PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF APPLIED PHYSICS

SEMESTER ONE EXAMINATION, 2022

AP 212: CLASSICAL MECHANICS

DATE: Friday 3rd June, 2022

Time: 8:20 am to 11:20 am

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS

1. **You have TEN MINUTES to read this question paper. Do not begin writing during this time.**
2. **QUESTION 1 IS COMPULSORY**

ANSWER ANY FIVE OF THE SIX QUESTIONS including QUESTION 1. (ALL QUESTIONS CARRY EQUAL MARKS)

3. **The Exam weighs 100 MARKS!**
4. **All answers must be written on the Answer Booklet provided**
5. **COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF THE ANSWER BOOLET. DO THIS NOW**
6. **Complete details on Attendance Slip. DO THIS NOW**
7. **Calculators are permitted in the examination room. Textbook, notebooks and mobile phones are NOT permitted.**

QUESTION 1 (COMPULSORY). (20 marks).

(A). State the conservation theorem for linear momentum of a particle $(F = 0, \dot{p} \neq 0)$. (2marks)

(B). State the conservation theorem for the angular momentum of a particle $(N = 0, \dot{L} \neq 0)$. (2 marks)

(C). In physics, the frames of reference are classified by two main types. What are they? (2 marks)

(D). A nucleus originally at rest, decays radioactively by emitting an electron of momentum 1.73 $\frac{M_eV}{c}$, and at right angle to the direction of the electron a neutrino with momentum $1.00\frac{M_eV}{c}$.

($M_eV = in\ million\ electron\ volts = 1.60 \times 10^{-13}J$. Correspondingly, $p = \frac{M_eV}{c} = 5.34 \times 10^{-22} kgms^{-1}$).

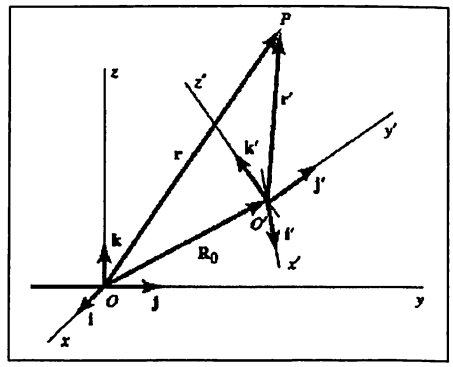
1. In what direction does the nucleus recoil? (2 marks)
2. What is its momentum in $\frac{M_eV}{c}$? If the mass of the residual nucleus is $3.90 \times 10^{-25}kg$, what is its kinetic energy in electron volts? (4 marks)

(E). A 120-lb person stands on a bathroom spring scale while riding in an elevator. If the elevator has (a) upward and (b) downward acceleration of $\frac{g}{4}$, what is the weight indicated on the scale in each case?

1. upward (Note: Upward force is equal to scale reading, $\vec{N} = W'$) (4 marks)
2. downward (4 marks)

QUESTION 2. (20 marks)

(A). The following figure gives the general equations for transforming from a fixed system to a moving and rotating system: (6 marks)



In the general case in which the primed system is undergoing both translation and rotation, the general equations for transforming from a fixed system to a moving and rotating systems is:

$$v = v' + \omega \times r' + V_0$$

$$a = a' + (\dot{\omega} \times r') + (2\omega \times v') + \omega \times (\omega \times r') + A_0$$

Define the Terms in a:

(B). Name the two types of constraints with their examples. (4 marks)

(C). Show that the radius for a circular orbit of a synchronous (24-h) Earth satellite is about 6.6 Earth radii. (5 marks)

(D). The distance to the Moon is about 60.3 Earth radii. From this calculate the length of the sidereal month (period of the moon's orbital revolution). (5 marks)

(Hint: $T = \frac{2\pi r}{V}, V = \left(\frac{gR_e^2}{r}\right)^{\frac{1}{2}}$)

QUESTION 3. (20 marks)

Find the center of mass of each of the following:
(a) A thin wire bent into the form of a three-sided, block-shaped "⊔" with each segment of equal length b
(b) A quadrant of a uniform circular lamina of radius b
(c) The area bounded by parabola $y = \frac{x^2}{b}$ and the line $y = b$
(d) The volume bounded by paraboloid of revolution $z = \frac{x^2+y^2}{b}$ and the plane $z = b$.
(e) A solid uniform right circular cone of height b

QUESTION 4. (20 marks)

(A). What is the difference between *perihelion* and *aphelion*? (4 marks)

(B). What are the Kepler's Laws of motion? Explain them. (6 marks)

(C). A small car of a mass m and initial speed v_0 collides head-on on an icy road with a truck of mass 4m going toward the car with initial speed $\frac{1}{2}v_0$. If the coefficient of restitution in the collision is $\frac{1}{4}$, find the speed and direction of each vehicle just after colliding. (10 marks)

QUESTION 5. (20 marks)

(A). A basketball is dropped from rest 2.0 m above the floor. After bouncing from the floor, the ball reaches a height of 1.5 m.
(a). What is the speed of the ball the instant before hitting the floor? (5 marks)
(b). What is the speed of the ball just after leaving the floor? (5 marks)
(c). The ratio of the speed before the bounce to the speed after the bounce is called the coefficient of restitution ε of the ball. Find ε for this basketball. (2 marks)
(d). If the ball is contact with the floor for 0.036s, what is the magnitude of average acceleration of the ball during this time interval? (5 marks)
(Hint: $x(t) = x_0 + v_{x_o}t + \frac{1}{2}a_x t^2, \quad v_x(t) = v_{x_o}t + a_x t$)

(B). An alpha particle emitted by radium ($E = 7\ million\ eV = 7 \times 10^6 \times 1.6 \times 10^{-12} erg$) suffers a deflection of 90° on passing near a gold nucleus.

What is the value of the impact parameter? Hint: For alpha particles $q = 2.5e$, and for gold Q = $83e$.
Where $e = 4.8 \times 10^{-10} esu$. $\left(\cot\frac{\theta_s}{2} = \frac{bmv_0^2}{Qq} = \frac{2bE}{Qq}\right)$ (3 marks)

QUESTION 6. (20 marks)

(A). At some point in its trajectory a ballistic missile of mass m breaks into three fragments of mass $\frac{m}{3}$ each. One of the fragments continues on with an initial velocity of one-half the velocity v_0 of the missile just before breakup. The other two pieces go off at right angles to each other with equal speeds. Find the initial speeds of the latter two fragments in terms of v_0. (8 marks)

(B). Find the center of mass of a solid homogeneous hemisphere of radius a, that we know from symmetry that the center of mass lies on the radius that is normal to the plane face? (8 marks)

(Hint: $z_{cm} = \frac{\int_0^a p\pi z(a^2-z^2)dz}{\int_0^a p\pi(a^2-z^2)dz}$)

(C). Give four (4) examples of the Laminar Motion of a Rigid Body. (4 marks)