INSTITUTION OF ENGINEERS, SRI L[illegible]A

PART I EXAMINATION – OCTOBER 2010

106 – APPLIED MECHANICS

Time allowed: Three Hours **Date:** October 2010

Before answering the question paper, read and adhere to the instructions given below.

This question paper has **two sections**, **SECETION A** and **SECTION B**. Answer **five (05)** questions only selecting **at least** two **(02)** questions from each section.

- All questions carry equal marks.
- Start answering each question from a new page. Write the relevant question No. on the starting page of the question.
- **It is extremely important that you write the question No. to which you answer appropriately in the cage appearing on the cover page**
- **Aanswers should be presented with relevant Units**. You should answer in SI Units only.
- Strike out any rough work and contents that you do not wish to draw the attention of the examiner.
- Wherever relevant, use free hand sketches to explain your answer. All calculations and analyses should be clearly presented and any symbol should be defined before use.
- Use density of water as 1,000 kg/m3, specific gravity of mercury as 13.6 and acceleration due to gravity as 10 m/s2, unless otherwise specified.
- **Marks will be deducted if the above instructions are not adhered to.**

SECTION A

Question 1

(a) Explain the following:

i) Impulse force

ii) Impulse momentum principle

iii) D'Alambert principle

(b) A person of mass 60 kg stands at one end of a 6 m long boat of mass 240 kg, which floats in water. When the boat is stationary, the person starts walking straight across to the other end at a steady rate of 1.2 m/s. Determine:

i) The velocity of the boat as observed by an observer on the ground during this process.

ii) The distance by which the boat is shifted during the period the person walks from first to the other end.

iii) The velocity of the boat if the person stops at the other end.

iv) The velocity of the boat if the person, while walking, falls out of the boat at the other end.

Question 2

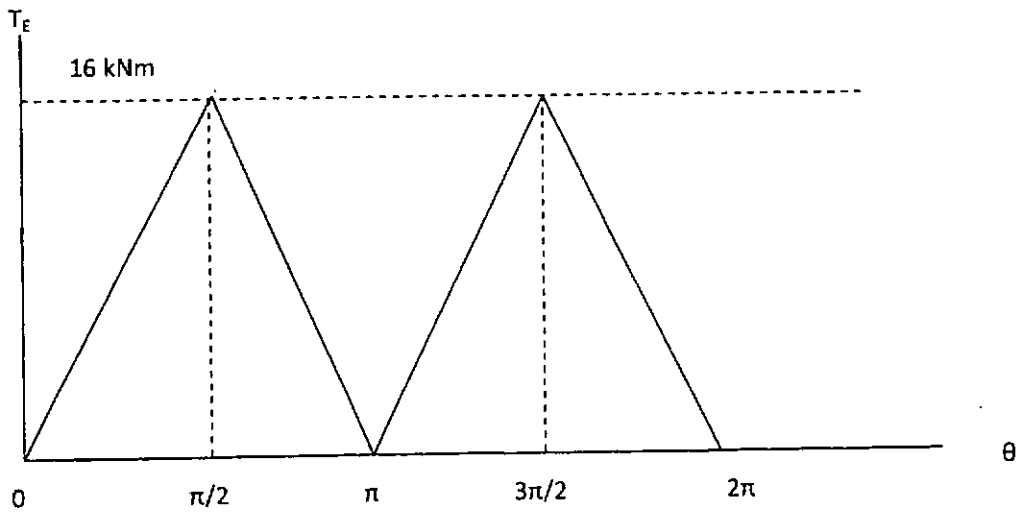

Figure Q2 (a)

