PHYSICS WORKBOOK
(PART I)
## MODULE DELIVERY PLAN
**AY 2018-19 (Term 2)**

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<tr>
<th>Title / Module Code / Programme</th>
<th>Physics / MTCG1017</th>
<th>Module Coordinator</th>
<th>Resources &amp; Reference books</th>
<th>Duration &amp; Contact Hours</th>
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<tr>
<td>Physics / MTCG1017</td>
<td></td>
<td>Dr. Rabin R. Rabe</td>
<td>MTC Workbook Part 1 &amp; 2</td>
<td>6 hrs x 12 weeks = 72 hrs</td>
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### Lecturers
- TBA

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<th>Week</th>
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2.3. States of matter (solid, liquid gas and plasma), and change of states.  
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2.6. Periodic table.  
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| 7 | 7. Rotational Motion  
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7.2. Uniform Circular Motion  
a. Centripetal force  
b. Centrifugal force  
7.3. Moment of Force (Torque)  
7.4. Moment of Couple (Couple)  
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7.7. Angular Momentum  
a. Conservation of angular momentum  
b. Gyroscope and precession  
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| 8 | 8. Solids  
8.1. Mechanical properties of solids  
a. Hooke’s law  
b. Pressure  
c. Stress, Strain and Young’s Modulus  
Kinds of stress (tension, compression, torsion, bending, and shear)  
Fluids  
9.1. Fluid statics  
a. Definition of fluids  
b. Density  
c. Specific gravity  
d. Hydrometer  
e. Atmospheric, absolute, and gauge Pressure  
f. Types of gauge pressure  
g. Hydrostatic pressure  
h. Buoyancy and Archimedes’ Principle  
i. Pascal’s Principle  
j. Hydraulic Press (Bramah’s Press)  
9.2. Fluid dynamics  
a. Viscosity and compressibility  
b. Laminar and turbulent flow  
c. Streamlining  
d. Continuity Equation  
e. Bernoulli’s Principle  
f. Venturi tube  
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| 9 | 10. Thermodynamics  
10.1. Heat, Temperature, and Temperature Scales  
10.2. Calorimetry  
a. Specific heat capacity  
b. Latent Heat  
10.3. Thermal Expansion  
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<td>b. Period</td>
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<td></td>
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<td></td>
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<td></td>
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<td>e. Interference</td>
<td></td>
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<td></td>
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<td>12.6. Law of refraction</td>
<td></td>
</tr>
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<td></td>
</tr>
</tbody>
</table>

| FINAL EXAM REVISION | 2 |
| TOTAL | 72 |

| 13 | FINAL EXAM (Part 7-12.8) | 2, 3, 4, 5 & 6 |

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Mr. Ahmed Al Dissi  
Department Head, GSD
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Chapter 1: Units and unit conversion

All quantities used to describe the laws of Physics and whose measurement is essential are referred to as physical quantities. For example- mass, force, speed etc.

A unit is defined as a standard (or reference) adopted for measurement of any physical quantity, which is agreed by all the countries in the world. For example- kilogram (kg), Newton (N), Kelvin (K) etc.

After measurement of any physical quantity the result is written as a number followed by its unit. For example - 3 kg, 5 N, 273 K etc.

1.1. System of Units

The system of units which is at present internationally accepted for measurement is the Système Internationale d’Unites (French for International System of Units), abbreviated as SI. Some other system of units are mentioned in the table 1.1 below.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>System of Units</th>
<th>Unit of Length</th>
<th>Unit of Mass</th>
<th>Unit of Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SI (System International)</td>
<td>meter (m)</td>
<td>kilogram (kg)</td>
<td>second (s)</td>
</tr>
<tr>
<td>2</td>
<td>CGS (Gaussian System)</td>
<td>centimeter (cm)</td>
<td>gram (g)</td>
<td>second (s)</td>
</tr>
<tr>
<td>3</td>
<td>FPS-US Customary/BES Units</td>
<td>foot (ft)</td>
<td>slug (slug)</td>
<td>second (s)</td>
</tr>
</tbody>
</table>

Table 1.1. System of Units

On the basis of the physical quantities and their dependence on one another, units can be divided as base units and derived units.

A. Base

<table>
<thead>
<tr>
<th>SI (System International) Units</th>
<th>Basic Units</th>
<th>Derived Units</th>
</tr>
</thead>
</table>

Table 1.2. Types of Units

These quantities are defined in an absolute way and do not depend on any other quantity, e.g. length, mass, time, etc. Table 1.3 shows the seven (7) base quantities and their corresponding units.
B. Derived quantities

All other physical quantities other than the fundamental / base quantities that are obtained in terms of two or more base quantities are called derived quantities. They depend on the base quantities. Some physical quantities and corresponding derived units are given in the table 1.4 below.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Physical Quantity</th>
<th>SI Units</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Length</td>
<td>meter</td>
<td>m</td>
</tr>
<tr>
<td>2</td>
<td>Mass</td>
<td>kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>3</td>
<td>Time</td>
<td>second</td>
<td>s</td>
</tr>
<tr>
<td>4</td>
<td>Temperature</td>
<td>Kelvin</td>
<td>K</td>
</tr>
<tr>
<td>5</td>
<td>Electric Current</td>
<td>Ampere</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>Amount of substance</td>
<td>Mole*</td>
<td>Mol</td>
</tr>
<tr>
<td>7</td>
<td>Luminous Intensity</td>
<td>candela</td>
<td>cd</td>
</tr>
</tbody>
</table>

*1 mole = $6.022 \times 10^{23}$ particles in any specific substance

### SOME DERIVED UNITS

<table>
<thead>
<tr>
<th>No.</th>
<th>Physical Quantity</th>
<th>SI Units</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Angular displacement</td>
<td>$\theta$ radial</td>
<td>rad</td>
</tr>
<tr>
<td>2</td>
<td>Density</td>
<td>$\rho$ kilogram per cubic meter</td>
<td>kg/m³</td>
</tr>
<tr>
<td>3</td>
<td>Speed, Velocity</td>
<td>$v$ meter per second</td>
<td>m/s</td>
</tr>
<tr>
<td>4</td>
<td>Acceleration</td>
<td>$a$ meter per square second</td>
<td>m/s²</td>
</tr>
<tr>
<td>5</td>
<td>Force</td>
<td>$F$ Newton</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>Work, Energy</td>
<td>$W$ or $E$ Joule</td>
<td>J</td>
</tr>
<tr>
<td>7</td>
<td>Power</td>
<td>$P$ Watt</td>
<td>W</td>
</tr>
<tr>
<td>8</td>
<td>Momentum</td>
<td>$p$ kilogram meter per second</td>
<td>kg m/s</td>
</tr>
<tr>
<td>9</td>
<td>Frequency</td>
<td>$f$ per second or hertz</td>
<td>s⁻¹ or Hz</td>
</tr>
<tr>
<td>10</td>
<td>Voltage</td>
<td>$V$ Volt</td>
<td>V</td>
</tr>
<tr>
<td>11</td>
<td>Resistance</td>
<td>$R$ Ohm</td>
<td>Ω</td>
</tr>
</tbody>
</table>

Table 1.4. Some Derived Quantities and Units

1.2. Unit conversions

A. For SI and metric units

For very large or very small numbers, we can use standard prefixes corresponding to the powers of 10. Each prefix has a specific name and abbreviation.

The main prefixes that you need to know in daily practical life are shown in table 1.5.
Below is an example of length unit conversion:

B. For SI/metric system to customary units

Different units are used in some countries for the measurement of various physical quantities. The table 1.6 below gives the conversion chart of some metric units to customary units.

<table>
<thead>
<tr>
<th>Metric to Customary Conversions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
</tr>
<tr>
<td>1 centimeter = 0.39 inch</td>
</tr>
<tr>
<td>1 meter = 3.28 feet</td>
</tr>
<tr>
<td>1 meter = 1.09 yards</td>
</tr>
<tr>
<td>1 kilometer = 0.621 mile</td>
</tr>
<tr>
<td>1 kilometer = 0.54 nautical mile</td>
</tr>
</tbody>
</table>

Table 1.5. Some Prefixes

<table>
<thead>
<tr>
<th>PREFIXES</th>
</tr>
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<tbody>
<tr>
<td>Prefix</td>
</tr>
<tr>
<td>tera</td>
</tr>
<tr>
<td>mega</td>
</tr>
<tr>
<td>kilo</td>
</tr>
<tr>
<td>centi</td>
</tr>
<tr>
<td>milli</td>
</tr>
<tr>
<td>micro</td>
</tr>
<tr>
<td>nano</td>
</tr>
<tr>
<td>pico</td>
</tr>
</tbody>
</table>

Table 1.6. Some Unit Conversions
Worksheet 1

I. Multiple choice questions:

1. Which of the given quantities is a base quantity?
   (a) Volume
   (b) Amount of substance
   (c) Voltage

2. What does SI stand for?
   (a) System International
   (b) System Incorporated
   (c) System for inches

3. What is the SI unit of time?
   (a) Minutes
   (b) Hours
   (c) Seconds

4. What is the SI unit of length?
   (a) Meter
   (b) Centimeters
   (c) Millimeters

5. What is the SI unit of temperature?
   (a) Fahrenheit
   (b) Kelvin
   (c) Celsius

6. What is the SI unit of force?
   (a) Newton
   (b) Volt
   (c) Hertz

7. The amount of space something takes up is
   (a) volume
   (b) density
   (c) mass

8. The value of k (kilo) is equivalent to
   (a) $10^3$
   (b) $10^3$
   (c) $10^2$

9. The prefix meaning 1000 is called?
   (a) Centi
   (b) Milli
   (c) Kilo

10. In SI system, the unit of area is:
    (a) meter per second
    (b) cubic meter
    (c) square meter

11. Cubic Centimeters is the unit of
    (a) length
    (b) volume
    (c) density

12. The prefix meaning of 0.001 is
    (a) milli
    (b) centi
    (c) kilo

13. The prefix meaning of 0.1 is
    (a) milli
    (b) deci
    (c) centi

    (a) 3
    (b) 4
    (c) 5

15. 100 cm is equal to
    (a) 0.1 m
    (b) 1.0 m
    (c) 10 m
II. Fill in the blanks:

1. In CGS system, the unit of length is ______________________.
2. In US customary (BES Units) system the unit of mass is ____________________.
3. The value of prefix μ (micro) is equivalent to ____________________.
4. The units which are obtained by multiplying or dividing base units are called ____________________.
5. The multiplier of nano is _________________.

III. Do the following unit conversions:

1) $10^2$ kPa = . . . . . Pa
2) 54 km/h = . . . . . m/s
3) 0.1mm = . . . . . m
4) 96.5 MHz = . . . . . Hz
5) 25 cm$^2$ = . . . . . m$^2$
6) 100 cm$^3$ = m$^3$
7) 800 kg/m$^3$ = g/cm$^3$

IV. Answer the following questions:

1) What is the volume of a cube with sides 0.5 cm? Give your answer in m$^3$.

2) The dimensions of a football court is 90 m x 120 m. Find the area of the field.
# Homework-1

## I. Unit Conversion

1) Convert the following measurements into meters.

<table>
<thead>
<tr>
<th>56100 mm</th>
<th>280 cm</th>
<th>3.7 km</th>
</tr>
</thead>
</table>

2) Convert the following measurements into m².

<table>
<thead>
<tr>
<th>150 mm²</th>
<th>20 cm²</th>
<th>0.7 km²</th>
</tr>
</thead>
</table>

3) Convert the following measurements into seconds.

<table>
<thead>
<tr>
<th>4 min</th>
<th>2h,15 min</th>
<th>1 day</th>
</tr>
</thead>
</table>
4) Convert the following measurements into mL.

<table>
<thead>
<tr>
<th>3.2 x 10^4 μL</th>
<th>0.75 liters</th>
<th>0.5 m³</th>
</tr>
</thead>
</table>

5) Which is greater 45 miles or 63 km?

6) How many cubic feet are there in a room measuring 5m x 10m x 2m?

7) What is the volume of a 12 oz can of soda in mL?

8) What is the mass of a 120 lb person in grams?
II. Match the quantities in column 1 with correct unit/meaning from column 2. Write the LETTER of your answer in the box given below.

