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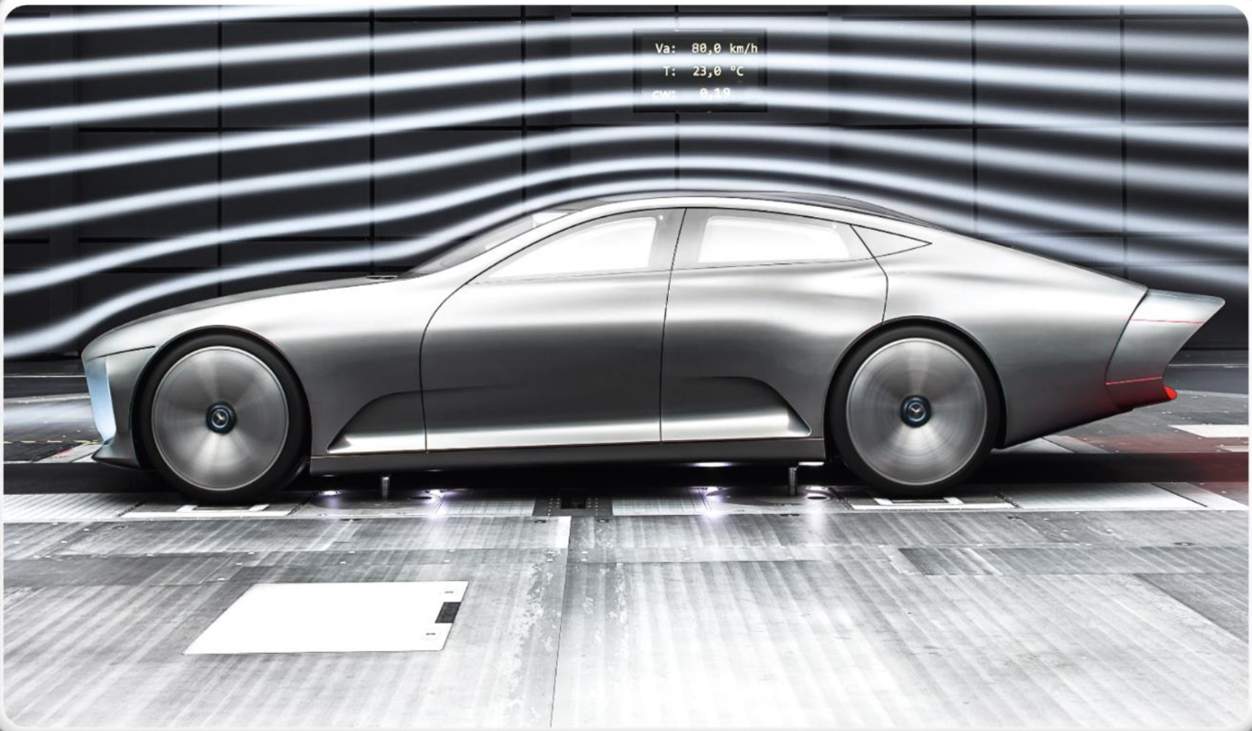

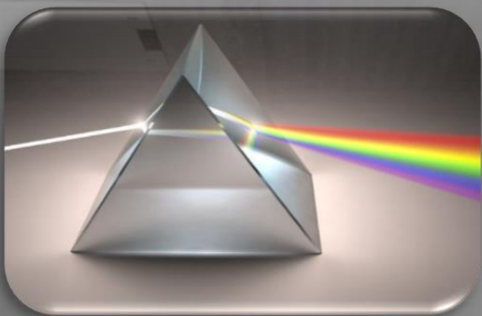

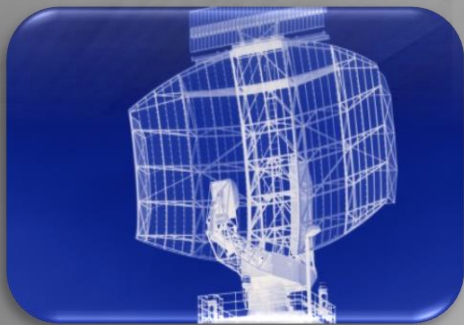

PHYSICS

WORKBOOK-3 MODULE CODE-MTCG1017

Term: 2 AY: 2023-2024 FPD

MILITARY TECHNOLOGICAL COLLEGE

Delivery Plan Year 2023-24 [Term 2]

