NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF SECOND SEMESTER EXAMINATIONS – APRIL 2014
MECHANICAL ENGINEERING – SCH 2205
TIME: 3 HOURS

INSTRUCTIONS TO CANDIDATES
Answer any five (5) Questions. Each question carries 20 marks.
Total Marks – 100

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1. (a) Define the following concepts with illustrative diagrams:
   (i) Dot product. [2]
   (ii) Vector product. [2]

   (b) The period **T** of a simple pendulum is measured in time units and is given by:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

   Where **L** is the length of pendulum and **g** is the free fall acceleration.
   (i) Show that the equation is dimensionally correct. [2]
   (ii) Describe briefly how you would accurately use the above equation to determine the height of a tall building. [5]

   (c) An inquisitive mechanical engineering student climbs a 50.0m cliff that overhangs a calm pool of water. She drops two stones vertically downward 1.00s apart and observes that they cause a single splash. The first stone has an initial velocity of 2.00m/s.
   (i) At what time after release of the first stone do the two stones hit the water? [2]
   (ii) What initial velocity must the second stone have if they are to hit the water simultaneously? [3]
   (iii) What is the velocity of each stone at the instant they hit the water? [4]

2. (a) Define the following terms:
   (i) projectile motion. [1]
   (ii) Derived quantity. [1]

   (b) A projectile is fired in such a way that its horizontal range is equal to three times its maximum height. What is the angle of projection? [3]

   (c) A car is parked overlooking the ocean on an incline that makes an angle of 37.0^0 with the horizontal. The distance from where the car is parked to the bottom of the incline is 50.0m, and the incline terminates at a cliff that is 30.0m above the ocean surface. The negligent driver leaves the car in neutral, and the parking brakes are defective. If the

car rolls from rest down the incline with a constant acceleration of $4.00 m/s^2$.

Find:

(i) The speed of the car just as it reaches the cliff and the time it takes to reach there. [5]

(ii) The velocity of the car just as it lands in the ocean. [4]

(iii) The total time the car is in motion. [4]

(iv) The position of the car relative to the base of the cliff just as it lands in the ocean. [2]

3. (a) Define the following terms:

(i) stress. [1]

(ii) strain. [1]

(iii) Young's modulus. [1]

(b) A block of mass m =20 kg is released from rest h=0.5m from the surface of a table, at the top of a 30^0 inclined plane. The incline is fixed on a table of height H =2.0m, and the incline is frictionless.

(i) Determine the acceleration of the block as it slides down the incline. [5]

(ii) What is the speed of the block as it leaves the incline? [2]

(iii) How far from the table will the block hit the floor? [2]

(iv) How much time has elapsed between when the block is released and when it hits the floor ? [4]

(v) Does the mass of the block affect any of the above calculation? [4]

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

Find:

(i) The velocity of the third particle. [6]

(ii) The total energy given off in the processes. [3]

(b) Ethanol has a density $\rho = 791 kg/m^3$ 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 Rv of the ethanol? [6]

(c) (i) A water hose 2.00cm in diameter is used to fill a 20.0 liter bucket. If it takes 1.00min to fill the bucket, what is the speed v at which the water leaves the hose? [3]

(ii) If the diameter of the hose is reduced to 1.00cm, what will the Speed of the water be as it leaves the hose, assuming the same flow rate? [2]

5. (a) State and explain the following:
   (i) continuity equation. [4]
   (ii) Bernoulli equation. [4]

   (b) Oil flows through a pipe in which the pipe contracts from 450mm diameter at A to 300mm diameter at B and then forks. One branch with, 150mm diameter, discharges at C and the other branch 225mm diameter discharges at D. If the velocity at A is 1.8m/s and the velocity at D is 3.6m/s.
      (i) What will be the discharge at C? [2]
      (ii) What will be the discharge at D? [2]
      (iii) What will be the velocity at B? [2]
      (iv) What will be the velocity at C? [2]

   (c) State the equilibrium conditions of a rigid body. [4]

6. (a) Define the following terms:
   (i) Torque. [1]
   (ii) Elastic collision. [1]
   (iii) Inelastic collision. [1]

   (b) A neutron in a reactor makes an elastic head on collision with the nucleus of a carbon atom initially at rest. Mass of carbon is about 12 times the mass of neutron
      (i) What fraction of neutron's kinetic energy is transferred to the carbon nucleus? [4]
      (ii) If the initial kinetic energy of the neutron is 1.6×10^{-13} J, find its final kinetic energy and the kinetic energy of the carbon after the collision. [4]

   (c) A 12kg block is released from rest on a 30^0 frictionless incline. Below the block is a spring that can be compressed 2.0cm by a force of 270N. The block momentarily stops when it compresses the spring by 5.5cm.
      (i) How far does the block move down the incline from its rest position to the stopping point? [6]
      (ii) What is the speed of the block just as it touches the spring? [3]

7. (a) State the work energy theorem giving the relevant equation. [4]

   (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. [4]
      (ii) The energy loss due to friction. [4]
      (iii) The change in kinetic energy of the box. [4]
      (iv) The final speed of the box. [4]

End of Examination!!!!!!!!!!!