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, 16 JULY 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 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. In the simply supported framework, shown in Fig Q1, the pin-jointed members are each 3 m in length.

   (a) Calculate the reaction forces at either end of the framework. (2)

   (b) Determine the magnitude and nature of the force in each of the members. (14)

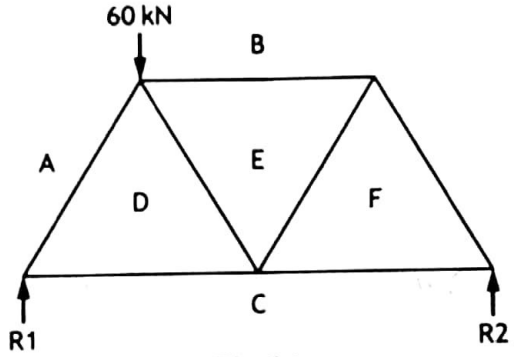

Fig Q1

2. A steel wedge is 450 mm long, 55 mm thick at the butt end, 5 mm thick at the sharp end with an equal taper on both sides. It is driven horizontally between an engine bedplate and the stools with a force of 4.5 kN, shown in Fig Q2. The coefficient of friction is 0.15.

   Calculate EACH of the following:

   (a) the equivalent mass lifted by the wedge; (10)

   (b) the force required to remove the wedge. (6)

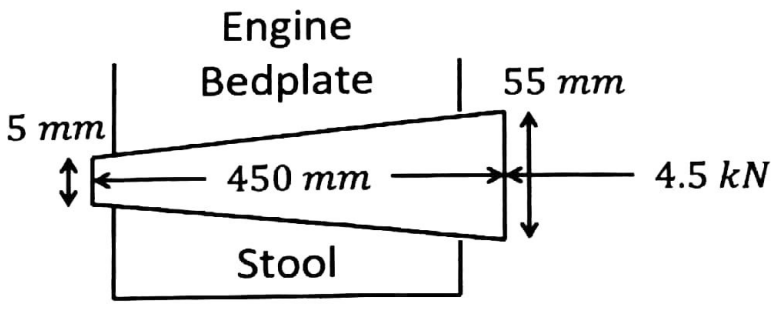

Fig Q2

3. A projectile is fired vertically upwards with an initial velocity of 305 m/s. The effect of air resistance is a constant force equal to one-seventh of the gravitational force experienced by the projectile.

Calculate EACH of the following:

(a) the time taken to reach the maximum height; (6)

(b) the maximum height attained by the projectile; (4)

(c) the time the projectile takes to fall from maximum height to its starting position. (6)

4. A screw jack is to be used to raise a casting of mass 1500 kg. The single start screw thread has a pitch of 2.5 mm. A force of 45 N is applied at right angles to a turning bar at a fixed radius of 600 mm to produce a constant rotational speed.

Calculate EACH of the following:

(a) the velocity ratio of the screw jack; (3)

(b) the efficiency of the screw jack lifting this casting; (5)

(c) the output work done per revolution; (3)

(d) the constant rotational speed, expressed in rpm, if the casting is lifted 150 mm in 12 seconds. (5)

5. A simple pendulum consists of a mass of 0.23 kg on the end of a wire of fixed length. The pendulum moves with simple harmonic motion with an angular amplitude of 7.5° completing 60 oscillations in 75 seconds.

Calculate EACH of the following:

(a) the maximum linear acceleration of the mass; (2)

(b) the length of the pendulum; (5)

(c) the maximum linear velocity of the mass; (4)

(d) the maximum tension in the wire. (5)

6. Three masses A, B and C are to rotate on a common plane with the same angular velocity. Their masses and radii from the centre of rotation are: 7 kg at 375 mm radius, 10 kg at 315 mm and 12.5 kg at 225 mm respectively.

Calculate the angles between each of the masses so that the system is balanced. (16)

7. A piston moving with simple harmonic motion passes points A and B 400 mm apart with the same speed.

If it takes 2 seconds to travel from A to B, and a further 3 seconds to reach point B when reciprocating, calculate EACH of the following:

(a) the periodic time; (6)

(b) the amplitude; (8)

(c) the maximum acceleration. (2)

8. A weight of 8.5 kN falls a 5 mm vertical distance onto a steel bar as shown in Fig Q8. The bar has a length 200 mm and a cross sectional area of 2500 mm^2.

Calculate EACH of the following:

(a) the stress induced within the bar; (12)

(b) the stress if the same load is applied gradually; (2)

(c) the stress if the same load is applied suddenly without impact. (2)

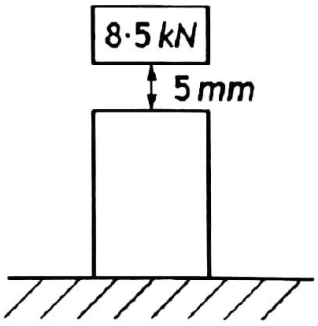

Fig Q8

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

9. A solid steel bar, 75 mm diameter, is fitted inside a 10 mm thick brass liner that has an internal diameter of 75 mm. The compound component is machined to a single length and positioned such that both ends are rigidly fixed. At ambient temperature there are no stresses in the steel or brass. During operation the temperature of the component is raised by 65°C.

Calculate EACH of the following:

(a) the direct stress in the steel bar induced by the temperature change; (14)

(b) the direct stress in the brass liner induced by the temperature change. (2)

Note: *Modulus of Elasticity for steel = 200 GN/m^2*
Coefficient of linear expansion for steel = 11 x 10^{-6} 1/°C
Modulus of Elasticity for brass = 90 GN/m^2
Coefficient of linear expansion for brass = 18.4 x 10^{-6} 1/°C