GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF GEOMATICS AND SURVEYING

MECHANICS (ESG 1209)

Final Examination Paper

June 2024

EPOCH MINE CAMPUS

Time Allowed: **3 hours**
Total Marks: **100**
Examiner's Name: **Mr. P. Sigwegwe**

INSTRUCTIONS

1. Answer **ALL** question in SECTION A.
2. Answer any **THREE** questions from SECTION B.
3. Use of calculators is permissible.

MARK ALLOCATION

Section A	**40**
Question A1	20
Question A2	20
Section B	**60**
Question B3	20
Question B4	20
Question B5	20
Question B6	20
Total Attainable	**100**

SECTION A

ANSWER ALL QUESTIONS IN THIS SECTION (40 Marks)

Question A1

a) State Newton's Second Law of motion and briefly describe how it can be used to define a Newton **(4)**

b) The definition of velocity states that $\boldsymbol{v = \frac{dx}{dt}}$

Show that the definition of velocity can be used to derive the equations of motion:

$$x = v_0 t + \tfrac{1}{2} a t^2 + C',$$

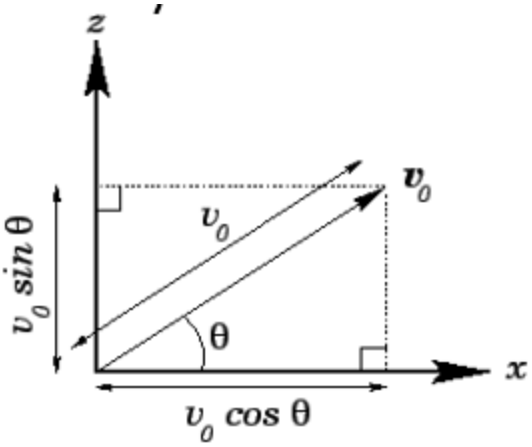
Where C is a constant of integration. **(6)**

c) State and explain Newton's laws of motion. **(6)**

d) Differentiate between static and kinetic friction. **(4)**

Question A2

a) The diagram below shows the vector decomposition of the initial conditions of projectile motion



(Figure A2.0)

Using the diagram above and any other relevant classical mechanics assumptions derive the following expressions

i. $$v_0 = (v_{x,0}^2 + v_{y,0}^2)^{1/2}$$ **(4)**

ii. $$R = \frac{v_0^2}{g} \sin 2\theta_0.$$ **(4)**

b) State Newton's Law of Gravitation **(3)**

c) Using the law stated above derive an equation for gravitational potential **(3)**

d) State and explain Kepler's laws of planetary motion. **(6)**

SECTION B

Answer ANY THREE questions from this section. (60 marks)

Question B3

a) A 68 kg crate is dragged across a floor by pulling on a rope attached to the crate and inclined 15 degree above the horizontal.

i. If the coefficient of static friction is 0.50, what minimum force magnitude is required from the rope to start the crate moving? **(4)**

ii. If μk=0.35, what is the magnitude of the initial acceleration of the crate? **(4)**

b) State the principle of conservation of energy **(2)**

c) State the principle of linear conservation of momentum **(2)**

d) One of the most important examples of periodic motion is simple harmonic motion (SHM), in which some physical quantity varies sinusoidal. Suppose a function of time has the form of a sine wave function,

$$y(t) = A\sin(wt)$$

For the harmonic oscillator stated above derive an expression for

i. Velocity **(2)**

ii. Acceleration **(2)**

iii. Kinetic energy **(4)**

Question B4

A block whose mass m is 680 g is fastened to a spring whose spring constant k is 65 N/m. The block is pulled a distance x = 11cm from its equilibrium position at x = 0 on a frictionless surface and released from rest at t = 0.

(a) What are the angular frequency, the frequency, and the period of the resulting motion? **(6)**

(b) What is the amplitude of the oscillation? **(2)**

(c) What is the maximum speed v_m of the oscillating block, and where is the block when it has this speed? **(4)**

(d) What is the magnitude a_m of the maximum acceleration of the block? **(4)**

(e) Given that the body of mass m starts from rest and reaches a speed v after moving through a distance s under the action of a constant force, F, show that kinetic energy (Ek) is given by:

$$E_k = \frac{1}{2}mv^2$$

(4)

Question B5

a) Figure B5.0 shows a train of four blocks being pulled across a frictionless floor by force. What total mass is accelerated to the right by:
(i) force,
(ii) cord 3, and
(iii) cord 1?
(iv)Rank the blocks according to their accelerations, greatest first.
(v) Rank the cords according to their tension, greatest first**.** **(5)**

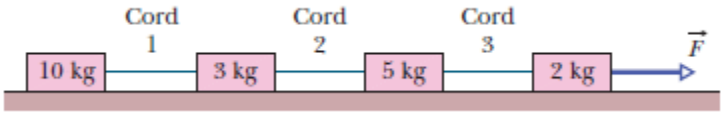


Figure B5.0

b) In Fig. B5.1, let the mass of the block be 8.5 kg and the angle be Ø=30 degrees.
Find
(i) the tension in the cord and
(ii) the normal force acting on the block.
(iii) If the cord is cut, find the magnitude of the resulting acceleration of the block. **(10)**

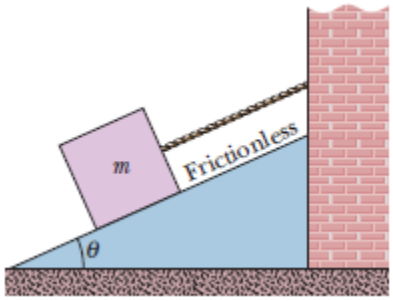


Figure B5.1

c) State any three ways in which heavy duty industrial machines can produce more work output in relation to the energy input **(5)**

Question B6

a) State Archimedes' principle **(2)**
b) a block of density 800 kg/m3 floats face down in a fluid of density 1200 kg/m3, The block has height of H =6.0 cm
   i. By what depth h is the block submerged? **(4)**
c) State and explain four assumptions that we make about our ideal fluid; they all are concerned with flow. **(8)**
d) While doing field work a Surveyor runs away from wasps in an open field on which a set of coordinate axes has, strangely enough, been drawn. The coordinates (meters) of the Surveyors's position as functions of time t (seconds) are given by

$$x = -0.31t^2 + 7.2t + 28$$
$$y = 0.22t^2 - 9.1t + 30.$$

Find the following

i. The velocity vector components in the *x y and* z directions **(2)**
ii. The acceleration vector components in the *x y and z* directions **(2)**
iii. Magnitude of velocity and its direction, using t = 1**(1)**
iv. Magnitude of acceleration and its direction, using t = 1**(1)**

End of Question Paper.

