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, 15 JULY 2025

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, pin-jointed framework is assembled using seven members that are each 4 m in length. It is loaded as shown in Fig Q1.

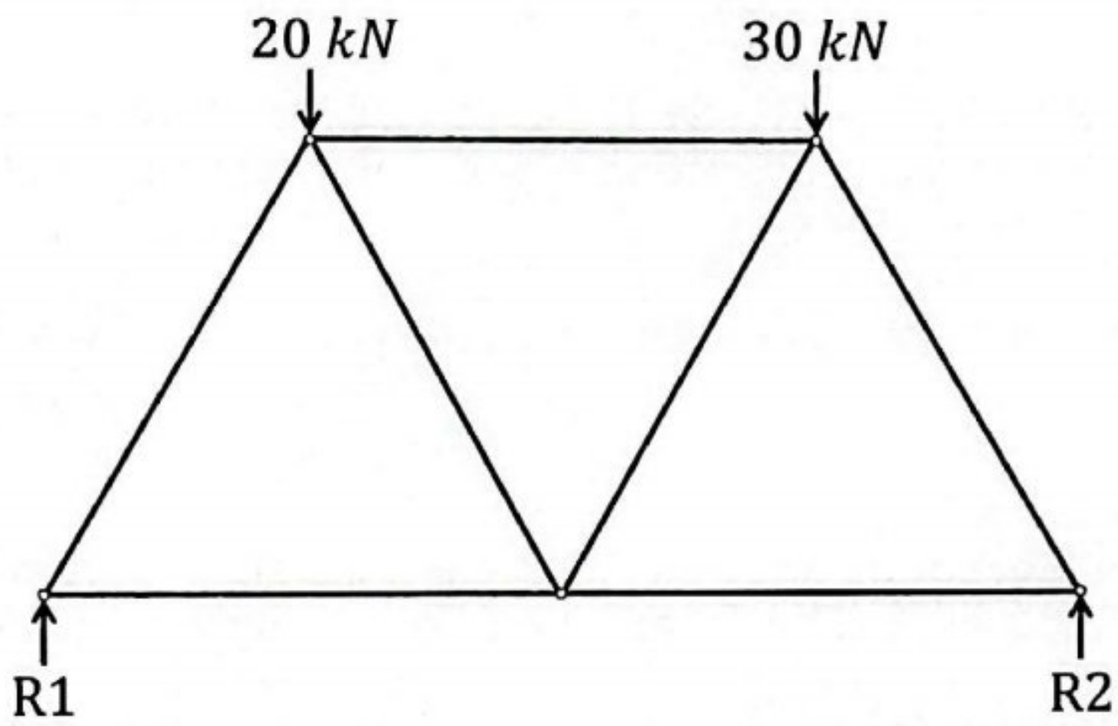

Fig Q1

Determine the magnitude and nature of the force in each of the seven members. (16)

2. TWO masses initially at rest on separate inclined planes are connected by a cable which runs on a 600 mm diameter pulley as shown in Fig Q2.

