be made clear in the answer.

1. A 7.5 m derrick arm of uniform cross section has mass of 6 kg/m. It carries a 325 N point load at one end and is supported by a pin and a cable as shown in Fig Q1.

   Calculate EACH of the following:

   (a) the force within the cable; (8)

   (b) the magnitude and direction of the reaction force at the pin. (8)

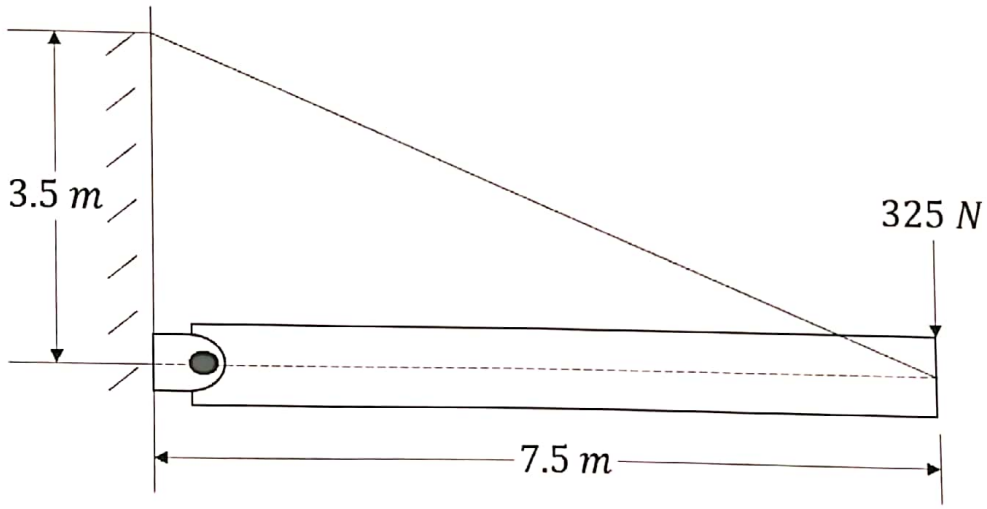

Fig Q1

2. A cotter has a 1 in 10 taper equally divided between two edges. It is driven into a plug and socket connection by a force of 350 N as shown in Fig Q2. The coefficient of friction is constant at 0.21.

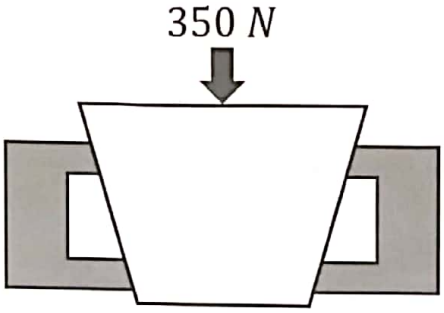

Fig Q2

Calculate EACH of the following:

(a) the force holding the plug and socket together; (10)

(b) the force required to remove the cotter. (6)

3. Two ships leave the same port at the same time. Ship A travels at 23° North of West at 17 knots and ship B travels 31° South of West at 14 knots.

(a) Sketch a vector diagram clearly indicating the relative velocity of ship A with respect to B; (4)

(b) Calculate EACH of the following:

(i) the magnitude and direction of the relative velocity of ship A with respect to B; (8)

(ii) the absolute distance covered by each of the ships when they are 100 nautical miles apart and both hold their original courses. (4)

4. In a belt driven pulley system the drive pulley is 300 mm diameter and the driven pulley is 240 mm diameter. The power transmitted is 8.2 kW when the tight side tension is 1.855 kN. The coefficient of friction between contact surfaces is 0.3 and the velocity of the belt is 6.6 m/s.

Using the relationship;

$$\frac{F_1}{F_2} = e^{\mu\theta}$$

where: F_1 = the maximum force in the tight side of the belt
F_2 = the minimum force in the slack side of the belt
μ = the coefficient of friction
θ = the angle of lap in radians.

Calculate EACH of the following:

(a) the torque generated at the driven pulley; (4)

(b) the speed of the drive pulley in rpm; (2)

(c) the drive pulley angle of lap in degrees. (10)

5. A 12 tonne truck is climbing a 1 in 50 incline (sine) with a tractive resistance of 120 N/tonne at 20 km/h. When the brakes are applied the truck comes to rest in a linear distance of 40m.

Calculate EACH of the following:

(a) the effective braking force applied to the wheels; (10)

(b) the time taken for the truck to reach a speed of 16 km/h rolling back down the incline once the brakes are released. (6)

6. A 3 tonne mass falls vertically 5.25 m onto a 1 tonne pile which is driven 150 mm into the ground it is resting on, assuming there is no rebound at impact.

Calculate EACH of the following:

(a) the percentage of energy lost during impact; (12)

(b) the average resistance of the ground. (4)

7. A 5 tonne turbine rotor has a 400 mm radius of gyration and is running at speed of 3000 rpm. It has a centre of gravity located 1.5 m to the right of its 150 mm bearing and 1 m to the left of its 200 mm bearing. The coefficient of friction between shaft and bearings is 0.0015. Assume there are no windage losses.

Calculate EACH of the following:

(a) the power lost to friction at this speed; (10)

(b) the time taken to come to rest when the driving torque is removed. (6)

8. A thin composite rim of steel and copper rotates about its axis at a constant speed of 2000 rpm as shown in Fig Q8.

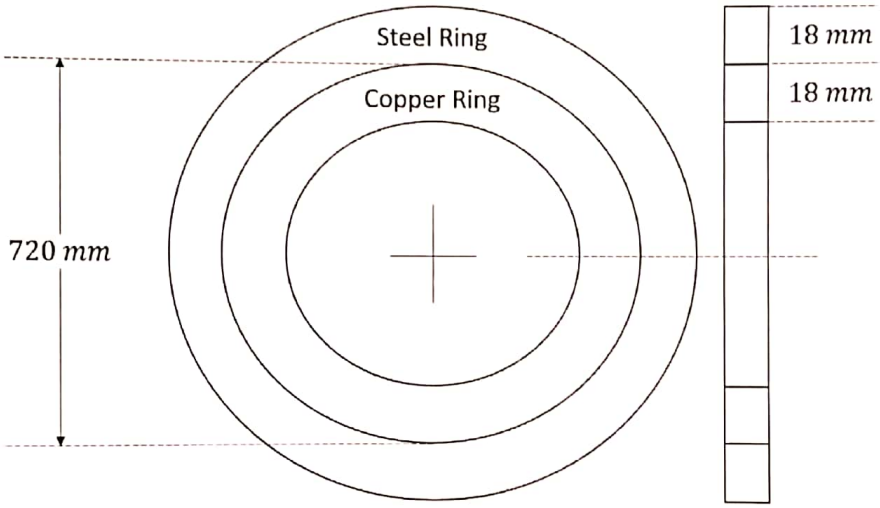

Fig Q8

Calculate the circumferential stress induced in both rings. (16)

Note: *Modulus of Elasticity for steel = 200 GN/m²*
Modulus of Elasticity for copper = 100 GN/m²
Density for steel = 7800 kg/m³
Density for copper = 8900 kg/m³

9. A 280 mm diameter solid propeller shaft is to be replaced with a hollow shaft that has an external diameter of 350 mm. The replacement shaft is manufactured from the same material so that the maximum shear stress and the angular twist per unit length of the original shaft remain the same.

Calculate EACH of the following:

(a) the maximum internal diameter of the hollow shaft; (12)

(b) the percentage reduction in weight. (4)