CHAPTER 1

MOTION

CHAPTER'S OBJECTIVES

- To introduce the properties of motion (position, speed and velocity, and acceleration)
- To use the metric (or SI) system of measurement and to learn how to convert units
- To differentiate between speed and velocity
- To differentiate between velocity and acceleration
- To learn how to analyze problem statements and to translate the information into a recipe, and
- To develop a problem solving skill.

Motion was the first natural event that triggered human interest to study natural phenomena long before recording time. To the ancient people, everything in the universe seems to move from one position to another and in a manner, which became part of their everyday life experience.

The ancient Greeks, between 600B.C. and 300B.C. learnt a great deal of motion based on philosophical views of cause and effect. Aristotle is one of their own who wrote many theories about motion that captured people attention until the 16th century.

In the mid of 16th century a modern and correct view of motion was established. Many contributed to this new understanding, but the outstanding contribution of Galileo and then Newton in the 17th century was significant.

Mechanics is the science of motion. It is divided into *kinematics*, which deals with motion with no reference to forces and *dynamics* that studies the effect of forces on motion. This chapter deals with kinematics only.

1.1 Motion

Motion is a change in the object's position with respect to time. Figure (1.1) describes an object changing position with time. A complete description of motion requires

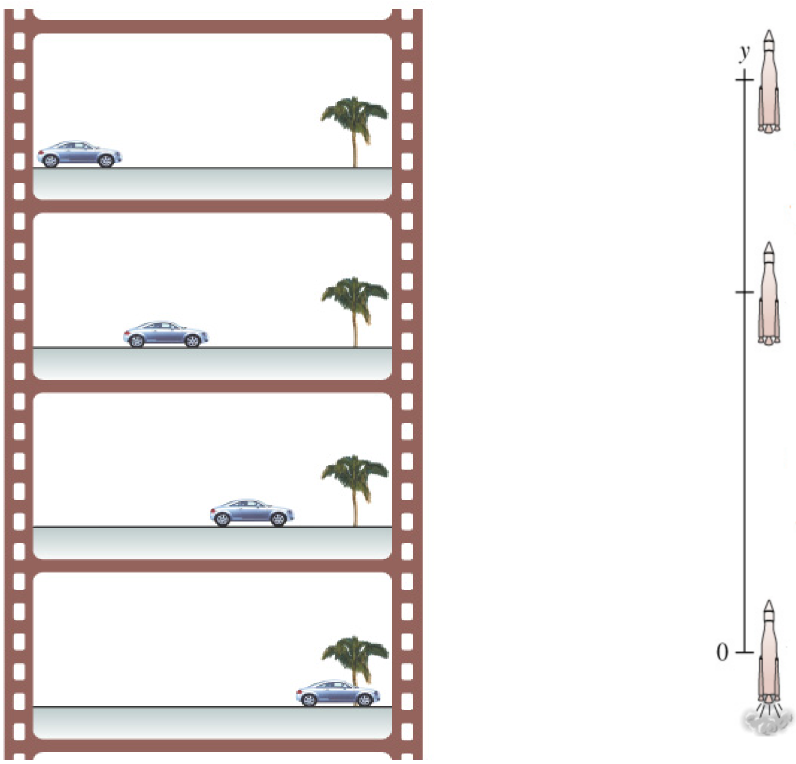
- A reference from which the position is measured or detected. The tree in Figure (1.1) is a reference to measure how far or close is the car from the tree

- A coordinate system (x, y) of measuring position

According to this description, the motion of any object is considered as

- Relative. For example, the motion of the car in Figure (1.1)is relative to the tree

Usually, the motion is either a long straight line as in Figure (1.1 a&b) or a long a curve (a circle for example) as shown in Figure (1.2)



(a) (b)

Figure (1.1) straight line motion . (a) a horizontal motion relative to a tree, and (b) vertical motion relative to earth. In both cases, the object postion is changing with time. Credit: "*Physics for scientists and engineers strategic approach*" by Randall D. Knight, Pearson-Addison Wesley 2004.

