Textbook of

BIOCHEMISTRY & BIOPHYSICS

for Post Basic BSc Nursing Students

(As per the INC Syllabus of Post Basic BSc Nursing)

Special Features

- Conforming to the syllabus of Post Basic BSc Nursing
- **150+** Tables, Flowcharts and Figures
- Text enriched with recent updates and Practical Examples
- A perfect amalgamation of Theoretical and Clinical Aspects
- Nursing Implications covered exclusively

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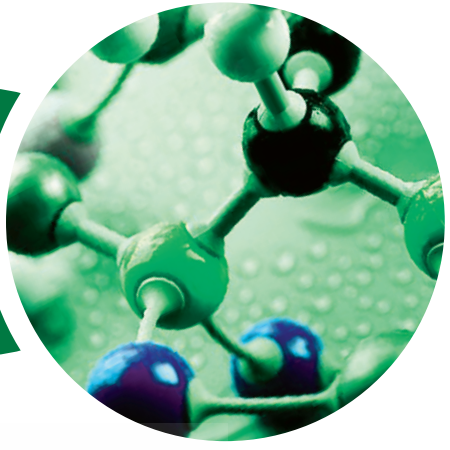
Chapter 9

Motion



Learning Objectives

After completion of the chapter, students will be able to:

- Understand the concept of motion.
- Discuss different types of motion.
- Understand the concept of speed, velocity, and acceleration.

Chapter Outline

- Introduction
- Concept of Motion
- Vector and Scalar Quantities
- Rest and Motion
- Speed, Velocity, Acceleration and Distance
- Acceleration
- Distance
- Application of Motion in Nursing

Keywords

Acceleration: Acceleration is the measurement of the change in an object's velocity.

Collision: A collision in physics occurs when any two objects bump into each other.

Displacement: Displacement refers to the overall change in position of an object.

Energy: Energy is the ability to do work. The standard unit of measure for energy is the Joule (J).

First law of motion: The first law of motion states that any object in motion will continue to move in the same direction and speed unless external forces act on it.

Force: Force is the measurement of a push or pull on an object. Force is a vector measured in newtons.

Friction: Friction is the resistance of motion when one object rubs against another. It is a force and is measured in newtons.

Gravity: Gravity is a force caused when the mass of physical bodies attracts each other. On they into the earth gravity pulls at objects with an acceleration of 9.8 m/s^2.

Impulse: An impulse is a change in momentum.

Joule: The joule is the standard unit of measure for energy and work.

Kinetic energy: Kinetic energy is the energy an object has due to its motion. It is a scalar quantity.

Mass: Mass is a measurement of how much matter is in an object. It is usually measured in kilograms.

Momentum: The momentum is a measurement of mass in motion.

Newton: The newton is the standard unit of measure for force.

Pascal: The pascal is the standard unit of measure for pressure.

Potential energy: Potential energy is the energy stored by an object due to its state or position. It is measured in joules.

Contd...

Power: Power is a measurement of the rate at which energy is used. Power is calculated by dividing work over time. The standard unit for power is the watt.

Pressure: Pressure is the force over a given area. Pressure is measured in pascals.

Scalar: A scalar is a measurement that only measures the magnitude. Unlike a vector, a scalar does not have direction.

Second law of motion: The second law of motion states that the greater the mass of an object, the more force it will take to accelerate the object.

Simple machine: A simple machine is a basic mechanical device for applying a force and doing work. Some examples of simple machines include the lever, pulley, inclined plane, wedge, and screw.

Speed: Speed is the measurement of how fast an object moves relative to a reference point. It is a scalar quantity measured by distance over time.

Third law of motion: The third law of motion states that every action has an equal and opposite reaction.

Vector: A vector is a quantity that has both a magnitude and a direction.

Velocity: Velocity is the rate of change in an object's position. Velocity is a vector quantity. The magnitude of velocity is the object's speed.

Weight: Weight is the force of gravity on an object. In physics, a weight is measured in newton.