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pressure</td>
<td>A. 10^-6</td>
</tr>
<tr>
<td>2. Electric Current</td>
<td>B. Hertz</td>
</tr>
<tr>
<td>3. Pico</td>
<td>C. gram</td>
</tr>
<tr>
<td>4. Frequency</td>
<td>D. Ampere</td>
</tr>
<tr>
<td>5. Mass</td>
<td>E. Pascal</td>
</tr>
<tr>
<td></td>
<td>F. Volt</td>
</tr>
<tr>
<td></td>
<td>G. 10^-12</td>
</tr>
</tbody>
</table>

1. ___  2. ___  3. ___  4. ___  5. ___
Chapter 2: Nature of Matter

2.1. Matter
In this universe everything is made up of material which we refer to as “matter”. The air around us, the food we eat, plants and animals, sun, moon, oil or a particle of sand—everything is matter. All the things mentioned above occupy space, that is, have volume and mass. Matter is made of tiny particles called molecules which are too small to be seen with the naked eye. These molecules are further made up of smaller particles called atoms.

A. Atom
Atoms are the smallest particles of matter that can take part in chemical reactions. An atom is composed of sub-atomic particles called electrons, protons and neutrons. The structure of an atom will be discussed later in the following sections.

B. Molecules
When atoms bond together they form a molecule. Atoms of the same element or of different elements can join together to form molecules.

1. Monatomic molecule
A molecule that consists of a single type of element is called a monatomic molecule. Example: Oxygen gas (O₂), nitrogen gas (N₂), and hydrogen gas (H₂).

2. Polyatomic molecule
A molecule that consists of two or more type of elements is called polyatomic molecule. Example: Water (H₂O), salt (NaCl), and carbon dioxide (CO₂).

2.2. Classification of matter
Classification is one of the basic processes in science. Matter can be classified in terms of its purity. The classification is in terms of “how pure” matter is. Please refer to the table 2.1.

A. Pure substances
How can we say that milk, oil, sugar, salt, shampoo, mineral water or juice that we buy from the supermarket are pure? For a common person pure means having no other substance in it. But, for a scientist all these things are actually mixtures of different substances and hence not pure. For example, milk is actually a mixture of water, fat, proteins etc.

When a scientist says that something is pure, it means that all the constituent particles of that substance are the same in their chemical nature. A pure substance consists of single type of particles. A pure substance has a definite and constant composition like salt or sugar. It can be either an element or a compound, but the composition of a pure substance doesn’t vary. Refer to table-2.1.
Table 2.1. Classification of Matter

1. Elements

An element is a form of matter that cannot be broken down by chemical reactions into simpler substances. An element is composed of a single kind of atom. An atom is the smallest part of an element that still has all the properties of the element.

Examples: All elements in the periodic table like Oxygen, Hydrogen, Nitrogen, Gold, Sodium, Aluminum, Chlorine, Lithium, Helium etc…as shown in fig-2.1

2. Compounds

A compound is composed of two or more elements in a specific ratio. For example, water is a compound made up of two elements, hydrogen (H) and oxygen (O) as shown in fig-2.2. These elements are combined in a very specific way — in a ratio of two hydrogen atoms to one oxygen atom, known as: $\text{H}_2\text{O}$. The compound water has physical and chemical properties different from both hydrogen and oxygen — water’s properties are a unique combination of the two elements.

Other Examples: Compounds - pure water (H$_2$O), table salt (NaCl), Sugar or sucrose (C$_{12}$H$_{22}$O$_{11}$), carbon dioxide (CO$_2$), methane (CH$_4$), Ammonia (NH$_3$) etc., as shown in fig-2.3

Fig-2.1. Some Elements-Gold, Aluminum, Copper

Fig-2.2. The water molecule. The oxygen atom has six electrons in the outer or valence shell. As there is room for eight electrons, one oxygen atom can combine with two hydrogen atoms by sharing the single electron from each hydrogen atom and turns stable water molecule
B. Mixtures

Mixtures are physical combinations of pure substances that have no definite or constant composition — the composition of a mixture varies according to who prepares the mixture.

Although chemists have a difficult time separating compounds into their specific elements, the different parts of a mixture can be easily separated by physical means, such as filtration.

For example, if you have a mixture of salt and sand, and you want to purify the sand by removing the salt. You can do this by adding water, dissolving the salt, and then filtering the mixture. You then end up with pure sand.

Mixtures can be either homogeneous or heterogeneous:

1. Homogeneous mixtures

A homogeneous mixture, sometimes called a solution, is relatively uniform in composition; we generally think of a solution as a liquid that contains either a solid, liquid or a gas dissolved in it. But, we can also have solid solutions (alloys) and gaseous solutions (air). Every portion of the mixture is like every other portion.

For example, if you dissolve sugar in water and mix it really well, your mixture is basically the same no matter where you sample it.

Alloys are homogeneous mixtures of metals and can be separated into their components by physical methods. For example, brass is a mixture of approximately 30% zinc and 70% copper. Some other alloys (steel, bronze, nichrome, etc.)

Other examples – Air, sugar solution, salt solution, rain water, dishwashing liquid, vinegar, soft drinks (Pepsi, Coca-Cola, Mountain Dew), petroleum, gasoline, etc., as shown in fig-2.4.
Air is a mixture of gas. Air is a homogeneous mixture of a number of gases. Its two main constituents are: oxygen (21%) and nitrogen (78%). The other gases are present in very small quantities.

2. Heterogeneous mixtures

A heterogeneous mixture is a mixture whose composition varies from position to position within the sample. For example, if you put some sugar in a jar, add some sand, and then give the jar a couple of shakes, your mixture doesn’t have the same composition throughout the jar. Because the sand is heavier, there is probably more sand at the bottom of the jar and more sugar at the top.

Other examples – Soil, rocks, muddy water, concrete, granite, wood, milk, blood, smoke, cloud etc., as shown in fig-2.5.

2.3. States of Matter

All matter exists in one of the four physical states. They are: Solid, Liquid, Gas and Plasma.

Solid
Matter in the Solid state maintains a fixed volume and shape, with component particles (atoms, molecules or ions) close together and fixed in place.

Liquid
Matter in the Liquid state maintains a fixed volume, but has a variable shape that adapts to fit its container. Its particles are still close together but move freely.

Gas
Matter in the Gaseous state has both variable volume and shape, adapting both to fit its container. Its particles are neither close together nor fixed in place.

Plasma
The plasma is a hot ionized gas consisting of approximately equal numbers of positively charged ions and negatively charged electrons. The characteristics of plasma are significantly different from those of ordinary neutral gases so that plasma are considered as a distinct "fourth state of matter."
Change between states:

**Melting (or Fusion):** Changing the state from **Solid** to **Liquid**. Examples: Melting of ice-cream, ice, butter, wax etc… Some examples are shown in fig-2.7.

**Melting Point:** The temperature at which a **Solid** changes to a **Liquid** is called the Melting Point. Example: The Melting Point of ice is 0 °C.

**Freezing (or Solidification):** Changing the state from **Liquid** to **Solid**. For Example: Change of water to ice, solidification of melted wax etc.

Fig-2.7. Examples of Melting, Melting of Ice-cream and Butter
Vaporization: Changing the state from Liquid to Gas.

**Boiling Point:** The temperature at which Liquid changes to Gas is called the Boiling Point.

Example: The Boiling Point of water is 100 °C.

Evaporation: Some Liquids have a low Boiling Point, so they easily change from Liquid to Vapour.

Example: Methylated spirits.

Condensation: Changing the state from Gas to Liquid.

Sublimation: Changing the state from Solid to Vapour without passing through liquid state.

Example: Dry ice, Camphor balls.

Deposition: Change of state from Gas to Solid without passing liquid state.

Example: Water vapour to ice during winter.

---

2.4. The Structure of an Atom

The modern structure of an atom is composed of a nucleus at the center with electrons moving around it at specified energy levels.

A Hydrogen atom is very small, about \(10^{-10}\) m in diameter, but if it could be magnified sufficiently it would be ‘seen’ to consist of a core or nucleus with a particle called an electron travelling around it in an elliptical orbit.
The nucleus has a positive charge and the electron an equal amount of charge but negative; so the whole atom is electrically neutral. The electrical attraction keeps the electron circling the nucleus.

2.4.1 Nucleus

The Nucleus is the positively charged central core of an atom. It consists of proton and neutrons. The mass of the nucleus is equal to the total mass of protons and neutrons.

2.4.2 Protons

Protons are the positively charged particles in the nucleus. The charge of a proton is equal to \[ q_p = +e = 1.6 \times 10^{-19} \text{ C} \] (\( e \) is the elementary charge). The mass of a proton is equal to \[ m_p = 1.672 \times 10^{-27} \text{ kg} \].

2.4.3 Neutrons

Neutrons are electrically neutral particles available in the nucleus. The mass of a neutron is equal to \[ m_n = 1.675 \times 10^{-27} \text{ kg} \].

2.4.4 Electrons

The electron(s) may be thought of as particle(s) moving in a circular or elliptical path around the nucleus and having negative charge. The charge of an electron is equal to \[ q_e = -1.6 \times 10^{-19} \text{ C} \]. While its mass is equal to \[ m_e = 9.110 \times 10^{-31} \text{ kg} \].

2.4.5 Shells (K, L, M, N)

Electrons are moving in discrete regions of space around the nucleus. These regions of space are known as Energy levels or Shells. The first shell is denoted by the letter K, the second shell by L, M for the third shell, and so on as shown in fig-2.11

Each shell/orbit can contain only a fixed number of electrons. The amount of electrons per shell can be found by using the equation \[ 2n^2 \], where ‘n’ represents the shell number.

Valence Shell

The outermost shell of the atom is called the valence shell, and the electrons in this shell are called valence electrons. Under normal condition, these valence electrons are the ones participating in the chemical reaction. Therefore understanding the electronic
structure of an atom leads to the understanding on how certain atoms will participate in chemical reactions.

**Atomic number (Z)**

The atomic number of an element relates to the number of protons in its nucleus and it is equal to the number of electrons in a neutral atom.

**Atomic mass (A)**

The atomic mass of an element is equal to the sum of mass of neutrons and protons in its nucleus.

**Isotopes**

Isotopes are atoms that have the same atomic number but different mass numbers. These atoms have different number of neutrons.

Examples: $^1\text{H}$, $^2\text{H}$, $^3\text{H}$ (Hydrogen) $^{12}\text{C}$, $^{13}\text{C}$, $^{14}\text{C}$ (Carbon)
Ions

If an atom or a molecule gains or loses one electron or more, this atom or molecule will be called an ion. So unlike the neutral atom, an ion is an atom or group of atoms in which the number of electrons is different from the number of protons. If the number of electrons is less than the number of protons, the particle is a positive ion, also called a cation. If the number of electrons is greater than the number of protons, the particle is a negative ion, also called an anion.

Example: Sodium and Chlorine ions as shown in fig-2.15 and 2.16

2.5. Chemical Bonds

Elements combine together to form compounds or molecules. There are many types of chemical bonds and forces that bind elements together. The two most basic types of bonds are characterized as either ionic or covalent bond.

2.5.1 Ionic bond

An ionic bond is the complete transfer of valence electron(s) between atoms. As a result, it generates two charged ions. This bonding occurs mostly in metals. An example is table salt (NaCl), sodium (Na) atom loses electron and becomes positive while the chlorine (Cl) atom gains electron and becomes negative as shown in Fig-2.17.

\[ \text{Na} - e^- \rightarrow \text{Na}^+ \quad \text{Cl} + e^- \rightarrow \text{Cl}^- \]

Fig-2.17. Ionic Bond

2.5.2 Covalent bond

A covalent bond is the sharing of electrons between atoms. This bonding occurs primarily between non-metals. However, it may also occur between metals and non-metals. For example, single bond in hydrogen gas or double bond in oxygen gas, water, methane etc as shown in Fig-2.18.
2.6. Periodic Table

When the elements are listed in the order of increasing atomic number, elements with similar chemical and physical properties repeat at regular intervals, like metals, non-metals, metalloids, etc. The periodic table is a way of arranging the elements to exhibit these regularities.