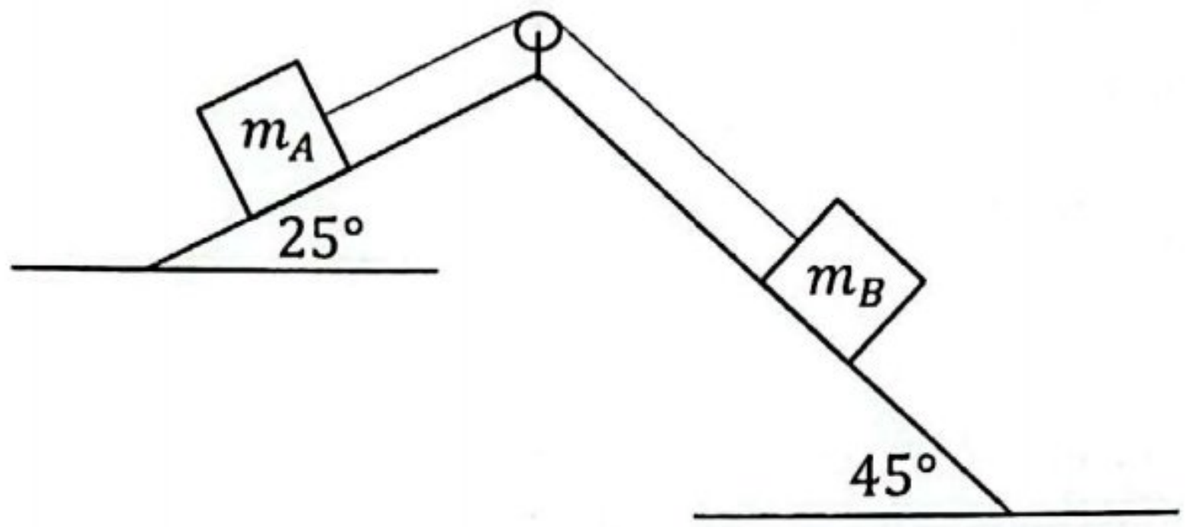

Fig Q2

The pulley has a mass of 5 kg and a 210 mm radius of gyration. Mass A is 40 kg, mass B is 50 kg and the coefficient of friction between the contact surfaces of each mass is 0.25 and 0.2 respectively.

Calculate the displacement of mass A when it reaches a velocity of 1.4 m/s. (16)

3. The drive shaft of a vertical engine rotates at a constant speed of 450 rpm. The stroke of the engine is 1080 mm and the length of the connecting rod is 1800 mm.

When the crank is 30° past top dead centre the instantaneous torque transmitted is 40 kNm.

Determine EACH of the following:

(a) the magnitude and nature of the force in the con-rod; (12)

(b) the reaction force at the guide face. (4)

4. A drive pinion and gear wheel system provides a 3 to 1 speed reduction ratio. The 50 kg pinion has a 160 mm radius of gyration whilst the 410 kg gear wheel has a 450 mm radius of gyration.

Under no load the pinion attains its maximum rotational speed of 900 rpm from rest in 150 revolutions.

Calculate EACH of the following:

(a) the minimum torque required at the pinion to accelerate the gearing system; (12)

(b) the total kinetic energy in the system at maximum speed. (4)

