JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL, PHYSICAL, MATHEMATICS AND ACTUARIAL SCIENCES

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

1ST YEAR 1ST SEMESTER 2022/2023

MAIN REGULAR

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, = 9.8m s^{-2}.
Universal gravitational constant, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
Radius of the earth = 6.37×10^6 m
Mass of the earth = 5.98×10^{24} kg

SECTION A (COMPULSORY)

Question 1 (30 marks)

(a) At a construction site, a hammer struck the ground at a speed of 18.5 m/s. Find the height from which it fell. (3 marks)

(b) A vehicle of mass 2500 kg travelling at 10 m/s on a horizontal surface is brought to rest in a distance of 10.5 m by the action of its brakes. Calculate the average retarding force. (4 marks)

(c) Find the dimensions of the constants *a* and *b* in the gas equation

$$\left(p + \frac{a}{V^2}\right)(V - b) = RT$$

where *p* is the pressure and *V* is the volume. (3 marks)

(c) A boy stands at the edge of a cliff and throws a stone horizontally over the edge with a speed of 18.0 m/s. The cliff is 50.0 m above a flat, horizontal beach. How far from the foot of the cliff does the stone land on the beach? (4 marks)

(d) A proposed communciation satellite would revolve round the earth in a circular orbit in the equatorial plane, at a height of 35880 km above the earth's surface. Find the period of revolution of the satellite in hours, and comment on the results. (3 marks)

(e) A 2 kg particle is projected horizontally with an initial velocity of 4 m/s along a surface for which $\mu_k = 0.6$.Find its displacement by the time it comes to rest. (3 marks)

(f) The head of a golf club strikes a 46 g golf ball at rest. If the collision lasts 0.5 ms and the ball is given a speed of 220 km/h, find the average force on the ball. (2 marks)

(g) The constant forces $F_1 = \hat{i} + 2\hat{j} + 3\hat{k}$N and $F_2 = 4\hat{i} - 5\hat{j} - 2\hat{k}$N act together on a particle during a displacement from position $\overrightarrow{r_1} = 7\hat{k}$cm to position $\overrightarrow{r_2} = 20\hat{i} + 15\hat{j}$cm. Determine the total work done on the particle. (3 marks)

(h) A rocket of mass *m* is to be 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)

(i) State Kepler's laws of planetary motion. (2 marks)

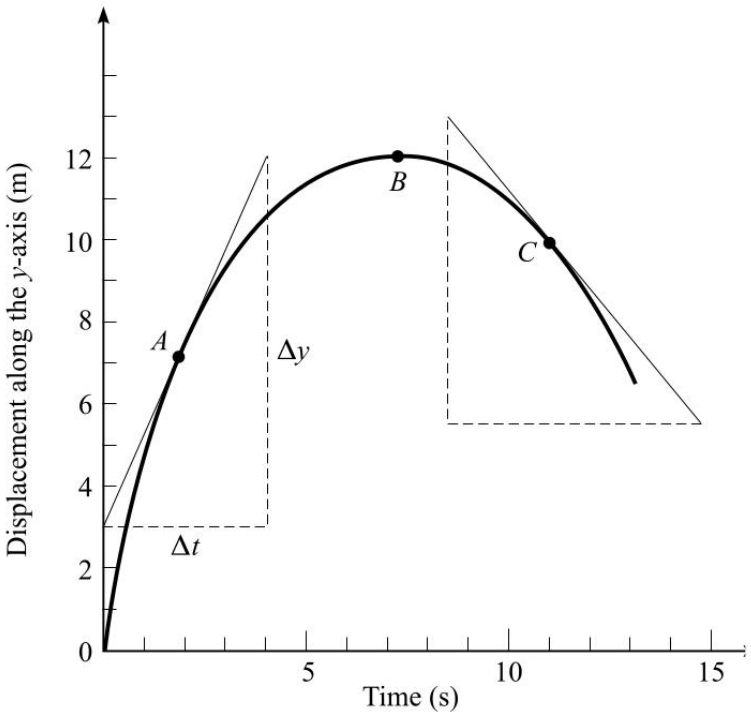
SECTION B (Attempt any TWO questions from this section)

Question 2 (20 marks)

(a) Given the first equation of linear motion, derive the second and third equations. (7 marks)

(b) A block of wood of mass 6 kg lies on a horizontal surface for which the coefficient of static friction $\mu_s = 0.15$ and the coefficient of kinetic friction $\mu_k = 0.10$. It is pulled by a 12 N force directed at 47° above the horizontal. Find the force of friction on the block if it is at rest. (6 marks)

(c) The graph of the vertical motion of an object is shown in Fig. 1 below. Describe this motion qualitatively, and find its instantaneous velocity at points A, B, and C. (7 marks)



Question 3 (20 marks)

(a) A spring of spring constant k is stretched from an original length x_1 to x_2. Find the work done in the process, hence write your answer in terms of k if x_1=0.01 m and x_2 = 0.015 m. (6 marks)

(b) A tennis ball of mass 60 g traveling at 30 m/s strikes a wall and rebounds in the opposite direction with 81% of its initial kinetic energy. Calculate the magnitude of the impulse on the ball. (6 marks)

(c) A car starts from rest at constant acceleration of 2.0 m/s^2 . At the same instant a truck travelling with a constant speed of 10 m/s overtakes and passes the car.

i. How far beyond the starting point will the car overtake the truck? (5 marks)
ii. After what time will this happen? (2 marks)
iii. At that instant what will be the speed of the car? (1 mark)

Question 4 (20 marks)

(a) A moving body makes a perfectly inelastic collision with a stationary body of equal mass at rest. Show that half of the original kinetic energy is lost. (5 marks)

(b) 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)

(c) A gun of mass 32.5 kg fires a bullet of mass 8 g at a velocity of 600 m/s. Find the recoil velocity of the gun. (3 marks)

Question 5 (20 marks)

(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

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

where g is the gravitational acceleration and r is the radius of the earth. (8 marks)

(b) (i) Derive an expression for the gravitational potential at a point which is a distance a from the center of the earth. (4 marks)

(ii) Hence calculate the gravitational potential at distance of 300 km from the surface of the earth. (3 marks)

(c) Approximating the orbit of a planet round the sun to be circular, show that Newton's law of universal gravitation leads to Kepler's third law. (4 marks)