Note that the vertical columns are called groups, and horizontal rows are called periods. The electrons in each group have the same number of valence electrons.
Worksheet 2

1. The smallest part of an element is
   (a) compound.
   (b) an atom.
   (c) a molecule.

2. Which state of matter has fixed shape and volume?
   (a) Liquid
   (b) Solid
   (c) Gas

3. Which state of matter can be compressed easily?
   (a) Gas
   (b) Liquid
   (c) Solid

4. The charge of an electron is__________.
   (a) positive
   (b) negative
   (c) no charge

5. What is the atomic number of an element?
   (a) The number of electrons in the atom.
   (b) The number of protons in the atom.
   (c) The number of neutrons plus protons in the atom

6. The maximum number of electrons in the innermost shell of an atom is
   (a) 18
   (b) 8
   (c) 2

7. The mass of a proton is almost equal to the mass of a __________.
   (a) Neutron
   (b) Nucleus
   (c) Electron

8. Oxygen has a valency of
   (a) 2
   (b) 6
   (c) 8

9. What is the atomic number of an element?
   (a) The number of neutrons in the atom.
   (b) The number of electrons in the atom.
   (c) The number of protons in the atom.

10. An isotope of an element will have more/less _________ than usual.
    (a) electrons.
    (b) neutrons.
    (c) protons.

11. A positive ion
    (a) has extra electrons.
    (b) has missing electrons.
    (c) is a radioactive isotope.

12. If the outer shell of an atom is full the element is.
    (a) unstable / reactive.
    (b) a good conductor.
    (c) practically inert.

13. If an atom has 2 protons, how many electrons will it have?
    (a) 1
    (b) 8
    (c) 2

14. What is the atomic number of the element \( ^3_2X \) ?
    (a) 2
    (b) 3
    (c) 5

15. What is the mass number of the element \( ^5_3X \) ?
    (a) 2
    (b) 3
    (c) 5
1. Label the following diagram by showing the protons, neutrons, electrons and valence shell.

![Diagram of an atom with electron shells and subatomic particles]

2. The atomic number of carbon is 6 and its mass number is 13.
   (a) The number of electrons in it is _______________.
   (b) The number of protons in it is _______________.
   (c) The number of neutrons in it is_______________.
   (d) Number of valence electrons _________________.
   (e) Valency of carbon is _________________.

3. Classify the following into elements, compounds and mixtures.

<table>
<thead>
<tr>
<th>Material</th>
<th>Pure Substance or Mixture</th>
<th>Element, Compound, Homogeneous mixture, Heterogeneous mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air inside a balloon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table salt (NaCl)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. How can you classify different types of matter based on the parameters given?

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Solid</th>
<th>Liquid</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arrangement of atoms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Homework-2**

1. Which of the following is neutral? Why?
   (a) Mg\(^{2+}\)
   (b) Al

2. Fill the table

<table>
<thead>
<tr>
<th>Element</th>
<th>No. of protons</th>
<th>No. of neutrons</th>
<th>No. of electrons</th>
<th>Valence electrons</th>
<th>Valency</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{28}_{14})Si</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{26}_{13})Al</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{40}_{18})Ar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(^{19}_{9})F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Classify the following into elements, compounds and mixtures.

<table>
<thead>
<tr>
<th>Material</th>
<th>Pure Substance or Mixture</th>
<th>Element, Compound, Homogeneous mixture, Heterogeneous mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shampoo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perfume</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muddy water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure water (H(_2)O)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 3: Classification of Physical Quantities

3.1 Scalar and vector quantities

Physical quantities in general can be classified as **Scalars** and **Vectors**.

A scalar quantity is a physical quantity that has **only size** (magnitude) and has no specific direction.

**Examples**: mass, distance, speed, work, energy, volume, frequency, temperature etc.

A vector quantity is a physical quantity that has **both size** (magnitude) and **specific direction**.

**Examples**: weight, displacement, velocity, acceleration, force, an airplane flies due **south 25 km**, etc.

3.2 Vectors Representation in Cartesian plane

Vector, as defined below, is a specific mathematical structure. It has numerous physical applications, which result mainly from its ability to represent magnitude and direction simultaneously.

A vector quantity is represented by an **arrowed line** that has a length proportional to the vector quantity, drawn to a suitable scale. Wind, for example, had both a speed and a direction and, hence, is conveniently expressed as a vector.

Note that either **bold capital letter** or **letters with an arrow on the top** will be used to name vectors. For example, a force vector could be written as $\mathbf{F}$ or $\vec{F}$.

The length of the line represents the **size** of the quantity, and the arrow indicates the **direction** in which the quantity acts.

For example, $\vec{A} = 10\text{ km}, N 30^0 E$ can be represented as follows,

Sample Problem: Sketch the graph of the following vectors.

a.) $\vec{B} = 50\text{ m/s}, S 45^0 W$
b.) \( \vec{C} = 100 \text{ N, W 60}\degree \text{ N} \)

c.) \( \vec{D} = 50 \text{ km, due South} \)

### 3.2.1 Components of a vector

Any vector in a rectangular coordinate system can be resolved into a pair of perpendicular vectors.

The vector \( \mathbf{A} \) in the rectangular coordinate system as shown below in Fig is resolved into two perpendicular vectors \( \mathbf{A}_x \) parallel to x-axis and \( \mathbf{A}_y \) parallel to y-axis, that is

\[ \mathbf{A} = \mathbf{A}_x + \mathbf{A}_y; \text{ Where: } \mathbf{A}_x \text{ and } \mathbf{A}_y \text{ are called the components of vector } \mathbf{A}. \]

Using trigonometry, the magnitudes of \( \mathbf{A}_x \) and \( \mathbf{A}_y \) are given by the equations:

\[ \mathbf{A}_x = A \cos \theta \quad \text{and} \quad \mathbf{A}_y = A \sin \theta \]

Where ‘\( \theta \)’ is the angle between the vector \( \mathbf{A} \) and positive x-axis.

These two components form two sides of a right angle triangle, the hypotenuse of which has a magnitude of ‘\( A \)’. \( A = \sqrt{A_x^2 + A_y^2} \) and angle (\( \theta \)) = \( \tan^{-1}(A_y / A_x) \). These components can be either positive or negative numbers with its unit.

The \( A_x \) and \( A_y \) components are called rectangular components of a vector \( \mathbf{A} \) and the process is called the resolution of a vector.
A. Some Properties of Vectors

Equality of Two Vectors:
Two vectors \( \mathbf{A} \) and \( \mathbf{B} \) are equal if they have the same magnitude and the same direction.

Using this property, any vector can be moved parallel to itself without being affected.

Multiplying or Dividing a Vector by a Scalar:
The multiplication or division of a vector \( \mathbf{A} \) by a scalar real number \( n \) gives a vector.

- If vector \( \mathbf{A} \) is multiplied by the scalar number 2, the result is \( 2\mathbf{A} \), is a vector with a magnitude twice that of \( \mathbf{A} \), pointing in the same direction as \( \mathbf{A} \).
  
  \[
  2 \text{(scalar)} \times \mathbf{A} \text{(vector)} = 2\mathbf{A} \text{(vector)}
  \]

- If multiplied by a scalar \( -2 \), the result is \( -2\mathbf{A} \), is a vector with a magnitude twice that of \( \mathbf{A} \), pointing in the direction opposite \( \mathbf{A} \) (because of the negative sign).
  
  \[
  -2 \text{(scalar)} \times \mathbf{A} \text{(vector)} = -2\mathbf{A} \text{(vector)}
  \]

If a vector \( \mathbf{A} \) is divided by the scalar number 2, the result is \( \frac{1}{2} \mathbf{A} \), is a vector with a magnitude half that of vector \( \mathbf{A} \), pointing in the same direction.

So we can write in general that: \( \|\alpha\mathbf{A}\| = |\alpha| \|\mathbf{A}\| \); where \( \alpha \) is a real number, and \( \tilde{\mathbf{A}} \) a vector.

3.3 Vector Addition and Subtraction

The summing up of all the vectors to find the resultant vector is called the addition of vectors. We can add vectors in two methods, namely: graphical and analytical methods. There are many graphical (using ruler and protractor) and analytical methods but we will only discuss the polygon method and component method, respectively, as introductory part.
3.3.1 Graphical method

Two graphical methods will be introduced here, namely: **Triangle method (Polygon method)** and the **Parallelogram method**. We use ruler and protractor to measure the angle and distance of a vector in graphical method. Here, ruler and protractor will not be used but instead we will sketch the vectors to approximate its distance and direction, and to show its correct quadrant.

**A. Triangle method (or Polygon method)**

When **two or more vectors** are to be added by polygon method then the vectors are arranged **head to tail**. The resultant \( \mathbf{R} \) is the vector drawn from the tail of the first vector to the head of the last vector. **The order in which the vectors are added doesn’t matter.**

For Example, \( \mathbf{A} = 20 \text{ km}, E 30^\circ N \) and \( \mathbf{B} = 50 \text{ km}, E 45^\circ N \). Find \( \mathbf{R} = \mathbf{A} + \mathbf{B} \) using **polygon method**.

Note that subtracting a vector from another is the same as adding a vector in the opposite direction.

For example, \( \mathbf{A} - \mathbf{B} = \mathbf{A} + (\mathbf{-B}) \), where \( \mathbf{-B} \) is a vector that has same magnitude as the vector but it has opposite direction.

**B. Parallelogram Method**

This method is applicable only when adding two (2) vectors. It is done by arranging the two vectors **tail to tail**. By drawing a parallelogram, the resultant vector is the diagonal line from the origin.

For example: \( \mathbf{A} = 20 \text{ km}, E 30^\circ N \) and \( \mathbf{B} = 50 \text{ km}, E 45^\circ N \). Find \( \mathbf{R} = \mathbf{A} + \mathbf{B} \) using **parallelogram method**.

3.3.2 Analytical method

Two analytical methods will be discussed here namely: Component method and the Law of cosine. **These methods are done by computation. Pythagorean theorem, law of sines and cosines are necessary to do this computation.**

**A. Component method**

In a Cartesian coordinate system any vector can be resolved in to two components, horizontal and vertical along the x and y directions. So, for the magnitude of vector \( \mathbf{A} \) we can write \( |\mathbf{A}| = \sqrt{A_x^2 + A_y^2} \) or \( |\mathbf{B}| = \sqrt{B_x^2 + B_y^2} \).
The magnitude of the resultant vector is given by

$$|\mathbf{R}| = \sqrt{R_x^2 + R_y^2}$$

where $R_x = A_x + B_x$ and $R_y = A_y + B_y$

While the direction of the resultant vector is given by

$$\tan \theta = \frac{R_y}{R_x}$$

$$\theta = \tan^{-1} \frac{R_y}{R_x}$$

Example #1: Taking the example from above, $\vec{A} = 20\text{ km}, E 30^0 N$ and $\vec{B} = 50 \text{ km}, E 45^0 N$. Find $\vec{R} = \vec{A} + \vec{B}$ using component method.

Solution:

Get the value of the components of $\vec{R}$,

$R_x = A_x + B_x$

Since $A_x = A \cos \theta = 20\text{ km}(\cos 30^0) = 17.32 \text{ km}$

$B_x = B \cos \theta = 50\text{ km}(\cos 45^0) = 35.35 \text{ km}$

Then, $R_x = 17.32 \text{ km} + 35.35 \text{ km} = 52.67 \text{ km}$

Also, $R_y = A_y + B_y$

Since $A_y = A \sin \theta = 20\text{ km}(\sin 30^0) = 10 \text{ km}$

$B_y = B \sin \theta = 50\text{ km}(\sin 45^0) = 35.35 \text{ km}$

Then, $R_y = 10 \text{ km} + 35.35 \text{ km} = 45.35 \text{ km}$

The magnitude is given by,

$$|\mathbf{R}| = \sqrt{(R_x)^2 + (R_y)^2}$$

$$|\mathbf{R}| = \sqrt{(52.67\text{ km})^2 + (45.35\text{ km})^2}$$

$$|\mathbf{R}| = 69.50 \text{ km}$$

And the direction is given by,

$$\tan \theta = \frac{R_y}{R_x}$$
\[ \theta = \tan^{-1}\left(\frac{45.35}{52.67}\right) \]
\[ \theta = E \, 40.73^\circ \, N \]

**B. Law of Cosine**

Two vectors \( \vec{A} \) and \( \vec{B} \) represented by the two sides of a triangle, having an angle \( \theta \) between them, can be added by the parallelogram law of vector addition.

\[ |\vec{R}| = \sqrt{|A|^2 + |B|^2 + 2|AB| \cos \theta} \]

where: \( \theta \) = the angle between vectors \( \vec{A} \) and \( \vec{B} \).

**Example** - Taking the example from above, \( \vec{A} = 20 \text{ km}, E \, 30^\circ \, N \) and \( \vec{B} = 50 \text{ km}, E \, 45^\circ \, N \). Find \( \vec{R} = \vec{A} + \vec{B} \) using parallelogram law of vector addition.

