# 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 95 CHIEF ENGINEER REG. III/2 (UNLIMITED)

**041-31 – APPLIED MECHANICS**

**TUESDAY, 15 OCTOBER 2013**

**1315 - 1615 hrs**

Examination paper inserts:

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Notes for the guidance of candidates:

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| 1. Non-programmable calculators may be used.<br><br>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:

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| Candidate's examination workbook<br>Graph paper |

**APPLIED MECHANICS**

**Attempt SIX questions only**

**All questions carry equal marks**

**Marks for each part question are shown in brackets**

1. A valve is fitted with two concentric close coiled helical springs, each having the same free length and made of the same material. The outer spring has 18 coils, mean diameter 110 mm and wire diameter of 9 mm. The inner spring has 22 coils of mean diameter 70 mm.

   Each spring is to have the same shear stress when the combined springs are compressed.

   Calculate EACH of the following:

   (a) a suitable wire diameter for the inner spring; (10)

   (b) the stiffness of the combined springs. (6)

   *Note: Modulus of Rigidity of Spring Material = 70 GN/m$^2$*

2. Fresh water flows through a horizontal pipeline at a rate of 600 tonnes per hour. A bend in the pipeline turns the water through 45° and is tapered from 180 mm diameter at the inlet to 140 mm diameter at the outlet.

   Calculate EACH of the following:

   (a) the magnitude and direction of the force on the bend due to the change of momentum of the water; (12)

   (b) the differential pressure across the bend. (4)

3. A solid steel column of 400 mm$^2$ square cross section and 1.8 m long is fixed at both ends and carries a compressive axial load. When the yield stress is applied to a 100 mm test specimen of the same material, the compression is measured at 0.14 mm.

Calculate EACH of the following:

(a) the critical load using Euler's relationship; (12)

(b) the ratio of the yield compressive stress to the critical stress. (4)

*Note: The Yield Compressive Stress limit = 320 MN/m$^2$*

$$For\ fixed\ ends\ Pc = \frac{4\pi^2 EI}{L^2}$$

4. The stepped steel shaft shown in Fig Q4 is to transmit a torque. The larger section of the shaft is to have a hole drilled in it to a depth of 80 mm.

Calculate EACH of the following:

(a) the diameter of the drilled hole *d* that would make the maximum stress in the hollow part of the shaft equal to that in the 30 mm diameter section; (8)

(b) the length of the 30 mm section if the total angle of twist for the shaft is to be 0.02 radians when a torque of 360 Nm is applied. (8)

*Note: Modulus of Rigidity for shaft material = 80 GN/m$^2$*

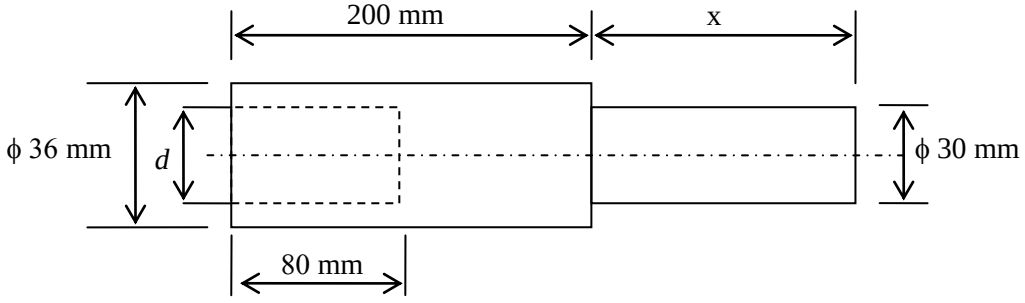


Fig Q4

5. When a mass is suspended vertically from a helical spring, the length of the spring is found to increase by 60 mm. The mass is pulled down 40 mm below its position of rest and then released. The arrangement can be assumed to move with Simple Harmonic Motion.

Calculate EACH of the following:

(a) the time taken for one complete oscillation of the mass; (6)

(b) the acceleration of the mass when it is 12 mm from its highest point; (6)

(c) the velocity of the mass when it is 12 mm from its highest point. (4)

6. A 5 m long ladder of uniform cross-section with a mass of 25 kg is placed with its base on the ground and resting against a pipe 1.8 m from the top of the ladder as shown in Fig Q6. The ladder makes an angle of 60° to the horizontal and the coefficient of friction is 0.3 at all surfaces. A person of mass 70 kg is to ascend the ladder.