Title / Module Code / Programme	Physics / MTCG1017/Foundation Programme Department (FPD)	Module Coordinator	Dr. Karim Sellami
Lecturers	TBA	Resources & Reference books	Moodle & Workbooks
Duration & Contact Hours	Term 2: 6 hrs. × 11weeks = 66 hrs.		

Week No.	Topics	Hours	Learning Outcome No.
1	**1. Units and unit conversions** 1.1. System of units, base and derived units 1.2. Unit conversions	2	1
	2. Nature of matter 2.1. Matter 2.2. States of matter (solid, liquid gas and plasma), and change of states. 2.3. Structure of an atom: shell, nucleus, electrons 2.4. Chemical Compounds 2.5. Periodic Table	4	
2	**3. Classification of physical quantities** 3.1 Scalar & Vector quantities 3.2 Vector representation in Cartesian plane 3.3 Properties of vectors 3.4 Vector addition and subtraction	4	
	4. Linear Motion 4.1 Distance and displacement 4.2 Speed and velocity 4.3 Accelerated Motion	2	2
3	4.4 Kinematic Equations of motion. 4.5 Motion under the influence of gravity	2	
	5. Force, momentum and impulse 5.1. Fundamental Forces 5.2. Types of Forces (Contact and Non-Contact Forces) 5.3. Mass and weight 5.4. Newton's 1^{st} Law and its application: Equilibrium **Revision Continuous Assessment-1**	4	
	Continuous Assessment-1 (Chapters 1 to 4)		**1**

4	5.5. Newton's 2^{nd} law and its application: Acceleration 5.6. Newton's 3^{rd} law and its application 5.7. Linear Momentum and Impulse 5.8. Conservation of linear momentum 5.9. Friction-Kinetic and Static Friction	2	2
	6. Work, Energy and Power 6.1 Work and Energy 6.2 Types of Mechanical Energy 6.3 Law of Conservation of Energy 6.4 Power	4	
5	6.5 Machines 6.6 Velocity ration, mechanical advantage and efficiency **7. Rotational Motion** 7.1. Linear and angular velocity 7.2. Uniform Circular Motion & Centripetal force 7.3. Moment of Force (Torque)	6	
6	7.4. Moment of Inertia 7.5. Angular Momentum a. Conservation of angular momentum **b.** Gyroscope	4	
	8. Solids 8.1. Hooke's law Stress, Strain and Young's Modulus **Revision Continuous Assessment-2**	2	3
	Continuous Assessment-2 (Chapters 5 to 8)		2
7	**9. Fluids** 9.1. Fluid statics a. Density b. Relative density c. Hydrometer d. Adhesion e. Cohesion f. Pressure in liquids g. Absolute and gauge pressure h. Measurement of pressure	4	3
	Lab Experiment	2	7
8	i. Buoyancy and Archimedes' Principle j. Pascal's law 9.2 Fluid dynamics a. Types of fluid b. Viscosity c. Fluid resistance and aerodynamic drag d. Bernoulli's Principle & Applications of Bernoulli's Principle	6	3

	10. Thermodynamics 10.1. Heat, Temperature, and Temperature Scales		
	Lab Experiment (continuation)		7
9	10.2. Calorimetry a. Specific heat capacity b. Latent Heat 10.3. Types of Heat Transfer 10.4. Thermal Expansion 10.5. Ideal Gas Law	6	4
10	10.6 Laws of Thermodynamics **11. Wave Motion and Sound** 11.1. Waves a. Anatomy of waves Types of waves 11.2. Standing waves 11.3. Fundamental frequency and harmonics 11.4. Sound waves	6	6
11	**12. Optics** 12.1. Introduction to light 12.2. Law of reflection and refraction 12.3. Critical Angle and Total internal reflection 12.4. Fibre Optics **Revision for Final Exam**	6	5
12	**FINAL EXAM (Chapter-9 to Chapter-12)**		**2, 3, 4, 5, 6 & 7**
	Total Hours	**66**	