Here the angle between \( \vec{A} \) and \( \vec{B} \) will be 15°, then

\[ |\vec{R}| = \sqrt{|A|^2 + |B|^2 + 2AB \cos \theta} \]

\[ |\vec{R}| = \sqrt{|20|^2 + |50|^2 + 2 \times 20 \times 50 \cos 15} \]

\[ |\vec{R}| = 69.5 \text{ km} \]
Multiple Choice Questions:

1. A quantity which has size but no direction is called ________.
   (a) scalar
   (b) moment
   (c) vector

2. A vector is a quantity that has __________.
   (a) magnitude and time
   (b) magnitude and direction
   (c) time and direction

3. Which of the following is a vector quantity?
   (a) Speed
   (b) Acceleration
   (c) Temperature

4. Which among the following is NOT a vector quantity?
   (a) Displacement
   (b) Force
   (c) Mass

5. The sum of two or more vectors is equivalent to a single vector called_______.
   (a) component
   (b) resultant
   (c) hypotenuse

6. Two vectors of the same magnitude are added; one going to the east and the other one to the west. The magnitude of the resultant vector is equal to?
   (a) 0
   (b) 1
   (c) -1

7. A boat moves 10 km due west, 5 km due north and then 10 km due east. The displacement of the boat from its initial position is:
   (a) 5 km North
   (b) 5 km South
   (c) 25 km, North

8. What is the minimum number of vectors with equal magnitudes whose vector sum can be zero?
   (a) Two
   (b) Three
   (c) Four

9. What is the minimum number of vectors with unequal magnitudes whose vector sum can be zero?
   (a) Two
   (b) Three
   (c) Four

10. Which one of the following quantities is a vector quantity?
    (a) The age of the earth
    (b) The earth's pull on your body.
    (c) The temperature of an iron bar

11. Two vectors are at 90 degrees to each other having magnitudes of 3N and 4N. The resultant is.
    (a) 5N.
    (b) 1N.
    (c) 7N.

12. A force has magnitude 20N. It’s one rectangular component is 12N, the other rectangular component must be:
    (a) 8N
    (b) 16 N
    (c) 32 N

13. Which of the following equations is the CORRECT vector addition from the vectors shown below?
    (a) B + C = A
    (b) A + C = B
    (c) B + A = C
14. Which of the following cannot be the resultant of the vector addition of two vectors of magnitude 6 units and 9 units?
   (a) 17 units
   (b) 12 units
   (c) 10 units

15. If $A_x = 5$ units and $A_y = 12$ units. The magnitude and direction of vector $A$ will be
   (a) 5 units and E 47.5° N
   (b) 12 units and E 86.8° N
   (c) 13 units and W 67.3° N

**Problem Solving:**

1. Draw the following vectors in Cartesian plane and compute the x & y components:

   a.) $\vec{A} = 35 \text{ km}, W 30° S$

   b.) $\vec{B} = 21 \text{ km}, E 18° N$

   c.) $\vec{C} = 67 \text{ km}, E 43° S$
2. A car is driven 50 km west and then 18 km north.
   a.) Using polygon and parallelogram method, sketch the diagram for the given vectors and the total displacement.

   b.) What is the total displacement (magnitude and direction) of the car from the point of origin? (Use Law of cosine)

3. From the given vectors below,
   \( \vec{A} = 32.5 \text{ km, E 40° N} \)
   \( \vec{B} = 15 \text{ km, W 68° N} \)
   \( \vec{C} = 59 \text{ km, South} \)

   Find the resultant vector and sketch the diagram using polygon method:
   a) \( \vec{R} = \vec{A} + \vec{B} \) (Using component method)
b) \( \vec{R} = \vec{B} + \vec{C} \) (Using Law of cosine)

4. A vector has an x component of 24.0 units and the magnitude of the vector is 25 units. Find its y component and direction.
Chapter 4: Linear Motion

4.1 Distance and displacement

<table>
<thead>
<tr>
<th>Distance</th>
<th>Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is the length of the actual path between the initial and final position.</td>
<td>It is the shortest distance between initial and final position of the body. It is the change in position of a body.</td>
</tr>
</tbody>
</table>

It is a scalar quantity | It is a vector quantity

The actual path travelled between the two points, \(x_i\) the initial and \(x_f\), the final position tells exactly how the object moved between these two points. | Displacement between two points does not tell exactly how the object moved between these two points. |

There could be many distances (many ways) between \(x_i\) and \(x_f\) because distance depends on the paths. | There is only one displacement between \(x_f\) and \(x_i\) |

Distance is always positive. | Displacement can be positive or negative. |

Note: Units of both distance and displacement will be same. Distance \(\geq\) displacement.

Example 1: Find the distance and displacement of a body in the following cases:

A. A car completes a half circle of radius 10.0 m.
B. A car completes a full circle of radius 10.0 m.

Solution:

A.) Distance covered = half the perimeter of circle
\[
\frac{2\pi r}{2} = \frac{2(3.14)10}{2} = 31.4m
\]
Distance = \(2\times r = 2\times10 = 20m\)

B.) Distance covered = perimeter of circle
\[
2\pi r = 2(3.14)10 = 62.8m
\]
Displacement = final position – initial position = 0
4.2 Speed and Velocity

A. Speed

Speed, being a scalar quantity, is the rate at which an object covers distance. The average speed is the ratio between distance and time. Speed is ignorant of direction. The speed is a physical quantity that tells us how fast an object is moving.

For example, a speedometer or a speedometer (which we can see in a car) is a device that measures and displays the instantaneous speed of a vehicle. It doesn’t give any information about the direction of the motion of the car.

B. Velocity

It is the rate of change of displacement of a body is called velocity. It is a vector quantity (it has magnitude and direction). Its SI unit is m/s (or m.s\(^{-1}\)).

The velocity (\( \vec{v} \)) of the jogger is equal to

\[
\vec{v} = \frac{\text{Displacement}}{\text{Time}} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t}.
\]

Where \( \Delta x \) is the displacement of the jogger which is equal to \( \Delta x = x_f - x_i \), where \( x_f \) and \( x_i \) are the initial and final position of the person respectively. While, \( \Delta t \) is the time of travel.

4.3 Accelerated Motion

A. Acceleration

The average acceleration, (\( a \)) of a body is a vector quantity that is defined as the rate of change of velocity. Let change of velocity as \( \Delta v \), and the time interval as \( \Delta t \).

\[
a = \frac{\Delta v}{\Delta t} = \frac{v - u}{t_f - t_i}.
\]

Its SI unit is m/s\(^2\) (or m.s\(^{-2}\)).

B. Relationship between velocity and acceleration

Case (i) If a car moves with constant velocity (uniform motion), then it has no acceleration or \( a = 0 \text{ m/s}^2 \). The length of arrows are the same as shown in the figure below.

\[ a = 0 \text{ m.s}^{-2} \text{ (No acceleration)} \]
*Uniform velocity (covers equal distance in equal time).
*Acceleration equals zero (because change in velocity is zero)

Example: a person driving his car on a highway at a constant speed of 120km/h.

**Case (ii)** If the car is moving with a positive velocity and a constant positive acceleration in the same direction, then the speed of the car increases as shown in the figure below.

![Car accelerating](image)

*The velocity and acceleration are in the same direction
*The acceleration is uniform (lower arrows maintain the same length)
*The velocity is increasing (upper arrows are getting longer)

Example: when a car driver is speeding up after stopping at a red traffic light, his motion is an accelerated motion as his velocity is increasing.

**Case (iii)** “If the car is moving with a positive velocity but with a negative acceleration then the speed of car decreases with time. Sometimes decrease in speed with time is called negative acceleration or deceleration or retardation.”

![Car decelerating](image)

Example: This type of motion happens when a car comes to a stop after applying brakes.

*The acceleration and velocity are in opposite directions
*The acceleration is uniform (lower arrows maintain the same length)
*The velocity is decreasing (upper arrows are getting shorter)

### 4.4 Kinematic Equations of Motion

The kinematic equations are set of equations that can be utilized to predict unknown information about an object's motion if other information is known. The equations can be utilized for any motion that can be described as being either a constant velocity motion (an acceleration of 0 m/s²) or a constant acceleration motion. The four kinematic equations for accelerated motion (2nd column) will be reduced to the equation for non-accelerated motion (1st column) when acceleration is zero, $a=0$. 

<table>
<thead>
<tr>
<th>Non-accelerated motion</th>
<th>Accelerated Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>(velocity is constant; (a=0))</td>
<td>(velocity is NOT CONSTANT; (a\neq0))</td>
</tr>
</tbody>
</table>

\[
v = \frac{s}{t}
\]

1. \(v = u + at\)
2. \(v^2 = u^2 + 2as\)
3. \(s = ut + \frac{1}{2}at^2\)
4. \(s = \left(\frac{v+u}{2}\right)t\)

where: \(v = \text{final velocity}\)
\(u = \text{initial velocity}\)
\(s = \text{displacement}\)
\(a = \text{acceleration}\)

**Example 1.** The average distance between Muscat and Barka is around 65 km. If you leave Muscat at 7:25 am and is travelling at constant velocity of 110 km/hr, at what time will you arrive in Barka?

Solution:

\[
t = \frac{s}{v} = \frac{65\text{ km}}{110\text{ km/hr}} = 0.59 \text{ hr or 35 mins and 27 secs} \approx 36 \text{ mins}
\]

Clock time = 7:25 + 36 mins = 8:01 am

**Example 2.** A certain aircraft has a takeoff speed of 42 m/s. If it starts from rest, what should be its acceleration (in m/s\(^2\)) if the maximum runway distance is 5 km?

Solution:

Using the 2nd kinematic equation above,
\[
v^2 = u^2 + 2as
\]
\[
(42\text{ m/s})^2 = 0 + 2a(5000\text{ m})
\]
\[
a = \frac{(1764 \text{ m}^2/\text{s}^2)}{10000\text{ m}} = 0.1764 \text{ m/s}^2
\]

**Example 3.** A fighter aircraft accelerates from rest to 200 km/h in 9 seconds. What is its acceleration in m/s\(^2\)?

Solution: Firstly, we must ensure that the units used are the same. As the question wants the answer given in m/s\(^2\), we must convert 200 km into meters and hours into seconds.

\[
200 \text{ km} = 200,000 \text{ m and 1 hour} = 60 \times 60 = 3,600 \text{ s. [km/sec} \times (5/18) \text{=}m/sec]\n\]

So, \(\frac{200,000 \text{ m}}{3600 \text{ s}} = 55.55 \text{ m/s}\)

Using equation (1): \(v = u + at\) we have, \(a = \frac{55.55 \text{ m/s}}{9 \text{ s}} = 6.17 \text{ m/s}^2\)

Therefore the aircraft has accelerated at a rate of 6.17 m/s\(^2\)
Example 4.) If an aircraft slows down from 160 km/h to 10 km/h with a uniform deceleration of 5 m/s². A.) How many seconds it took to reduce the speed?

Solution: using $v = u + at$ and use $\frac{1}{h} = \frac{1000m}{3600s} = \frac{5}{18} m/s$

$u = 160 \times \frac{5 m}{18 s} = 44.44 m/s$

$v = 10 \times \frac{5 m}{18 s} = 2.78 m/s$

$2.78 = 44.44 - 5t$

$5t = 44.44 - 2.78$

$t = \frac{41.66}{5}$

$t = 8.33s$

B.) What distance the aircraft has travelled on that change of speed?

Solution: We can use either;

1. $s = ut + \frac{1}{2} at^2$  or  2. $s = \frac{v^2 - u^2}{2a}$

Note: $u = 44.44 m/s$, $v = 2.78 m/s$, $t = 8.3sec$ and $a = -5m/s^2$

Using equation (2),

$s = \frac{2.78^2 - 44.44^2}{2(-5)} = \frac{-1963.63}{-10} = 196.36 m$

4.5 Motion under the influence of gravity

An object moving under the influence of gravity has a constant acceleration of $g = -9.8 m/s^2$. The negative sign indicates the direction of the acceleration which is towards the earth or downward. The magnitude of the acceleration due to gravity is 9.8 m/s², however, it is taken as negative because we consider the upward direction as positive. Furthermore, when the motion is affected by the gravitational force only, it is called a free fall. And so, when we are referring to free fall air friction is neglected in this case.