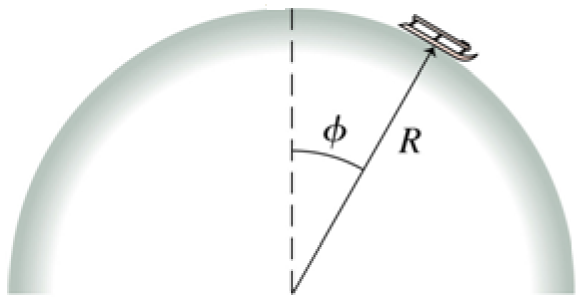


Figure 1.2 motion of an object along a curve. Credit: "*Physics for scientists and engineers strategic approach*" by Randall D. Knight, Pearson-Addison Wesley 2004

1.2 Aristotle and Galileo Views of Motion

The Greek philosopher Aristotle (4th Century BC) studied motion and divided it into to two kinds

1. **Natural motion**

- Motion that is caused by no external forces. For example, the downward motion of a falling stone and the rise of smoke
- Heavy objects fall faster than light objects
- The state of rest is the only equilibrium state. All moving objects will end up at rest

2. **Violent motion**

- Motion that is caused by an external force. For Aristotle, the force is any push or pull on an object. He thought, objects do not move unless a force act on them. For example, the motion of a cart pulled by a horse and the motion of an arrow by a stretched bow

Aristotle used rational thinking and not experimentation as a key to describe and understand motion. His view captured people attention for over 2000 years (until 16th century).

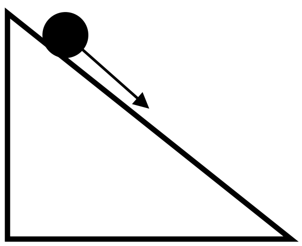
For Galileo (16th Century), on the other hand, both rational thinking and experimentation were the keys to describe and understand motion. He developed his own views of motion, which can be outlined by the following

- Forces act through a physical contact (push or pull) or non-contact (at a distance, gravitational force for example) to move objects. Notice that a non contact force is Galileo's term
- Forces change object's velocity or direction over time. A force cause an object initial at rest move (throwing a ball, for example) or to stop it if it was moving (catching a ball, for example). Forces can also cause a moving object to change its direction (hitting a moving ball with a bat, for example)

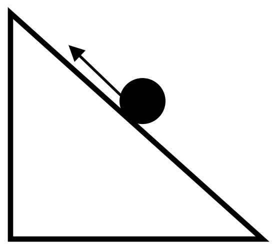
- Friction is a contact force that act between two objects that move past each other. Friction force is parallel to the surfaces in contact and act in a direction that opposes the motion. Friction was introduced first by Galileo
- Without air friction, all objects heavy and light would reach the ground at the same time dropped from the same height and at the same time
- In the absence of friction force, an object does not need a force to keep it moving

Galileo's experiments on motion: Forces and friction

- A ball rolling down an inclined plane (a) speeds up because of gravity. A ball rolling up an incline plane (b) slows down because of gravity

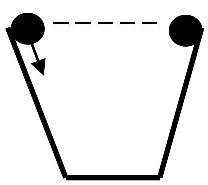


(a)

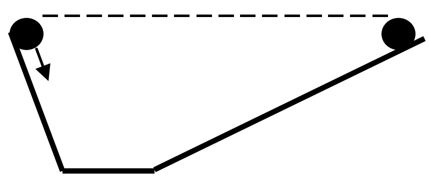


(b)

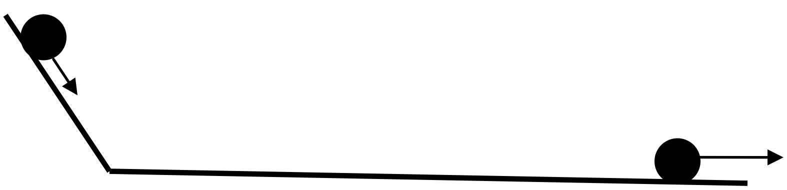
- If friction could be eliminated then the initial and final heights of the ball are equal ((c), and (d)), or the ball will never stops (e).



(c)



(d)



(e)

1.3 Scalars and Vectors

A ***Scalar*** is a physical quantity that has magnitude only. Mass, length, time, and temperature are examples of scalar quantities. A scalar can be described by a number with a unit. For example, the length of an object is 3 meters and its mass is 10 kilograms.

A ***vector*** is a physical quantity that has both magnitude and direction. Vectors are usually represented by an arrow; the length of the arrow gives the magnitude and the arrow's tip or head indicates its direction.

Force, weight, acceleration, velocity, and displacement are just few examples of vectors. Usually, a vector is represented by an upper or lower case letter and an arrow on top. For instance, $\vec{A}, \vec{B}$ or $\vec{a}, \vec{b}$. Figure (1.3) shows a pictorial representation of a vector.