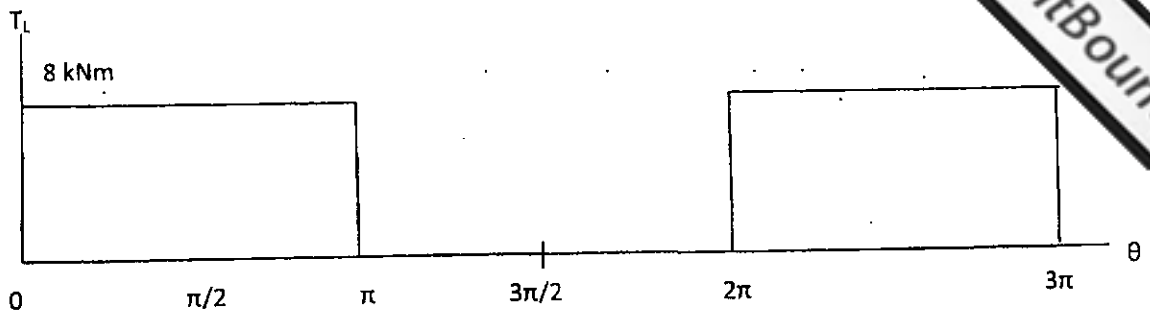

Figure Q2 (b)

(a) Explain Inertia force and Inertia torque.

(b) The turning moment diagramme shown in Figure Q2 (a) is developed by a double acting single cylinder sream engine, which rotates at 130 rev/min. The mass of the flywheel is restricted to cause a speed fluctuation of ±1.8% of the mean speed. The load on the engine is repetitive as in Figure Q2 (b). If the flywheel has a radius of gyration of 1.1 m, determine the power developed by the engine and the mass of the flywheel.

Question 3

Crank OA of the link mechanism shown in Figure Q3 is 125 mm long and rotates clockwise with a uniform velocity of 180 rev/min. The link AC, which is 600 mm long, slides in a swivel pin at B. The end C slides on a swinging link DE. For the configuration shown in the figure the angle BOA is 120^0. Draw the link mechanism for the given configuration to an appropriate scale. Use graphical method and find the velocity and acceleration of the link DE. Use graph papers.

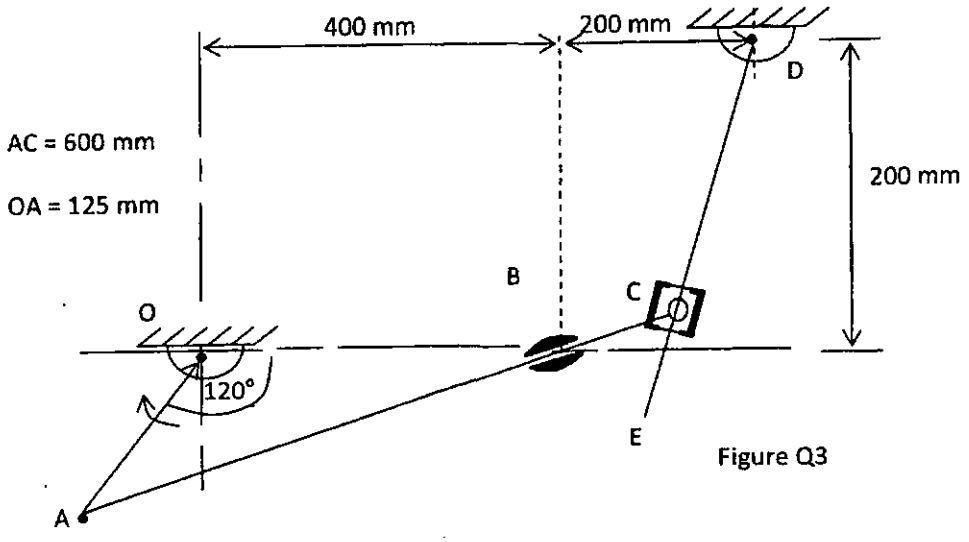

Figure Q3

Question 4

(a) A screw jack with a square thread with helical angle α and friction angle λ is used to lift a vertical load W. If the load is to be sustained, show that $\alpha < \lambda$.