5. A 100 kg stepped flywheel supports two masses on separate cables as shown in Fig Q5.

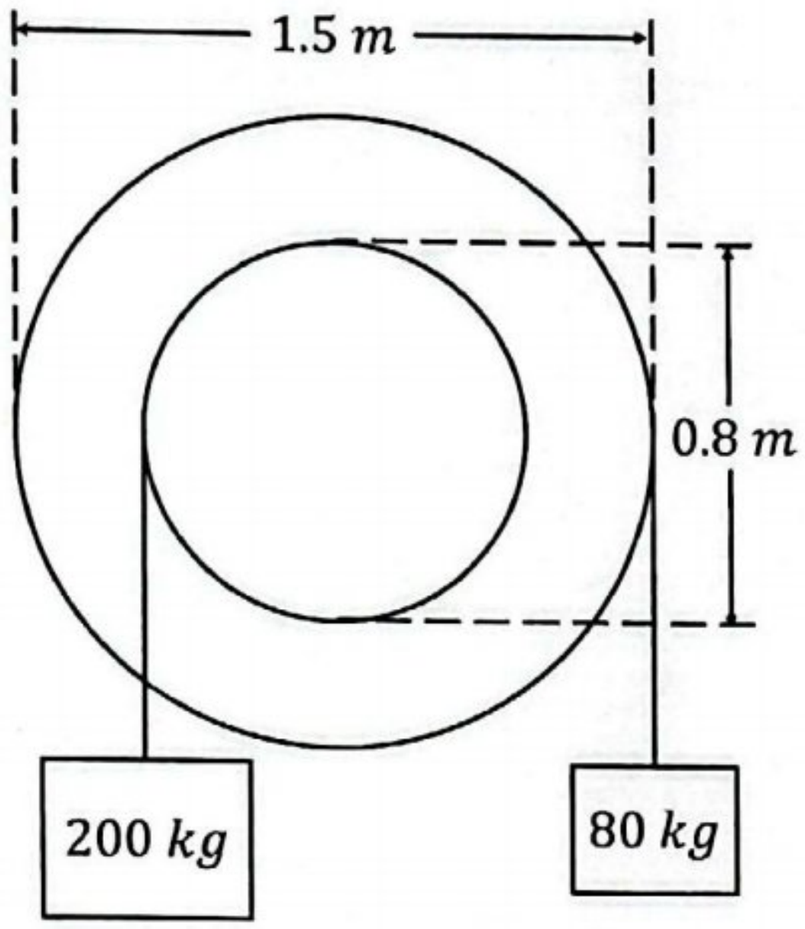

Fig Q5

The radius of gyration for the flywheel is 0.9 m and the bearing torque is a constant 20 Nm.

Calculate the total kinetic energy of the system on completing 3 full revolutions from rest. (16)

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6. A 25 kg mass is initially descending at a constant rate of 6 m/s and is connected by a cable to the drum supporting it as shown in Fig Q6.

