NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

DYNAMICS I

TIE 2106

First Semester Main Examination Paper

December 2014

This examination paper consists of five (5)printed pages

Time Allowed: **3 hours**

Total Marks: **100**

Examiner's Name: **Mr. W. Tumbudzuku**

INSTRUCTIONS AND INFORMATION TO CANDIDATE:

1. Answer any five(5) questions
2. Each question carries 20 marks
3. Use of calculators is permissible

Question 1

a) Define the following engineering mechanics terms:
   i) Designanalysis, [2]
   ii) Technological processes, [1]
   iii) Structures, [1]
   iv) Frames, [2]
   v) Kinematic chains, [2]
   vi) Actuator. [2]

b) With the aid of diagrams and equations write short notes on:
   i) Uniform motion, [2]
   ii) Uniformly accelerated/decelerated motion, [2]
   iii) Nonuniformly accelerated motion, [2]
   iv) Motion where the acceleration is given as a function of position, velocity and timethat is, $\boldsymbol{a = f(x, v, t)}$. [4]

Question 2

The acceleration of a particle moving along the x-axis is given as a function of time, the position and velocity of the particle at some instant are shown.

$$\boldsymbol{a(t) = 30sinwt}\ \text{m/s where} \boldsymbol{w=2.5\ rad/s,\ x(10)=40m;\ v(10)=8m/s.}$$

a) Determine the position of the particle as a function of time. [4]
b) Determine the velocity as a function of time. [4]
c) Evaluate the position, velocity and acceleration of the particle at time*t=7*seconds. [4]
d) Determine the total distance travelled by the particle between time t=4seconds and t=8seconds. [2]
e) Sketch ***x(t), v(t)*** and ***a(t)*** for $0 \leq \boldsymbol{x} \leq 12secs$. [6]

Question 3

A projectile is fired from the edge of a 1000m cliff with an initial velocity of $250ms^{-1}$ at an angle of 75^{o} with the horizontal. Neglecting air resistance, find:
a) The horizontal distance from the gun to the point where the projectile strikes the ground. [8]
c) The greatest elevation above the ground reached by then projectile. [6]
d) The range when the projectile is at a height of 1000m. [6]

Question 4

A particle falls under the force of gravity in a medium that exerts a resisting force proportional to the velocity of the particle as shown in Figure Q4.

a) Develop an equation for the velocity given that the velocity is zero at time t=0. [10]
b) Develop an equation for the displacement given that the displacement is zero at time, t=0. [10]

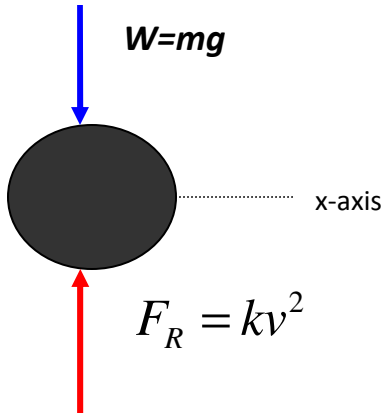

Figure Q4Falling particle.

Question 5

a) Name and define two forms of mechanical energy. [4]
b) List conditions to be satisfied for work to be done. [2]
c) State the law of conservation of energy. [1]
d) From the impact event, two separate phases (deformation and restoration phase) can be identified. Derive the expression for the coefficient of restitution **e** from basic principles. [6]
e) A 15kg collar A is moving to the right along a frictionless rod with a speed of **30** ms^{-1} when it strikes the 10kg collar B that is at rest. The two bodies travel together and hit a spring with a spring constant k= 8kN/m, determine the maximum deflection , if the coefficient of restitution between the collars is e= 0,7. [7]

Question 6

a) The total linear momentum of a system of four particles at time $t = 30\ secondsse$ is given by $\boldsymbol{G_{2.2} = 150i - 80j + 60k}$ kgm/s. At time $t = 20seconds$, the linear momentum has changed to $\boldsymbol{G_{2.4} = 50i - 58j + 60k}$ kgm/s. Calculate the magnitude$\boldsymbol{F}$of the time average of the resultant of the external forces acting on the system during the interval. [10]

b) Small packages of explosives travelling on the conveyor belt fall off into a 1m long loading truck as shown in ***Fig Q6b***. If the conveyor is running at a constant speed of $\boldsymbol{v_c = 2m/s}$, determine the smallest and largest distance R at which the end A of the car may be placed from the conveyor so that the packages enter the car. [10]

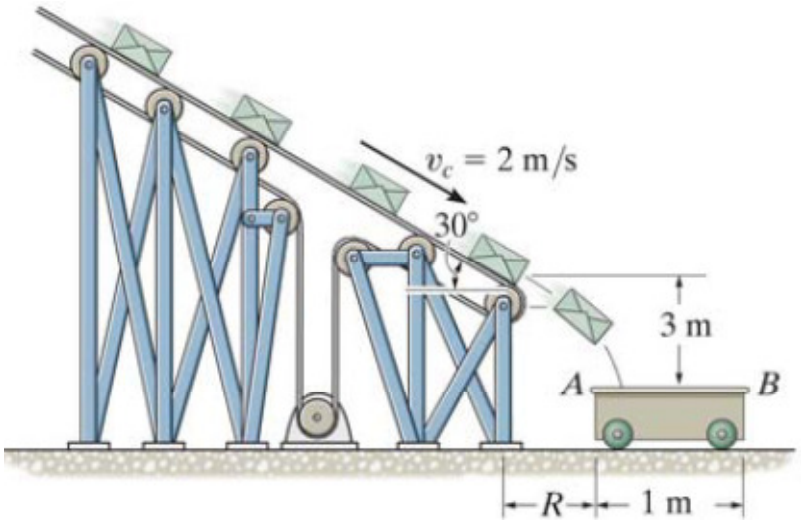

Fig 6b Conveying system

Question 7

a) Determine the first and second moment of inertia for a rectangle of length *b m* and height *h m* about the centroidal x and y axis. [10]

b) A 2kg package slides on a frictionless floor and strikes the bumpers shown in ***Figure 7b***.The two linear springs are identical , with spring constants of $k = 3.5KN/m$.Determine the work done on the package by the springs as spring 1 is compressed by 60mmand spring 2 is compressed by 10mm. Note that spring one is120mm long and spring two is 80mm long.
[10]

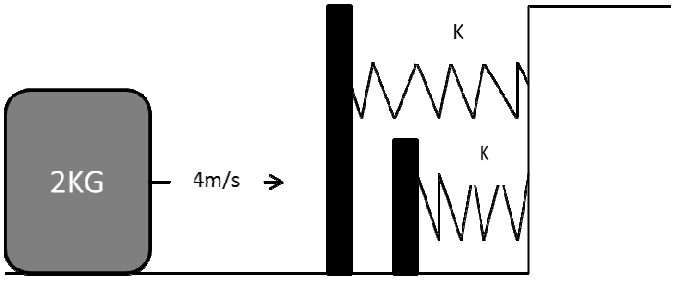

Fig 7bSpring mass system

End of Examination