JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION (SCIENCE)

1ST YEAR 1ST SEMESTER 2022/2023

MAIN SPECIAL

COURSE CODE: SPB 9111

COURSE TITLE: MECHANICS

EXAM VENUE: **STREAM: (BED SCI)**

DATE: **EXAM SESSION:**

TIME: 2:00HRS

Instructions:

1. **Answer question 1 (Compulsory) in Section A and ANY other 2 questions in Section B.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room**

Useful constants

Acceleration due to gravity , g, = 9.8 m s^{-2}

Universal gravitational constant, G = 6.67 x 10^{-11} N m^2 kg^{-2}

Radius of the earth = 6.37 x 10^6 m

Question 1

(a) (i) Check whether the right hand side of the following equation is dimensionally consistent.
(4 Marks)

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

(ii) The period of oscillation of a simple pendulum is given by

$$T = km^x l^y g^z$$

Use dimensional analysis to find x, y and z, hence write down the complete equation.
(4 Marks)

(b) A tennis player moves in a straight-line path as shown in Figure 1. Find:

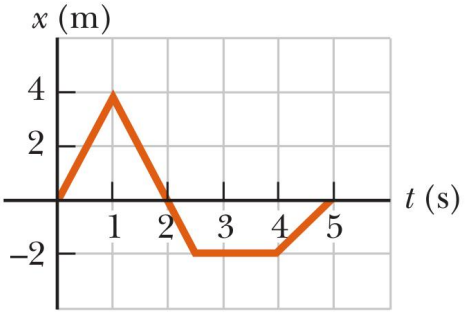

Figure 1

(i) her displacement in the time interval 1 – 4.0 s.
(ii) her velocity at t = 2.0 s.
(iii) her average velocity in the time interval 0.5 – 3.0 s

(6 Marks)

(c) State Newton's first law of motion and explain its implications. (2 Marks)

(d) A block of wood of mass 4 kg lies on a horizontal surface for which the coefficient of static friction $\mu_s = 0.25$ and the coefficient of kinetic friction $\mu_k = 0.15$. It is pulled by a 10 N force directed at 53° above the horizontal. Find the force of friction on the block if it is at rest. (6 Marks)

(e) A ball is projected horizontally at 20 m/s from a cliff of height 30 m. Find its range.
(5 Marks)

(f) A rocket of mass m is fired from a point P on the surface of the earth so that it just escapes from the gravitational influence of the Earth. Find the minimum velocity at which the rocket must move.
(3 Marks)

Question 2

(a) Derive the work-energy theorem.
(6 Marks)

(b) A 1.8 kg block is moved at constant speed over a horizontal surface for which $\mu_k = 0.25$. The displacement is 2 m. It is pulled by a force F = 20 N directed at 45° to the horizontal. Find the work done on the block by:

(i) the force F.

(ii) friction

(iii) gravity

(7 Marks)

(iv) What is the final velocity of the block if its initial velocity was 3 m/s?

(3 Marks)

(c) The length of an elastic spring with spring constant k changes from x_1 to x_2 when it is acted upon by a force F. Find the work done in stretching the spring.

(4 Marks)

Question 3

(a)(i) State the law of conservation of linear momentum. (1 Mark)

(ii) A bullet of mass 10 g travelling horizontally with a velocity of 300 m/s strikes a block of wood of mass 290 g which rests on a rough horizontal floor. After impact, the block and bullet move together and come to rest when the block has travelled a distance of 15 m. Calculate the coefficient of kinetic friction between the block and floor.

(10 Marks)

(b) A rifle of mass 3.25 kg, initially at rest, fires a 12.8 g bullet with a muzzle velocity of 800 m/s.

(i) Find the recoil velocity of the rifle. (4 Marks)

(ii) Determine the ratio of the kinetic energies of the bullet and the rifle.

(5 Marks)

Question 4

(a) A projectile is fired from the ground with an initial velocity u at an angle θ to the horizontal. It returns to the same horizontal level. Find:

(i) the time of flight.
(5 Marks)

(ii) the horizontal range, R.
(4 Marks)

(iii) the equation of the trajectory.
(3 Marks)

(b) A ball is thrown at 21 m/s at 30° above the horizontal from the top of a roof 16 m high. Find:

(i) the maximum height reached.
(3 Marks)

(ii) the time of flight.
(5 Marks)

Question 5

(a)(i) State Newton's law of universal gravitation. (1 Mark)

(ii) A satellite orbits the earth at a considerable distance R from the center of the earth in the plane of the equator and in the same direction of rotation as the earth. Show that the period of the satellite T is given by

$$T^2 = \frac{4\pi R^3}{gr^2}$$

where g is the gravitational acceleration and r is the radius of the earth.

(8 Marks)

(iii) If R = 25000 km, find T.
(2 Marks)

(b) Given the first equation of linear motion, derive the second equation of motion.
(5 Marks)

(c) An aircraft has a liftoff speed of 120 km/h.

(i) What minimum constant acceleration does the aircraft require if it is to be airborne after a takeoff run of 240 m?
(3 Marks)

(ii) How long does it take the aircraft to become airborne?