Work: Work is a force that acts on an object to move to some distance. Work is equal to the force times the distance and is measured in joules.

INTRODUCTION

Motion helps in many ways in day-to-day life. For example, it allows us to move around and get things done, which is essential to accomplishing tasks and fulfilling our needs. It also allows to engage in physical activity, which is important for maintaining our overall health and well-being. Additionally, motion can be used in various forms of transportation, such as cars, buses, and trains, which allow to move from one place to another. Overall, motion is a fundamental aspect of our daily lives that help to accomplish our goals and maintain our physical and mental well-being.

CONCEPT OF MOTION

Motion is defined as the change in position of an object with respect to its surroundings in a given interval of time. Motion is an important part of everyday life; for example, the earth moves around sun in an orbit, all the heavenly bodies have its own motion, the organs inside the body have motion, and the heart pumps blood all over the body, thus circulating blood each and every cell.

Motion seems to be essential in our lives as well as influences so many of our activities. We will state that a boy is in motion, if he is walking down the street from his school to his home. Therefore, the motion may be seen in all aspects of our existence. To understand the concept of motion, one should understand vector and scalar quantities.

VECTOR AND SCALAR QUANTITIES

The physical quantities can be divided into two categories; scalar and vector quantities as follows:

1. **Scalar quantities:** The physical quantities which have magnitude but no direction are called scalar quantities. They can be added, subtracted, multiplied and divided using the laws of algebra. A scalar quantity is specified by a number and unit where number represents its magnitude.
   Mass, length, temperature, time, work, etc., are some examples of scalar quantities.

Table 9.1: Differences between scalar and vector quantity

Scalar quantity	Vector quantity
It has only the magnitude	It has direction and magnitude
It is only one-dimensional	It is multidimensional
The quantity changes with the change in magnitude	The quantity changes with magnitude and direction.
Normal rules of algebra are applicable.	There is a different set of rules known as vector algebra
One scalar quantity can divide another scalar	One vector cannot divide another vector

2. **Vector quantities:** The physical quantities having both the magnitude and the direction are called vector quantities.
   For examples, displacement, velocity acceleration, force, weight, etc. Vectors can be negative, positive or zero.

The magnitude of a vector is always a scalar quantity. The differences between scalar and vector quantity is given in Table 9.1.

Application of Scalar and Vector Quantities in Nursing

Both vector and scalar quantities are used to describe various physical and biological aspects of the human body and medical processes.

Scalar Quantities

Temperature: Temperature is a scalar quantity that measures the degree of hotness or coldness of a substance. Temperature is a scalar used for diagnosing and monitoring various conditions. For example, body temperature is monitored to detect fever, which can be a sign of infection or other medical issues.

Pressure: Pressure is used in medicine to measure the force exerted on a given area. Blood pressure is a important parameter of human body. Systolic and diastolic blood pressure measurements are used to assess the health of the cardiovascular system and diagnose conditions like hypertension.

Mass: Mass is a scalar quantity that measures the amount of matter in an object. Mass is used to quantify body composition and is essential for assessing nutrition and diagnosing conditions related to weight management. The measurement of body mass index (BMI) is used to categorize individuals as underweight, normal weight, overweight or obese.

Vector Quantities

Velocity: Velocity can be important when studying blood flow in arteries and veins. For instance, in Doppler ultrasound, velocity vectors are used to assess blood flow direction and speed in vessels, which are crucial in diagnosing conditions like deep vein thrombosis or assessing the heart function.

Force: Force vectors can be applied to study biomechanics, such as the forces exerted on bones and joints during movement or impact. This is useful in orthopedics and physical therapy for assessing and treating musculoskeletal conditions.

Magnetic field: Magnetic fields are used in medical imaging, particularly in magnetic resonance imaging (MRI). MRI machines generate powerful magnetic fields with specific orientations to create detailed images of the body's internal structures. The vector nature of magnetic fields is essential for understanding the precise spatial information captured in MRI scans.