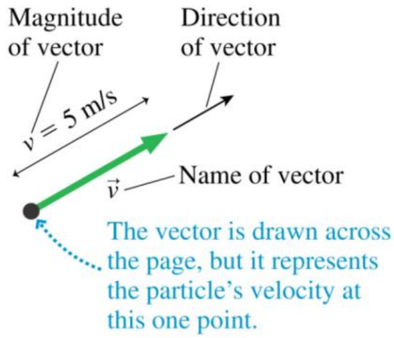


Figure 1.3: A vector $\vec{v}$ is represented by its length (magnitude) and direction. Credit: "*Physics for scientists and engineers strategic approach*" by Randall D. Knight, Pearson-Addison Wesley 2004.

1.3 The Role of Measurements in Physics

Measurements in physical sciences are so important. It consists of comparing of a physical quantity like length or mass with a ***standard*** or ***unit*** using a tool. The process of measurement consists of the following four steps

1. **Select** a standard unit of measurement.
2. **Follow** a procedure or operation of how the comparison is made. Choose a tool of measurement
3. **Count** how many standard units that match the physical quantity.
4. **Record** the result. The result consists of numerical number and a unit.

The following example explains this procedure.

Example 1.1

Measure the length of your thumb

Solution

This example is concerned with the physical quantity length. Length can be measured by standard units of centimeter, meter, kilometer, inch, foot, and mile. The choice must match the demand

1. Select the centimeter as the standard unit of measurement. This is a reasonable choice.
2. Follow a procedure or operation to measure (compare).
   (a) Use a ruler or a measurement tape as a tool. Place the ruler parallel to and along your thumb so that it lined up with the bottom edge of the thumb.
   (b) Make a small pencil mark at the ruler at the point that matches the end of your thumb. You can use your eye sight instead of the pencil mark.
3. Count how many centimeters are in the finger length. You come up with the number 3.2.
4. Record your final result: 3.2 cm

Caution: A number without unit carries no information and does not serve the purpose.

1.3.1 Measurement systems: The Metric System and Its Modification the SI system

There are many measurement systems. The top three are the cgs (centimeter, gram, second) system, mks (meter, kilogram, and second) system, and the English (foot, slug, and second) system.
The metric system of measurement (established in 1791) or it's *SI* (System International) modernized version (established in 1960) is the most common and widely used system by scientists worldwide. Table (1.1) shows measurements of some basic physical quantities and their standard units in both metric and *SI* units.

Table (1.1) Measurements in Metric and SI Systems

measurement	Metric (symbol)	SI (symbol)
Length	Meter (m)	Meter (m)
Mass	Gram (g)	Kilogram (kg)
Volume	Liter (L)	Cubic meter (m^3)
Time	Seconds (sec)	Seconds (sec)
Temperature	Celsius (^{0}C)	Kelvin (K)

In this course we will use the metric system. This system employs prefixes or powers of 10 to describe large or small quantities. This will make it easy in writing large and/or small numbers. Table (1.2) lists some prefixes with their abbreviation and their meaning.

Table (1.2) Some Common Prefixes

Prefix	Symbol	Meaning
tera-	T	10^{12} (1,000,000,000,000 times the unit)
giga-	G	10^9 (1,000,000,000 times the unit)
mega-	M	10^6 (1,000,000 times the unit)
kilo-	k	10^3 (1,000 times the unit)
hecto-	h	10^2 (100 times the unit)
deka-	da	10^1 (10 times the unit)
Unit		
deci-	d	10^{-1} (0.1 of the unit)
centi-	c	10^{-2} (0.01 of the unit)
milli-	m	10^{-3} (0.001 of the unit)
micro-	μ	10^{-6} (0.000001 of the unit)
nano-	n	10^{-9} (0.000000001 of the unit)
pico-	p	10^{-12} (0.000000000001 of the unit)

Each prefix up or down in Table (1.2) represents an increase or decrease by power of 10.

Example 1.1

Use Table (1.1) and indicate whether the unit of each of the following measurements describes (1) length, (2) mass, or (3) volume

________ _ **A**. A basket of apples is 5.7 kg.

___________ **B**. A bridge is 10.4 m tall.

__ ________ **C.** A medication pill contains 0.35 g aspirin.

___________ **D**. A bottle contains 1.5 L of water.

Example 1.2

Identify the measurement that has an SI unit.

