NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF SECOND SEMESTER EXAMINATIONS – JUNE 2010
MECHANICAL ENGINEERING – SCH 2205
TIME: 3 HOURS

Instructions to candidates

Answer any five (5) Questions. Each question carries 20 marks.

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1. (a) Define the following quantities giving their appropriate units:

    (i) Shear stress [2]

    (ii) Young's modulus [2]

   (b) State and explain two equilibrium conditions, giving the corresponding equation. [4]

   (c) Two round rods, one steel and the other brass, are joined end to end. Each rod is 0.500m and 2.00cm in diameter. The combination is subjected to a tensile force with magnitude 4000N. For each rod, what is:-

    (i) The strain. [2]

    (ii) The elongation. [2]

    (iii) The Young's Modulus [4]

   (ii) Draw a stress- strain graphs for the two rods on the same axis. [4]

2. (a) At the instant the traffic light turns green, an Automobile starts with a constant acceleration **a** of $2.2 m/s^2$. At the same instant a truck traveling with a constant speeds of 9.5m/s, overtakes and passes the Automobile.

    (i) How far beyond the traffic signal will the car overtake the Automobile? [4]

    (ii) How fast will the car be traveling at that instant. [4]

(iii) Plot a well labeled velocity- time graph for the two on the same axis. [4]

(b) A car travels 20.0km due North and then 35.0km in the direction 60.0^0 west of north. Find the magnitude and direction of the car's resultant displacement. [4]

(c) Show that the following equation is dimensionally consistent.

$P + 1/2\rho v^2 + \rho gy$ = a constant

Where;-

ρ = density, v = velocity, g = acceleration; p = pressure; y = height [4]

3. (a) There is 0.600kg of 190 proof alcohol in each 0.750L bottle. Flowing as an idealized fluid in a pipe, this alcohol has a mass flow rate that will fill 160 of these bottles per minute. At point two in the pipe, the gauge pressure is 152kPa and the cross section area is $8.00cm^2$. At point one 1.81m above point two, the cross sectional area is $2.00cm^2$. Find:-

(i) Mass flow rate [2]

(ii) Volume flow rate [2]

(iii) The speeds at point 1 and 2. [2]

(iv) Gauge pressure at point 1. [2]

(b) A 40kg box initially at rest is pushed 5.0m along a rough horizontal floor with a constant applied horizontal force of 130N. If the coefficient of friction between box and floor is 0.30. Find:-

(i) The work done by the applied force. [2]

(ii) The energy loss due to friction. [2]

(iii) The change in kinetic energy of the box. [4]

(iv) The final speed of the box. [4]

4. (a) A nylon tennis string on a racquet is under tension of 250 N. If it has a diameter of 1.00 mm, by how much is it lengthened from its un-tensioned length of 30.0cm? (Young's modulus for nylon is 5×10^9 N/m^2). [2]

(b) A Puck of mass 0.5kg moves along the **x** axis with a velocity of 4.00m/s. It collides elastically with another stationary Puck. After the collision the first Puck moves with a velocity of 2.00m/s making an angle **α** with the horizontal. The other Puck makes an angle **β** below the horizontal and moves at a velocity V_2.

(i) Find V_2 and [5]

(ii) α and β [6]

(c) A 3.0kg mass starts from rest and slides a distances **d** down a frictionless 30^0 incline, where it contacts an unstressed spring of negligible mass. The mass slides an additional 0.20m as it is brought momentarily to rest by compressing the spring (k = 400N/m). Find the initial separation **d** between mass and spring. [7]

5. (a) Ethanol has a density $\rho = 791 kg/m^3$ and it flows smoothly through a horizontal pipe that tapers in cross sectional area from $A_1 = 1.20 \times 10^{-3} m^2$ to $A_2 = A_1/2$. The pressure difference between the wide and narrow sections of pipe is 4120Pa. What is the volume flow rate R_v of the ethanol? [5]

(b) A ball is shot from the ground into air. At a height of 9.1m its velocity is:-

$\mathbf{V} = [7.6\mathbf{i} + 6.1\mathbf{j}]$ m/s.

(i) To what maximum height does the ball rise? [3]

(ii) What total horizontal distance does the ball travel [4]

(iii) What is the magnitude and direction of the velocity just before touching the ground [4]

(c) Consider two vectors **A** = 3**i** – 2**j** and **B** = -i – 4**j.** Calculate:

(i) A + B [2]
(ii) A – B [2]

6. (a) A 5.0kg block is set into motion up an inclined plane with an initial speed of 8.00m/s. The block comes to rest after travelling 3.0m along the plane, which is inclined at an angle of 30^0 to the horizontal.

Determine:-

(i) The change in the block's kinetic energy. [4]

(ii) The change in its potential energy. [4]

(iii) The frictional force exerted on it (assumed to be constant. [4]

(b) An unstable nucleus of mass 17 x 10^{-27} kg initially at rest disintegrates into three particles. One of the particles, of mass 5.0 x 10^{-27} kg, moves along the **y** axis with a speed of 6.0 x 10^{6}m/s. Another particle, of mass 8.4 x 10^{-27} kg moves along the **x** axis with a speed of 4.0 x 10^{6}m/s. Find:

(i) The velocity of the third particle. [4]

(ii) The total energy given off in the processes. [4]

7. (a) A 3.70kg mass rest on a rough inclined plane (μ_k= 0.5) that makes an angle 30^0 to the horizontal and is connected to a vertically suspended mass of 2.30kg through a frictionless pulley. What are:-

(i) The magnitude of the acceleration of each block [3]

(ii) The direction of acceleration of hanging block [2]

(iii) The tension in the cord [2]

(b) You throw a ball towards a wall with a speed 25.0m/s and at an angle 40^0 above the horizontal. The wall is 22m from release point of the ball.

(i) How far above the release point does the ball hit the wall? [4]

(ii) What are the horizontal and vertical components of its velocity as it hits the wall. [4]

(iii) When it hits the wall has it passed the highest point on its trajectory? [4]

END OF QUESTION PAPER!!!!!