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, 23 MARCH 2021

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 pin-jointed frame is loaded as shown in Fig Q1.

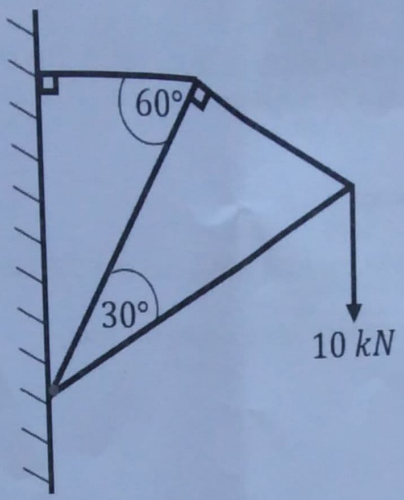

Fig Q1

Determine the magnitude and nature of the force in EACH of the four members. (16)

2. When released blocks A and B slide freely down the incline as shown in Fig Q2. Block A is 15 kg with a 0.25 coefficient of friction acting between its contact surface and the plane. Block B is 55 kg with a 0.1 coefficient of friction acting between its contact surface and the plane.

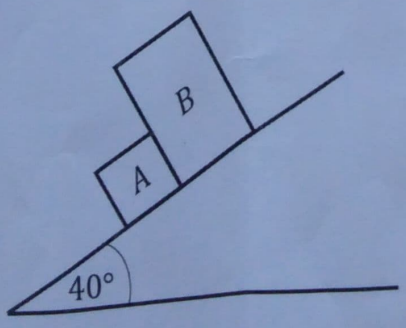

Fig Q2

Calculate the magnitude of the contact force between the blocks. (16)

3. Ship A is at rest preparing to launch a tow rope onto the deck of ship B during a training exercise at sea. At the instant the tow rope is fired ship B is 5 m from ship A moving directly away from it at 9 m/s. The tow rope is fired at an angle of 45° above the horizontal and the length of the target on ship B is 2.5 m.

Calculate EACH of the following:

(a) the minimum required launch velocity; (12)

(b) the maximum permissible launch velocity. (4)

4. A 500 kg mass is to be raised vertically by a screw jack. The single start thread is square with a 12 mm pitch and a 50 mm mean diameter. The coefficient of friction is 0.15.

Calculate EACH of the following:

(a) the effort required to raise the load at the end of a 300 mm lever; (12)

(b) the efficiency of the screw jack when raising the load. (4)

5. A winch motor drives a pinion with 320 teeth. The friction at the motor bearings is a constant 20 Nm. The pinion meshes with a gear wheel that has 640 teeth which drives a 120 mm diameter shaft. The shaft is supported in bearings with a coefficient of friction of 0.12 and drives a winch drum with an effective diameter of 340 mm. The winch drum raises a mass of 2 tonnes at a constant vertical velocity of 0.3 m/s as shown in Fig Q5.

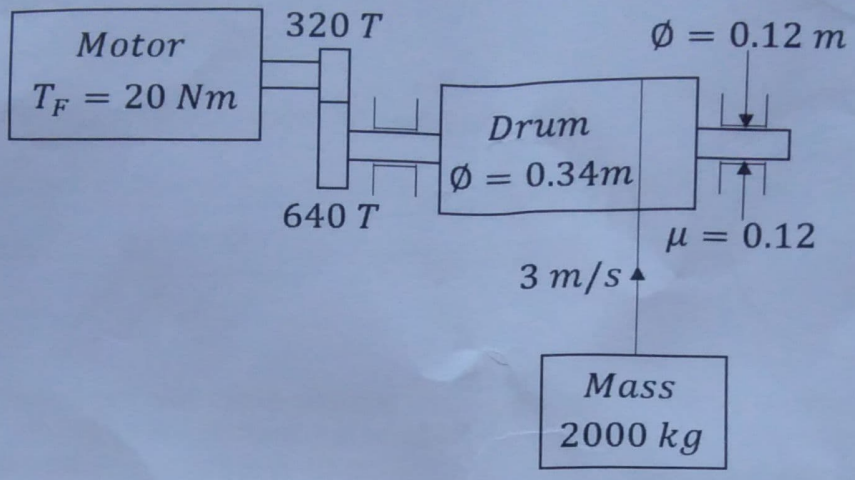

Fig Q5

Calculate EACH of the following:

(a) the driving torque required by the motor; (12)

(b) the input power if the motor is 86% efficient. (4)

6. A slider crank mechanism drives a block between two parallel, horizontal guides as shown in Fig Q6. The block has a stroke of 120 mm and oscillates in simple harmonic motion with a frequency of 1.667 Hz. The mass of the block is 2kg and the coefficient of friction at the contact surfaces of the guide is 0.12. When the connecting rod is 15° above the line of stroke, the block is 40 mm away from its mid-stroke position.