1. Salem's height is

(A) 1.75 yd (B) 5.8 ft (C) 1.75 m (D) 0.5 km

2. The temperature is

(A) 75 ^{0}C (B) 345 K (C) 160 ^{0}F (D) 230

3. The mass of an orange is

(A) 59 lb (B) 65 L (C) 34 oz (D) 0.123 kg

4. The 100m dash race was won in

(A) 10.1 s (B) 12.7 min (C) 1.3 hr (D) 0.25 yr

1.3.2 Scientific Notation

In science, scientists use scientific notation to write very large or very small numbers. The scientific notation for a large number such as 56 000, 000 is 5.6×10^{7} and for a small number such as 0.000 0005 is 5×10^{-7}.

A number in a scientific notation contains two parts, a coefficient and a power of 10. In the two examples above, the 5.6 and 5 are the coefficients followed by the powers of ten respectively.

The procedure of writing a number in scientific notation consists of the following steps:

A. <u>If the number is greater than 1</u>

(1) Move the decimal point to the left after the first digit to give a number between 1 and 9.

(2) The spaces moved are shown as a power of ten.

(3) The power is positive

For example: 34 0000 = 3.4×10^{5} (5 spaces moved to the left, and 3 is the first digit)

B. <u>If the number is less than 1</u>

(1) Move the decimal point to the right after the first digital point to give a number between 1 and 9.
(2) The spaces moved are shown as a power of ten.

(3) The power is negative.

For example: 0.00378 = 3.78×10^{-3} (3 spaces moved to the right, and 3 is the first digit)

Example 1.3

Write the following numbers in scientific notation

(1) Diameter of earth is 12 800 000 m = _______________ m

(2) Mass of a human is 78 kg = _______________ kg

(3) Length of a virus is 0.000 03 cm = _______________ cm

1.4 Properties of Motion: speed, velocity, and acceleration

1.4.1 Speed

Speed v is a measure of how fast or how slowly an object moves. It is defined as the distance traveled per unit of time, and can be written as

$$\text{speed} = \frac{\text{distance}}{\text{time}}, \text{ or}$$

$$v = \frac{d}{t} \tag{1.1}$$

Speed is a scalar quantity and does not include a direction. In the metric (SI) system, the unit for speed is kilometer per hour (km/hr) or meter per second (m/s). Practically, the speed is not constant. Therefore, an average speed is used, which can be represented by a dash over the letter v and shown as

$$\bar{v} = \frac{d}{t}$$

For example, if you drive 240 km distance from Yanbu to Jeddah in 2.5 hr, then your average speed is

$$\bar{v} = \frac{240\,km}{2.5\,hr} = 96\,km/hr$$

The Change in a physical quantity

For any physical quantity such as the distance x, the change in x is written as $\Delta x = x_f - x_i$ (always the final value – initial value). The symbol Δ (or delta), a Greek letter, representing a change, and x_f, x_i are the final and the initial (starting) values of the quantity x respectively. Figure (1.4) shows an object changing its position during a time of travel $\Delta t = t_f - t_i$.

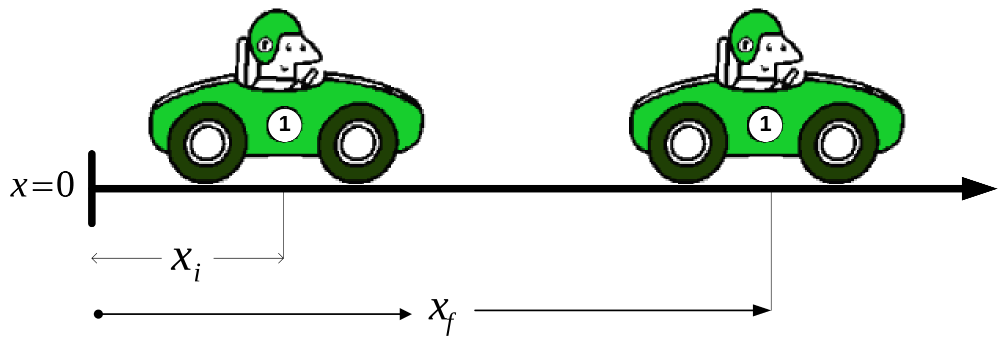


Figure 1.4: During time interval Δt, the object (person and a car) changes its position by Δx.

