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 26 MARCH 2013

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. A steel shaft is 650 mm long and 48 mm diameter. It transmits a power of 20 kW at a speed of 120 rev/min. The shaft is to have a hole of 25 mm diameter bored axially from one end. The angle of twist between the ends of the shaft is not to exceed 1.5°.

   Calculate EACH of the following:

   (a) the maximum depth to which the hole can be bored; (12)

   (b) the maximum torsional shear stress in the shaft. (4)

   Note: Modulus of Rigidity = 80 GN/m^2.

2. A high voltage cable, 220 m long, consists of 24 strands of 3 mm diameter aluminium wire and eight strands of 4 mm diameter steel wire. It is subject to a tensile force of 16 kN.

   Calculate EACH of the following:

   (a) the stress in EACH material; (12)

   (b) the extension of the cable. (4)

   Note: Modulus of Elasticity for Steel = 190 GN/m^2
   Modulus of Elasticity for Aluminium = 68 GN/m^2

3. A body rests on a plane inclined at 20 degrees above the horizontal. A force of 1600 N acting parallel to, and up the plane just causes the body to move up the incline. A horizontal force of 2400 N will also cause the same body just to move up the incline.

   Calculate EACH of the following:

   (a) the coefficient of friction between the body and the incline; (12)

   (b) the mass of the body. (4)

[OVER

4. A basic flapper/nozzle device is shown in Fig Q4. The pneumatic signal for the input bellows unit is proportional to the measured temperature within the range 0-100°C. The output signal range is to be 20-100kN/m^2.

The characteristic of the input bellows is 10 μm/°C, and the characteristic of the nozzle is 0.2kN/m^2 per μm of flapper movement.

$$The\ gain\ of\ the\ device = \frac{\%\ change\ in\ output}{\%\ change\ in\ input}$$

Calculate EACH of the following:

(a) the flapper movement at the nozzle for 100% input change; (2)

(b) the resulting change in output; (2)

(c) the gain of the device; (2)

(d) the new setting of *x*, the distance from the pivot to the nozzle, to achieve a gain of 0.7; (5)

(e) the output pressure at 90°C with a gain of 0.7 if the output pressure was 50 kN/m^2 at a temperature of 80°C. (5)