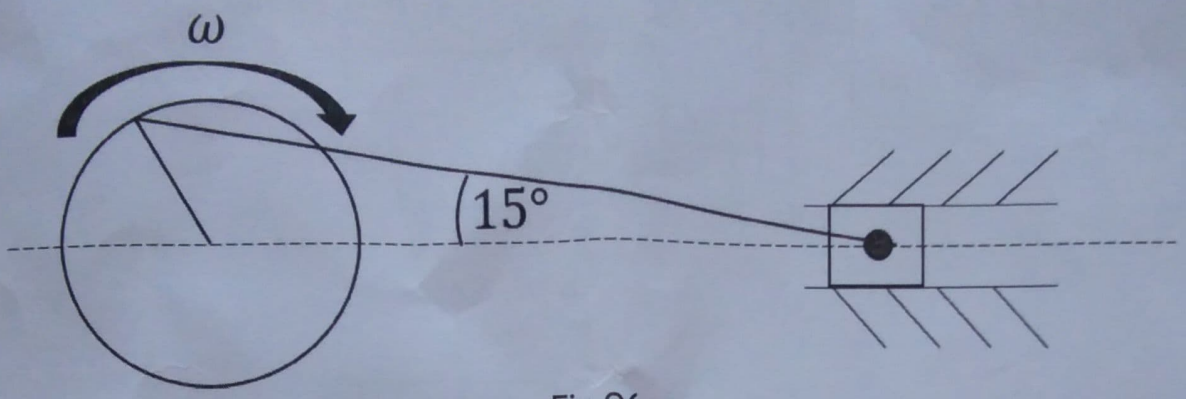

Fig Q6

Calculate EACH of the following:

(a) the kinetic energy of the block; (6)

(b) the force in the operating rod. (10)

7. A simply supported beam is loaded as shown in Fig Q7.

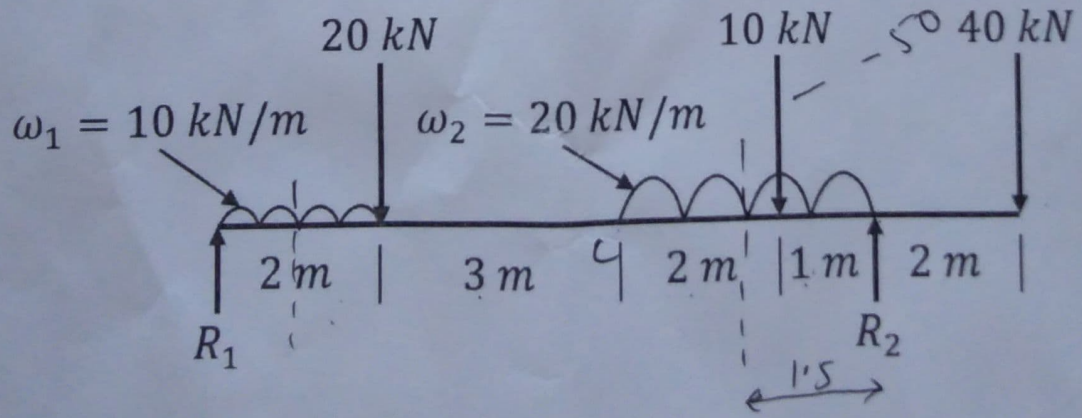

Fig Q7

Calculate the position of any points of contra-flexure. (16)

8. A diesel engine exhaust valve is controlled by two concentric springs. The outer spring is made from 20 mm diameter wire with 10 active coils, a free length of 360 mm and a mean diameter of 254 mm. The inner spring is made from 16 mm diameter wire with 12 active coils, a free length of 380 mm and a mean diameter of 178 mm. When the exhaust valve is shut, the length of both springs is 320 mm.

The travel of the valve from shut to open is 38 mm.

Calculate EACH of the following:

(a) the work done to fully open the exhaust valve; (10)

(b) the increase in strain energy to fully open the exhaust valve. (6)

Note: Modulus of Rigidity for both springs = 80 GN/m²

9. A 16 mm diameter steel cable running over a pulley is used to vertically lower a mass of 2 tonnes at a constant velocity of 0.2 m/s. The pulley suddenly jams when the length of the cable is 10 m.

Calculate EACH of the following:

(a) the stress in the cable due to the sudden stop; (14)

(b) the extension of the cable due to the sudden stop. (2)

Note: Modulus of Elasticity for steel = 208 GN/m²