The average speed can, therefore, be written as

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{\Delta t} \qquad (1.2)$$

1.4.2 Velocity

Velocity $\vec{v}$ is how fast or slowly an object changes its displacement (position). The displacement $\vec{D}$ is a vector quantity, which tells us both the distance traveled by the object as well as the direction of motion. From this we conclude that velocity is a ratio of displacement (not distance) over time and, therefore, it is a vector quantity. The average velocity is written as

$$velocity = \frac{\text{displacement}}{\text{time to cover that displacement}}, \; or$$

$$\vec{v} = \frac{\vec{D}}{t} \qquad (1.3)$$

Example 1.4

A man starts moving from home (origin (0)) and walks 6m east (to the right), stopped and found that he forgot his wallet at home. Therefore, he rushed backward (west) heading home. If the total time of his walk both ways is 2min then find (a) his average speed and (b) his average velocity.

Solution

(a) $\because \bar{v} = \frac{total\ distance\ traveled}{total\ time} \Rightarrow \therefore \bar{v} = \frac{12m}{2 \times 60\sec} = 0.1m/\sec$

(b) $\because \bar{v} = \dfrac{Displacement}{total\ \ time} \Rightarrow \therefore \bar{v} = \dfrac{(6-6)}{2\times 60\sec} = \dfrac{0}{120} = 0m/\sec$

Caution: if an object doesn't change its direction, then speed and velocity are the same.

For convenience, we will drop both the arrow on top of the velocity vector and speed, but will keep the distinction between speed and velocity.

1.5 Problems Solving Method

One of the objectives of this chapter is to help students learn a procedure for solving problems in science. The procedure can be outlined in the following:

- Read the problem carefully. Read it at least twice, slowly and completely from the beginning to the end
- Make a sketch of the problem if it is necessary. You can substitute or represent any object by a dot or a box
- In your notebook, write down all given information (data) with units. Look at some terms that carry some information. For example, motion from rest means initial velocity equals zero. Also, the term 'smooth surface' indicates no friction
- Write down the unknown quantity or quantities the question asked for
- Write down the basic equation or formula that relates all the known and the unknown quantities
- Find the working equation or formula for the unknown quantity
- Substitute the data in the working equation, including the units. Verify your work

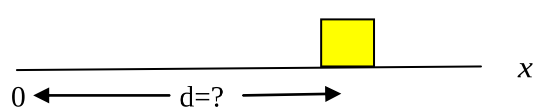
The following example illustrates this procedure

Example 1.5

Find the distance traveled by a car travels with an average speed of 80km/hr in 2.0 hr.

Solution:

Sketch:



Data (given information)**:** $\bar{v} = 80\,km/hr$, $t = 2.0hr$, wanted: d ?

Basic equation**:** $\bar{v} = \dfrac{d}{t}$

Working equation**:** $d = \bar{v}\,t$

Substitute and solve**:** $d = (80km/hr)\times(2hr) = 160km$

1.6 Types of Motion: Uniform (constant) and Non Uniform Motion

1.6.1 Uniform motion

Uniform motion is defined as**:**

- Motion on a straight line, and
- Occur when successive displacement/distances are equal at equal time intervals

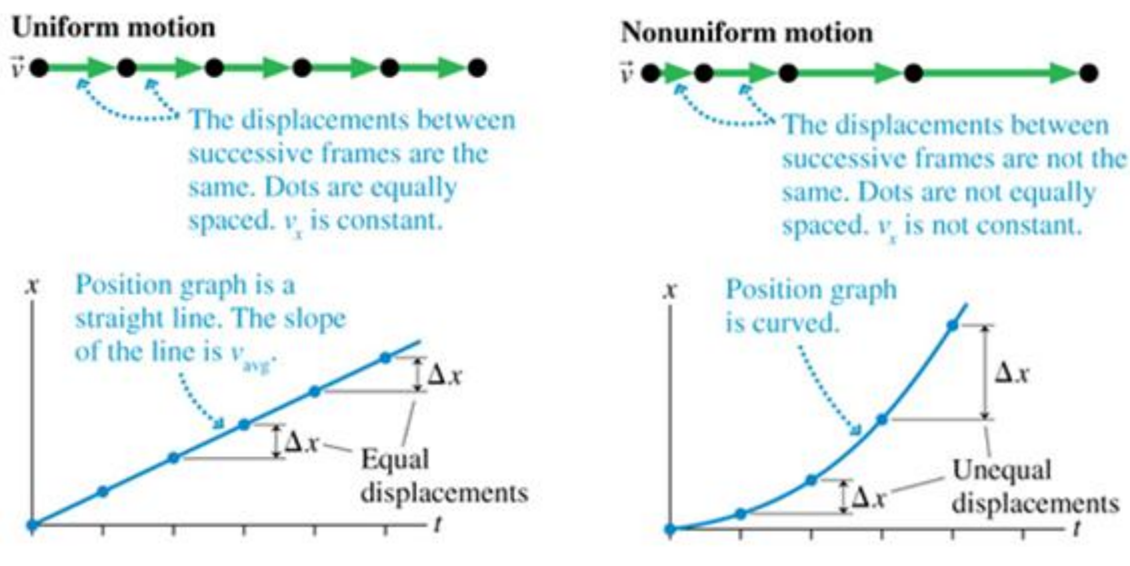
If you drive a car at a constant velocity of 80 km/h, you will cover 80km during the first hour, another 80km during the second hour, another 80km during the third hour, and so on. The 80km covered during each hour is not the position but the change of position or displacement. Also, the time of 1 hour is the time interval between successive equidistance displacements. On (x,t) diagram, the uniform motion is shown as straight line with a slope giving the velocity. Figure (1.5(a)) illustrates a pictorial and graphical representation of uniform motion in (x,t) plane.