(a) Redraw the arrangement showing all of the forces. (4)

(b) Calculate the highest point up the ladder that the person of mass 70 kg can ascend without the ladder slipping. (12)

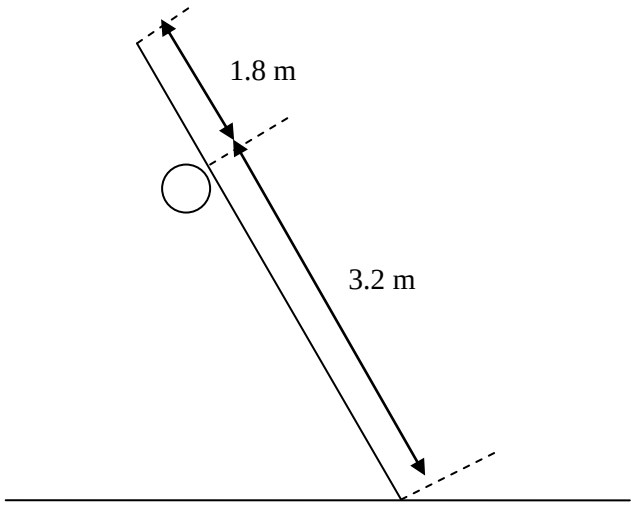


Fig Q6

7. A vertical gate valve is used to regulate the flow from a pipeline of 360 mm diameter. The moving parts of the valve have a mass of 80 kg and the coefficient of friction between the valve and its guides is 0.2. On one side of the valve there is a static head of fresh water to a height of 6 m above the centre of the pipe. On the other side of the valve the pipeline is empty.

Calculate EACH of the following:

(a) the position of the centre of pressure on the valve; (8)

(b) the upward vertical force required to open the valve. (8)

8. An engine runs at 720 rev/min and has two connecting rods attached to a single crank-pin *A* as shown in Fig Q8. The longitudinal axis of each cylinder is inclined at 30° to the vertical and the stroke for each piston is 480 mm. The connecting rod length is 600 mm. The crank-pin is 60° before its top position and moving clockwise.

Determine EACH of the following:

(a) the instantaneous linear velocity of piston X; (8)

(b) the instantaneous linear velocity of piston Y. (8)

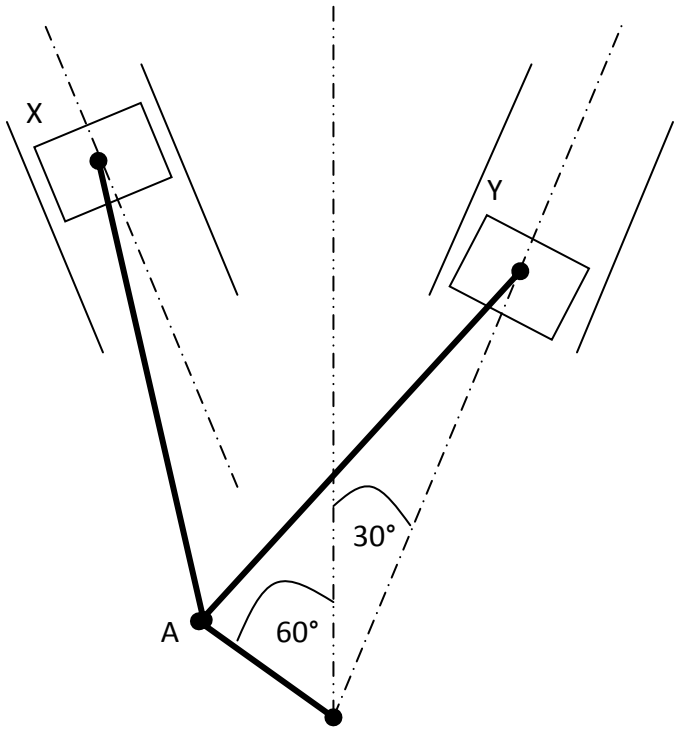


Fig Q8

9. A conical friction clutch has a semi-apex angle of 20° and transmits torque at an effective diameter of 200 mm. An axial force of 300 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 140 mm.

Calculate EACH of the following:

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

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

(c) the angular impulse given to the flywheel during the period of acceleration. (2)