

MECHANICS AND MOTION

A SEMINAR 2 PRESENTATION

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CERTIFICATION

This is to certify that this report was undertaken and submitted by **AYOOLA TIJESUNI SAMUEL** with matriculation number **20183008**, a student of the department of Mathematics, College of Physical Sciences, Federal University of Agriculture, Abeokuta, for SEMINAR 2.

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Table of Contents

CERTIFICATION	2
1.0 INTRODUCTION	4
1.1 Introduction	4
1.2 Preliminaries and Definition of Terms	6
1.3 Motivation of Study	8
1.4 Literature Review	9
1.5 Applications of Mechanics and Motion	11
1.6 Objectives.....	13
2.0 DISCUSSION.....	14
2.1 Projectile Motion	14
2.2 Circular Motion	18
3.0 CONCLUSION AND RECOMMENDATION	22
3.1 Conclusion.....	22
3.2 Recommendation.....	23

1.0 INTRODUCTION

1.1 Introduction

Think about a simple action like kicking a soccer ball or swinging on a swing. Have you ever wondered why things move the way they do? That's where the fascinating world of Mechanics and Motion comes into play.

Welcome to a journey where we'll explore the secrets of how things move. Mechanics is like the rulebook that our universe follows for any motion, from a car racing down the highway to a leaf falling from a tree. And the best part? You don't need to be a rocket scientist to understand it!

Imagine you're riding a bike. You push the pedals, and off you go. But what makes your bike move? Why don't you just stay still? We'll uncover the answers to these questions and more as we dive into the world of Mechanics

Mechanics and motion are foundational concepts that underpin our understanding of how objects move and interact in the physical world. From the graceful flight of a bird to the complex machinery of a car engine, mechanics governs the behavior of these systems, allowing us to predict and control their motions. The study of mechanics not only has practical applications in engineering and technology but also provides profound insights into the workings of the natural world.

In this seminar report, we will embark on an exploration of mechanics and motion, unraveling the principles, theories, and applications that shape this fascinating discipline. By delving into the theoretical foundations and examining real-world examples, we aim to provide a comprehensive overview that will deepen your understanding of the mechanics behind motion.

To begin, let us set the stage with a brief historical context. Mechanics has a rich history, with notable contributions from pioneering scientists who laid the groundwork for our understanding of motion. Sir Isaac Newton, with his groundbreaking work in the 17th century, introduced the laws of motion that revolutionized the field of mechanics. Newton's laws, which describe the relationship between forces and motion, form the cornerstone of classical mechanics¹. Their applications are vast and encompass everything from the motion of celestial bodies to the mechanics of everyday objects.

Mechanics and motion find practical applications in numerous fields. In engineering, mechanics is crucial for designing structures that withstand forces and move efficiently. In sports, an understanding of mechanics helps athletes optimize their performance and minimize the risk of injury. Even in fields as diverse as robotics, biomechanics, and astrophysics, mechanics plays a pivotal role.

Throughout this seminar report, we will explore various subtopics within mechanics and motion, including projectile motion, circular motion, conservation laws, oscillations, and more.

1.2 Preliminaries and Definition of Terms

Before we embark on our journey through the captivating world of Mechanics and Motion, let's establish some essential concepts and terminology to ensure that we're all on the same page. Whether you're new to this subject or a seasoned enthusiast, these definitions will serve as our guiding stars throughout our exploration.

✓ **Mechanics**

Mechanics is the branch of physics that deals with the behavior of objects under the influence of forces, including their motion and how they respond to different types of forces.

✓ **Motion**

Motion refers to the change in an object's position with respect to time. It encompasses a wide range of phenomena, from the slow crawl of a snail to the swift flight of a rocket.

✓ **Force**

Force is a vector quantity that causes an object to change its state of motion or rest. It has both magnitude and direction and is measured in units called Newtons (N).

✓ **Velocity (v) and Speed (s)**

Velocity is a vector quantity that describes the rate of change of an object's position with respect to time and includes both magnitude and direction.

Speed, on the other hand, is a scalar quantity that only considers the magnitude of velocity. It is expressed in units like meters per second (m/s).