1.6.2 Non Uniform Motion

Non Uniform motion is defined as:

- Motion on a curve, and
- Occur when successive displacements/distances are not equal at equal time intervals

A pictorial and graphical representation of non uniform motion is shown in Figure (1.5 (b))



(a) (b)

Figure 1.5: pictorial and graphical representation of a uniform (a) and (b) non uniform motions . The term frame referes to an event. Credit: *Physics for scientists and engineers strategic approach*" by Randall D. Knight, Pearson-Addison Wesley 2004.

Instantaneous Velocity

The ***instantaneous velocity*** v_{ins} is the average velocity when the time interval between displacements approach zero (not zero). The instantaneous velocity is therefore the velocity at the moment and not the average over the entire hour. Usually, car's speedometer gives the instantaneous velocity.

1.7 Acceleration $\vec{a}$

Acceleration $\vec{a}$ is a measure of how fast or how slowly is the change in velocity. It is defined as the change in velocity over time. It is a vector and always points in the same direction as velocity change vector and has a unit of m/s^2.

$$\vec{a}_{avg} = \frac{Change\ in\ velocity}{Time\ of\ \ change} = \frac{final\ \ velocity - initial\ \ velocity}{time}, or$$

$$\vec{a}_{avg} = \frac{\Delta\vec{v}}{t} = \frac{\vec{v}_f - \vec{v}_i}{t} \qquad (1.4)$$

The change in velocity is either

- Up (speeding up) and the acceleration and velocity are at the same direction (positive acceleration), or

- Down (slowing down) and the acceleration and velocity are oppositely directed (negative acceleration.). Figure (1.6) demonstrates this fact for a moving car

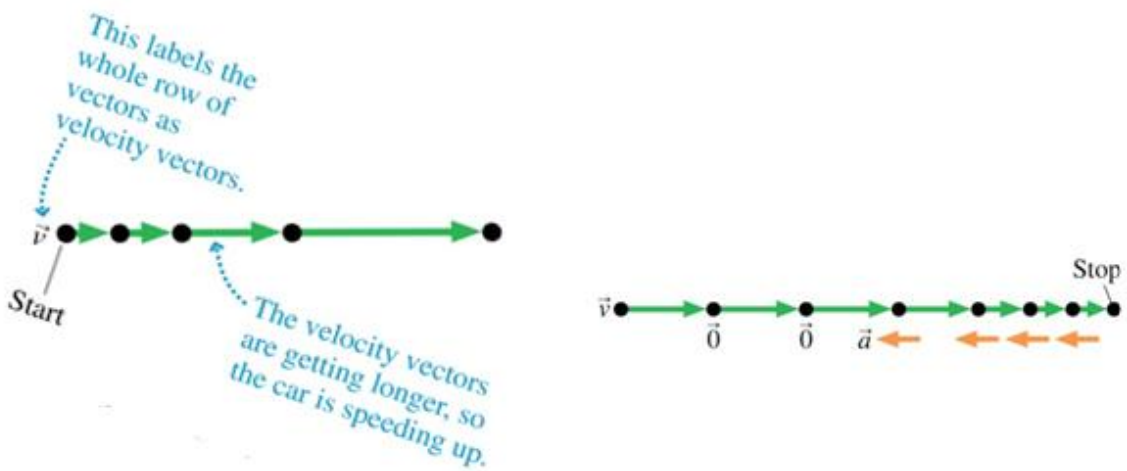


Fig (1.6): Motion diagram of a speeding car (left diagram) and a slowing down car (right diagram). Credit: *Physics for scientists and engineers a strategic approach*" by Randall D. Knight Pearson-Addison Wesley 2004.

