NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY

MECHANICAL ENGINEERING

SCH 2205

Second Semester Examination Paper

May 2016

This examination paper consists of 7 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.

CONSTANTS

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

Gravitational Constant G = 6.67 x 10^{-11} Nm^2kg^{-2}

MARK ALLOCATION

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

1. a) Suppose that the three fundamental standards of the metric system were length, *density,* and time rather than length, *mass,* and time. The standard of density in this system is to be defined as that of water. What considerations about water would you need to address to make sure that the standard of density is as accurate as possible? [3]

   b) A jet plane lands with a speed of 100 m/s and can accelerate at a maximum rate of -5.00 m/s^2 as it comes to rest.

      i. From the instant the plane touches the runway, what is the minimum time interval needed before it can come to rest? [2]

      ii. Can this plane land on a small tropical island airport where the runway is 0.800 km long? [5]

   c) A student determined to test the law of gravity for himself walks off a skyscraper 275 m high, stopwatch in hand, and starts his free fall. Five seconds later, Superman arrives at the scene and dives off the roof to save the student. Assume that Superman's acceleration is that of any freely falling body.

      i. What must Superman's initial velocity be in order that he catch the student just before the ground is reached? [5]

      ii. What must be the height of the skyscraper so that even Superman can't save him? [5]

2. a) 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 $\overrightarrow{v_i} = 5.00\hat{\imath}$ 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]

   b) An archer shoots an arrow with a velocity of 45.0 m/s at an angle of 50.0° with the horizontal. An assistant standing on the level ground 150 m downrange from the launch point throws an apple straight up with the minimum initial speed necessary to meet the path of the arrow.

      i. What is the initial speed of the apple? [3]

ii. At what time after the arrow launch should the apple be thrown so that the arrow hits the apple? [2]

b) 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.

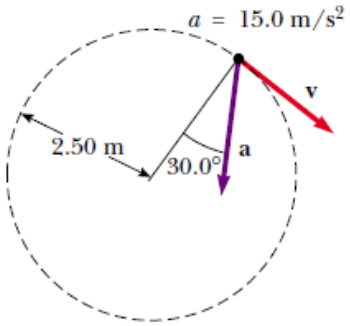

Figure 1.

At this instant, find

i. the radial acceleration, [1]

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

iii. its tangential acceleration. [2]

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

d) 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) A crate of mass 10.0 kg is pulled up a rough incline with an initial speed of 50m/s. The pulling force is 100 N parallel to the incline which makes an angle of 20^o with the horizontal. The co efficient of kinetic friction is 0.400 and the crate is pulled 5.00 m.

i. How much work is done by the gravitational force on the crate? [2]

ii. Determine the increase in the internal energy due to friction. [2]

iii. How much work is done by the 100N force on the crate? [2]

iv. What is the change of the kinetic energy on the crate? [2]

v. What is the speed of the crate after being pulled 5.00m? [2]

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

c) Explain the meaning of the following terms:

i. Elastic collision [2]

ii. Internal energy [2]

iii. Temperature [2]

4. a) Define the following terms:

i. Young's modulus [2]

ii. Poisson ratio [2]

b) A 1 mm diameter manganese bronze test specimen was subjected to an axial tensile load, and the following data were obtained.

Gauge length	10 mm
Final gauge length	12.25 mm
Load at proportional limit	18.50 N
Elongation at proportional limit	0.016 mm
Maximum load	55.00 N
Load at rupture	42.00 N
Diameter at rupture	0.845 mm

Calculate the following the following:

i. Proportional limit. [2]

ii. Modulus of elasticity. [2]

iii. Ultimate strength. [2]

iv. Percentage elongation. [1]

v. Percentage reduction in area. [1]

vi. Indicated rupture strength. [2]

vii. True rupture strength. [2]

(b) A solid shaft 5 m long is stressed at 80 MPa when twisted through 4^{o}, using G = 83 MPa.

i. Compute the shaft diameter. [2]

ii. What power can be transmitted by the shaft at 20 Hz? [2]

5. a) State the four assumptions of an ideal fluid flow? [4]

b) 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]

c) 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]

d) 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]

e) 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]

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

b) A 40 kg box initially at rest is pushed 5.0 m along a rough horizontal floor with a constant applied horizontal force of 130 N. 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]

7. 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 [4]

ii. The water pressure at the second floor? [4]

b) Write down an expression for the work energy system for a non-conservative system. [2]

c) 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]

d) 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. [3]

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

END OF EXAMINATION!!!!