Indicative Reading		
#	**Title/Edition/Author**	**ISBN**
1	Advanced Level Physics -7th Edition, 1986 By Michael Nelkon and Philip Parker	ISBN-13 : 978-0435923037 ISBN-10 : 043592303X
2	Physics-5th Edition, 2016 by Walker S. James	ISBN-13: 978-0321- 97644-4 ISBN-10: 0-321- 97644-4
3	Advanced Physics for You –2nd Edition, 2015 by Keith Johnson, Simmone Hewett, Sue Holt, John Miller	ISBN: 9780198355991
4	College Physics-11th Edition,2017 By Raymond A. Serway, Jerry S. Faughn	ISBN-13: 978-1305952300 ISBN-10: 9781305952300

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Dr. Karim Sellami	**Dr. T Raja Rani**	**MQM. Salim Al Shibli**
Module Coordinator	**Deputy Head FPD**	**Head FPD**

Contents

Chapter 9: Fluids

Introduction:

We begin our study with **fluid statics**, the study of fluids at rest in equilibrium situations. In this section, we will explore the concepts of adhesion, cohesion, density, pressure and buoyancy. While **fluid dynamics**, the study of fluids in motion, is much more complex and has many different principles than fluid statics. Meaning, the physics of fluids at rest is different from that of the fluid in motion. And so, we will treat them here separately.

9.1. Fluid statics

Fluid statics or sometimes called as "hydrostatics" is the science that deals with fluids at rest or not moving. A **fluid** is any substance that flows. It can be a liquid or gas.

A. Density

The density ρ (rho) of a substance is the ratio of its mass and volume. Mathematically, it can be written as:

$$\rho = \frac{mass}{volume} = \frac{m}{V}$$

The SI unit of density is $\frac{kg}{m^3}$. The density of pure water is:

$$\rho_{water} = 1\frac{g}{cm^3} = 1000\frac{kg}{m^3} = 1\frac{kg}{L}$$

Example 1: What is the density of a liquid substance that has a mass of 25.0 grams and a volume of 29.4 cm^3?

Ans: $\rho = \frac{m}{v} = \frac{25g}{29.4cm^3} = 0.85$ g/cm^3

Example 2: Find the volume of a rock, if its density is equal to 2000 kg/m^3 and mass equal to 60g.

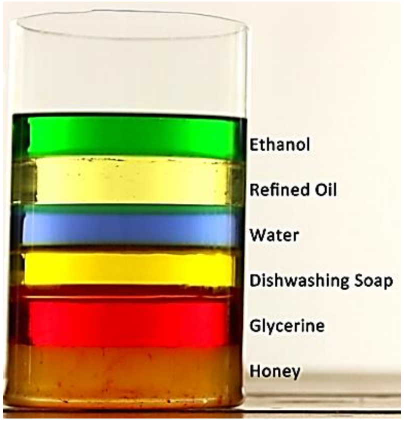
Ans:

$$\rho = \frac{m}{V}$$

$$V = \frac{m}{\rho} = \frac{60 \times 10^{-3}kg}{2000\, ^{kg}/_{m^3}}$$

$$V = 30 \times 10^{-6}m^3 = 30cm^3$$

B. Relative Density



Relative density of a substance (for solid and liquid) is defined as the ratio between the density of the substance to the density of water at 4.0˚C.