(b) A differential screw jack is shown in Figure Q4. The part B, which has a right handed square thread with 9.5 mm pitch on a 57 mm mean diameter, is screwed to the nut fitted in base C. The part A, which is prevented from rotation, carries a right handed square thread with 6 mm pitch on a 30 mm mean diameter. It is screwed into part B. If the coefficient of friction of each thread is 0.15, find the torque necessary to be applied on B to raise a load of 5 kN.

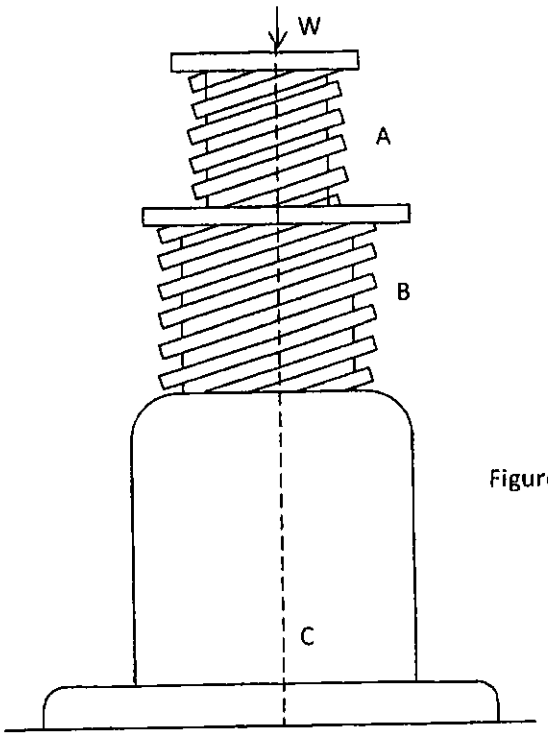

Figure Q4

Question 5

(a) Explain briefly the following:

i) Free vibration
ii) Damped vibration
iii) Forced vibration

(b) A mass of 10 kg is connected at the end C of arm ABC with angle ABC being 90° supported at C by a vertical spring having a stiffness of 5 N/mm. The arm, which is pivoted at B, is connected at the end A to a horizontal spring with stiffness 10 N/mm damping system with unknown damping coefficient. This arrangement is shown in Figu Q5.

i) Starting from first principles set up the equation of motion for small angular displacements of the mass C. Show clearly the derivation of the equation.

ii) If the system is critically damped, what should be the damping coefficient?

iii) If the damping ratio is reduced to 0.5, explain the response of mass C for small angular displacements.

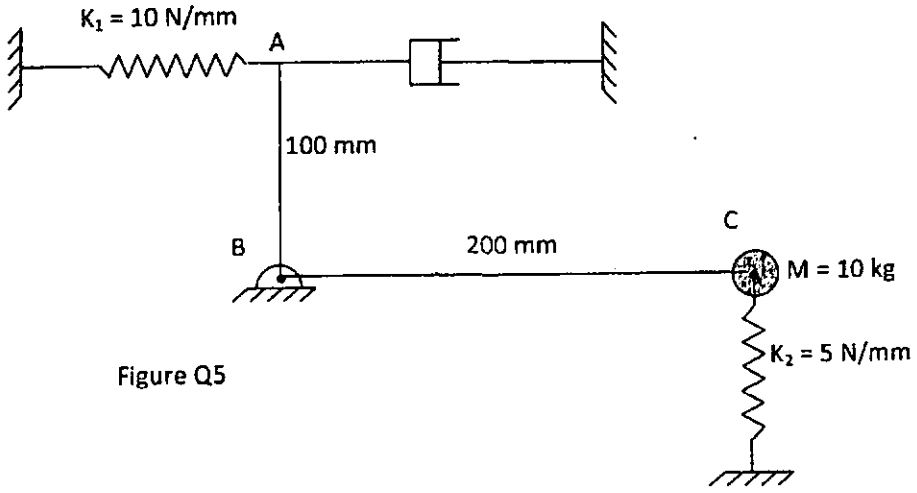

Figure Q5

SECTION B

Question 6

(a) What is Coefficient of Velocity (C_v) for an orifice?