✓ **Acceleration (a)**

Acceleration is the rate of change of velocity with respect to time. It can be caused by changes in speed or direction and is measured in units like meters per second squared (m/s^2).

✓ **Kinematics and Dynamics**

Kinematics is the branch of mechanics that deals with the description of motion, including the positions, velocities, and accelerations of objects without considering the forces causing the motion.

Dynamics, on the other hand, is concerned with the forces and torques (rotational forces) that cause motion.

✓ **Equilibrium**

Equilibrium is a state in which the net force acting on an object is zero, resulting in a stable condition where the object remains at rest or moves with constant velocity.

✓ **Friction**

- Friction is a force that opposes the relative motion or tendency of such motion between two surfaces in contact. It plays a significant role in determining the behavior of objects in motion.

These preliminary definitions will provide a solid foundation for our exploration of Mechanics and Motion. As we venture further into the seminar, these terms and concepts will become the building blocks of our understanding, allowing us to unravel the mysteries of the dynamic world around us.

1.3 Motivation of Study

Why study Mechanics and Motion? What drives our curiosity to explore this captivating field of science and its profound impact on our world? The motivation behind this study lies in the recognition of the pivotal role that mechanics plays in shaping our understanding of the physical universe and its practical applications. Let's delve into the motivations that drive our exploration of Mechanics and Motion.

➤ **Everyday Phenomena**

Mechanics governs the behavior of objects in our daily lives, from the motion of vehicles on the road to the swaying of trees in the wind. Understanding these phenomena through the lens of mechanics enhances our comprehension of the world around us.

➤ **Innovation and Design**

Mechanics is at the heart of innovation and design in engineering and technology. It enables the creation of safer vehicles, efficient machinery, and cutting-edge robotics. As we study Mechanics and Motion, we gain insights into how to design more advanced and sustainable solutions.

➤ **Performance Enhancement**

In sports and athletics, mechanics is the key to unlocking human potential. By optimizing the mechanics of an athlete's movements, we can enhance performance, reduce the risk of injury, and push the boundaries of achievement.

1.4 Literature Review

The study of mechanics and motion has a rich history and has been extensively explored by scientists and researchers over the years. In this literature review, we will examine key studies, theories, and advancements that have contributed to our understanding of mechanics and motion.

- One of the foundational works in mechanics is Sir Isaac Newton's "Philosophiæ Naturalis Principia Mathematica" (1687), which introduced his **three laws of motion**. Newton's laws provide a fundamental framework for analyzing the motion of objects and the forces acting upon them. They have stood the test of time and continue to be widely applied in various scientific fields.
- Advancements in mechanics continued with the works of other prominent scientists. In the 18th century, Leonhard Euler developed the principles of rigid body dynamics, which laid the groundwork for the study of rotational motion. His contributions to the field were instrumental in understanding the complex motion of objects in three dimensions.
- The 19th century witnessed significant progress in mechanics, with the development of analytical mechanics by William Rowan Hamilton and Joseph Louis Lagrange. Lagrange's formulation of mechanics, known as Lagrangian mechanics, provided a powerful mathematical framework for describing the motion of systems using generalized coordinates and the principle of least action. Hamilton's formulation, known as Hamiltonian mechanics, introduced a different approach using generalized momenta and Hamilton's equations. These formulations revolutionized the field of mechanics and allowed for more advanced analyses of complex systems.

- In the realm of fluid mechanics, Daniel Bernoulli's work on hydrodynamics in the 18th century has been foundational. Bernoulli's principle, derived from the conservation of energy, relates the pressure, velocity, and height of a fluid in motion. This principle has found extensive applications in fields such as aerodynamics and hydraulic engineering.
- The study of oscillations and waves has also been a significant area of research in mechanics. Jean-Baptiste Fourier's work on Fourier series in the early 19th century paved the way for understanding the decomposition of complex waveforms into simple sine and cosine functions. Fourier analysis is crucial for analyzing various wave phenomena, including sound waves, electromagnetic waves, and quantum mechanical wave functions.
- Furthermore, the integration of mechanics with other scientific disciplines has led to exciting interdisciplinary research. Biomechanics, for example, combines principles from mechanics with biology to understand the mechanics of biological systems, such as the human musculoskeletal system. Robotics and mechatronics also rely on principles of mechanics to design and control robotic systems for various applications.

