

**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 14 DECEMBER 2010**

**1315 - 1615 hrs**

Examination paper inserts:

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Notes for the guidance of candidates:

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| <ol style="list-style-type: none"><li>1. Non-programmable calculators may be used.</li><li>2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.</li></ol> |
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Materials to be supplied by colleges:

Candidate's examination workbook Graph paper
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## APPLIED MECHANICS

Attempt SIX questions only

All questions carry equal marks

Marks for each part question are shown in brackets

1. A truck of mass 18 tonnes is pulled up an incline of 1 in 40 by a wire wound round the drum of a winch. The effective length of the incline is 420m and frictional resistance to motion is constant at 100N/tonne. The winch drum has a mass of two tonne, a diameter of 1.8m and a radius of gyration of 0.8m. The tension in the wire is not to exceed 12kN.

Calculate EACH of the following:

- (a) the shortest time in which the truck, starting from rest, can ascend the incline; (8)
- (b) the torque required at the drum. (8)

2. A compound shaft consists of two sections of the same material arranged in series and is required to transmit 16kW at 80 rev/min. Section A is solid of outside diameter 60mm and length 120mm. Section B is hollow with a concentric hole 70% of the outside diameter. The angle of twist is to be the same for each section. The torsional stress in section A is 150% of that in section B.

Calculate EACH of the following:

- (a) the outside diameter of section B of the shaft; (8)
- (b) the length of section B; (5)
- (c) the maximum shear stress in both sections of the shaft. (3)

3. A steel rod is 280mm long with a diameter of 28mm. It is firmly attached at one end to a copper rod of length 580mm. When the combined assembly is subjected to a tensile pull of 40kN, the extensions of the steel and copper portions are found to be equal.

Calculate EACH of the following:

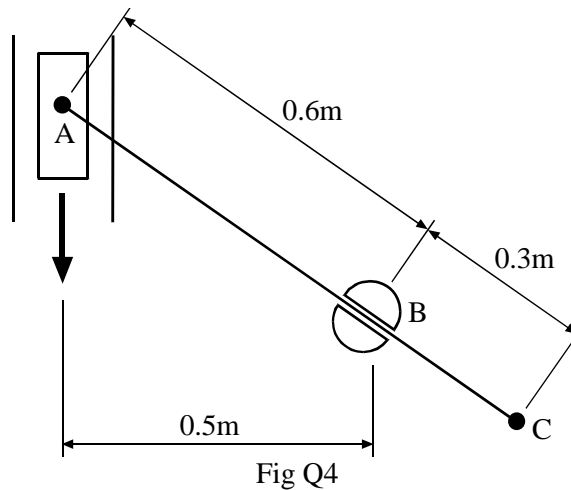
- (a) the diameter of the copper rod; (4)
- (b) the stress in each rod; (4)
- (c) the total extension; (4)
- (d) the work done in straining the assembly. (4)

Note: Modulus of Elasticity for Steel =  $210 \text{ GN/m}^2$   
 Modulus of Elasticity for Copper =  $90 \text{ GN/m}^2$

4. A slider swivel mechanism is shown in Fig Q4. At the instant shown, block A is moving vertically down at 1.8m/s. The bar AC passes through a fixed swivel bearing fitted at point B.

Determine EACH of the following:

- (a) the angular velocity of the bar AC; (8)
- (b) the absolute velocity of point C. (8)



5. In a four-ram hydraulic steering gear the centre line of the rams is 0.9m from the centreline of the rudder stock. The diameter of the rams is 280mm and the diameter of the rudder stock is 390mm.

When in the mid-ships position, the rudder is struck by a heavy sea which causes the relief valves of the ram cylinders to operate. The relief valves are set to operate at  $4\text{MN/m}^2$ .

Calculate EACH of the following:

- (a) the maximum shearing stress imposed on the rudder stock; (12)
- (b) the percentage increase in shearing stress imposed on the rudder stock if the relief valves are set at  $4.2\text{MN/m}^2$ . (4)
6. A circular flap valve AB of 1.8m diameter is hinged at A to close an opening in the sloping side of a fresh water storage tank as shown in Fig Q6. The hinge at A is 1.2m vertically below the surface of the water.

