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 OCTOBER 2019

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 jib-crane supports a 15.29 tonne mass from the crane head as shown in Fig Q1. The Samson post is 10 m in length between the derrick and the tie-bar. The ties are not horizontal.

   Determine EACH of the following:

   (a) the magnitude and nature of the force in the derrick; (10)

   (b) the magnitude and nature of the force in each tie. (6)

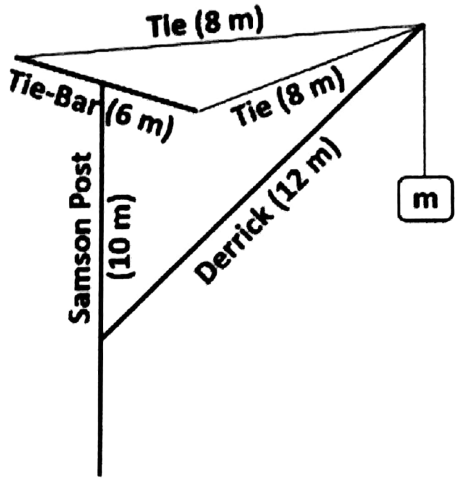

Fig Q1

2. A container of mass 500 kg is hauled up a slope by a light cable attached to a drive mass of 325 kg via a frictionless pulley as shown in Fig Q2. The slope rises 2 m in every 5 m (tan) and the friction angle is 14°.

Calculate EACH of the following:

(a) the acceleration of the container; (10)

(b) the additional mass required to move the container down the slope at constant velocity. (6)

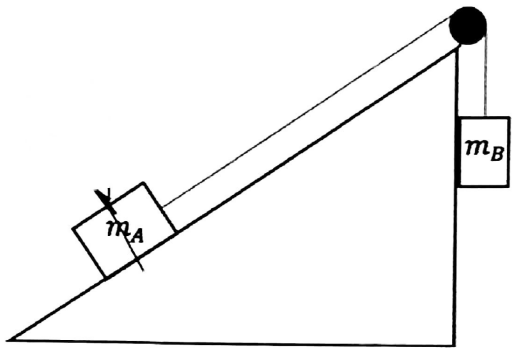

Fig Q2

3. A projectile is fired at an angle of 40° above the horizontal on a cliff top 80 m above sea level. Its initial velocity is 35 m/s.

Calculate EACH of the following:

(a) the velocity and angle of impact; (8)

(b) the maximum linear displacement of the projectile. (8)

4. The tension in a flat belt pulley is 110 N when stationary. The drive wheel is 240 mm diameter and rotates at 1500 rpm. The coefficient of friction between contact surfaces is 0.32 and the angle of lap is 165°.

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 tension on each side of the belt during operation; (14)

(b) the maximum power transmitted. (2)

5. A 300 mm diameter 525 kg solid shaft is held at rest on an inclined plane. When released it rolls down the incline and takes 2.3 s to attain a velocity of 4.5 m/s.

Calculate EACH of the following:

(a) the release height; (10)

(b) the angle of incline. (6)

6. A 3 kg mass rotates as a conical pendulum on a 1.6 m cord at constant velocity. The cord forms a 25° angle with the vertical axis of its fixing point.

Calculate EACH of the following:

(a) the instantaneous linear velocity of the mass; (8)

(b) the rotational frequency; (4)

(c) the change in height for an increase of 10% in angular velocity. (4)

7. A 1.75 m long steel tube, 4 mm thick with external diameter of 35 mm is simply supported 130 mm from either end. It is loaded with 1.3 kN point loads at both ends.

Neglecting the weight of the tube:

(a) sketch the shear force and bending moment diagrams; (6)

(b) calculate EACH of the following.

(i) the radius of curvature of the tube at mid-span position; (6)

(ii) the shearing stress induced at either support. (4)

Note: Modulus of Elasticity for steel = 206 GN/m²

8. A 300 mm diameter solid steel drive shaft transmits 2500 kW at 115 rpm to a hollow steel shaft via a flanged coupling. The coupling has 8 bolts with a safe working stress of 46 MN/m² fitted on a pitch circle diameter of 650 mm. The hollow shaft has a diameter ratio of 0.75 with the same external diameter as the drive shaft.

Calculate EACH of the following:

(a) the minimum diameter of the coupling bolts; (6)

(b) the maximum shear stress in the hollow shaft; (6)

(c) the angle of twist per unit length of the solid shaft in degrees. (4)

Note: Modulus of Rigidity for steel = 80 GN/m²

9. A 10 m straight length of steel steam pipe, 180 mm external diameter and 7 mm thick, connects two bulkheads. It is fitted at a temperature of 16°C with linear expansion restricted to 8 mm.

Calculate EACH of the following:

(a) the stress in the pipe when heated to 200°C; (6)

(b) the force exerted by the pipe due to compression; (6)

(c) the strain energy stored within the pipe. (4)

Note: Modulus of Elasticity for steel = 206 GN/m²
Coefficient of linear expansion for steel = 12 x 10^{-6} /°C