# GWANDA STATE UNIVERSITY

EGS 1209

FACULTY OF ENGINEERING AND THE ENVIRONMENT

**DEPARTMENTS OF GEOMATICS AND SURVEYING**

MECHANICS

EPOCH MINE CAMPUS

MR M MPOFU

2021 EXAMINATIONS
Time : 3 hours

This paper contains **TWO** sections. Attempt **ALL** questions from Section A and any **THREE** questions from Section B

INSTRUCTION AND MATERIALS

- Answer **all** questions in section A and any **three** questions in section B
- Calculators are allowed
- Decimal answers which are not exact should be given correct to three significant figures unless stated otherwise.

Gravitational constant $G = 6.6710^{-11} Nm^2kg^{-2}$
Acceleration of free fall $g = 9.81ms^{-2}$

SECTION A (40 marks)

**Answer ALL questions in this section**

**A1.** (a) Distinguish between a vector quantity and a scalar quantity. [2]

(b) Find the resultant in terms of magnitude and direction, given that a particle had a displacement of 12 km south followed by a displacement of 5 km east. [4]

**A2.** A small ball is projected with speed $20ms^{-1}$ at an angle of $45^o$ above the horizontal from a point $O$ on horizontal ground. At time $t$ after projection, the horizontal and vertically upwards displacements of the ball from $O$ are $x$ and $y$ respectively.

(a) What is a trajectory? [2]

(b) Express $x$ and $y$ in terms of $t$ [4]

(c) Show that the equation of the trajectory of the ball is $y = x - \frac{1}{40}x^2$. [4]

(d) State the distance from $O$ of the point at which the ball first strikes the ground. [2]

**A3.** (a) State Kepler's Law of planetary motion. [6]

(b) An inextensible light string is attached at one end to a fixed point $A$, and at the other end to a bob of mass 4 kg. The bob is describing horizontal circles of radius $1.8m$, with a speed $3.2ms^{-1}$. Find the angle made by the string with the downward vertical. [7]

**A4.** (a) Define acceleration and momentum. [4]

(b) Consider a racing car with constant mass $m$ moving along a straight path with an initial velocity of $u$. Given that the car takes $t$ seconds to reach the finish line when its acceleration is $a$, determine the final velocity $v$. [2]

Given that the displacement of the straight path is $s$, show that

$$s = ut + \frac{1}{2}at^2$$

. [3]

SECTION B (60 marks)

**Answer any THREE questions in this section**

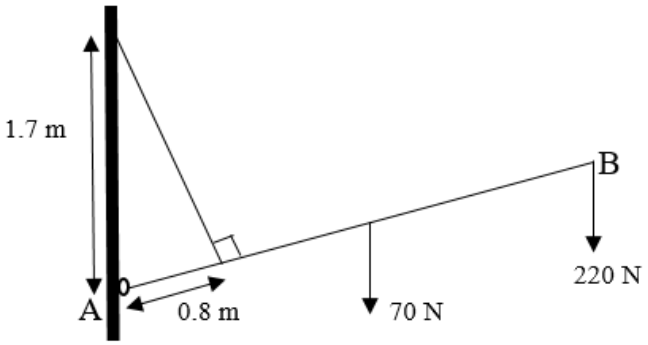
**A5.** (a) State Newton's Laws of motion. [6]

(b) A small block of mass 8 kg rests on a table top and is connected by a light inextensible string that passes over a smooth pulley, fixed on the edge of the table to another small block of mass 6 kg which is hanging freely. Find, in terms of $g$, the acceleration of the system and the tension in the string if,

(i) the table is smooth, [5]

(ii) the table is rough and exerts a frictional force of $2g$ N. [5]

(c) A uniform ladder rests with its foot on rough ground and the top against a smooth wall. Show all the forces acting on the ladder. [4]




**A6.** (a) A uniform beam AB has length 2 m and weight 70 N. The beam is hinged at $A$ to a fixed point on a vertical wall, and is held in equilibrium by a light inextensible rope. One end of the rope is attached to the wall at a point 1.7 m vertically above the hinge. The other end of the rope is attached to the beam at a point 0.8 m from $A$. The rope is at right angles to $AB$. The beam carries a load of weight 220 N at $B$ as shown in the diagram.

(i) Find the tension in the rope. [4]

(ii) The direction of the force exerted on the beam at $A$. [6]

(b) (i) State the principle of conservation of mechanical energy. [3]

(ii) What is the difference between work and energy. [1]

(iii) 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 ($E_k$) is given by:

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

. [6]

**A7.** (a) Given that the centripetal acceleration $a = \frac{v^2}{r}$, show that the centripetal force acting on a particle of mass $m$ is given by a

$$F = mr\omega^2$$

where $\omega$ is the angular velocity. [5]

(b) A curved section of a race track, where the radius is 120m, is banked at $40^o$. By modelling a car that drives round the track as a particle,

(i) show that the design speed for this section, $vms^{-1}$, is independent of the mass of the car and find its value. [8]

(ii) If the car is of mass 850 kg and drives round the magnitude and direction of the lateral frictional force exerted by the track on the car. [7]

**A8.** (a) State and explain Newton's Law of universal gravitation. [6]

(b) A rocket of mass $M$ is fired vertically from the surface of the earth with a speed $V$ and moves under the action of gravity only. The speed $V$ is not enough for the rocket to escape from the earth's gravitational field.
Use the law of gravitation in the form $F = \frac{kM}{x^2}$ where $x$ is the distance at any time between the rocket and the centre of the earth.

(i) Express $k$ in terms of $g$ and $R$, the radius of the earth at the launch site. [3]

(ii) Find the greatest distance from the centre of the earth reached by the rocket, giving your answer in terms of $g$ and $R$. [11]

**END OF QUESTION PAPER**

"*Do not worry about your difficulties in mathematics.*
*I can assure you mine are still greater.*" Albert Einstein