Must Know

- **Unit vector:** A unit vector is a vector pointing a given direction with a magnitude of one.
- **Equal vector:** Two vectors are said to be equal, if they have direction and equal magnitude.
- **Negative vector:** A negative vector of a given vector is a vector of the same magnitude but acting in a direction opposite to the given vector.
- **Coinitial vector:** The vectors are said to be coinitial, if they have the same starting points.
- **Collinear vector:** Vector having the same direction and equal or unequal magnitude.
- **Coplanar vector:** Vector acting on the same plane.
- **Position vector:** It is the vector giving the direction to the position of the object with respect to its origin.
- **Equilibrant vector:** A single vector which balances two or more vectors acting on a body at the same time is called equilibrant vector. It is equal and opposite to the resultant of various vectors acting on that body.

Application of Vectors in Nursing

The concept of vectors has numerous applications in nursing. These are as follows:

- **Application of equilibrium and vector addition:** Force is a vector quantity. The concept of equilibrium and vector addition is applied in the force produced by traction and muscle action respectively.
- **Muscle action:** The fibers of muscles of body pass in different directions from a point of attachment which is common. The resultant force produced is an outcome of the addition of these forces based on laws of vectors addition. Rarely, the force of a single muscle in one direction is involved in its movement.

Examples are action of trapezius muscle and action of pectoralis muscle.

REST AND MOTION

When we read a book in a moving vehicle, the person who is outside the vehicle observes the book is in motion whereas the passenger in bus sees the book in rest. The phenomenon of motion is best explained from the observer's point of view. If the object changes its position with respect to time from observer's point of view, object is said to be in motion.

Rest: A body is said to be in rest, if it does not change its position with reference to a fixed point with time interval.

Motion: Motion is defined as the change in the position of an object when compared to time. Motion can be described in the terms of distance or the displacement:

- Distance moved is the actual length of the path traveled by a body.
- Displacement is the length of the shortest path traveled by a body from initial position to its final position.

Types of Motion

Rotary motion: This type of motion exists when the object is traveling in a circle, it usually occurs when the object is rotating around its place or axis, e.g., earth revolves around the sun.

Linear motion: In this type of motion, the object moves either in a straight line or in a curved path. The classification of linear motion is:

- **Rectilinear motion:** The object here moves in a straight line, e.g., vehicles traveling in straight line.
- **Curvilinear motion:** The path is curved in this case.

Oscillatory motion: The movement that occurs in this type of motion is the front and back movement or rather oscillation that takes place. It is described as the movement of an object around its mean position. If the

object is repeating its cycle of motion after a particular period, then it is called oscillating motion. For example, a pendulum of a clock (Fig. 9.1).

Periodic motion: The periodic motion is a type of motion that is repeated at equal intervals of time. E.g., vibration of tuning fork.

Vibratory motion: Vibration is a very mechanical phenomenon whereby oscillations occur only at an equilibrium point. These can be periodic or random (unpredictable).

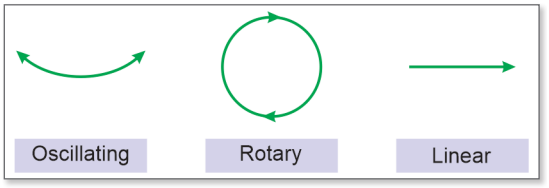


Figure 9.1: Different types of motion

Some vibrations are desirable and undesirable: The desirable vibrations are considered to be motions like harmonium sound or sound from mobile phone. The vibration can also be undesirable, when it is considered to waste energy and create disturbing sounds.

Random motion: Random motion is the type of motion that is unpredictable and the object is likely to move in any direction. E.g., movement of gas molecules.

Must Know

- **Kinematics:** Kinematics refers to the study of motion. Kinematics deals with any type of motion of any particular object. Kinematics refers to the study of objects in motion and their inter-relationships.
- **Dynamics:** Dynamics, is a branch of physical science and subdivision of mechanics that is concerned with the motion of material objects in relation to the physical factors that affect them. Dynamics considers the forces that affect the motion of moving objects and systems. Newton's laws of motion are the foundation of dynamics.