Overall, the literature on mechanics and motion demonstrates a rich history of scientific inquiry and ongoing research. From the foundational works of Newton to the modern advancements in computational methods and interdisciplinary applications, the study of mechanics continues to expand our understanding of the physical world and enable innovative technological developments.

1.5 Applications of Mechanics and Motion

Mechanics and motion have numerous applications across various fields of science, engineering, and everyday life. Here are some notable applications:

- ❖ **Engineering and Design:** Mechanics is crucial in engineering and design processes. It is used to analyze and design structures, machines, and systems that withstand forces and motion. Engineers apply mechanics principles to optimize the performance, stability, and safety of buildings, bridges, vehicles, aircraft, and other mechanical systems.
- ❖ **Sports Science and Biomechanics:** Mechanics plays a significant role in sports science and biomechanics. By analyzing the mechanics of sports movements, such as running, jumping, throwing, and kicking, scientists and coaches can optimize athletic performance, prevent injuries, and refine technique. Biomechanical analysis helps understand the forces and motion involved in sports activities, leading to advancements in training methods, equipment design, and injury rehabilitation.
- ❖ **Robotics and Automation:** Mechanics is essential in robotics and automation systems. It is used to design and control robotic manipulators, humanoid robots, and autonomous vehicles. Understanding the mechanics of motion allows engineers to develop robots with precise movement, efficient energy usage, and safe interaction with the environment.
- ❖ **Automotive Industry:** Mechanics is utilized extensively in the automotive industry for vehicle design, performance optimization, and safety analysis. It involves analyzing the motion and forces acting on vehicle components, optimizing engine efficiency, improving suspension systems, and enhancing crashworthiness through impact analysis.

- ❖ Civil and Structural Engineering: Mechanics is employed in civil and structural engineering to analyze and design buildings, bridges, dams, and other infrastructure. It ensures structures can withstand loads, forces, and environmental conditions. Mechanics principles help determine the structural integrity, stability, and resilience of civil engineering projects.

These are just a few examples of the broad range of applications of mechanics and motion.

Mechanics is a foundational discipline that influences many aspects of our daily lives, from the design of everyday objects to the exploration of the universe. Its practical applications continue to drive advancements in technology, engineering, and scientific understanding.

1.6 Objectives

In this seminar, we'll break down complex concepts into simple ideas. We'll learn about the forces that make things go faster or slower, the tricks behind acrobats' flips, and even the science behind superheroes' super jumps.

But Mechanics isn't just for superheroes or scientists in lab coats. It's for everyone who's curious about the everyday magic of movement. Whether you're a sports enthusiast looking to improve your game or just someone who enjoys the thrill of a rollercoaster ride, this seminar is for you.

So, join us as we embark on a journey through Mechanics and Motion. Together, we'll unlock the mysteries behind our world's most incredible movements. It's like learning the rules of a fascinating game – a game where you're the player, and Mechanics is your playbook. Get ready to be amazed by the simple yet extraordinary science of how things move!

2.0 DISCUSSION

2.1 Projectile Motion

Definition

Projectile motion refers to the motion of an object that is launched into the air and moves under the influence of gravity alone, without any additional horizontal propulsion after the initial launch.

Discussion

- **Key Components:** Projectile motion involves two key components: horizontal motion (in the x-direction) and vertical motion (in the y-direction). The horizontal motion is uniform and unaffected by gravity, while the vertical motion is influenced by gravity.
- **Independence of Motions:** A crucial principle in projectile motion is that the horizontal and vertical motions are independent of each other. This means that the horizontal velocity remains constant throughout the motion, while the vertical velocity changes due to gravity.
- **Parabolic Trajectory:** The combination of constant horizontal velocity and accelerated vertical motion results in a parabolic trajectory. The object follows a curved path through the air.

Equations

Mathematical equations govern projectile motion. For example, the equations for horizontal and vertical positions over time are as follows:

- Horizontal position (x) = Initial horizontal velocity (V_{0x}) \times time (t)
- Vertical position (y) = Initial vertical velocity (V_{0y}) \times time (t) - (1/2) \times acceleration due to gravity (g) \times time²

Example 1: Projectile Motion - Soccer Ball Kick

Scenario: A soccer player kicks a ball with an initial speed of 20 m/s at an angle of 45 degrees to the horizontal. Calculate the ball's maximum height, the total time it's in the air, and the horizontal distance it travels.