The equation of motion for free fall is the same as the equation in Section 4.4. However, some quantities will be changed to fit its description. In this case,

<table>
<thead>
<tr>
<th>Quantities</th>
<th>Accelerated Motion (from Section 4.4)</th>
<th>Free fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>displacement</td>
<td>s</td>
<td>h</td>
</tr>
<tr>
<td>acceleration</td>
<td>a</td>
<td>$g = -9.8 m/s^2$</td>
</tr>
</tbody>
</table>

And so, the kinematic equations for free fall is given by
Accelerated Motion
(velocity is NOT CONSTANT; \(a \neq 0\))

1. \(v = u + at\)
2. \(v^2 = u^2 + 2as\)
3. \(s = ut + \frac{1}{2}at^2\)
4. \(s = \left(\frac{v+u}{2}\right)t\)

Free fall
(velocity is NOT CONSTANT; \(a = g = -9.8m/s^2\))

1. \(v = u + gt\)
2. \(v^2 = u^2 + 2gh\)
3. \(h = ut + \frac{1}{2}gt^2\)
4. \(h = \left(\frac{v+u}{2}\right)t\)

There are a few concepts of free fall motion that will be significant in analyzing problems in free fall.

- The acceleration due to gravity is always negative whether the object is moving upward or downward.
- When the object is travelling upwards, the velocity is positive and decreasing. And when it is travelling downwards, the velocity is negative and increasing.
- When the object is projected upwards, its velocity is zero at the maximum height.
- When the object is being dropped, its initial velocity is zero.

**Example 1.** An object is being dropped from a cliff at a height of 20 m. A.) At what time will it reach the ground? B.) What is the final velocity of the object when it reached the ground?

Solution:

A.) We can use equation (3) to solve for time,
\[
h = ut + \frac{1}{2}gt^2
\]
\[
h = 0 + \frac{1}{2}gt^2
\]
\[
t = \frac{2h}{g}
\]
\[
t = \frac{2(-20m)}{-9.8m/s^2} = \frac{40m}{9.8m/s^2}
\]
\[
t = 2.02 \text{ s}
\]

B.) We can use equations 1, 2 and 4 for this problem. In principle, you should get the same answer. But let us use the simplest equation among them to avoid unnecessary errors.
\[
v = u + gt
\]
\[
v = 0 + \left(-9.8 \frac{m}{s^2}\right)(2.02s)
\]
\[
v = -19.796 \text{ m/s}^1
\]

\(^1\) The negative sign indicates that the direction of the velocity of the object is downward.
**Example 2.** An object is being thrown vertically upwards with initial velocity of 12 m/s. Find: A.) maximum height, B.) time to reach the maximum height.

Solution:

A.) Using equation 2,
\[ v^2 = u^2 + 2gh \]
At \( h_{max} = v = 0 \) then,
\[ 0 = (12m/s)^2 + 2(-9.8m/s^2)(h_{max}) \]
\[ h_{max} = \frac{(12m/s)^2}{2(9.8m/s)} \]
\[ h_{max} = 7.35 \text{ m} \]

B.) Using equation 1,
\[ v = u + gt \]
\[ 0 = 12m/s + (-9.8m/s^2)t \]
\[ t = \frac{12m/s}{9.8m/s^2} \]
\[ t = 1.22 \text{ s} \]
Worksheet 4

A. Multiple Choice

1. Ibrahim jogs 10 km south, 5 km east and then needs back to his starting point using the same path. Which of the following statements is TRUE?
   (a) The total distance covered is zero.
   (b) The total distance covered is 15 km.
   (c) The displacement is zero

2. What is the distance travelled and the displacement by a person that walks 20 m East, then 5 m West?
   (a) distance = 20 m and displacement = 20 m, East
   (b) distance = 20 m and displacement = 15 m, East
   (c) distance = 25 m and displacement = 15 m, East

3. An engineering student adds two displacement vectors with magnitudes 3.0 m and 4.0 m. Which one of the following could NOT be a possible choice for the resultant?
   (a) 0.3 m
   (b) 5.0 m
   (c) 6.8 m

4. A bicycle’s breaks can produce a deceleration of 2.5 ms\(^{-2}\). How far will the bicycle travel before stopping, if it is moving at 10 m/s when brakes are applied?
   (a) 10 m
   (b) 20 m
   (c) 30 m

5. When you throw a ball directly upward, its acceleration is ________________.
   (a) Zero all the time
   (b) 9.8 m/s\(^2\) all the time
   (c) Constant when going up and zero when going down.

6. If a body starts from rest and reaches 84 m/s in 3 sec, its acceleration is ___________.
   (a) 28 m/s\(^2\)
   (b) 14 m/s\(^2\)
   (c) 252 m/s\(^2\)

7. What acceleration is produced if an object increases its speed from rest to 10 ft/sec in 5 seconds?
   (a) 2 ft/sec\(^2\)
   (b) 50 ft/sec\(^2\)
   (c) 0.5 ft/sec\(^2\)

8. A stone is being dropped from a high tower and falls to the ground without air friction. Which of the following is TRUE about its acceleration?
   (a) Constant
   (b) Increasing
   (c) Decreasing

9. What is acceleration?
   (a) Rate of change of velocity
   (b) Rate of change of movement
   (c) Rate of change of position

10. How long will it take a car moving at 60 km/hr to travel 90 km?
    (a) 40 minutes
    (b) 75 minutes
    (c) 90 minutes

B. Problem Solving

1. An aircraft accelerates from rest to 200 km/h in 25 seconds. What is its acceleration in m/s\(^2\)?
2. A ball hits a wall horizontally at 6 m/s. It rebounds horizontally at 4.4 m/s. The ball is in contact with the wall for 0.040 s. What is the acceleration of the ball?

3. If an aircraft slows down from 160 km/h to 10 km/h with a uniform retardation of 5 m/s^2, how long will it take to reach this speed?

4. Starting from rest, an airplane takes off after covering 0.7 km on the runway. If it takes off at 35 ms^{-1}, calculate (i) the acceleration (ii) the time for which it moves on the runway

5. A super-deluxe car accelerates uniformly from rest to a speed of 38.9 m/s in 8 s.
   (a) Determine the acceleration of the car.
   (b) Find the displacement of the car in 8 s.
6. A ball is thrown directly downward with an initial speed of 8 ms\(^{-1}\) from a height of 30 m. After what interval does the ball hit the ground?

7. A ball is thrown vertically upward and is caught by the thrower after 2 s. Find
   (i) The initial velocity of the ball
   (ii) The maximum height it reaches.

C. Fill in the blanks:

<table>
<thead>
<tr>
<th>Mass</th>
<th>Initial speed</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>Final speed</td>
<td>Less than</td>
</tr>
<tr>
<td>Distance</td>
<td>Weight</td>
<td>Equal to</td>
</tr>
</tbody>
</table>

1. Rate of change in velocity is also known as_____________________.
2. When an object thrown into air the time of ascent is ____________________time of descent.
3. ________________________ is the path between initial and final position.
4. The force of gravity on an object is also equal to ________________________.
5. ________________________is starting speed of an object.
Chapter 5: Forces

A force is “a physical quantity which makes the body to move or tries to move.” It is a push or pull upon an object resulting from the object’s interaction with another object. Whenever there is an interaction between two objects, there is a force upon each of the objects. When the interaction ceases, the two objects no longer experience the force. Forces only exist as a result of an interaction.

5.1. Fundamental Forces
There exists four fundamental forces in nature, which are known as field forces. These are listed below in the order of decreasing strength:

1. **Strong nuclear force** – force that exist and binds protons and neutrons in the nucleus of an atom.
2. **Electromagnetic forces** – force between electric charges.
3. **Weak nuclear forces** - exists in certain radioactive decay processes.
4. **Gravitational force** – force of attraction between objects.

5.2. Types of forces

A. **Contact forces**: A contact force results from a physical contact between two objects.

Examples of contact forces are:

i. If we pull on a spring the spring stretches as in Figure 1.a.
ii. A child is pulled by a lady Figure 1.b.
iii. When a football is kicked it is deformed and set in motion Figure 1.c.

B. **Field (non-contact) forces**: No physical contact between two objects. Michael Faraday had introduced the concept of the field.

Examples of field (non-contact) forces:

i. Gravitational field force, is the force of gravitational attraction between two objects, as in Fig 2.d.

ii. Electric filed force, is the force that one electric charge exerts on another electric charge as in Fig 2.e.
iii. Magnetic field force, is the force when you bring a magnet near a piece of iron, the iron piece is attracted as in Fig 2.f. While the two similar poles of magnet moves away from each other.

5.3. Mass and Weight

A. Mass (m)

The mass of an object is the amount of matter it contains. The more the matter an object contains, the greater will be its mass. An elephant contains more matter than a mouse, so it has a greater mass. In SI unit mass is measured in kilograms (kg).

Note: Mass is a scalar quantity and object's mass remains the same wherever it is.

B. Weight (W)

The weight of an object is defined as the force of gravity on the object and may be calculated as the mass times the acceleration of gravity.

\[ W = mg \]

‘m’ is the mass in kg and ‘g’ is the acceleration due to gravity. Since the weight is a force, so it is a vector quantity and its SI unit is Newton.

The acceleration due to gravity, g, varies depending on the location. For example, on the surface Earth, the acceleration due to gravity is \( g_{\text{Earth}} = 9.8 \text{ m/s}^2 \). While the on the surface of the moon, acceleration due to gravity is \( g_{\text{Moon}} = 1.6 \text{ m/s}^2 \). Near the surface of the sun, \( g_{\text{Sun}} = 270 \text{ m/s}^2 \).

5.4. Newton’s First Law of Motion and its application: Equilibrium

An object at rest will remain at rest and an object in motion will continue in motion with its constant velocity unless it experiences a net external force acting on it.

Inertia:

“The inherent property of a body which does not change its state of rest or direction of motion by itself”. Inertia is the tendency of the object to remain at rest, and if moving, to continue its constant motion. Hence, if a body is moving with constant velocity it won’t alter its velocity or direction, unless a force is applied on it.

The inertia of an object depends on its mass. A larger mass needs a larger force to overcome its inertia and change its motion.
Example 1. The coin on top of the cardboard is an object at rest. It is not moving. When the cardboard is thumped, it moves out from under the coin, but because of inertia, the coin has a tendency to remain at rest instead of moving forward with the cardboard. Since the coin does not move forward, it drops into the glass when the cardboard was removed from underneath it. See fig-4.

Example 2 When a bus or train stops suddenly, a passenger sitting inside tends to fall forward. See figure 5.

Reason: This is because the lower part of his body comes to rest first with the bus or train but the upper part tends to continue its motion due to inertia of motion.

Example 3: If a cloth placed under a book is given a sudden pull, it moves without disturbing the book.

Reason: This is because the book continues to be at the rest due to its inertia, when the cloth is suddenly pulled out.

Application of first law: Equilibrium

“An object either at rest or moving with a constant velocity is said to be in equilibrium if the net force acting on the object is zero, i.e. $\sum F = 0$.”

Equilibrium problems can be solved easily in terms of the components of the external forces acting on an object. For two-dimensional problem $\sum F_x = 0$ and $\sum F_y = 0$.

For three-dimensional problem $\sum F_x = 0$, $\sum F_y = 0$ and $\sum F_z = 0$.

Example 1.) A traffic light weighing 85.0 N hangs vertically with the help of two other cables which makes an angle 45° with the horizontal as shown in the figure below. Find the tension in each cables.
Solution:

Draw the components of each vector here:

From Fig. 5. The condition of equilibrium gives us equations

\[ \sum F_y = 0 \text{ and } \sum F_x = 0 \]

\[ \sum F_y = T_{1y} + T_{2y} - 85 = 0 \]

or \[ T_1 \sin 45^\circ + T_2 \sin 45^\circ = 85 \] \[ \text{------------- (1)} \]

\[ \text{and } \sum F_x = T_{1x} + T_{2x} = 0 \]

or \[ -T_1 \cos 45^\circ + T_2 \cos 45^\circ = 0 \] \[ \text{------------- (2)} \]

solving equation (2) we get

\[ T_1 = T_2 \left( \frac{\cos 45^\circ}{\cos 45^\circ} \right) = T_2 \] \[ \text{------------- (3)} \]

Substituting this value in equation (1) we get

\[ T_1 \sin 45^\circ + T_1 \sin 45^\circ = 85 \]
\[ 2T_1 \sin 45^\circ = 85 \]
\[ T_1 = T_2 = 60.1 \text{ N} \]
5.5. Newton’s Second Law of Motion and its application

“The net force, $F$, acting on an object with mass, $m$, is directly proportional to the product of its mass and acceleration.”