Calculate EACH of the following:

- (a) the hydrostatic force on the valve; (6)
- (b) the distance to the line of action of this thrust, measured vertically from the surface of the water. (10)

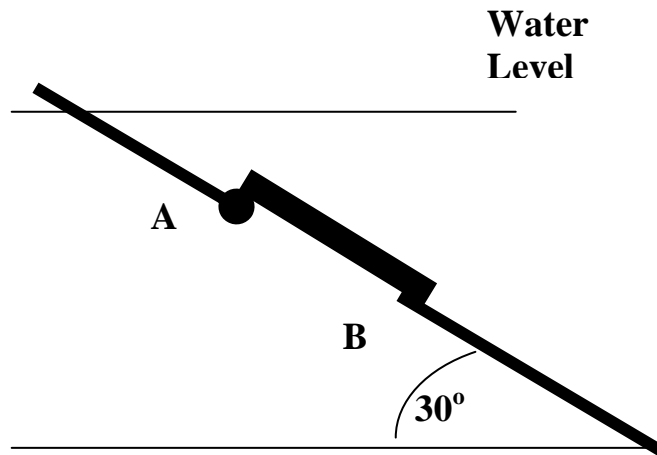


Fig Q6

7. A centrifugal pump has an impeller with an inlet diameter of 240mm and an outlet diameter of 600mm. The impeller rotates at 600 rev/min and has a flow rate of 550 tonnes of fresh water per hour. Water flow at entry is radial and the radial velocity through the impeller can be assumed constant. The impeller width at entry is 55mm and the vane exit angle is  $40^\circ$ .

Calculate EACH of the following:

- (a) the width of the impeller at the outlet; (3)
- (b) the whirl velocity at outlet; (5)
- (c) the angle of the outlet diffuser vanes for shockless entry; (2)
- (d) the theoretical pump head; (3)
- (e) the theoretical pump power. (3)

8. A starter motor with eight teeth engages with a flywheel rim having 128 teeth. The starter motor pinion mass is 10kg with a radius of gyration of 0.1m and the engine rotational mass is 400kg with an effective radius of gyration of 0.5m. The engine must be accelerated to 320 rev/min from rest in 8 seconds.

Calculate EACH of the following:

- (a) the angular acceleration of the starter motor; (4)
- (b) the average driving power required by the starter motor. (12)

9. The operating arrangement for a hydraulic ram used to operate a watertight door is shown in Fig Q9. A spool valve is operated to supply or drain hydraulic fluid to either side of the hydraulic ram. The system is filled with an incompressible fluid, which can be supplied to the door at a pressure of 9 bar and at a rate of  $75 \text{ cm}^3/\text{sec}$ . The back pressure in the drain system can be taken as 0.8 bar.

The ram diameter is 5.8 cm and the piston rod has a diameter of 1.3 cm. The door moves 1.1 metre during opening or closing.

Calculate EACH of the following:

- (a) the force available to close the door; (4)
- (b) the force available to open the door; (3)
- (c) the maximum closing speed of the door; (3)
- (d) the time taken for the door to close; (3)
- (e) the maximum volumetric delivery rate if the door must take more than 20 seconds to close. (3)

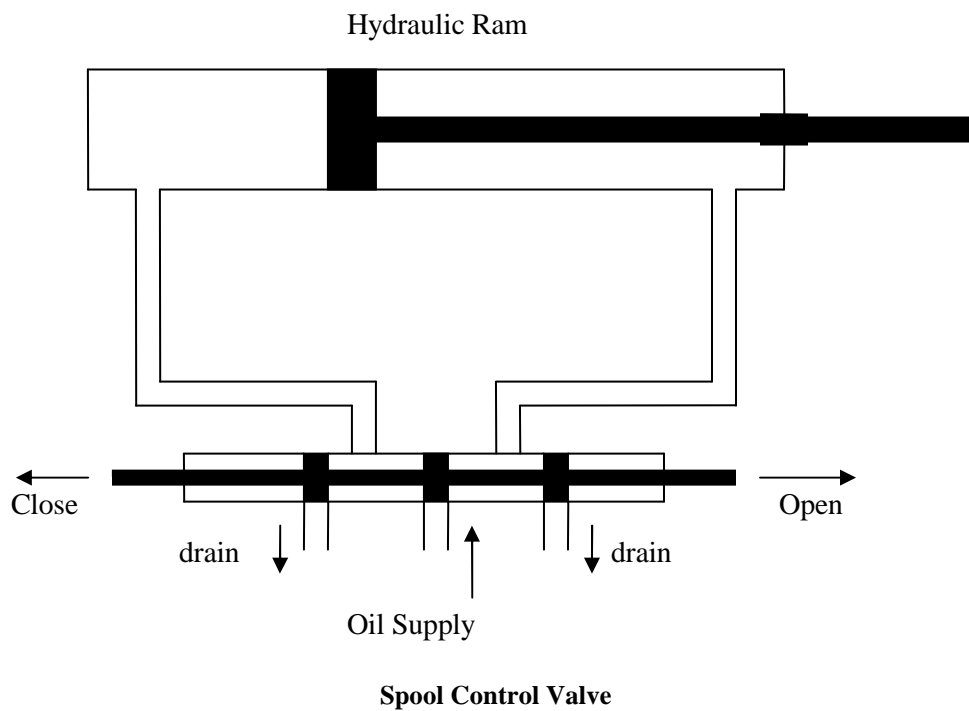


Fig Q9