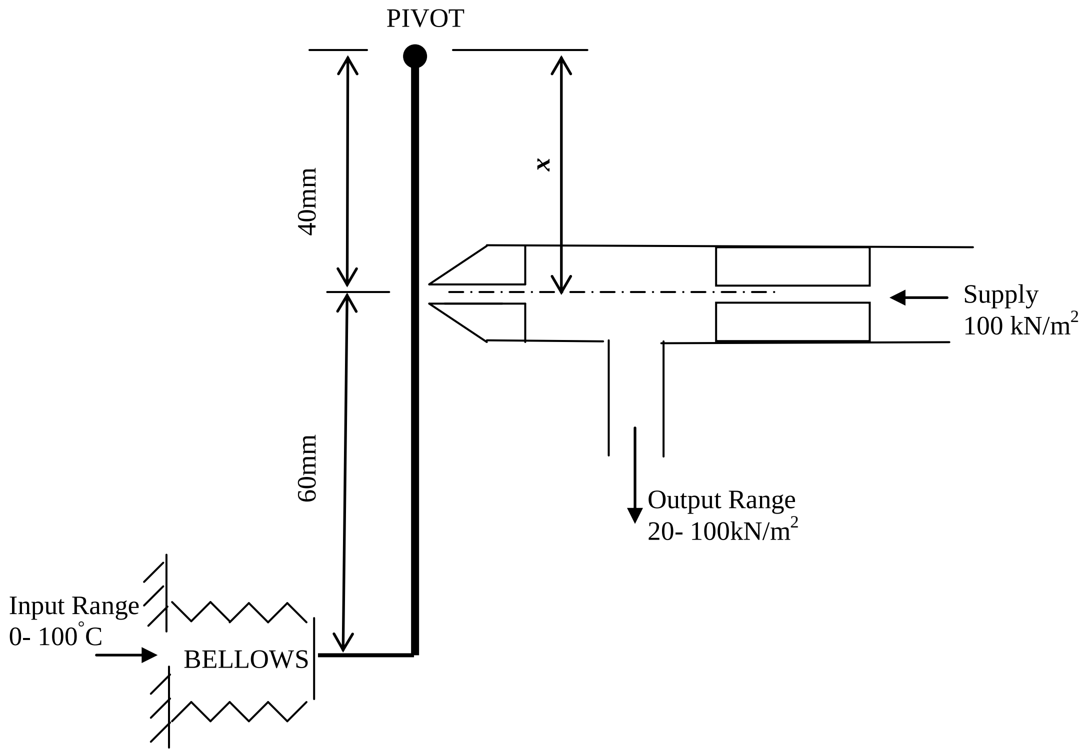

Fig Q4

5. A starter motor with 24 teeth engages with a flywheel rim having 384 teeth. The rotating parts of the starter motor have a mass of 12 kg with a radius of gyration of 0.1 m and the engine rotational mass is 700 kg with an effective radius of gyration of 0.5 m. The engine must be accelerated to 200 rev/min from rest in 6 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)

6. A hollow square section beam of external dimension 200 mm, and thickness 10 mm, is loaded as shown in Fig Q6.

Calculate EACH of the following:

(a) the maximum stress due to shear in the beam; (6)

(b) the point of contraflexure. (10)

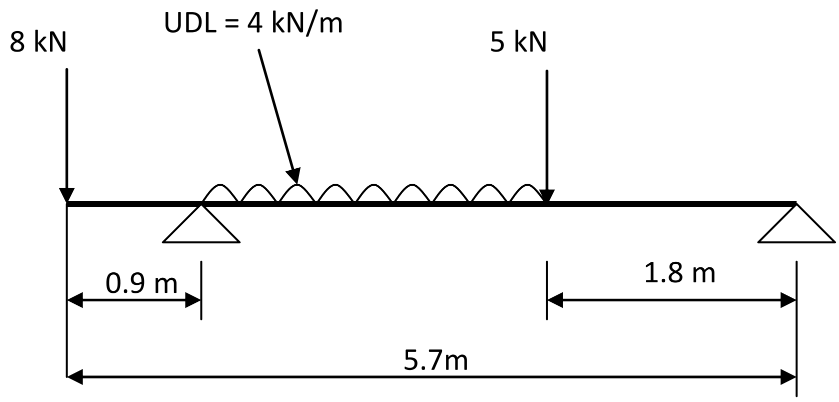

Fig Q6

[OVER

7. A single plate clutch with both sides effective has an outside diameter of 400 mm and an inside diameter of 180 mm. The clutch is designed to transmit 20 kW at 720 rev/min when new. In this condition the coefficient of friction between the clutch contact surfaces can be assumed to be 0.6.

Once the clutch starts to wear and the surfaces become contaminated, the maximum power that the clutch can transmit will be reduced. The axial thrust on the clutch faces is provided by eight identical springs placed in parallel, each with a spring stiffness of 16 kN/m. Maximum wear of the clutch plates is limited to 0.6 mm at each contact surface.

Calculate EACH of the following:

(a) the total spring load (W) required when the clutch is new; (8)

(b) the minimum coefficient of friction of the worn clutch plates if 80% of the original maximum power can be transmitted. (8)

Note: *For constant pressure* $T = \frac{2\mu NW(r_1^3 - r_2^3)}{3(r_1^2 - r_2^2)}$

For constant wear $T = \frac{\mu NW(r_1 + r_2)}{2}$

N = Number of surfaces in contact.

8. An oil tank is 5 m high and of square cross section with vertical sides 3 m wide. The tank contains oil to a depth of 4 m and the air space above the oil is pressurised to 70 kN/m^2. The relative density of the oil is 0.9.

Calculate EACH of the following:

(a) the theoretical velocity at which the oil would escape from the base of the tank; (4)

(b) the total force on one side of the tank; (6)

(c) the position of the resultant centre of pressure on one side of the tank. (6)

9. A centrifugal pump delivers 800 tonne of sea water per hour. The impeller has an inlet width of 120 mm and an exit diameter of 480 mm. When running at 720 rev/min the radial flow velocity of the water is constant at 3m/s and the absolute velocity at exit is 12 m/s.

Calculate EACH of the following:

(a) the impeller diameter at inlet; (5)

(b) the inlet angle of the impeller vanes for shock-less flow; (5)

(c) the exit angle of the impeller vanes for shock-less flow. (6)

Note: Density of sea water = 1025 kg/m^3