Mathematically, we can write it as $\sum F = ma$.

If an object of mass ‘$m$’ is acted on by a net force ‘$F$’, it will experience an acceleration $a$, where, $a = \frac{F}{m}$. This means that it takes less force to move a smaller object than a bigger one or you have to push a heavy ball harder to get it move as fast as the smaller one.

**Example 1.** A 65 Kg runner exerts a force of 52 N. What is the acceleration of the runner?

**Solution:**

$$F = ma$$

$$a = \frac{F}{m} = \frac{52N}{65kg} = 0.8m/s^2$$

**Example 2.** Four (4) men push a stalled car in the same direction. Each man pushes with a 350 N force. What is the mass of the car if the car accelerates at 0.8 m/s$^2$? Neglect friction.

**Solution:**

$$\sum F = ma$$

$$4(350N) = m(0.8m/s^2)$$

$$m = \frac{1400N}{0.8m/s^2} = 1750kg$$

**Example 3.** A sports car accelerates from 0 to 26 m/s in 6.5 seconds. The car exerts a force of 6600 N. What is the mass of the car?

**Solution:**
5.6. Newton’s Third Law of Motion and its application

“For every force that acts on an object, there is an equal and opposite reaction force on the other object”.

Note: Action and reaction force always occur in pairs, acts on two different bodies simultaneously.

Example 1: Chemical reactions inside the rocket push gases out at a very high speed, there is an equal and opposite reaction to the force of the gases, which pushes the rocket upwards.

Example 2: Feet push down on the floor and the floor pushes up at feet as we walk.

5.7. Linear Momentum and Impulse

A. Linear Momentum
The linear momentum, \( p \), of an object is equal to the product of its mass \( (m) \) and its velocity \( (v) \) it is a vector quantity. Mathematically, \( p = mv \) and its unit is \( kg \cdot m/s \)

Example 1.) An 85.5 kilogram motorcycle is moving at a speed of 40.5 m/s. What is its momentum?
Solution:
\[
p = mv
\]
\[
p = 85.5 kg \cdot (40.5 m/s)
\]
\[
p = 3462.75 \, kg \cdot m/s
\]

B. Impulse

If a body is subjected to a sudden blow, shock load or impact, it is possible to measure the change in momentum. Forces which have the short time of action are called the impulsive forces.

Change of momentum due to impulsive force is called Impulse.
impulse (I) = change in momentum = Force × time
\[ I = m \Delta v = m(v - u) = F \times \Delta t \]

Note: Impulse is a vector quantity, and its SI unit is Kg m/s or Ns (Newton seconds)

**Example 1.)** When a tennis ball is hit by a racket, a large force is exerted on the ball in a very short period of time. Typical impact time is in the order of milliseconds

**Example 2.)** A 1000 kg car accidentally drops from a crane and crashes at 30 m/s to the ground below and comes to an abrupt halt. What impulse acts on the car when it crashes?

**Solution:**

\[ I = m \Delta v = m(v - u) \]
\[ I = 1000 kg [0 m/s - (-30 m/s)] \]
\[ I = 3.0 \times 10^4 kg \cdot m/s \]

**Example 3.)** A batsman hits back a ball straight in the direction of the bowler without changing its initial speed of 12 m/s. If the mass of the ball is 0.15 kg, determine the impulse imparted to the ball.

**Solution:**

**5.8. Conservation of Linear Momentum**

We say that momentum is a conserved quantity: “the total momentum before collision is equal to the total momentum after collision”. There are two (2) types of collision, namely: Inelastic and Elastic collisions. In this content, we will deal only the **perfectly elastic collision**. In this type of collision, the total kinetic energy of the system is conserved.

According to the law of conservation of linear momentum:
Total momentum before collision = Total momentum after collision
\[
(p_1 + p_2)_\text{initial} = (p_1 + p_2)_\text{final}
\]
\[
m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2
\]

where \(m_1\) is mass of first object, \(m_2\) is mass of second object, \(u_1\) is velocity of the first object before collision, \(u_2\) is velocity of second object before collision, \(v_1\) is velocity of the first object after collision, \(v_2\) is velocity of the second object after collision.

Example 1. A car of mass 1000 kg moving at 20 ms\(^{-1}\) collides with a car of mass 1200 kg moving at 5 ms\(^{-1}\) in the same direction. If the second car is shunted forwards 15 ms\(^{-1}\) by the impact, what is the velocity of the first car immediately after the crash?

Solution:

**BEFORE COLLISION**

<table>
<thead>
<tr>
<th>First Car</th>
<th>Second Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>(m_1 = 1000) kg</td>
<td>(m_2 = 1200) kg</td>
</tr>
<tr>
<td>(u_1 = 20) m/s</td>
<td>(u_2 = 5) m/s</td>
</tr>
</tbody>
</table>

**AFTER COLLISION**

<table>
<thead>
<tr>
<th>First Car</th>
<th>Second Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>(m_1 = 1000) kg</td>
<td>(m_2 = 1200) kg</td>
</tr>
<tr>
<td>(v_1 = ?)</td>
<td>(v_2 = 15) m/s</td>
</tr>
</tbody>
</table>

\[
m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2
\]
\[
1000\text{kg}(20\text{m/s}) + 1200\text{kg}(5\text{m/s}) = 1000\text{kg}(v_1) + 1200\text{kg}(15\text{m/s})
\]
\[
2.0 \times 10^4 \text{kg} \cdot \text{m/s} + 6.0 \times 10^3 \text{kg} \cdot \text{m/s} = 1000\text{kg}(v_1) + 1.8 \times 10^4 \text{kg} \cdot \text{m/s}
\]
\[
2.6 \times 10^4 \text{kg} \cdot \text{m/s} - 1.8 \times 10^4 \text{kg} \cdot \text{m/s} = 1000\text{kg}(v_1)
\]
\[
v_1 = \frac{8 \times 10^3 \text{kg} \cdot \text{m/s}}{1000\text{kg}} = 8\text{m/s}
\]

Example 2. An object A of mass 6 kg, travelling in a straight line at 5 m/s collides with an object B of mass 4 kg travelling in the same straight line, but in the opposite direction, with a speed of 3 m/s. After the collision, object A continues to move in the same direction at 1.5 m/s. What is the speed object B after the collision?
5.9. Friction and its effects

Friction - force that resists the sliding or rolling of one solid object over another.

“The resistance to the motion of the object because of the interaction between the body and the surroundings is called the force of friction”.

Without the force of friction we cannot walk or run and is very important for the motion of wheeled vehicles. Actually it arises due to the contact between two surfaces.

A. Advantages of friction

Friction plays a vital role in our daily life. Without friction we are handicap.

1. It is becomes difficult to walk on a slippery road due to low friction. When we move on ice, it becomes difficult to walk due to low friction of ice.
2. We cannot fix nail in the wood or wall if there is no friction. It is friction which holds the nail.
3. We can hold things in our hand because of friction.
4. Without friction the vehicles cannot move or brought to rest on the roads.
5. Power is transmitted from a motor to a machine by friction belt.

B. Disadvantages of friction

Despite the fact that the friction is very important in our daily life, it also has some disadvantages like:
1. The main disadvantage of friction is that it produces heat in various parts of machines. In this way some useful energy is wasted as heat energy.
2. Due to friction we have to exert more power in machines.
3. It opposes the motion.
4. Due to friction, noise is also produced in machines.
5. Due to friction, engines of automobiles consume more fuel which is a money loss.

Everyday life examples of friction
Methods of reducing friction

There are a number of methods to reduce friction in which some are discussed here.

**Use of lubricants:**

The parts of machines which are moving over one another must be properly lubricated by using oils and lubricants of suitable viscosity.

**Use of ball bearing:**

In machines where possible, sliding friction can be replaced by rolling friction by using ball bearings.

**Design modification:**

Friction can be reduced by changing the design of fast moving objects. The front of vehicles and airplanes are streamlined to minimize friction.

5.10. **Kinetic and static friction**

There are two kinds of frictional forces, Static and Kinetic friction.

**A. Static Friction:**

“When there is no motion or object just starts to slide”.

The maximum force of static friction, $f_s$, between an object and a rough surface is proportional to the product of the magnitude of normal force ($N$) acting on the object and the coefficient of static friction. The maximum force occurs when the object starts to move. Mathematically, static friction can be written as

$$f_s = \mu_s N$$

Where $\mu_s$ is the coefficient of static friction and $N$ is the normal force.

Static friction varies between zero and a maximum value, which depends upon the nature of the two surfaces in contact.

**B. Kinetic Friction:**

“When a body slides over a rough surface, the force of kinetic friction ($f_k$) opposes the motion and is also proportional to the magnitude of normal force ($N$)”.

$$f_k = \mu_k N$$

Values of dimensionless constant ‘$\mu$’ ranges from around 0.01 to 1.5. The table given below shows both the coefficient of static and kinetic friction for some materials.

<table>
<thead>
<tr>
<th>Coefficients of Friction$^a$</th>
<th>$\mu_s$</th>
<th>$\mu_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel on steel</td>
<td>0.74</td>
<td>0.57</td>
</tr>
<tr>
<td>Aluminum on steel</td>
<td>0.61</td>
<td>0.47</td>
</tr>
<tr>
<td>Copper on steel</td>
<td>0.53</td>
<td>0.36</td>
</tr>
<tr>
<td>Rubber on concrete</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Wood on wood</td>
<td>0.25–0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Glass on glass</td>
<td>0.94</td>
<td>0.4</td>
</tr>
<tr>
<td>Wax wood on wet snow</td>
<td>0.14</td>
<td>0.1</td>
</tr>
<tr>
<td>Wax wood on dry snow</td>
<td>—</td>
<td>0.04</td>
</tr>
<tr>
<td>Metal on metal (lubricated)</td>
<td>0.15</td>
<td>0.06</td>
</tr>
<tr>
<td>Ice on ice</td>
<td>0.1</td>
<td>0.03</td>
</tr>
<tr>
<td>Teflon on Teflon</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Synovial joints in humans</td>
<td>0.01</td>
<td>0.003</td>
</tr>
</tbody>
</table>

$^a$ All values are approximate. In some cases, the coefficient of friction can exceed 1.0.
A. Multiple Choice:
1. Newton is equal to
   (a) 1 kg m/s
   (b) 1 kg m/s²
   (c) 1 kg/s

2. Which of the following is an example of the type of force that does not act at a distance?
   (a) gravitational
   (b) magnetic
   (c) contact force

3. If we know an object is moving at constant velocity, we may assume:
   (a) the net force acting on the object is zero.
   (b) there are no forces acting on the object.
   (c) the object is accelerating.

4. A force of 10 million Newton’s is expressed numerically as:
   (a) 10 MN
   (b) 10 mN
   (c) 1 MN

5. An apple weighs 3N. The net force on the apple when it is in free fall is _____.
   (a) 0 N
   (b) 3 N
   (c) 9.8 N

6. Which of the following relation is CORRECT?
   (a) Kinetic friction = Rolling friction
   (b) Rolling friction > Kinetic friction
   (c) Static friction > Kinetic friction

7. The physical quantity, which is equal to change in momentum, is
   (a) Force
   (b) Impulse
   (c) Inertia

8. The physical quantity, which is equal to rate of change of momentum, is
   (a) Work
   (b) Impulse
   (c) Force

9. 1 kg m/s = ________.
   (d) 1 N m
   (e) 1 N s
   (f) 1 N/m

10. A piece of paper and an iron are dropped simultaneously from the same point. They will reach ground simultaneously, if they,
    (a) have the same weight
    (b) have the same density
    (c) are in the vacuum

B. Problem Solving

1. Three forces F₁, F₂ and F₃ are applied to an object as shown in the figure below. If the object is not moving, find then the magnitude of the two unknown forces F₂ and F₃.
2. An aircraft weighing 6400 pound lands at a speed of 10 ft/sec and stops in 10 seconds. What is the force was generated by the breaks (consider g = 32 ft/sec²)

3. Two identical balls A and B moving with velocities +0.5 m/s and -0.3 m/s, respectively, collide head-on perfectly elastic. Find the velocity of the balls A and B after the collision.
4. A force of 15N is needed to move a body of mass 30kg along a footpath with uniform velocity. Find the coefficient of dynamic friction. (Consider \( g = 10 \text{m/s}^2 \))

C. Fill in the blanks:

1. Forces passing through a common point are said to be__________________.

2. Newton’s first law explains__________________.

3. The product of mass of a body and its velocity in known as__________________.

4. No physical contact between two objects take place in __________________forces.

5. __________________is the force between two objects sliding one over on the other.

