CHUKA   **UNIVERSITY**

UNIVERSITY EXAMINATIONS

SECOND YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE (MATHEMATICS)

MATH 223: MECHANICS 1

STREAMS:BSC(GEN)   **TIME: 2 HOURS**

DAY/DATE: THURSDAY 14/12/2017   **2.30 P.M – 4.30 P.M**

INSTRUCTIONS:
- **Answer question one (compulsory) and any other two questions.**
- **Adhere to the instructions in the answer booklet.**

1.   (a) A particle moving in a straight line with constant acceleration travels 10m in the first second and 15m in the second. Find its initial velocity and acceleration.   [4marks]

(b) The velocity of a hockey ball before and after being struck by a stick are

$$\begin{pmatrix} 6 \\ 15 \\ 10 \end{pmatrix} ms^{-1} \quad \text{and} \begin{pmatrix} 12 \\ -9 \\ 1 \end{pmatrix} ms^{-1}$$

Respectively. If the ball weighs 1.5kgs and the contact lasts for 2 seconds .calculate the magnitude of the average force between the stick and the ball.   [4marks]

(c) A shopper in a supermarket pushes a cart with a force 35N directed at an angle of 25° downwards from the horizontal. Find the work done by the shopper on the cart as the shopper moves along as on length of aisle.   [3marks]

 (d) A 75 kg cart is pushed along a horizontal surface . After the cart is pushed a distance of 4.5 starting from vest its speed is 6.0 m/s. Find the magnitude of the net force on the cart.   [4marks]

(e) A rain cloud contains 2.66 x 10^7 kg of water vapour. How long would it take for a 2.0kw pump to raise the same amount of water to the cloud's attitude of 2 km.

[4marks]

(f) A footballer kicks a ball towards the goal 30m away with a velocity of $\binom{25}{8}$ m/s. The cross bar is 2.5m above the ground . Neglecting any effects by the goalkeeper does the footballer score? [4marks]

(g) Determine the acceleration due to gravity ;

(i) For an air plane flying at an attitude of 10km. [2marks]

(ii) A shuttle at 300km. [2marks]

Take G =6.67 x $10^{-11} m^3$/kg/5^2 month = 5.98 x 10^{24} kg

Rearth = 6.37 x 10^6m

(l) Acrave lifts a 2.5 x 10^3 kg beam vertically upwards with a force of 28 +35^2) KNa. Determine the speed of the beam when it has risen through 5 =3m take g = 9.81 m/s^2.

[3marks]

2.   (a) A butchery throws a cut of beef on spring scales which oscillates about the equilibrium position with a speed of T= 0.500 s. The amplitude of the vibration is A= 2.00 cm. Calculate.

(i) Frequency [1mark]

(ii) Maximum velocity . [2marks]

(iii) The equilibrium of motion as a function of time if the displacement is A at t = 0.
[2marks]

(b) One end of a light inextensible string x metres ling is fixed and a particle od mass mkg is attached t the other end. The particle is released from rest when the string is stout and horizontal.

(i) Show   that the speed of the particle when the spring angle to the horizontal is given

by; $V = \sqrt{2gl \cos\left(\frac{\pi}{2} - \theta\right)}$ [4marks]

(ii) Show that the maximum velocity of the particle occurs when the string is vertical.
[3marks]

(iii) Given that the spring is 60m. Find the speed of the particle when the string makes an angle of 30° to the horizontal and the maximum speed of the particle.

(c) A particle p is projected vertically upwards from 0 with V= 40m/s . One second later another particle Q is projected from 0 with the same vertical velocity. Find the time and height when the particles collide. [3marks]

3. (a) It is from experiment that a load with a mass of 200g will stretch a spring 10.0 cm . The spring is then stretched an additional 5.00cm and released . Find ;

(i) The spring constant. [2marks]

(ii) The period of vibration and frequency. [3marks]

(iii) The maximum acceleration. [1mark]

(iv) The velocity through equilibrium position. [1mark]

(v) The equilibrium of motion. [2marks]

(b) A stone is thrown horizontally over the edge of a vertical cliff with an initial velocity of 20m/s. The cliff is 150m high. Find the distance from the cliff at which the stone hits the ground. Calculate the magnitude and direction of the velocity at the instant the stone hits the ground. [8marks]

(c) A pendulum bob is released from some initial height such that the speed of the bob at the bottom of the swing is 1.9 m/s. Obtain the initial height of the bob. [3marks]

4. (a) 0.5kg mass is vibrating in a system in which the vestoring constant is 100N/m. The amplitude of the vibration is 0.2m . Find

(i) The energy of the system . [2marks]

(ii) Maximum knetic energy and maximum velocity. [2marks]

(iii) The PE and K.E when $x = 0.1$m. [2marks]

(iv) The equation of motion if x = A at t = 0   [2marks]

(b) (i) A space ship is between the earth and the moon. Obtain the distance from the earth when the net gravitational force is zero?   [8marks]

(ii) Given that the distance from the spaceship to the earth is 7.5 x 10 km, obtain the distance from the earth to the moon when the net gravitational force is zero take

$$M_{earth} = 5.98 \text{ x } 10^{24} \text{ kg}$$

$$M_{moon} = 7.3477 \text{ x } 10^{23} \text{ kg} \hspace{4cm} [4marks]$$

5.   (a) Determine the gravitational force due to a hollowed sphere separated by a distance of 100 kms, assuming that the mass of the sphere was 1000kgs before hollowing the mass of remaining sphere 200 kgs and the vaders of the original sphere 8000kms. Take G= 6.67 x 10^{-11} m^3/kg /5^2.   [6marks]

(b) The figure below shows two bodies A and B with masses 30kg and 50kg respectively placed on two rough sloping faces of the sloping sides are 30° and 60° . The coefficient of friction is ⅓ between A and the left hand face and $\frac{3}{5}$ between B and the right hand face. Calculate the acceleration of the bodies when they are released from vest. [4marks]

(c) Angid body is rotating with angular velocity of radians /second about an axis or where R= 2i -2j +k and 0 is the origin . Find the velocity of the point 3i +4j =k on the body.   [5marks]

(d) A machine mounted on vibration isolators is modeled as a single degree of freedom system. The relevant parameters are estimated to be as follows : mass = 370 kg, spring rate = 2 x 105 N/m, damping constant (δ)= 0.2 per second. Calculate the natural frequency of the mounted machine and the displacement amplitude of the machine if its excited at that frequency by a force with peak amplitude of 10N.   [5marks]