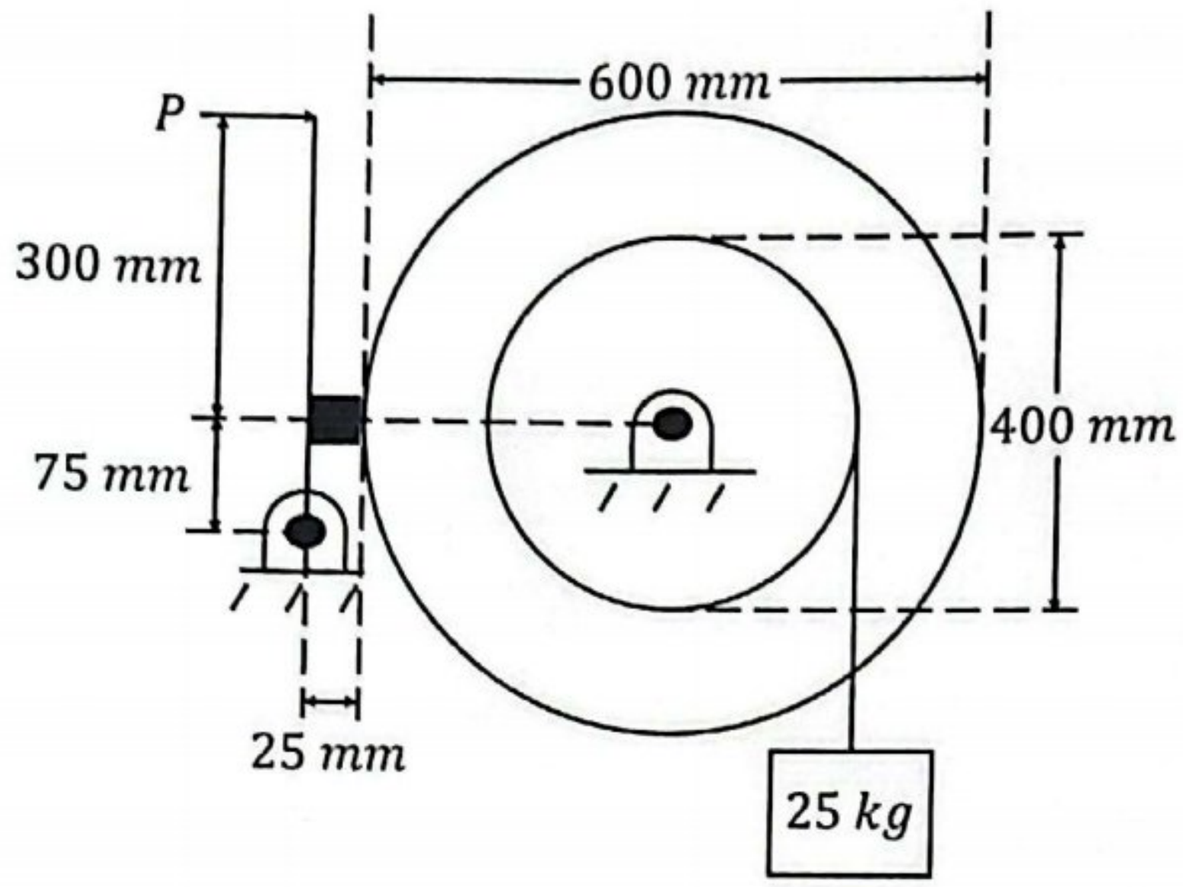

Fig Q6

The drum rotates on frictionless bearings and has a moment of inertia of 0.34 kgm^2. The coefficient of friction between the brake pad and the drum is 0.4. When the brake is applied, the system is brought to rest in a time of 2 s.

Calculate EACH of the following:

(a) the force 'P' which must be applied to the brake lever; (10)

(b) the magnitude and direction of the reaction force at the hinge of the brake lever. (6)

7. A 3 kg sphere secured to a light 2 m long rod is initially at rest as shown in Fig Q7.

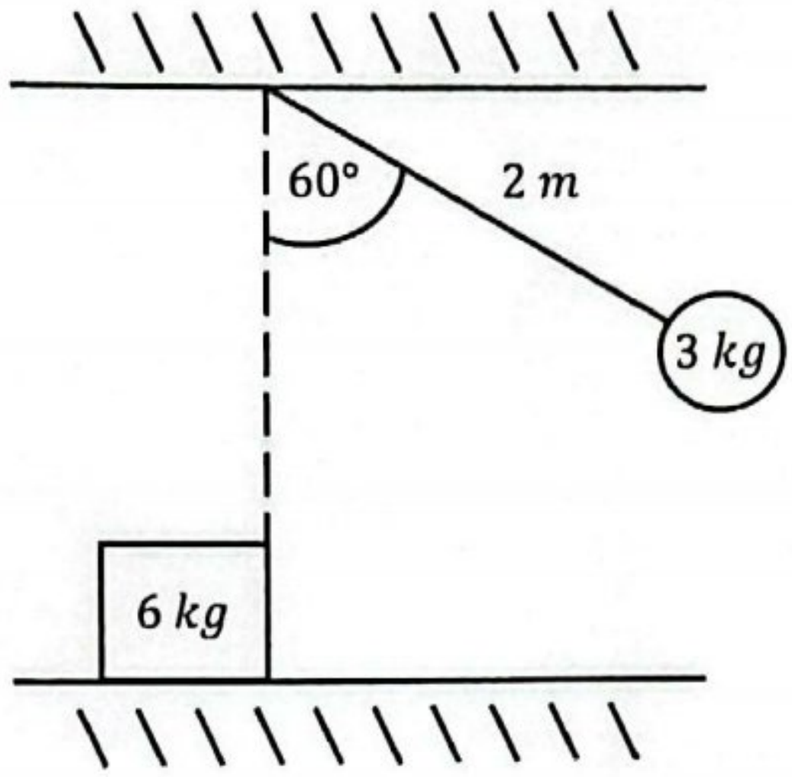

Fig Q7

On release the sphere strikes the stationary 6 kg block and rebounds through an angle of 10°.

Calculate the energy lost on impact. **(16)**

8. A solid steel bar 100 mm diameter is encased by a brass sleeve 8 mm thick. The component is securely fixed at both ends and the temperature is evenly increased by 100°C.

Calculate EACH of the following:

(a) the magnitude and nature of the stress within the steel bar; **(14)**

(b) the magnitude and nature of the stress within the brass liner. **(2)**

Note: Modulus of Elasticity for steel = 206 GN/m²
Modulus of Elasticity for brass = 92 GN/m²
Coefficient of linear expansion for steel = 11 x 10^{-6} / °C
Coefficient of linear expansion for brass = 19 x 10^{-6} / °C

9. A 240 mm diameter solid shaft transmits 224 kW at 150 rpm. A hollow shaft made from the same material has an external diameter of 200 mm diameter and an internal diameter of 140 mm. When the hollow shaft rotates at 100 rpm the maximum shear stress in both shafts is equal.

Calculate the difference in the power transmitted by each of the shafts. **(16)**