Home Work

1. Inertia is the property by virtue of which the body is unable to change by itself the
   (a) state of uniform motion only
   (b) direction of motion only
   (c) steady state of rest and of uniform linear motion.

2. A force of 5.0 N acts on a body of weight 9.8 N. The acceleration produced in ms\(^{-2}\) is:
   (a) 49.0
   (b) 5.0
   (c) 0.51

3. The weight of a man on the earth is 60 N. What is the weight of the same man on the moon?
   (a) 360 N
   (b) 60 N
   (c) 6 N

4. Essential characteristic of equilibrium is
   (a) momentum equal to zero
   (b) acceleration equal to zero
   (c) kinetic energy equal to zero

5. A body is at rest in the middle of a pond on a perfectly smooth ice. He can reach to the shore by making use of Newton’s
   (a) first law
   (b) second law
   (c) third law

6. All materials below can help reduce friction except ____________.
   (a) Lubricants
   (b) Sand
   (c) Wax

7. For a car weighing 1000 N, what force would be required to accelerate the car to 3 ms\(^{-2}\).
   (a) 3270 N
   (b) 305.8 N
   (c) 3000
Chapter 6: Work, Energy and Power

6.1. Work

The work done by a constant force is measured by the dot product of the force and the displacement vectors.

\[
W = F \cdot \Delta x
\]

If the force \( \vec{F} \) displaces an object through a distance \( \Delta x \) in the direction of force as shown in the figure above then the work done is:

Work is a **scalar** physical quantity. The SI Unit of work is Joule (J) or N.m.

In case the force \( \vec{F} \) acts along a direction making angle \( \theta \) with the direction of displacement \( \Delta x \) as shown in the figure then work done by a constant force \( \vec{F} \) is:

\[
W = (F \cos \theta) \cdot \Delta x
\]

Depending on the value of the angle \( \theta \) between the force and the displacement we have 3 cases.

(i) If \( \theta \) is between \( 0^\circ \) and \( 90^\circ \) \( (0 \leq \theta \leq 90^\circ) \) then, \( \cos \theta > 0 \), so the work done by the force is positive and in this case when \( \vec{F} \) and \( \Delta x \) are in the same direction i.e. \( \theta = 0^\circ \) then \( \cos 0^\circ = 1 \), then \( W = F \times \Delta x \) the work done by the force in this case is maximum.

(ii) If \( \theta = 90^\circ \), \( \vec{F} \) and \( \Delta x \) are perpendicular to each other i.e. \( \theta = 90^\circ \) then \( \cos 90^\circ = 0 \), then the work done will be zero.

(iii) If \( \theta \) is between \( 90^\circ \) and \( 180^\circ \) \( (\cos \theta < 0) \), so the work done by the force is negative. \( \vec{F} \) is said to be a resistant force like for example the work done by the friction force.

Note: 1 Joule could be defined as the work done when a force of 1 Newton moves a body through a distance of 1 meter.

**Example 1.)** A man exerts a force of 50 N to push a trolley through a distance of 20 m. What work is done by the man?

Solution:

\[
W = F \cdot \Delta x
\]

\[
W = (50 \text{ N})(20 \text{ m})
\]

\[
W = 1000 \text{Nm or Joule}
\]
6.2. Energy

Energy is the capacity to do work. Energy is a scalar quantity and its SI unit is Joule (J) or N.m.

\[
\text{Work done} = \text{Energy transferred}
\]

6.3. Types of mechanical energies

We will be studying mainly mechanical energy, which is of two types, namely kinetic and potential energy.

A. Kinetic Energy

“The kinetic energy of a body is the energy due to its motion.” Mathematically,

\[
K.E. = \frac{1}{2}mv^2
\]

where ‘m’ is the mass of a body moving at a speed ‘v’.

KE. is also scalar quantity.
KE unit in SI and CGS systems are J and erg same as that of work.

Example 1. A body of mass 5.0 kg initially at rest is subjected to a force of 20.0N. What is the kinetic energy gained by the body at the end of 10.0 s?

Solution:

Given: \(m = 5.0 \text{ kg, } F = 20.0 \text{ N, } v_i = 0 \text{ and } t = 10.0 \text{ s}\)

\[
a = \frac{F}{m} = \frac{20}{5} = 4.0 \text{ms}^{-2}
\]

Let \(v_f\) as the velocity of the body after 10.0 s, then

\[
v = u + at = 0 + 4.0 \times 10 = 40.0 \text{ms}^{-1}
\]

K.E. of the body after 10.0 s = \(\frac{1}{2}mv^2 = \frac{1}{2} \times 5.0 \times (40.0)^2 = 4000.0 \text{ J}\)

B. Potential Energy

“The potential energy of a body is the energy due to its position or shape or size.” Mathematically,

\[
PE = mgh
\]

where ‘m’ is the mass of a body, ‘g’ is acceleration due to gravity = 9.8 m/s² and ‘h’ is height.

PE is also a scalar quantity. PE unit in SI and CGS systems are J and erg, respectively the same as that of work.
6.4. Law of Conservation of energy

It states that “Energy can neither be created nor destroyed, it only changes from one form to another form.”

or

“In an isolated conservative system, the sum of K.E. and P.E. of the system always remain constant”.

Mathematically \[ E_{\text{final}} = E_{\text{initial}} \]
\[ (\text{K.E. + P.E})_{\text{final}} = (\text{K.E. + P.E})_{\text{initial}} \]
\[ \text{K.E final} - \text{K.E. initial} = \text{P.E. initial} - \text{P.E. final} \]
\[ \Delta \text{K.E.} = - \Delta \text{P.E} \]

**Example 1.** Using conservation of mechanical energy, find the velocity with which a stone will strike the ground when it is dropped from a height of 80.0 m. \((g = 10 \text{ m/s}^2)\)

Solution:

\[
\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = -(mgh_f - mgh_i) \\
\frac{1}{2} m v_f^2 - 0 = -[0 - mg(80)] \\
\frac{1}{2} m v_f^2 = mgh_i \\
\]
\[ v_f^2 = 2(10 \text{m/s}^2)(80) \]
\[ v_f = \sqrt{1600 \text{m}^2/\text{s}^2} = 40.0 \text{m/s} \]

6.5. Power

The rate of doing work is called power \((P)\). Thus, the power is written as follows:

\[ P = \frac{\text{work done}}{\text{time}} = \frac{\text{Force } \times \text{ displacement}}{\text{time}} \]
\[ P = \frac{F \cdot d}{t} = F \cdot v \]

SI unit: Watt or ‘W’. 1 watt = 1 joule per second.

Note: Power is a **scalar** quantity.

**Example 1.** Calculate the work done in one hour by an electric motor in a washing machine which has an output power rated 1.5 kW.

Solution:

\[ P = \frac{W}{t} \]
\[ W = Pt = 1.5 \times 10^3 W(3600s) = 5.4 \times 10^6 \text{ J} \]

6.6. Machines

Machines are mechanical devices that help make our work easier. It makes us easier to move objects from one point to another or help us lift heavier objects. There are two (2) types of machines: 1.) Simple machine and 2.) Compound machine.

Simple machines have different types. These include inclined plane, levers, pulleys, wheel and axle, wedges, screws, and gears (See Figure 6). Compound machines are made up of combination of these simple machines (See Figure 7).

![Simple machines](image)

**Figure 6. Examples of Simple machines**

A. Inclined Plane

An inclined plane is a flat surface that is at an angle to the load. An example of an inclined plane is ramp for wheelchairs. The inclined plane of the ramp makes it easier for the person in the wheelchair to move up into a building. (See Figure 8)

![Inclined plane](image)

**Figure 8. A ramp. An example of inclined plane.**

B. Levers:
A lever is a rigid bar that rotates around a fixed point called fulcrum. A lever is a rigid body capable of rotating on a point on itself used to gain mechanical advantage. On the basis of the location of fulcrum, load and effort, the lever is classified into three types, namely: class 1, class 2 and class 3 levers.

1. **Class 1 lever** - A lever has a fulcrum between the load and the effort. Less effort is required to lift the load.

2. **Class 2 lever** – it has a fulcrum at one end of the lever and effort is applied to the opposite force.

3. **Class 3 lever** - Force is applied between the fulcrum and the load. This is used to move the load a greater distance than the effort applied. Disadvantages: much greater effort required to produce moment.

**C. Pulleys and Gears:**
A pulley consists of a rope (or belt or chain) that passes around a wheel. Pulleys are used to change the direction of force and to gain a mechanical advantage greater than one. The three types of pulley are fixed pulley, movable pulley and compound pulley.

1. Fixed pulley - A single fixed pulley is one with a fixed support that does not move with either the effort or the load. The arrangement is used because it is often easier to pull a rope downwards than to lift a rope upwards by changing only the direction of the pulling force but not changing its magnitude. Typically the velocity ratio is one, and the mechanical advantage is almost one as there is only a small amount of work wasted due to work done against the friction of the pulley bearings. (See Figure 7.A)

2. Movable pulley - A movable (class 2) pulley has an axle in a movable block. A moveable pulley supports an object with two ropes, placing the pulley in the middle. Since the pulley is being supported by two ropes, the amount of force you need to move an object is cut to half. It has a mechanical advantage of two. (See Figure 7.B).

3. Compound pulley - A compound pulley is a combination of a fixed and movable pulley that forms a block and tackle, which can have several pulleys mounted on the fixed and moving axles, thereby increasing the amount of force. The block and tackle has been a key tool for raising boat sails and cargo for centuries. (See Figure 7.C)

D. Wheel and axle:

A wheel and axle is made up of a smaller cylinder (axle) and joined to a larger cylinder (wheel).

E. Wedge

A wedge is an inclined plane that tapers to a sharp edge. The wedge is used to separate an object apart such as cutting, splitting and fastening.
F. Screw:

The screw is a twisted inclined plane. It allows movement from lower position to a higher position but at the same time it moves in a circle. Examples of the uses of screw are in a jar lid, a drill, a bolt, and bottle caps.

Figure 10. Examples of screw.

G. Gear

A gear is a wheel with teeth around its rim that mesh with the teeth of another wheel to transmit motion. Gears are used to transmit power (as in a car transmission) or change direction of motion in a mechanism (as in a differential axle). Fixed ratios of speed in various parts of a machine is often established by the arrangement of gears.

6.7. Velocity ratio, mechanical advantage and efficiency

A. Velocity Ratio – the ratio of the distance moved by the effort and distance moved by the load. Mathematically, it can be written as

\[ VR = \frac{\text{distance moved by the effort}}{\text{distance moved by the load}} \]

For example, a load is being lifted using a lever. The distance moved by the effort is 1 m while the distance moved by the load is 200 mm. Then the velocity ratio of the lever is

\[ VR = \frac{1 \text{ m}}{1 \times 10^{-3} \text{ m}} = 5 \]

B. Mechanical Advantage – the ratio of the load (weight) and the effort (force exerted). Larger mechanical advantage means the machine can move heavier objects with less application of force. For example, from the figure

\[ MA = \frac{\text{load}}{\text{effort}} = \frac{400 \text{ N}}{160 \text{ N}} = 2.5 \]

Figure 11. Different combination of gears used in a car transmission.
C. **Efficiency** – describes the ratio of the useful work done by the machine to the total work input. It is mathematically written as,

\[
Efficiency = \frac{\text{work output}}{\text{work input}} \times 100\% , \text{ since}
\]

\[
Work = F \cdot d \text{ then}
\]

\[
Efficiency = \frac{F_{\text{load}} \cdot d_{\text{load}}}{F_{\text{effort}} \cdot d_{\text{effort}}} \times 100\%
\]

or

from the definition of velocity ratio and mechanical advantage,

\[
Efficiency = \frac{MA}{VR} \times 100\%
\]

**Example 1.** A wheelbarrow with a load of 300 N is being carried by a man who exerted a force of 100 N. The distance moved by the effort is 300 mm and the distance moved by the load is 100 mm (See figure on top). Find the A.) Mechanical advantage, B.) Velocity ratio and C.) Efficiency of the wheelbarrow.

