CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY
MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

STCW 78 as amended MANAGEMENT ENGINEER REG. III/2 (UNLIMITED)

040-31 - APPLIED MECHANICS

TUESDAY, 17 OCTOBER 2017

1315 - 1615 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used. 2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook Graph paper

APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A derrick arm of uniform cross section is 6 m long and has a mass of 5 kg/m length. It is pinned at A and has a cable attached at B as shown in Fig Q1. A vertical force of 250 N is applied at B.

   Calculate EACH of the following:

   (a) the force in the cable; (8)

   (b) the reaction force in magnitude and direction at the pin. (8)

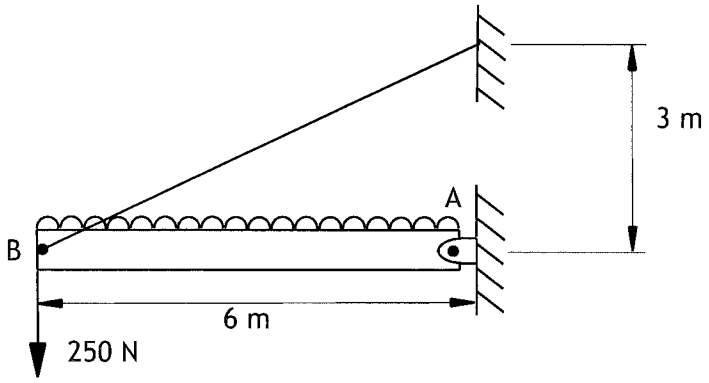

Fig Q1

2. A body rests on an incline of 12°. A force of 1.5 kN acting parallel to and up the plane is applied and moves the body up the incline with a constant velocity. When a force of 1.62 kN is applied to the same body but now horizontal and acting into the plane, the body also moves up the incline with a constant velocity.

   Calculate EACH of the following:

   (a) the coefficient of friction between the body and the plane; (12)

   (b) the mass of the body. (4)

3. A projectile is launched over level ground and its initial horizontal velocity component is 0.75 of the initial vertical velocity component. The maximum height reached by the projectile is 950 m.

Calculate EACH of the following:

(a) the initial projection angle relative to the horizontal; (4)

(b) the initial vertical projection velocity; (4)

(c) the time the projectile is in flight; (6)

(d) the range of the projectile. (2)

4. A lift of mass 800 kg is attached to a balance mass of 450 kg by a cable passing over a power driven drum of diameter 2.3 m and mass 200 kg. The drum has a radius of gyration of 0.75 m. At a certain instant the lift is ascending at 3 m/s but is slowing down at a rate of 0.25 m/s^2.

Calculate the driving power required at the drum at this instant. (16)

5. A four wheel truck starts from rest and travels 60 m down a 2° incline before striking a set of buffers. The truck has a total mass of 1.5 tonne, each wheel has a mass of 50 kg, diameter 600 mm and radius of gyration 200 mm. The kinetic energy of the truck is absorbed by the compression of four buffer springs, arranged in parallel, each having a stiffness of 400 N/mm.

Calculate EACH of the following:

(a) the linear velocity of the truck just before striking the buffers; (8)

(b) the compression of the springs when the truck comes to rest. (8)

6. A pile driver of mass 1 tonne moves vertically downwards with a velocity of 7 m/s to drive a post of mass 180 kg into a horizontal ground surface to a depth of 700 mm.

Calculate EACH of the following:

(a) the common velocity of the driver and post immediately after impact; (4)

(b) the percentage loss of energy at impact; (5)

(c) the average resisting force offered by the ground. (7)

7. A compound bar comprises a steel bar 300 mm long and 45 mm diameter which is joined rigidly at one end to a round brass bar 400 mm long. It is to be subjected to a tensile load.

Calculate EACH of the following:

(a) the diameter of the brass bar such that the extension of both portions of the compound bar will be the same; (11)

(b) the stress in each part of the bar when the load is 30 kN. (5)

Note: The Modulus of Elasticity for steel = 208 GN/m²
The Modulus of Elasticity for brass = 97 GN/m²

8. A solid steel shaft 190 mm diameter and 10 m long transmits an average power of 1.8 MW at a speed of 250 rev/min. The maximum torque is 1.3 times the mean torque. The solid shaft is to be replaced by a hollow shaft 200 mm outside diameter and be subject to the same torque and stress conditions as the solid shaft.

Calculate EACH of the following:

(a) the maximum stress in the shaft material; (7)

(b) the inside diameter of the replacement hollow shaft; (6)

(c) the weight saving gained by using the hollow shaft. (3)

Note: The density of steel = 7800 kg/m³

9. A worm and worm wheel lifting machine has a two start worm with 50 teeth on the worm wheel. The load drum is 187.5 mm diameter and the effort wheel is 240 mm diameter. During testing operations the following results were obtained for the effort required to lift various loads.

Effort (kN)	5.76	8.88	12	15.12	17.76	21.12	24
Load (kN)	25	50	75	100	125	150	175

(a) Draw a graph of load against effort. (6)

(b) From the graph, obtain the law of the machine. (4)

(c) Calculate the efficiency of the machine when lifting a mass of 10 tonne. (6)