

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, 18 OCTOBER 2022

1315 - 1615 hrs

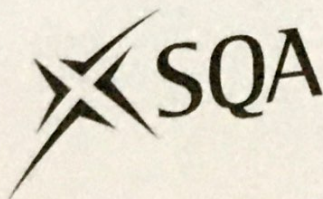
Materials to be supplied by centre

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.



APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A 30 mm diameter hole is drilled in the centre of the rectangular section of the component shown in Fig Q1 such that it is normal to top surface.

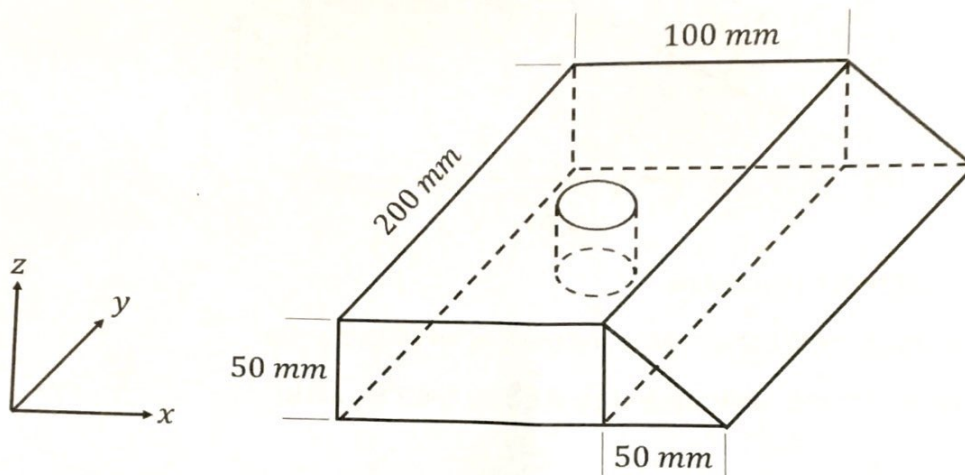


Fig Q1

Calculate the position of the centroid $(\bar{x}, \bar{y}, \bar{z})$ using the bottom left hand corner of the component as the datum and the axes orientation provided.

(16)

2. A FOUR-stroke internal combustion engine running at 4500 RPM has a camshaft driven exhaust valve. The camshaft has a lift of 25 mm, a duration of 270° and moves with SHM. The 0.8 kg spring loaded follower is vertically orientated.

Calculate EACH of the following:

(a) the follower velocity when the valve is 7 mm from fully open;

(12)

(b) the minimum spring force required to ensure contact between cam and follower at the upper limit of the vertical lift.

(4)

[OVER

THREE blocks initially at rest are connected by TWO separate cables as shown in Fig Q3. The 2 kg block is connected to the 5 kg block by a cable running on a frictionless pulley at the top of a plane inclined 30° above the horizontal.

The 5 kg block is connected to the 6 kg by a separate cable and the coefficient of friction between contact surfaces on the inclined plane is 0.25.

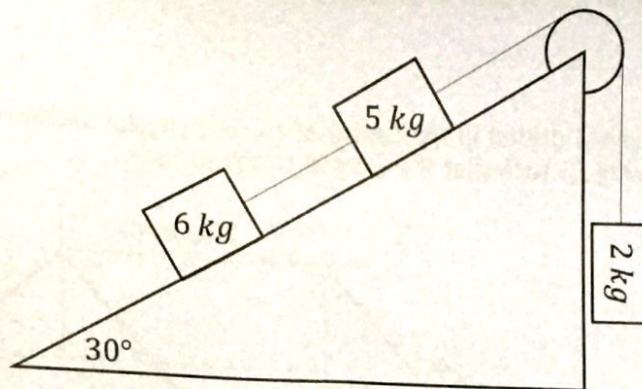


Fig Q3

Calculate EACH of the following:

- (a) the tension in the cable connecting the 6 kg and 5 kg blocks; (14)
 - (b) the tension in the cable connecting the 5 kg and 2 kg blocks. (2)
4. An intermediate shaft is fitted to an engine of power 8 MW operating at 114 rpm. The shaft is solid with a diameter of 320 mm, and a coupling flange at each end which carries 12 bolt holes on a pitch circle diameter of 460 mm.
- The maximum shear stress is 180 MN/m^2 for the shaft and is 160 MN/m^2 for the bolts.
- Calculate the minimum diameter of a coupling bolt to ensure that the operating safety coefficient is the same in both the intermediate shaft and EACH of the coupling bolts. (16)
5. A flare is fired with an initial velocity of 180 m/s at an angle of 40° above level ground at the base of a slope inclined at 5° above the horizontal.
- Calculate the magnitude and direction of the impact velocity of the flare. (16)

6. A 30 kN truck moving at 6 km/h is brought to rest by a spring-loaded buffer that is compressed by a total of 200 mm during the process. The buffer springs are made from 20 mm diameter alloy wire with 20 coils of 200 mm mean diameter.

Calculate the minimum number of springs that are fitted to the buffer.

(16)

Note: Modulus of Rigidity for spring wire = 100 GN/m^2

7. A cylindrical gas bottle is pressurised to 95 bar. The internal diameter of the bottle is 200 mm with a wall thickness of 8 mm.

Calculate the magnitude and direction of the resultant stress on an oblique plane angled at 20° above the longitudinal axis of the gas bottle.

(16)

8. A starter motor with 8 teeth engages with a flywheel rim having 128 teeth. The starter motor pinion mass is 10 kg with a radius of gyration of 0.1 m and the engine rotational mass is 400 kg with an effective radius of gyration of 0.5 m.

The engine must be accelerated to 320 rev/min from rest in EIGHT seconds.

Calculate EACH of the following:

- (a) the angular acceleration of the starter motor;
- (b) the average driving power required by the starter motor.
9. During the combustion process of an engine, a cylinder pressure of 10 bar is recorded when the crank is 32° past top dead centre.

The piston diameter is 90 mm, the stroke of the engine is 1.2 m, the connecting rod is 2.25 m long and the solid circular drive shaft has a diameter of 300 mm.

Calculate EACH of the following:

- (a) the instantaneous torque on the crank at this position;
- (b) the instantaneous shearing stress induced in the drive shaft due to this torque.

(12)

(4)