(b) The rectangular tank shown in Figure Q6 has two identical orifices one vertically below the other on the same side of the tank. The lower orifice is 3 m below, whereas the other is 1.5 m below the water surface. The water level of the tank is maintained at a constant height. Determine the point at which the two water jets will intersect each other if the coefficient of velocity (C_v) is 0.02 for both orifices.

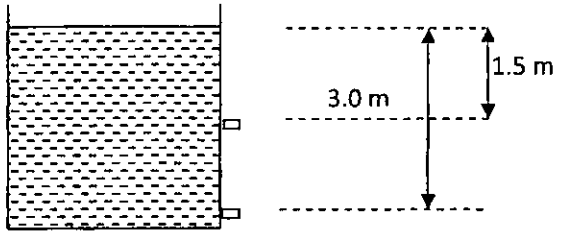

Figure Q6

Question 7

(a) Illustrate the application of venturimeter to measure the rate of discharge in a pipeline when the pipe line is

i) horizontal

ii) vertical

(b) A U tube mercury differential manometer has been used to measure the pressure differential across the inlet and throat of a venturimeter that conveys water. Calculate the pressure difference in kPa when

i) Venturimeter is laid horizontally and manometer reads 250 mm.

ii) Venturimeter is laid vertically, inlet lies 200 mm above the throat and manometer reads 100 mm.

Question 8

(a) Explain the principle of momentum which is an useful tool in solving problems in fluid mechanics.

(b) A pipe bend placed in a vertical plane tapers from 500 mm section at inlet to 250 mm diameter at outlet. An oil of density 9,000 kg/m^3 enters the reducing bend and turns through 45^0 in the clockwise direction following the profile of the pipe bend, which is shown in Figure Q3. When the oil flows at the rate of 0.45 m^3/s and the pressure at the inlet is 140 kN/m^2, determine the magnitude and direction of the resultant force on the bend.

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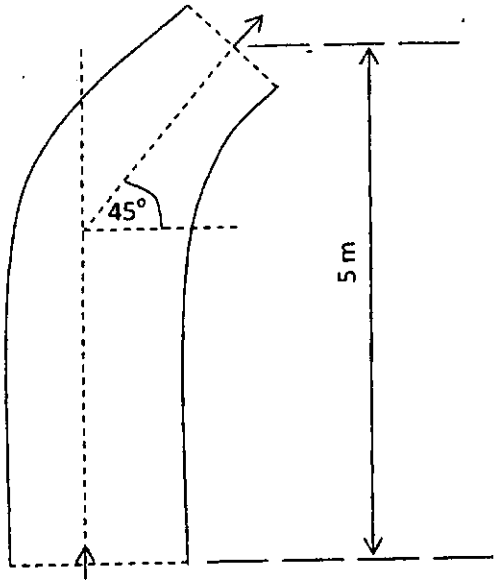

Figure Q3

Question 9

(a) Derive Darcy-Weisbach formula for calculating loss of head due to friction in a pipe. Define clearly any symbols used and state any assumptions.

(b)

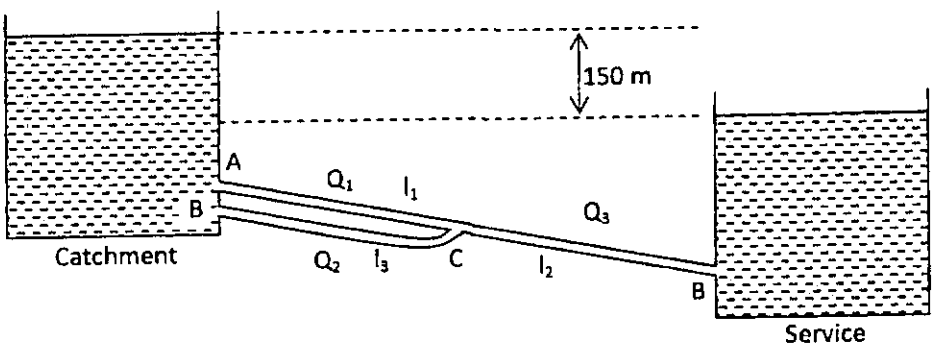

Figure Q2

(36)