Mathematical Problem:

Given:

Initial speed (V_0) = 20 m/s

Launch angle (θ) = 45 degrees

Acceleration due to gravity (g) = 9.81 m/s²

Find:

- Maximum height (H)
- Total time in the air (T)

- Horizontal distance (R)

Solution:

Maximum Height (H):

Use the formula for maximum height in projectile motion:

$$H = \frac{(V_0^2 * \sin^2(\theta))}{2g}$$

$$H = \frac{((20 \text{ m/s})^2 * (\sin^2(45^\circ)))}{(2 * 9.81 \text{ m/s}^2)}$$

$$H \approx 10.2 \text{ meters}$$

Total Time in the Air (T):

The total time can be calculated using the formula:

$$T = \frac{(2 * V_0 * \sin(\theta))}{g}$$

$$T = \frac{(2 * 20 \text{ m/s} * \sin(45^\circ))}{9.81 \text{ m/s}^2}$$

$$T \approx 4.08 \text{ seconds}$$

Horizontal Distance (R):

The horizontal distance can be calculated using the formula:

$$R = V_0 * \cos(\theta) * T$$

$$R = 20 \text{ m/s} * \cos(45^\circ) * 4.08 \text{ s}$$

$R \approx 81.6$ meters

Results:

- ✓ The maximum height reached by the ball is approximately 10.2 meters.
- ✓ The total time the ball is in the air is approximately 4.08 seconds.
- ✓ The horizontal distance traveled by the ball is approximately 81.6 meters.

Applications

Projectile motion has practical applications in fields like engineering and physics. It's used in designing projectiles such as missiles, artillery shells, and even in understanding the motion of celestial bodies like planets and satellites.

2.2 Circular Motion

Definition

Circular motion involves an object moving in a circular path, where its velocity and acceleration are continuously changing due to the changing direction of its motion.

Discussion

- **Centripetal Force:** In circular motion, there is always a force directed toward the center of the circle, known as the centripetal force. This force is required to keep an object moving in a circle.
- **Acceleration:** Even if the speed remains constant, circular motion involves acceleration because acceleration is a change in velocity, and velocity is a vector that includes both magnitude and direction. In a circle, the direction of velocity is constantly changing.

Example 2: Circular Motion - Satellite Orbiting Earth

Scenario: A communication satellite orbits Earth at an altitude of 35,786 kilometers. Calculate the satellite's velocity, centripetal force required to maintain its orbit, and its orbital period.

Mathematical Problem:

Given:

Altitude above Earth's surface (h) = 35,786 km (converted to meters: 35,786,000 m)

Gravitational constant (G) = $6.674 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Mass of Earth (M) = $5.972 \times 10^{24} \text{ kg}$

Find:

- Satellite's velocity (V)
- Centripetal force required (Fc)
- Orbital period (T)

Solution:

Satellite's Velocity (V):

To calculate the satellite's velocity, we need to find the radius of its orbit (R) first:

R = Radius of Earth + Altitude above Earth's surface

R = 6,371,000 m (Earth's radius) + 35,786,000 m (altitude)

R = 42,157,000 m

Now, we can calculate the satellite's velocity using the formula for circular orbit velocity:

$$V = \sqrt{\frac{G * M}{R}}$$

$$V = \sqrt{\frac{(6.674 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2 * 5.972 \times 10^{24} \text{ kg})}{42,157,000 \text{ m}}}$$

$V \approx 3,076.6 \text{ m/s}$

Centripetal Force Required (Fc):

The centripetal force required to maintain the orbit is given by:

$$F_c = \frac{M * V^2}{R}$$

$$F_c = \frac{5.972 \times 10^{24} \text{ kg} * (3,076.6 \text{ m/s})^2}{42,157,000 \text{ m}}$$

$$F_c \approx 4.434 \times 10^{13} \text{ N}$$

Orbital Period (T):

The orbital period can be calculated using Kepler's third law:

$$T = 2\pi * \sqrt{\frac{R^3}{G * M}}$$

$$T = 2\pi * \sqrt{\frac{(42,157,000 \text{ m})^3}{6.674 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2 * 5.972 \times 10^{24} \text{ kg}}}$$

$$T \approx 27,322 \text{ seconds (approximately 7.59 hours)}$$

Results:

- ✓ The satellite's velocity is approximately 3,076.6 m/s.
- ✓ The centripetal force required to maintain the orbit is approximately $4.434 \times 10^{13} \text{ N}$.
- ✓ The orbital period of the satellite is approximately 7.59 hours.

