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, 26TH MARCH 2019

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. An oil rig is being positioned by two support vessels. Due to a localised tidal effect the system is in a state of static equilibrium in the water as illustrated in Fig Q1.

   (a) Calculate the magnitude and direction of the localised tidal effect. (12)

   (b) Explain the difference between coplanar force systems described as concurrent and parallel. (4)

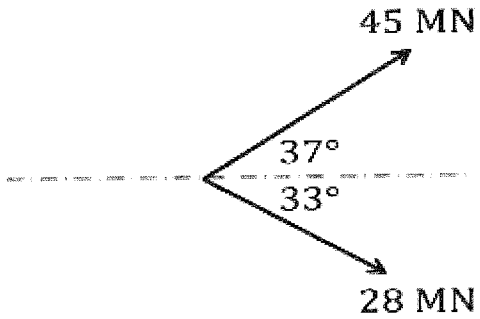

Fig Q1

2. A body can be hauled up an inclined plane at constant velocity by a 2.5 kN force applied parallel to the plane. The same body can be lowered with constant velocity by a force of 150 N applied parallel to the plane.

   If the plane rises 1 m in height for every 5 m of length:

   (a) sketch the force diagram for the body being hauled up the inclined plane; (4)

   (b) calculate the mass of the body; (8)

   (c) calculate the coefficient of friction between the contact surfaces. (4)

3. A flare is fired with an initial velocity of 500 m/s at 40° above the horizontal from level ground at the base of a slope inclined at 5° above the horizontal.

   Calculate the range of the flare as measured along the slope. (16)

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4. A gear drive consists of a 28 tooth pinion on the input shaft driving an 84 tooth wheel on the output shaft. The input shaft is 75 mm diameter, runs at a speed of 300 rpm with a maximum shear stress of 13.9 MN/m^2. The output shaft is 100 mm diameter. The efficiency of the gear drive is 90%.

Calculate EACH of the following:

(a) the speed of the output shaft; (2)

(b) the output power; (8)

(c) the maximum shear stress in the output shaft. (6)

5. A conical friction clutch, with an apex angle of 30°, transmits torque at an effective diameter of 150 mm when an axial force of 175 N is applied. The clutch connects an electric motor running at 900 rpm to a flywheel, which has a mass of 22.5 kg with a radius of gyration of 100 mm.

If the coefficient of friction between contact surfaces is 0.7, calculate EACH of the following:

(a) the maximum power transmitted from the clutch to the flywheel; (8)

(b) the time taken for the flywheel to accelerate to full speed from rest; (6)

(c) the angular impulse applied to the flywheel whilst accelerating. (2)

6. A vessel of mass 1250 tonnes is to be raised up the incline of a dry dock by a steel cable wound clockwise around a power-driven capstan. The capstan drum has a mass of 5 tonnes, an effective diameter of 3 m and a radius of gyration of 1.3 m. The capstan is driven by an electric motor via a reduction gearbox of ratio 1:48. The dry dock has an incline of 1:40 (sine) and the coefficient of friction between contact surfaces is assumed to be constant at 0.4. The velocity of the vessel increases uniformly from 0.1 m/s to 0.2 m/s in 20 seconds during the operation. The thickness of the steel cable may be neglected.

Calculate EACH of the following:

(a) the angular acceleration of the capstan drum; (4)

(b) the torque required at the capstan drum; (10)

(c) the electric motor input torque assuming there are no losses. (2)

7. Four masses m_1, m_2, m_3 and m_4 on a common axis of rotation are 20 kg, 30 kg, 24 kg and 26 kg respectively. Their radii from the centre of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m, with the angles separating the masses measured as 45°, 75° and 135°.

(a) Determine the magnitude of the balance mass if its radius of rotation is 0.2 m. (10)

(b) Calculate the angular position of the balance mass in relation to m_1. (6)

8. A hollow shaft drives a solid shaft of diameter 75 mm at a constant rotational speed of 250 rpm via a diametrically fitted shear pin as shown in Fig Q8. The output power is 11.5 kW and the maximum allowable shear stress within the pin is 70 MN/m^2.

Calculate EACH of the following:

(a) the diameter of the shear pin; (8)

(b) the minimum external diameter of the hollow drive shaft if the maximum angle of twist per unit length must not exceed 0.12°. (8)

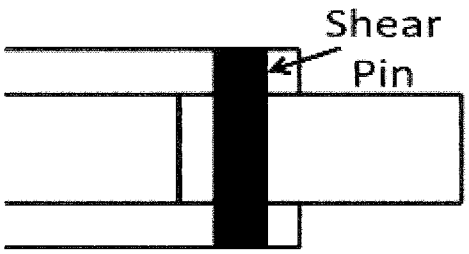

Fig Q8

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

9. A winch cable comprises a central steel wire of 7.5 mm diameter encased by six alloy wires each of 4 mm diameter. The maximum permissible stress within the alloy wires is 55 MN/m^2.

Calculate EACH of the following:

(a) the maximum load the cable can lift vertically; (10)

(b) the equivalent modulus of elasticity for the winch cable. (6)

Note: Modulus of Elasticity for steel = 205 GN/m^2
Modulus of Elasticity for alloy = 100 GN/m^2