NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

MECHANICAL ENGINEERING

SCH 2205

Supplementary Examination Paper

July 2016

This examination paper consists of 6 pages

Time Allowed: **3 hours**
Total Marks: **100**
Special Requirements: Scientific Calculator
Examiner's Name: Dr. P. Baricholo

INSTRUCTIONS TO CANDIDATES

Answer ANY FIVE questions. Each question carries 20 marks.
Make use of clear sketches where necessary.

MARK ALLOCATION

QUESTION	MARKS
1.	**20**
2.	**20**
3.	**20**
4.	**20**
5.	**20**
6.	**20**
7.	**20**
TOTAL POSSIBLE MARKS	**100**

CONSTANTS

Acceleration due to gravity, g $= 9.81\ ms^{-2}$

Gravitational Constant G $= 6.67 \times 10^{-11}\ Nm^2kg^{-2}$

1. a) Ethanol has a density ρ = 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 $A_2 = 0.5A_1$. The pressure difference between the wide and narrow sections of pipe is 4120 Pa. What is the volume flow rate R_v of the ethanol? [4]

   b) A ball is tossed from an upper story window of a building. The ball is given an initial velocity of 8.00 m/s at an angle of 20.0^0 below the horizontal. It strikes the ground 3.00 s later.

      i. How far horizontally from the base of the building does the ball strike the ground? [3]

      ii. Find the height from which the ball was thrown. [4]

      iii. How long does it take the ball to reach a point 10.0m below the level of launching? [4]

   c) A particle initially located at the origin has an acceleration of $\vec{a} = 3.00\hat{j}$ m/s^2 and an initial velocity of $\vec{v_i} = 5.00\hat{\imath}$ m/s. Find

      i. the position vector and velocity at any time *t*. [2]

      ii. the coordinates and speed of the particle at *t* = 2.00 s. [3]

2. a) Show that the following equation is dimensionally consistent.

$$P + \frac{1}{2}\rho v^2 + \rho g y = a\ constant$$

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

   b) Define the following terms giving the appropriate S.I. unit for each

      i. Viscosity [1]

      ii. Young's Modulus, [2]

      iii. Stress [2]

      iv. Strain [1]

   c) Figure 1 represents the total acceleration of a particle moving clockwise in a circle of radius 2.50 m at a certain instant of time.

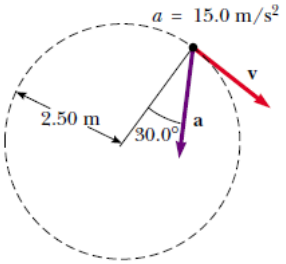

Figure 1.

At this instant, find

i. the radial acceleration, [1]

ii. the speed of the particle, and [2]

iii. its tangential acceleration. [2]

d) A rubber ball is dropped onto the floor. What force causes the ball to bounce? [2]

e) If the action and reaction forces are always equal in magnitude and opposite in direction to each other, then doesn't the net vector force on any object necessarily add up to zero? Explain your answer. [3]

3. a) Define elastic and inelastic collision. State the quantities that are conserved, and those that are not conserved in the two types of collisions. [6]

b) A force $\vec{F} = (30\hat{\imath} - 40\hat{\jmath})N$ acts on an object which undergoes a displacement $\vec{s} = (-9.0\hat{\imath} - 3.0\hat{\jmath})m$. Calculate the work done by the force $\vec{F}$ on the object during this displacement. [4]

c) A golf ball rolls off a cliff with an initial velocity of 2.50 m/s in the horizontal direction, and falls a vertical distance H into the lake below, as shown in Figure 2. The horizontal range of the ball is R= 5.55 m. Ignore air resistance.

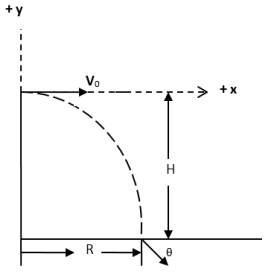

Figure 2

i. Calculate H. [4]

ii. Determine the magnitude and direction of the velocity of the ball just before it strikes the water. (Express the direction in terms of an angle θ relative to the horizontal) [4]

iii. A 50.0 kg woman balances on one heel of a pair of high heeled shoes. If the heel is circular and has a radius of 0.500 cm, what pressure does she exert on the floor? [2]

4. a) Draw a well labeled stress- strain diagram for a material of your choice. Explain the meaning of all important terms on the graph. [4]

   b) Explain the meaning of the following terms:

      i. Elastic collision [2]

      ii. Internal energy [2]

      iii. Temperature [2]

   c) State the four assumptions of an ideal fluid flow? [4]

   d) An unopened can of diet cola floats when placed in a tank of water, whereas a can of regular cola of the same brand sinks in the tank. What do you suppose could explain this behaviour? [4]

   e) A 50.0 kg woman balances on one heel of a pair of high heeled shoes. If the heel is circular and has a radius of 0.500 cm, what pressure does she exert on the floor? [2]

5. a) Water flows through a fire hose of diameter 6.35 cm at a rate of 0.0120 m^3/s. The fire hose ends in a nozzle of inner diameter 2.20 cm. What is the speed with which the water exits the nozzle? [2]

   b) Figure 2 shows a claw hammer as it is being used to pull a nail out of a horizontal board.

Figure 2.

If a force of 150 N is exerted horizontally as shown, find

i. the force exerted by the hammer claws on the nail and [4]

ii. the force exerted by the surface on the point of contact with the hammer head. Assume that the force the hammer exerts on the nail is parallel to the nail. [4]

c) State the work energy theorem giving the relevant equation. [3]

d) i. What do you understand by a conservative and a non-conservative force? [2]

ii. State the characteristic of the work done by a conservative force. [2]

e) A 3.0 kg 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 0.20 m as it is brought momentarily to rest by compressing the spring (k = 400 N/m). Find the initial separation **d** between mass and spring. [3]

6. a) A water pipe having a 2.5 cm inside diameter carries water into the basement of a house at a speed of 0.90 m/s and a Pressure of 170 kPa. If the pipe tapers to 1.2 cm and rises to the second floor 7.6 m above the input point, what are?

i. The speed [5]

ii. The water pressure at the second floor? [5]

b) 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? [4]

7. a) State and explain the following:

i. continuity equation. [4]

ii. Bernoulli equation. [4]

b) Draw a well labelled stress- strain diagram for a material of your choice. Explain the meaning of all important terms on the graph. [6]

c) A pitcher throws a ball at an angle of 37^o with the horizontal and observes that the ball stays in the air for 2.5 s before hitting the ground. Neglecting, air friction and the height of the pitcher.

Find:

i. The initial speed of the ball. [3]

ii. The maximum height reached by the ball. [3]

END OF EXAMINATION!!!!