Applications

Circular motion has applications in engineering, from designing roller coasters to understanding the orbits of planets and satellites. It's also relevant in sports, such as the curved path of a pitched baseball or the dynamics of a figure skater's spin.

These two examples, projectile motion and circular motion, illustrate fundamental principles of Mechanics and Motion. Projectile motion showcases the interplay of horizontal and vertical motion, while circular motion emphasizes the need for centripetal forces to maintain a curved path. Both concepts have practical applications across various fields and are essential for understanding the motion of objects in our everyday lives and the cosmos.

3.0 CONCLUSION AND RECOMMENDATION

3.1 Conclusion

In the journey through the realm of Mechanics and Motion, we have explored the fundamental principles that govern the behavior of objects in motion, from the graceful arcs of a satellite in orbit to the intricate maneuvers of an athlete on the field. As we conclude this seminar, let us reflect on the insights and knowledge gained from our exploration.

Key Takeaways

- **Foundation of Understanding:** Mechanics is the bedrock of understanding how the physical world operates. It provides the tools to analyze and predict the behavior of objects in motion, from the macroscopic to the microscopic scale.
- **Interplay of Forces:** Our exploration revealed the interplay of forces, whether it's the centripetal force keeping a satellite in orbit or the fluid forces affecting the flight of a soccer ball. Forces are the driving factors behind motion.
- **Practical Applications:** Mechanics is not confined to textbooks and equations; it has practical applications across numerous fields. Whether it's designing efficient machines, optimizing athletic performance, or exploring outer space, the principles of mechanics are ever-present.
- **Curiosity and Wonder:** Mechanics invites us to be curious about the world around us. It inspires us to ask questions, seek answers, and marvel at the elegance of nature's laws.

3.2 Recommendation

As we conclude our seminar, we offer the following recommendations for further study and practical applications of Mechanics and Motion:

- **Continuous Learning:** Mechanics is a vast field, and there's always more to explore. We recommend a commitment to continuous learning, whether through further study in physics or engineering or by staying updated with the latest advancements in the field.
- **Interdisciplinary Applications:** Mechanics finds applications in various disciplines. Consider interdisciplinary collaborations to solve complex real-world problems. For instance, merging mechanics with biology can lead to breakthroughs in biomechanics and medical technologies.
- **Practical Problem Solving:** Mechanics is a powerful tool for practical problem-solving. Use your understanding of mechanics to contribute to innovative solutions in engineering, technology, and other fields.
- **Research and Innovation:** If you're involved in research, explore uncharted territories within mechanics. Investigate emerging areas such as nanomechanics, quantum mechanics, or applications in renewable energy technologies.

In conclusion, Mechanics and Motion are more than just scientific concepts; they are the underpinning of our understanding of the physical world. Our journey through this seminar has revealed the elegance of mechanics, and we encourage you to continue exploring, learning, and applying these principles to shape a better, more informed, and innovative future.

References

- Halliday, D., Resnick, R., & Walker, J. (2014). Fundamentals of physics (10th ed.). John Wiley & Sons.
- Serway, R. A., Jewett, J. W., & Vuille, C. (2020). College physics: Volume I. Cengage Learning.
- taylor-2005-classical-mechanics
- Newton, I. (1687). *Philosophiæ Naturalis Principia Mathematica*.
- Euler, L. (1765). *Mechanica, sive motus scientia analytice exposita*.
- Lagrange, J. L. (1788). *Mécanique analytique*.
- Hamilton, W. R. (1834). On a general method in dynamics.
- Bernoulli, D. (1738). *Hydrodynamica*.
- Fourier, J. B. (1822). *Théorie*