Example 1.6

A car starts from rest (velocity = 0 m/s) and speeds up to 20 m/s in 10 s. Find its acceleration.

Solution:

Sketch: Not needed

Data: Δv =20 m/s – 0 m/s = 20 m/sec, t = 10 s, wanted: a?

Working equation: $$a = \frac{\Delta v}{t}$$

Substitute: $$a = \frac{v_f - v_i}{t} = \frac{20\,m/s - 0m/\sec}{10\,s} = 2\,m/s^2$$

1.8 Unit Conversion

To a scientist or a student studying science, unit conversion is extremely important. Therefore, the students must be able to convert back and forth between metric (SI) units.

Unit conversion is based on the availability of ***conversion factors*.** Table (1.3) shows a few common conversion factors.

Table (1.3) some useful conversion factors

1 km = 10^3 m	1m = 10^{-3} km
1 m = 10^2 cm	1 cm = 10^{-2} m
1 cm = 10 mm	1 mm = 10^{-1} cm
1 kg = 10^3 g	1g = 10^{-3} kg
1 day = 24 hr	1 cm^3= 10^{-6} m^3
1 min = 60 sec	
1 y = 365 d	

The process of unit conversion is based on replacing an unwanted unit by a wanted unit; it can be summarized as follows

- Write down the given number with its unwanted unit
- Multiply this by a ratio of 1. The ratio is written from a given conversion factor and it consists of two units, the unwanted unit and the wanted unit. Remember that you need to cancel the unwanted unit

Caution: It should be kept in mind that multiplying any expression by one does not change its value but change its unit.

Writing a conversion factor as a ratio equal to 1

Using information from table1.3 and pick up a conversion factor such as

1 m = 10^{-3}km

From this conversion factor, we can construct two ratios each equal to 1, namely,

$$\frac{1m}{10^{-3}km}=1 \quad and \quad \frac{10^{-3}km}{1m}=1$$

In solving a problem, one should pick up the right ratio; the one that eliminate the unwanted unit and keep the wanted.

Example 1.7

Convert 54 m to km.

Solution

The meter (m) is unwanted unit and the kilometer (km) is the wanted unit. Following the above steps of conversion of units, one gets

$$(54\,m)\times(\frac{10^{-3}km}{1m}) = 54\times10^{-3} = 5.4\times10^{-2}\,km$$

Notice that we chose the second ratio with the meter (m) at the bottom because it cancels the meter (m) unit from both quantities in the two parentheses. In some problems you are asked to continue this process of multiplying by 1 as many times as necessary to complete the conversion (look at exercise 7 of Chapter's 1 worksheet.)

SUMMARY OF CHPTER 1

Motion is a change in position/displacement over time. Motion can be measured by its three properties; ***speed***, ***velocity***, and ***acceleration***. Speed is a measure of how fast or how slowly an object is moving. It is a ratio of the distance traveled divided by time. Distance and time are two examples of scalar quantities. A ***scalar quantity*** can be completely described by a number (magnitude) and unit. Because speed is not constant over the entire distance traveled, a most common ***average speed*** is used. Measurement in physical sciences is so important. It consists of comparing a quantity to a standard or unit and associating a numerical number and unit to the measured quantity. Usually, numerical values are either extremely large or small. Scientists used ***scientific notation*** to make these numbers more readable. Contrary to speed, velocity is a ***vector quantity***, which requires a direction for a complete description. ***Acceleration*** is a measure of how fast or slowly is the change in velocity (not speed). It is a vector quantity and is directed in the direction of the change in velocity. Average values of velocity and acceleration are again more common. ***Instantaneous speed*** is the speed at the moment, namely it is the speed at very short intervals of times that reach, but not equal zero. Motion is either uniform or non uniform. ***Uniform motion*** is motion on a straight line and occurs when its successive distances or displacements are equal at equal times. Contrary to this is the ***non uniform motion***. The ***metric system*** of measurement or its extended version SI is the mostly used system around the world because it is based on prefixes or power of ten. ***Acceleration*** is a measure of how fast or how slowly is the change in velocity over time. It is a vector and points in the direction of the change in velocity. Changing units require conversion factors. A ***conversion factor*** is a statement that relates two units. Forming a ratio of value 1 from this statement allows us to eliminate the unwanted units and come up with the wanted unit.