SPEED, VELOCITY, ACCELERATION AND DISTANCE

Speed

Speed of a body is the distance traveled by the body in the unit time or it is the measure of distance covered in a time limit. It is the rate of change of distance with time. So, we can say that:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

- If a body travels a distance in time, the speed is:

$$S = D/T$$

- The SI unit of speed is meter per second (m/s) or (ms^{-1}). Since, speed has only magnitude and no direction it is a scalar quantity. The unit of speed is obtained from the unit of speed and unit of time.

Velocity

The quantity which specifies both the direction of motion and speed is velocity.

Velocity: Velocity of a body is the displacement of the body per unit time.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

- Since velocity has both magnitude and direction, it is a vector quantity.
- **Average velocity:** Average velocity is the ratio of the total displacement to the total time taken.
- Average velocity = Total displacement/total time.
- Average velocity is also like the mean of the initial velocity and final velocity.

- Average velocity $= \frac{(\text{initial velocity} + \text{final velocity})}{2}$

Or

$$= \frac{(u + v)}{2}$$

- Speed and velocity have the same unit (m/s) or (ms^{-1}).

Types of Velocity

- **Uniform velocity:** An object is said to be moving with uniform velocity, if it has equal displacements with equal intervals of time.
- **Variable velocity:** An object is said to have variable velocity when its speed or direction or both changes.
- **Average velocity:** It is the uniform velocity in which object will cover the same displacement in same interval of time.
- **Instantaneous velocity:** The velocity of an object at a particular point of time is instantaneous velocity.

Application of Speed and Velocity in Nursing

The speed and velocity concepts from biophysics find applications in various aspects of medicine.

Gait analysis: Speed and velocity are crucial in analyzing human and animal movements. Gait analysis helps diagnose and treat conditions like orthopedic disorders and neurological diseases. It can provide insights into a patient's walking or running speed and help assess the effectiveness of treatments or rehabilitation programs for different musculoskeletal disorders.

Ultrasound imaging: Ultrasound uses the speed of sound to create images of internal body structures. By measuring the time, it takes for sound waves to travel and bounce back, medical professionals can calculate the velocity of fluids (e.g., blood flow) and assess the health of organs and blood vessels.

Echocardiography: In cardiology, the velocity of blood flow is measured using Doppler echocardiography. This technique helps assess the functioning of heart valves, detect abnormalities, and evaluate the severity of heart diseases.

Intravenous (IV) infusion: The speed or velocity of medication infusion is crucial to ensure proper dosing and avoid complications. Controlling the rate of IV infusion is essential in delivering medications safely and effectively.

Pacemakers and implantable cardioverter defibrillators (ICDs): These devices use the concept of pacing and controlling electrical impulses to maintain proper heart rate and rhythm, which can be related to speed and velocity in terms of electrical conduction through the heart.

Spirometry: Spirometry measures the speed and volume of air inhaled and exhaled during breathing. It is essential in diagnosing and monitoring lung conditions like asthma, chronic obstructive pulmonary disease (COPD), and restrictive lung diseases.

Magnetic resonance imaging (MRI): MRI can provide velocity-encoded images to assess blood flow patterns in vessels. This is valuable in diagnosing vascular abnormalities, aneurysms, and stenosis.

Rehabilitation: Understanding an athlete's speed and velocity during different phases of rehabilitation helps therapists design personalized programs to recover strength and function following injuries.

Trauma analysis: When assessing trauma patients, speed and velocity measurements can be crucial in determining the forces involved in accidents, falls, or injuries. This information can guide treatment decisions.

Pharmacology: The concept of speed and velocity is used to describe drug absorption, distribution, and elimination rates within the body. Understanding these parameters helps in drug dosage optimization and therapeutic monitoring of different drugs.

Blood flow in arteries: Carotid ultrasound is a safe, noninvasive, painless procedure that uses sound waves to examine the blood flow through the carotid arteries. The normal peak systolic velocity is <125 cm/s (30–40 cm/s) and end diastolic velocity is 40 cm/s.

