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, 28 MARCH 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 colleges:

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 engine is being aligned on its seating using steel wedges under its base. The wedges have a taper of 3° and can be assumed to have face-to-face contact with the seating and the engine. The coefficient of friction at all surfaces is 0.4. The vertical load on EACH wedge can be assumed to be constant at 200 kN.

   Calculate EACH of the following:

   (a) the horizontal force required to drive EACH wedge in; (10)

   (b) the work input to the wedge necessary to raise the engine 3 mm and the efficiency of the operation during this movement. (6)

2. A winch drum has a mass of 800 kg and a radius of gyration of 600 mm. The winch has a single brake shoe acting on a brake drum of diameter 1.2 m. The coefficient of friction between the shoe and the drum is 0.8. Friction in the winch bearings is constant at 10 Nm.

   Calculate EACH of the following:

   (a) the normal force to be applied to the brake shoe to slow the winch down from 320 rev/min to 100 rev/min in 30 seconds; (12)

   (b) the work done by the brake in bringing the drum to rest from 320 rev/min using the brake force calculated in Q2(a). (4)

3. A cam operated valve moves vertically with simple harmonic motion. The camshaft speed is 600 rev/min and the valve is opened and closed during 160° of cam rotation. The valve travel is 100 mm and its mass is 1.8 kg. The valve opens downwards against a spring.

Calculate EACH of the following:

(a) the maximum velocity of the valve; (6)

(b) the instantaneous velocity of the valve when its displacement is 40 mm from the end of its downward travel; (2)

(c) the minimum spring force required at full opening to ensure that the valve remains in contact with the cam profile. (8)

4. A ship is test firing a towing line by the use of a rocket launcher. The rocket hits a target on land that is 80 m higher than the launcher and 540 m away horizontally. The rocket hits this target 7.2 seconds after being fired. Neglect air resistance on the rocket or towing line.

Calculate EACH of the following:

(a) the elevation of the rocket launcher; (7)

(b) the speed of the rocket as it leaves the launcher; (2)

(c) the speed of the rocket as it hits the target; (4)

(d) the angle of the rocket as it hits the target. (3)

5. A steel shaft is 3 m long and has an outside diameter of 100 mm. The shaft is solid for 1 m of its length and hollow for the remainder with an inside diameter of 50 mm. The shaft is fixed at both ends and a torque of 30 kNm is applied at the junction of the solid and hollow sections.

Calculate the maximum torsional shear stress in the shaft material. (16)

6. A four ram hydraulic steering gear is to have a maximum rudder angle of 35° either side of midships. The rams are 300 mm diameter and the distance between the centreline of the rams and the centre of the rudder stock is 1.5 m. The rudder stock has a diameter of 400 mm and the yield torsional shear stress in the rudder stock material is 320 MN/m^2. To avoid damage to the rudder stock, a safety coefficient of 4 is applied.

Calculate EACH of the following:

(a) the maximum torque which can be applied to the rudder stock; (6)

(b) the required pressure relief valve setting on the hydraulic rams. (10)

7. The two side walls of a boiler are supported by solid bar stays to prevent excessive movement. Each stay is 50 mm diameter, 10 m long and supports a wall area of 0.5 m^2. The boiler internal pressure is 6 bar.

Calculate EACH of the following:

(a) the stress in the stay; (4)

(b) the strain energy in the stay; (4)

(c) the strain energy in a hollow stay of the same length and external diameter but with an internal diameter of 20 mm. (8)

Note: Modulus of Elasticity of stay material = 190 GN/m^2

8. A 2 kg sphere hangs from a 1.5 m long cord as shown in Fig Q8. The sphere is released and strikes a stationary block of mass 5 kg before rebounding back through an angle of 15°.

Calculate EACH of the following:

(a) the speed at which the sphere strikes the block; (5)

(b) the speed at which the block starts to move; (8)

(c) the total loss of kinetic energy from the impact. (3)

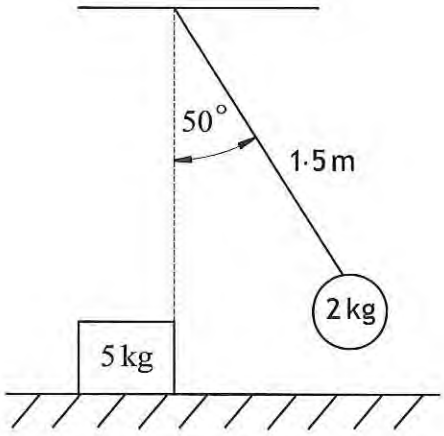

Fig Q8

9. A conical friction clutch has a semi-apex angle of 15° and transmits torque at an effective diameter of 120 mm. An axial force of 160 N is applied to the clutch and the coefficient of friction at the contact surfaces is 0.7.

The clutch is used to connect an electric motor running at 720 rev/min to a flywheel of mass 14 kg and radius of gyration 120 mm.

Calculate EACH of the following:

(a) the maximum power which can be delivered through the clutch at the motor speed; (8)

(b) the time taken to accelerate the flywheel from rest to full speed; (5)

(c) the angular impulse given to the flywheel during the period of acceleration assuming maximum clutch torque is applied. (3)