Basic Equations

$$speed\ \ v = \frac{d}{t}$$

$$average\ \ speed = \bar{v} = \frac{d}{t}, \quad or = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t}$$

$$velocity\ \ \vec{v} = \frac{\vec{D}}{t}$$

$$acceleration\ \ \vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

Chapter 1 Worksheet

Part 1: Sentence Completion

1. Motion is a ------------------- in the object's ---------------- with respect to ------------------.

2. A -------------------------------------- is needed to measure the position of an objects in motion.

3. A physical quantity that has a magnitude (number and a unit) only is called a **-------------------.**

4. A physical quantity that has both magnitude and direction is called a ------------------------.

5. 1 meter is equivalent to ------------ centimeter and 1 millimeter is equivalent to --------------- centimeter.

6. The ----------------- is the metric (SI) unit of length in the metric system and the --------------- is the unit for time.

7. The prefix ---------------- has a power of ten as ------------- and the 10^{-9} has the prefix ------------.

8. The measure of how fast or how slowly an object is called -------------------.

9. The measure of how fast or how slowly the velocity is changing is called ---------------------.

10. Change of velocity over time is called -------------------------.

11. The ------------------------------- is any straight line motion in which equal displacements occurs during any successive equal time intervals.

12. The ------------------------- velocity is the velocity (speed and direction) at the moment and not the average over the entire hour.

13. Millisecond = ----------------- second.

Part 2: General Review Questions

1. What is the basic metric unit of mass? What is the basic SI unit of mass?

2. Give the metric prefix for 1000,000

3. Give the power of ten of 0.0002

4. Write the abbreviation of 5.6 kilometers, 2.3 millimeters

5. Which is larger? 1cm or 1mm, 100m or 1km

6. Does the car speedometer measures average speed or the instantaneous speed?

7. You throw a ball against a wall and the ball bounces back toward you with the same speed as it had before it hits the wall. Does the velocity of the ball remain the same as the speed?

8. Suppose in an unidentified system of measurement the distance/velocity is measured by the unit J and time by K

A. What would the unit of speed be in this system?

B. What would the unit of velocity be in this system?

C. What would the unit of acceleration be in this system?

9. Two cars A and B are moving with constant velocities v and 2v respectively at a certain amount of time. During this time interval, which car A or B is moving with greater acceleration?

Part3: Multiple Choices

1. Which is a vector quantity?

A. Speed.
B. Displacement.
C. Distance.
D. Mass.

2. When a quantity is multiplied or divided by one, the value is

A. Increased.
B. Decreased.
C. Unchanged.
D. None of the above.

3. The unit m/s^2 is for

A. Velocity
B. Speed
C. Instantaneous speed
D. Acceleration

4. Displacement

A. Is a measurement of mass
B. Is a measurement of time
C. Can be described only with a number
D. Showing direction and distance

5. Temperature is

A. A vector quantity.
B. A scalar quantity.
C. Neither a vector nor a scalar.

D. None of the above.

Part4: True/False (If your answer is F, then try to correct the statement)

1. Velocity is the same as speed**.**

   A. True
   B. False

2. Velocity is always constant.

   A. True
   B. False

3. Velocity is a scalar and speed is a vector quantity.

   A. True
   B. False

4. Uniform motion is motion along a straight line of constant slope.

   A. **True**
   B. False

5. The average speed and instantaneous speed are the same.

   A. True
   B. False

Part6: Exercises

1. A driver covers a distance of 300 km in a time of 2.5 hours. What is the average speed for this trip?

2. A driver drives for 4.5 hours at an average speed of 65 km/h. What distance does he travel in this time?

3. A student walks a distance of 320 m with an average speed of 1.5 m/s. What time was required to walk this distance?

4. Starting from rest and moving in a straight line, a runner runs with velocity of 6 m/s in a time of 2 s. What is average acceleration of the runner?

5. The velocity of a train decreases from 40 m/s to 20 m/s in 4 s. What is the average acceleration of the train?

6. A car is moving at 25 m/s when the driver applies the brakes. If it stops in 3 s, what is its average acceleration?

7. Convert 0.05 km to centimeters

Part 7: Challenge Problems

1. A car is travelling in a straight line with an initial velocity of 10 m/s accelerates at 2 m/s^2 to a velocity of 20 m/s.

   A. How much time does it take for the car to reach velocity of 20 m/s?

   B. What is the distance traveled by the car during this time?

2. A car traveling around a circle track with constant speed. Is this car moving with constant velocity? Explain

3. What is your age in milliseconds?