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, 27 MARCH 2018

1315 - 1615 hrs

Examination paper inserts:

Worksheet Q1

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

APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A simple framework is hinged at the left hand side and rests on rollers at the right hand side and is loaded as shown on Worksheet Q1.

   Using Worksheet Q1:

   (a) label the Worksheet in accordance with Bow's notation and draw to scale the vector force diagram for the framework. Suggested scale 1 kN = 20 mm; (10)

   (b) determine the framework reactions on the hinge and rollers from the vector diagram (2)

   (c) determine the magnitude and nature of the forces in members marked P and Q from the vector diagram. (4)

2. A block of mass 250 kg rests on a plane inclined at 45°. A force *F* is applied horizontally as shown in Fig Q2. The coefficient of friction between the block and the plane is 0.3.

   Calculate EACH of the following:

   (a) the value of *F* required to just start to move the block up the plane with a constant velocity; (10)

   (b) the value of *F* required to hold the block stationary on the plane; (3)

   (c) the magnitude and direction of the friction force if *F* = 1.8 kN (3)

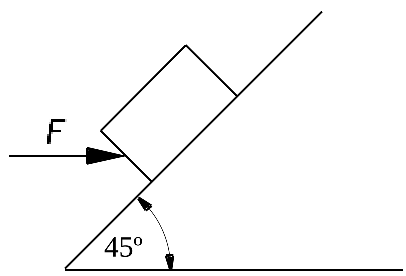

Fig Q2

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3. Two cars move from the same stationary point, the first car moves in a straight line with an acceleration of 0.45 m/s^2. The second car then follows the same path with an acceleration of 0.75 m/s^2, starting four seconds after the first car began moving.

(a) Sketch a graph of speed against time to show the motion of each car up to the point overtaking occurs and state what is common to both graphs at the point of overtaking. (3)

(b) Calculate EACH of the following:

(i) the distance the cars will have travelled when the second car overtakes the first; (10)

(ii) the speed, in km/h of EACH car when the overtaking occurs. (3)

4. A stationary flywheel of mass 300 kg has a constant torque of 1 kNm applied to it for a period of 30 seconds after which it freewheels to rest in a period of 15 minutes. The maximum speed attained by the flywheel is 40 rad/second.

Calculate EACH of the following:

(a) the radius of gyration of the flywheel about its axis; (14)

(b) the frictional torque in the bearings assuming this to be constant. (2)

5. The piston of a reciprocating engine moves with simple harmonic motion and the engine speed is 100 rev/min. When the piston is 1 m from mid stroke its velocity is 65% of its maximum velocity.

Calculate EACH of the following:

(a) the stroke of the engine; (10)

(b) the instantaneous velocity of the piston when it is 600 mm from top dead centre; (3)

(c) the maximum acceleration of the piston. (3)

6. The effort wheel of a worm and worm wheel chain block is 220 mm diameter, the worm is single start and the worm wheel has 45 teeth. The load wheel is 130 mm diameter. A load of 7 kN requires an effort of 180 N.

(a) Sketch the arrangement. (4)

(b) When lifting a load of 7 KN, calculate EACH of the following:

(i) the efficiency; (8)

(ii) the ideal effort; (2)

(iii) the effort required to overcome friction. (2)

7. A hollow cast iron shaft is to transmit a power of 750 kW at 120 rev/min. The angle of twist in the shaft is not to exceed one degree over a length of 30 times the external diameter. The ratio of the external to the internal diameters is 3:2.

Calculate EACH of the following:

(a) the minimum outside diameter for the shaft; (12)

(b) the maximum shear stress at the inner and outer surfaces of the shaft. (4)

Note: The Modulus of Rigidity for cast iron = 40 GN/m²

8. A horizontal cantilever beam has a hollow rectangular cross section, with outside dimensions 100 mm wide by 150 mm deep and inside dimensions 82 mm wide by 126 mm deep. The beam is 3 m long, has a mass of 110 kg and carries a concentrated load of 1.85 kN at its free end.

Calculate EACH of the following:

(a) the maximum stress in the beam; (10)

(b) the maximum deflection at the free end of the beam. (6)

Note: Deflection, $\delta = \frac{W\lambda^3}{3EI}$ *for a concentrated load, where W = concentrated load in newtons.*

Deflection, $\delta = \frac{w\lambda^4}{8EI}$ *for a distributed load, where w = udl in newtons per metre.*

The modules of Elasticity = 210 GN/m².

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9. A vertical steel rod welded to a heavy platform is 1.2 m long and 18 mm diameter. Twenty millimetres above the end of the rod, a mass of 100 kg becomes dislodged and falls onto the end of the rod.

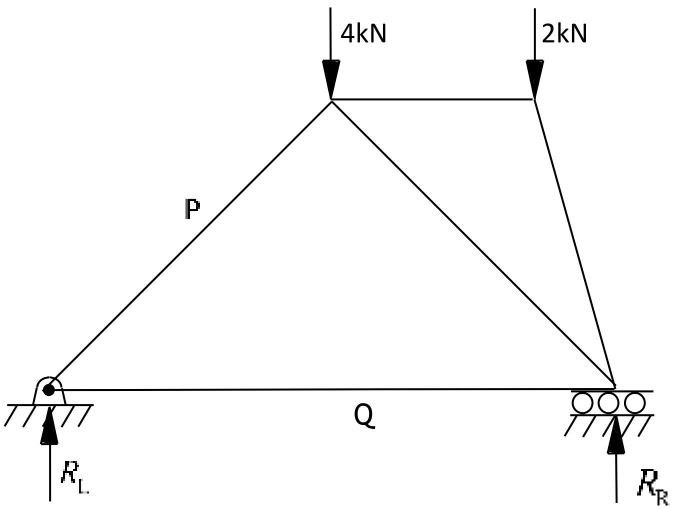
Calculate EACH of the following:

(a) the instantaneous compression of the rod; (14)

(b) the instantaneous initial stress induced into the end of the rod. (2)

Note: The Modulus of Elasticity for steel = 208 GN/m^2

(This Worksheet must be returned with your answer book)



Candidate's Name ……………………………………… Examination Centre ………………………………..………………