(a) A Catchment area and a service reservoir, which supply water to a town, lie 65 km apart have a difference of 150 m in their water levels as shown in Figure Q9. These two reservoirs are connected by a single pipe AB that can carry 0.3 m^3/s of water. Calculate the diameter of the pipe.

Subsequently it was required to increase the flow rate between the two reservoirs by another 0.15 m^3/s. This was achieved by laying a second pipe BC of the same diameter in parallel over a part length of the pipe AB. Find the necessary length of the second pipe. Consider only friction losses of pipes and for each pipe f (Darcy Coefficient) = 0.008.

Question 10

(a) An inclined plane surface is immersed in a liquid. Starting from first principles derive an expression for the depth of centre of pressure from the surface of the liquid. Define clearly any symbols used.

(b) The tank shown in Figure Q10 has a square opening 1.2 m x 1.2 m, which is closed by a square door of same size. The door edge shown in the elevation has an inclination of 60^0 to the horizontal, while it is hinged to the tank along the edge A. The tank contains oil with specific gravity of 0.8 under a pressure and the gauge indicates a pressure of 23.5 kN/m^2. This condition is maintained by a force F applying perpendicular to the door along the edge B. Determine the following:

i. Total oil pressure applied on the door,

ii. Magnitude of the force F

iii. Hinge reaction.

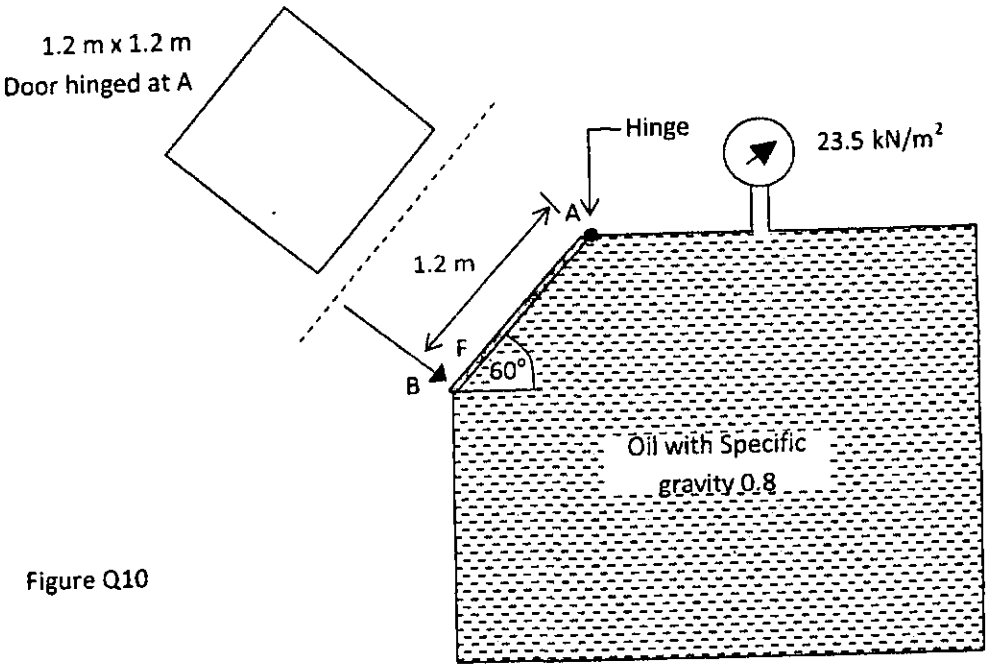

Figure Q10

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