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 December 2015

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 truck of mass 18 tonnes is pulled up an incline of sine 1 in 40 by a wire wound around the drum of a winch. The effective length of the incline is 420 m and frictional resistance to motion is constant at 100 N/tonne. The winch drum has a mass of 2 tonnes, a diameter of 1.8 m and a radius of gyration of 0.8 m. The tension in the wire is not to exceed 12 kN.

   Calculate EACH of the following:

   (a) the shortest time in which the truck, starting from rest, can ascend the incline; (8)

   (b) the driving torque required at the drum. (8)

2. Two masses are connected by a wire passing over a light, smooth pulley as shown in Fig Q2. The coefficient of friction between the masses and the inclines is 0.2.

   When the masses are released from rest, calculate EACH of the following:

   (a) the acceleration of the masses; (10)

   (b) the tension in the cable; (3)

   (c) the time taken for the masses to move 10 m. (3)

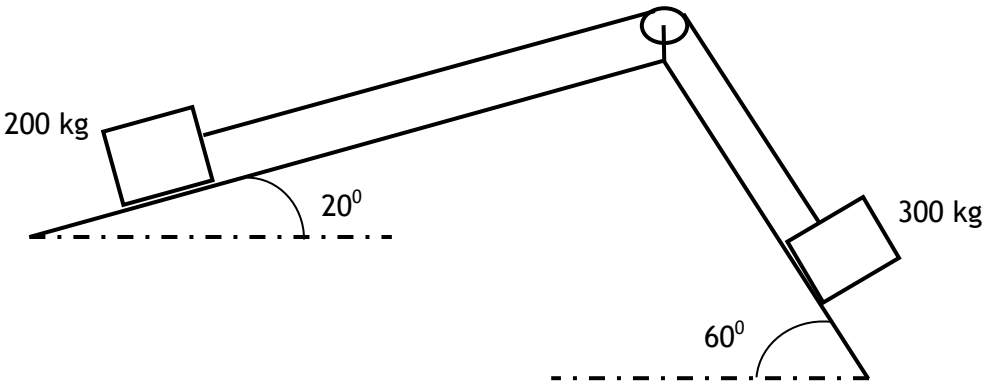

Fig Q2

3. An engine of total moment of inertia 180 kgm^2 drives a propulsion shaft by means of a clutch. The propulsion shaft has a diameter of 180 mm and a mass of 4 tonne. Before the clutch engages, the engine is rotating at 300 rev/min and the shaft is stationary. The engine is capable of delivering 550 Nm of torque.

Calculate EACH of the following:

(a) the common speed of the engine and shaft after the clutch engages; (6)

(b) the time taken for the engine and shaft to reach this common speed (the time of slip); (3)

(c) the angular impulse received by the shaft due to the clutch engagement; (4)

(d) the time taken for the engine and shaft to regain the original speed of 300 rev/min after the time of slip if the torque remains constant at 550 Nm. (3)

Note: For a solid shaft the radius of gyration (k) is $\frac{r}{\sqrt{2}}$

4. A speedboat has an initial velocity when it is then subjected to a constant acceleration. During the acceleration period it travels a distance of 60 m in 5 seconds and then a further 110 m in the next 5 seconds.

(a) Sketch the velocity – time graph that represents this accelerated motion. (3)

(b) Calculate EACH of the following:

(i) the acceleration of the speedboat; (8)

(ii) the initial and final velocities of the speedboat. (5)

5. A valve is fitted with two close coiled helical springs, each of the same material and with the same free length.

The outer spring has 14 coils, mean diameter 120 mm and wire diameter 8 mm. The inner spring has 20 coils of wire diameter 5 mm.

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

Calculate EACH of the following:

(a) the mean coil diameter of the inner spring; (10)

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

Note: Modulus of Rigidity for spring material = 70 GN/m^2

6. A solid steel shaft of 80 mm diameter is connected to a hollow steel shaft by a shear pin of 10 mm diameter fitted diametrically through the solid and hollow shafts. The inside diameter of the hollow shaft is 80 mm. The shear stress in the pin must not exceed 60 MN/m^2.

Calculate EACH of the following:

(a) the maximum power that can be transmitted at a speed of 300 rev/min; (8)

(b) the minimum outside diameter of the hollow shaft so that its angle of twist does not exceed 0.1^0 per metre length when transmitting the maximum power. (8)

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

7. An "I" section beam is loaded as shown in Fig Q7.

Calculate EACH of the following:

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

(b) the maximum bending moment on the beam; (6)

(c) the maximum bending stress in the beam. (4)

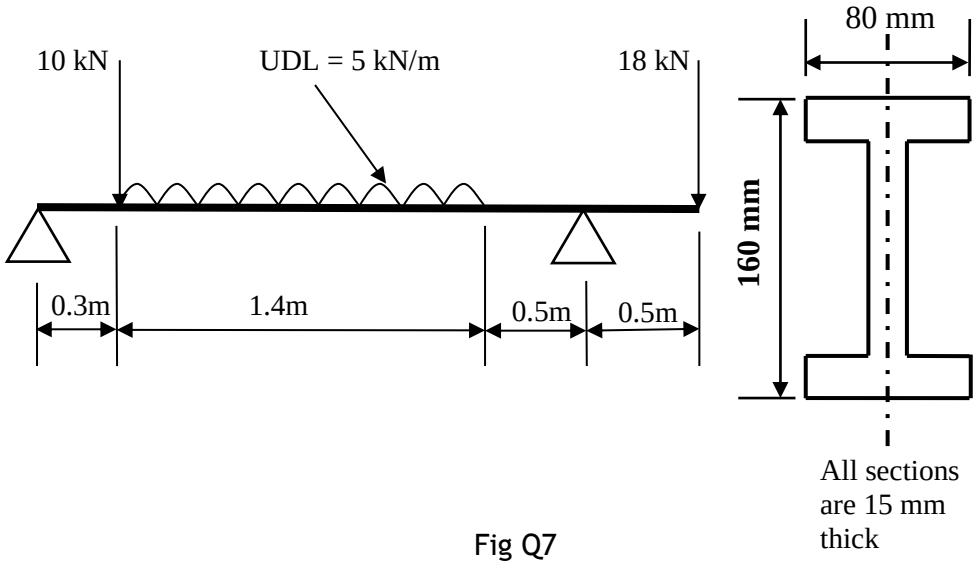

Fig Q7

8. A tank 3 m wide contains fresh water to a depth of 2 m. Oil of depth 1.2 m floats above the fresh water.

Calculate EACH of the following:

(a) the total hydrostatic force acting on the vertical tank wall; (6)

(b) the position of the resultant centre of pressure above the tank base; (6)

(c) the equivalent depth of fresh water alone that would exert the same force on the vertical wall as the TWO liquids combined. (4)

Note: Density of the oil = 780 kg/m^3

9. A Venturi meter having an inlet diameter of 60 mm and a throat diameter of 30 mm is used to measure the upward vertical flow of fresh water in a pipeline. The throat of the Venturi is 160 mm above the inlet and a differential pressure device connected to these points gives a reading equivalent to 250 mm head of fresh water. The Venturi coefficient is 0.95.

Calculate the mass flow rate of fresh water in tonnes per hour. (16)