**Solution:**

A.) \( MA = \frac{\text{load}}{\text{effort}} = \frac{300\,N}{100\,N} = 3 \)

B.) \( VR = \frac{\text{distance moved by the effort}}{\text{distance moved by the load}} = \frac{300\,mm}{100\,mm} = 3 \)

C.) \( Efficiency = \frac{MA}{VR} \times 100\% = \frac{3}{3} \times 100\% = 100\% \)
Worksheet 6

A. Multiple Choice Questions:

1. Which of the following is a set of units for Work?
   (a) Newton, m/s², Joule
   (b) Joule, Kg m²/s², N*m
   (c) Erg, m/s², N/m

2. The work done by gravity during the descent of a freely falling object_____.
   (a) Is positive
   (b) Is negative
   (c) Zero

3. The mechanical advantage of any machine is:
   (a) The work done by the machine
   (b) The ratio of the work done by the machine to the work expended on it.
   (c) The ratio of the force exerted by the machine to the force applied to it.

4. Which of the following is a set of units for Power?
   (a) Watt, erg, J/s
   (b) J/s, kg m²/s², Watt
   (c) Watt, N*m/s, erg

5. Khalid lifts a barbell 2.0m above the ground in 5s. If he lifts it the same distance in 10s, the work done by him is:
   (a) Four times as great
   (b) Two times as great
   (c) The same

6. A person holds an 80-N weight 2 m above the ground for 30 seconds steadily. How much power is needed to do this?
   (a) 160 W
   (b) 5.33 W
   (c) 2.67 W

7. A 6.0 kg block is released from rest 80m above the ground. When it has fallen 60m, its kinetic energy is approximately:
   (a) 4700 J
   (b) 3500 J
   (c) 1200 J

8. What is the kinetic energy of an aircraft of mass 2 metric tonnes and has a velocity of 6 m/s?
   (a) 36 kJ
   (b) 3.6 kJ
   (c) 360 J

9. A flying bird possesses ____________.
   (a) Kinetic energy
   (b) Gravitational energy
   (c) Potential and Kinetic energy

10. If the speed of an object is doubled then its kinetic energy is ____________.
    (a) Doubled
    (b) Quadrupled
    (c) Halved

11. 1.5 kW =
    (a) 150 Watts
    (b) 1500 Watts
    (c) 15000 watts

12. A man of mass 60 kg jumps to a height of 2 m. Assuming ‘g’ as 10 m/s², his potential energy at the highest point is
    (a) 1200 J
    (b) 12 J
    (c) 1.2 J

13. The physical quantity which is equal to the product of force and velocity is
    (a) Work
    (b) Energy
    (c) Power
14. If a machine has a mechanical advantage of 20 and a velocity ratio of 40. The efficiency of the machine is__.
(a) 80 %
(b) 0.5
(c) 2

15. If you push an object with a force of 10 N for 5 m in 20 second, how much power is used?
(a) 25 watts
(b) 2.5 watts
(c) 250 watts

16. One (1) Watt can be expressed as:
(a) 1 kg/h
(b) 1 joule/s
(c) 1 HP

17. A mass of 400kg moves 27 metres with a force of 54. What is the work produced?
(a) 10.1kJ
(b) 583.2 kJ
(c ) 1458 J

B. Identification: Write the name of the given simple/compound machines. Write your answer on the space provided.

1. 

2. 

3. 

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C. Problem Solving:

1. How much work must be done to stop a 1250-kg car travelling at 100 km/hr?

2. How high will a 1.85 kg rock go if thrown straight up by someone who does 90J of work?

3. A novice skier, starting from rest, slides down a frictionless 35° incline whose vertical height is 185 m. How fast is he going when he reaches the bottom?
4. A bullet of mass 10 g leaves a rifle at an initial velocity of 1000 m/s and strikes the earth at the same level with a velocity of 500 m/s. Find the work done in joule to overcome the resistance of air.

5. How long will it take a 1750W motor to lift a 315 kg piano to a sixth-story window 16.0m above?

6. If a 1500-kg car can accelerate from 35km/h to 55 km/hr in 3.2s, how long will it take to accelerate from 55km/h to 75km/h? Assume the power stays the same, and neglect frictional losses.

7. Calculate the mechanical advantage of a ramp (inclined plane) that is 8.0m long and 1.75m high?

8. Suppose you have a 10m first class lever and you put a fulcrum 1.20m from the load which is at one end of the lever. If you can push down 460N, what is the heaviest load that you can lift?
9. A lever of length 112 cm is used with a fulcrum placed 16 cm from the end bearing the load. Find the mechanical advantage of the lever.

D. Fill in the blanks:

<table>
<thead>
<tr>
<th>Velocity ratio</th>
<th>Machines</th>
<th>Mechanical advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Work</td>
<td>Zero</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy</td>
</tr>
</tbody>
</table>

1. Capacity to do work is called__________________.

2. The ratio of load to effort is known as ________________.

3. ________________are mechanical devices that help make our work easier.

4. The product of force and distance is known as__________________.

5. Efficiency of any engine is always less than__________________.
### ترجمة المصطلحات الفيزيائية إلى اللغة العربية (الجزء الأول)

**Chapter 1**

<table>
<thead>
<tr>
<th>Arabic Term</th>
<th>English Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>التسارع</td>
<td>Acceleration</td>
</tr>
<tr>
<td>الإزاحة الزاوية</td>
<td>Angular displacement</td>
</tr>
<tr>
<td>وحدات أساسية</td>
<td>Base units</td>
</tr>
<tr>
<td>التحويل</td>
<td>Conversion</td>
</tr>
<tr>
<td>الكثافة</td>
<td>Density</td>
</tr>
<tr>
<td>وحدات مثاثلة</td>
<td>Derived units</td>
</tr>
<tr>
<td>التيار الكهربائي</td>
<td>Electric current</td>
</tr>
<tr>
<td>القوة</td>
<td>Force</td>
</tr>
<tr>
<td>التردد</td>
<td>Frequency</td>
</tr>
<tr>
<td>الطاقة الحرارية</td>
<td>Heat Energy</td>
</tr>
<tr>
<td>الطول</td>
<td>Length</td>
</tr>
<tr>
<td>شدة الإضاءة</td>
<td>Luminous intensity</td>
</tr>
<tr>
<td>الكتلة</td>
<td>Mass</td>
</tr>
<tr>
<td>كمية الحركة أو الزخم</td>
<td>Momentum</td>
</tr>
<tr>
<td>مضاعف</td>
<td>Multiplier</td>
</tr>
<tr>
<td>كمية فيزيائية</td>
<td>Physical quantity</td>
</tr>
<tr>
<td>القدرة</td>
<td>Power</td>
</tr>
<tr>
<td>البادئة</td>
<td>Prefixes</td>
</tr>
<tr>
<td>الضغط</td>
<td>Pressure</td>
</tr>
<tr>
<td>المقاومة</td>
<td>Resistance</td>
</tr>
<tr>
<td>السرعة</td>
<td>Speed</td>
</tr>
<tr>
<td>حلقة دائرية</td>
<td>Sphere: Circular loop</td>
</tr>
<tr>
<td>نظام الحدات</td>
<td>System of Units</td>
</tr>
<tr>
<td>الحرارة</td>
<td>Temperature</td>
</tr>
<tr>
<td>الزمن</td>
<td>Time</td>
</tr>
<tr>
<td>وحدة الطول</td>
<td>Unit of length</td>
</tr>
<tr>
<td>وحدة الكتلة</td>
<td>Unit of mass</td>
</tr>
<tr>
<td>وحدة الزمن</td>
<td>Unit of time</td>
</tr>
<tr>
<td>قيمة</td>
<td>Value</td>
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<tr>
<td>السرعة المتنجية</td>
<td>Velocity</td>
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<tr>
<td>فرق الجهد</td>
<td>Voltage</td>
</tr>
<tr>
<td>الحجم</td>
<td>Volume</td>
</tr>
<tr>
<td>الشغل</td>
<td>Work</td>
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</table>

**Chapter 2**

<table>
<thead>
<tr>
<th>Arabic Term</th>
<th>English Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>نوينأ</td>
<td>Anion</td>
</tr>
<tr>
<td>الذرة</td>
<td>Atom</td>
</tr>
<tr>
<td>العدد الكتلي</td>
<td>Atomic mass</td>
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<tr>
<td>العدد الذري</td>
<td>Atomic number</td>
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<tr>
<td>نقطة الغليان</td>
<td>Boiling point</td>
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<tr>
<td>كاتيون</td>
<td>Cation</td>
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<tr>
<td>الروابط الكيميائية</td>
<td>Chemical bonds</td>
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<tr>
<td>تصنيف المادة</td>
<td>Classification of matter</td>
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<tr>
<td>مزج</td>
<td>Combinations</td>
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<tr>
<td>مركب</td>
<td>Compound</td>
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<tr>
<td>الاصطناع</td>
<td>Condensation</td>
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<tr>
<td>الرابطة التساهمية</td>
<td>Covalent bond</td>
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<tr>
<td>التترسب</td>
<td>Deposition</td>
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<tr>
<td>الالكترونات</td>
<td>Electrons</td>
</tr>
<tr>
<td>عنصر</td>
<td>Element</td>
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<tr>
<td>التبخر</td>
<td>Evaporation</td>
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<tr>
<td>التجديد</td>
<td>Freezing</td>
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<tr>
<td>اكتساب الالكترونات</td>
<td>Gain of electrons</td>
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<tr>
<td>غاز</td>
<td>Gas</td>
</tr>
<tr>
<td>غير متجانس</td>
<td>Heterogeneous</td>
</tr>
<tr>
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<td>Homogeneous</td>
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<td>Ionic bonds</td>
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<td>Isotopes</td>
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<tr>
<td>السائل</td>
<td>Liquid</td>
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<tr>
<td>فقدان الالكترونات</td>
<td>Loss of electrons</td>
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<tr>
<td>المادة</td>
<td>Matter</td>
</tr>
<tr>
<td>نقطة الذوبان</td>
<td>Melting point</td>
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<tr>
<td>ذوبان</td>
<td>Melting</td>
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<tr>
<td>خليط</td>
<td>Mixture</td>
</tr>
<tr>
<td>طبيعة المادة</td>
<td>Nature of matter</td>
</tr>
<tr>
<td>ذرة متعادلة</td>
<td>Neutral atom</td>
</tr>
<tr>
<td>النيترون</td>
<td>Neutrons</td>
</tr>
</tbody>
</table>
**Chapter 3**

Adding: جمع
Cartesian plane: المستوى الديكارتي
Component of a vector: مكونات المتجه
Direction: إتجاه
Displacement: الإزاحة
Distance: المسافة
Dividing: قسمة
East: الشرق
Equality of vectors: مساواة متجهين
Magnitude: مقدار
Multiplying: ضرب
North: الشمال
Perimeter of circle: محيط الدائرة
Properties: خصائص
Resultant: محصلة
Scalar quantity: كمية عددية
South: الجنوب
Subtracting: طرح
Vector quantity: كمية متجهة
Vector representation: تمثيل المتجهات
Vector: متجه
Weight: الوزن

**Chapter 4**

Accelerated motion: متسارعة
Center of gravity: (الثقل) المركز الجاذبي
Cliff: جرف
Final velocity: السرعة النهائية
Free fall: السقوط الحر
Gravity: الجاذبية
Initial velocity: الحركة الإبتدائية
Kinematic equations of motion: معادلات الحركة
Motion: حركة
Non-accelerated motion: حركة غير متسارعة

**Chapter 5**

Action and reaction: الفعل و ردة الفعل
Advantages of friction: مزايا الإحتكاك
Aluminum: الألومنيوم
Ball bearing: (المحمل) كريات المحمل
Coefficient of kinetic friction: معامل الإحتكاك الحركي
Coefficient of static friction: معامل الإحتكاك السكوني
Collision: تصادم
Conservation of linear momentum: حفظ كمية التح
Conserved: محفوظ
Contact force: قوة تصادم
Copper: النحاس
Disadvantages of friction: سلبيات (عيوب) الإحتكاك
Elastic collision: تصادم مرن
Electric field force: قوة المجال الكهربائي
Electromagnetic force: القوة الكهرومغناطيسية
Equilibrium: التوازن
Force: قوة
Chapter 6

Centripetal force: القوة المركزي

Centrifugal force: قوة الطرد المركزي