Speed test: Speed's test is used to test for superior labral tears or bicipital tendonitis. To perform the Speed's test, the examiner places the patient's arm in shoulder flexion, external rotation, full elbow extension, and forearm supination. Manual resistance is then applied by the examiner in a downward direction. The test is considered to be positive, if pain in the bicipital tendon or bicipital groove is reproduced.

ACCELERATION

The quantity which specifies changes in velocity is acceleration. The rate of increase in speed is known as acceleration.

- Acceleration is rate of change in velocity.
- Acceleration = $\frac{(\text{final velocity} - \text{initial velocity})}{2}$
- If the velocity of a body changes from initial value in time, then acceleration is:

$$a = \frac{(v - u)}{2}$$

- The SI unit of acceleration is ms^{-2}

DISTANCE

The length of the actual path covered by an object during motion in given time interval is called distance traveled by that object.

Unit of distance:

The SI unit of distance = meter (m)
CGS unit of distance = centimeter (cm)
Dimensional formula [D] = $(M^0L^1T^0)$

APPLICATION OF MOTION IN NURSING

Range of motion therapy: It is useful for determining the value of the ability of bones and muscles to move, assessing bones and joints, muscles, preventing joint stiffness and improving blood circulation.

Flow of blood inside the human body: The flow of blood inside the human body takes place with various velocities. The velocity is increased when blood flows in major arteries and reduced when blood flows from arteries to capillaries and further reduced when blood flows from capillaries to veins.

Effect of accelerated motion on human body: The body is accelerated when a person sits on an accelerated vehicle. All the organs and body fluids undergo positive acceleration. Sometimes, it can be fatal.

Circular motion: Centrifuges move in high circular motion. This is used in laboratories in the hospital.

SUMMARY

- Speed and velocity concepts are integral to various aspects of medicine.
- Concepts of speed and velocity are used to diagnose, treat, and monitor patients.
- The fundamental concepts of motion are applied to design and evaluate medical devices and therapies.

- Range of Motion Therapy is useful for determining the value of the ability of bones and muscles to move.
- These principles provide valuable quantitative data that contribute to the advancement of medical science and patient care.

ASSESS YOURSELF

Long Answer Questions

1. Discuss rest and motion.
2. Explain the types of motion.
3. Discuss the application of the principles of motion in nursing.

Short Answer Questions

1. Define vector and scalar quantities.
2. Write about application of speed and velocity in nursing.

Multiple Choice Questions

1. **A nurse is monitoring a patient's breathing rate. The patient takes 12 breaths in one minute. What is the patient's respiratory rate in breaths per second?**
   a. 0.2 breaths/s
   b. 0.5 breaths/s
   c. 1 breath/s
   d. 2 breaths/s
2. **A physician is analyzing a patient's electrocardiogram (ECG) to measure the speed of electrical signals through the heart. The electrical signal travels from the atria to the ventricles in 0.08 seconds. If the distance it travels is 2 centimeters, what is the velocity of the electrical signal in centimeters per second?**
   a. 16 cm/s
   b. 4 cm/s
   c. 25 cm/s
   d. 50 cm/s
3. **Newton's first law of motion is also called:**
   a. Law of momentum
   b. Law of force
   c. Law of inertia
   d. None of these
4. **In a uniform circular motion:**
   a. Velocity is constant
   b. Distance is constant
   c. Displacement is constant
   d. Speed is constant
5. **Scalar quantity is:**
   a. Length
   b. Displacement
   c. Velocity
   d. Force
6. **Dimensional formula of speed:**
   a. $[M^{\circ}LT^{-1}]$
   b. $[M^{\circ}LT^{-1}]$
   c. $[M^{\circ}L^{1}T^{-1}]$
   d. $[M^{1}L^{1}T^{-1}]$
7. **When a car rounds a curve suddenly, the person sitting inside is thrown outward. Which type of inertia is followed:**
   a. Inertia of rest
   b. Inertia of motion
   c. Inertia of direction
   d. None of these

