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, 20 OCTOBER 2020

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

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

1. A 100 N cylinder with a radius of 600 mm is supported between crosspieces which make an angle of 60° as shown in Fig Q1. The crosspieces are pinned at point C and tied by a cord between points D and E.

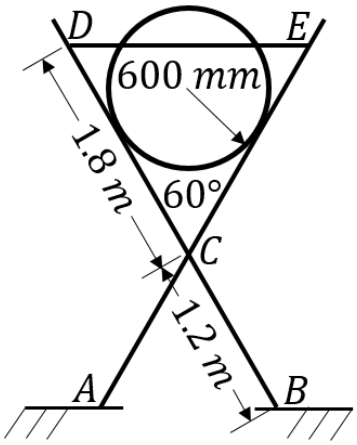

Fig Q1

Calculate the tension in the cord DE. (16)

2. A 30 kg block is tethered to a 15 kg block on a plane inclined at 45º above the horizontal as shown in Fig Q2. The coefficient of friction between the 30 kg block and the plane is 0.25. The coefficient of friction between the 15 kg block and the plane is 0.375.

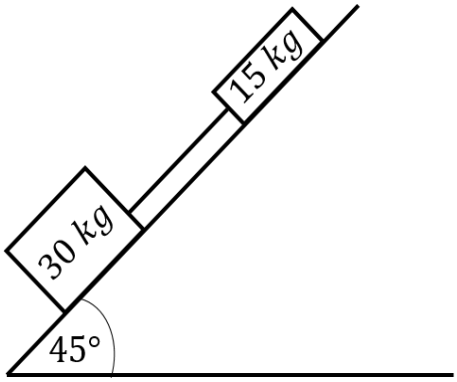

Fig Q2

Calculate the tension in the cord. (16)

3. A ship leaves port travelling North West at 12 knots. A second ship leaves the same port 3 hours later travelling 20º West of South at 15 knots. Determine how long after the second ship leaves port that the ships will be 100 nautical miles apart. (16)

4. A worm and wheel lifting machine is rotated by a 450 mm effective diameter pulley. The axial thrust of the worm is absorbed by a 70 mm effective diameter ball-race. During a 62% efficiency lifting operation the pulley effort is 30 N, the ball-race thrust is 1.9 kN and the ball-race coefficient of friction is 0.0018. Whilst lifting the ball-race fails and the balls slide instead of roll increasing the coefficient of friction to 0.09.

Calculate EACH of the following:

(a) the increased effort required to lift the same load; (8)

(b) the decrease in lifting efficiency of the machine. (8)

5. A coal truck with a total mass of 5 tonnes has four 300 kg wheels that are each 0.6 m in diameter with a 0.4 m radius of gyration. It is initially travelling at 3 m/s as it begins to descend a 3° incline that is 250 m in length. Tractive resistance to motion is 60 N/tonne.

Calculate EACH of the following:

(a) the energy lost descending the incline; (2)

(b) the speed of the truck at the bottom of the incline. (14)

6. Three masses A, B and C are fixed to a balanced disc at radii 120 mm, 100 mm and 80 mm respectively as shown in Fig Q6.

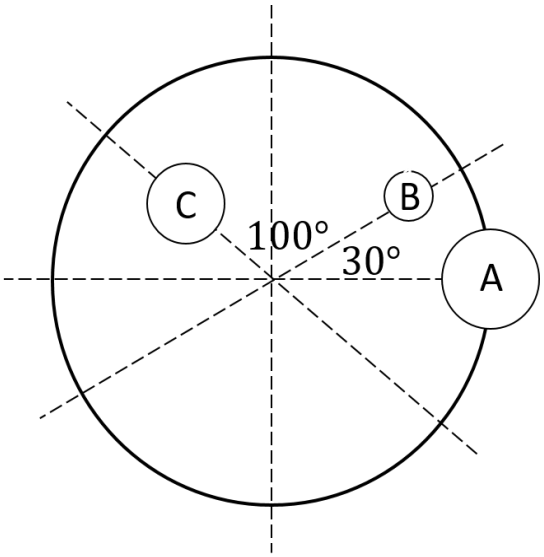

Fig Q6

A has mass 1 kg, B has mass 0.5 kg and C has mass 0.7 kg. A fourth mass D is required to statically balance the system.

Calculate EACH of the following:

(a) the magnitude of the balancing mass to be fitted at a radius of 60 mm; (12)

(b) the angular position of the balancing mass in relation to mass A. (4)

7. A reciprocating engine runs at 110 rpm with a stroke of 1.6 m and a connecting rod 2.4 m in length. It imparts simple harmonic motion to a 250 mm diameter piston. When the crank pin is 32° beyond top dead centre the pressure on the piston is 0.8 MN/m^2.

Calculate EACH of the following:

(a) the instantaneous velocity of the piston; (6)

(b) the instantaneous torque at the crank pin; (8)

(c) the instantaneous acceleration of the piston. (2)

8. A solid intermediate shaft is to be fitted to a 16 MW engine operating at 110 rpm. The shaft is in sections with flanged couplings with 12 bolt holes on a pitch circle diameter that is 1.5 times greater than the shaft diameter. The limiting shear stress for the shaft is 180 MN/m^2 and 160 MN/m^2 for the bolts respectively.

Calculate EACH of the following:

(a) the shaft diameter for a safety coefficient (factor of safety) of two; (8)

(b) the diameter of the bolts for a safety coefficient (factor of safety) of two. (8)

9. A steel rod has a single start thread with 6 threads per centimetre and an effective cross sectional area of 1200 mm^2. It is placed inside a bronze tube 300 mm long, 55 mm external diameter that is 5 mm thick. Nuts at each end of the screw are made finger tight against the tube. One nut is then tightened by an additional $1/10^{th}$ of a turn.

Calculate EACH of the following:

(a) The stress in the bronze tube; (14)

(b) The stress in the screwed steel rod. (2)

Note: Modulus of Elasticity for steel = 200 GN/m^2
Modulus of Elasticity for bronze = 120 GN/m^2