Answer Key

1. c 2. a 3. c 4. d 5. a 6. c 7. b

Textbook of

BIOCHEMISTRY & BIOPHYSICS for Post Basic BSc Nursing Students

Salient Features

- The book has been divided into two Sections—Biochemistry and Biophysics—strictly as per the INC syllabus for Post Basic BSc Nursing.
- An extensive number of practical examples and applied aspects have been covered throughout the book for the easy and quick understanding.
- The chapters are well-illustrated with easy-to-reproduce figures and tables keeping in mind the pattern of the syllabus.
- Most essential chemical structures and chemical cycles have been elucidated in-between the text for better understanding.

Learning Objectives given in all the chapters focus on the areas that a student shall gain after completing the chapter.

Learning Objectives

After completion of the chapter, students will be able to:

- Discuss the water balance and regulation in human body.
- Explain the various electrolytes needed for human body and the need for electrolyte balance in body.
- Discuss the acid base balance in human body.

Every chapter starts with a **Chapter Outline** that gives a glimpse of the content covered in the chapter.

Chapter Outline

- Introduction
- Water
- Electrolytes
- Acids
- Bases
- Salts
- Buffers—Acid Base Balance In Human Body

Important terms used in the chapter are enlisted under **Keywords**.

Keywords

Aldosterone: A mineralocorticoid hormone, secreted by the adrenal cortex, that regulates the balance of sodium and potassium in the body.

Antidiuretic hormone: A hormone secreted by the posterior pituitary gland that regulates the amount of water excreted by the kidneys.

Must Know facts are covered throughout the book from clinical practice point of view.

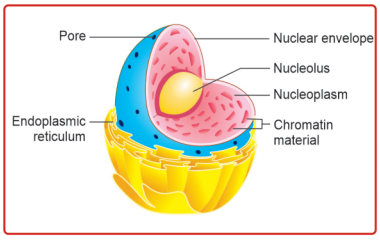
Must Know

When the body does not absorb or convert enough glucose, blood sugar levels remain high. Insulin reduces the body's blood sugar levels and provides cells with glucose for energy by helping cells absorb glucose.

When blood glucose falls, several things happen to restore homeostasis:

- Messages are received from brain and nervous system and person feels hungry.
- Glucagon is released from the pancreas into the bloodstream. In liver cells, it stimulates the breakdown of glycogen releasing glucose into the blood.

Several images and **diagrams** have been used at relevant places to simplify the concepts for the students.



Each and every chapter ends with **summary** for quick glance of the chapter.

SUMMARY

- Lipids are heterogeneous group of compounds including fats, oils, steroids, and wax.
- Subcutaneous lipids serve as insulating materials against heat and cold and protect internal organs.
- Bile salts act as emulsifying agents during digestion and absorption of lipid.
- Based on clinical nature, lipids are classified as simple, compound, and derived.

Detailed **Assess Yourself** exercises in each and every chapter will facilitate structured learning and revision of the material provided in the respective chapters.

ASSESS YOURSELF

Long Answer Questions

1. Describe the uses of radioisotopes in the field of medicine.
2. Discuss the hazards of radiation exposure and methods to prevent it.
3. Discuss the use of radioisotopes in cancer therapy.

Short Answer Questions

1. What are the types of radiation?
2. Write about the limitations of the Rutherford atomic model.

About the Author

Sheela Tiwari, *PhD, MSc (N), MBA, MA (Sociology)* is currently working as Principal at Bora Institute of Allied Health Sciences, Lucknow, Uttar Pradesh. She possesses a considerable teaching experience and more than 25 years of administrative experience. She is the active member of TNAI and various other professional organizations. She has published and presented various scientific papers in national and international journals. She has been research guide for undergraduate, postgraduate and doctorate students. Besides, she has been active BOS member, Program coordinator, question paper setter, evaluator, inspector and consultant in various Indian Universities and Nursing Councils.

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