Relative density is also known as **specific gravity**.

$$\rho_{rel} = \frac{\rho_{subs}}{\rho_{water}\,(at\ 4℃)}$$

Where, $\boldsymbol{\rho_{water}}$ is the density of water and is equivalent to

$$\rho_{water} = 1\,\frac{g}{cm^3} = 1000\,\frac{kg}{m^3} = 1\,\frac{kg}{L}$$

$\boldsymbol{\rho_{subs}}$ **is the density of the substance.**

1. If $\rho_{substance} > \rho_{water}$, then the substance sinks in water.

2. If $\rho_{substance} < \rho_{water}$, then the substance floats in water.

For gases

$$\rho_{rel} = \frac{\rho_{gas}}{\rho_{air\ at\ 20℃}}$$

$$\rho_{air\ at\ 20℃} = 1.2\ \times 10^{-3}\,\frac{g}{cm^3} = 1.2\,\frac{kg}{m^3}$$

20 ˚C is called the temperature at normal condition

Substance	Density (kg m^{-3})	Relative
Gases		
Hydrogen	0.085	0.0695
Helium	0.169	0.138
Air	1.2	1.0
Liquids		
Alcohol	790	0.79
Kerosene	820	0.82
Water	1000	1.0
Mercury	13,600	13.6
Solids		
ice	920	0.92
Glass	2400-2800	2.4-2.8
Lead	11,340	11.34

Density and relative density of some common substances

Example 3:

The volume of a solid is equal to 350 cm^3 and its mass is 500 g.
(a) What is the density of the solid? Give your answer in SI Unit.

Solution: $\rho_s = \frac{m}{v} = \frac{500}{350} = 1.43\frac{g}{cm^3}$

$= 1.43 \times 10^3\ kg/m^3$

(b) What will be the relative density of the solid?

Solution: $RD_{solid} = \frac{\rho_{solid}}{\rho_{water}} = \frac{1.43}{1} = 1.43$

(c) Will it float or sink?

Solution: $\rho_{solid} > \rho_{water}$ $\because 1.43 > 1$ hence, the substance sinks.

Class Activity 1

Choose the correct answer:

1. The units of relative density is ____
a) kg/m^3
b) kg/m
c) No units

2. If you poured 3 liquids that do not mix how you could tell which one is the most dense?
a) The liquid on top
b) The liquid in the middle
c) The liquid at the bottom

3. Which of the following bodies will float on water? (Density of water = 1000 kg/m^3)
a) Body A having density 500 kg/m^3
b) Body B having density 2520 kg/m^3
c) Body C having density 1100 kg/m^3

Problem Solving

1. The dimensions of a hall are 10 m × 7 m × 5 m. If the density of air is 1.11 kg/m^3, find the mass of air in the hall.

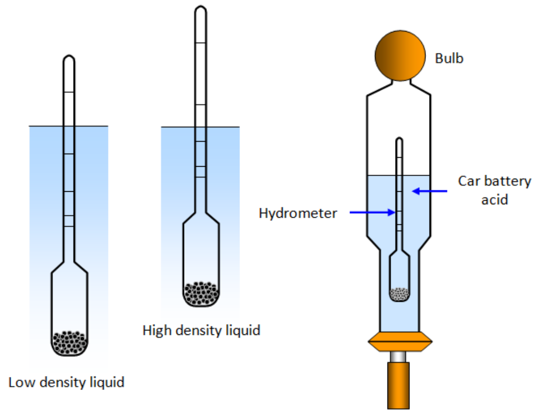
2. A piece of zinc of mass 438.6 g has a volume of 86 cm^3. Calculate the density of zinc in SI units.

3. Calculate the relative density of the liquid from the following information:
Mass of empty bottle = 24.5g
Mass of bottle filled with water = 56.2g
Mass of bottle filled with liquid = 51.2g

C. Hydrometer

The hydrometer is used to measure the relative density of liquids. It normally has a glass float contained within a cylindrical glass body. The float has a weight in the bottom and a graduated scale at the top. When liquid is drawn into the body, the float displays the relative density on the graduated scale.

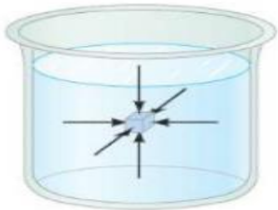
If we immerse a hydrometer in pure water, it reads 1.000.



Hydrometer

D. Pressure in liquids

The static pressure P_s is the pressure if the fluid is not moving (stationary). It is the ratio of force to area. Mathematically, it is written as $P_s = \frac{F}{A}$. The force, *F*, is acting perpendicularly on the surface of the object and it acts in all direction.



Force acts on all sides and is perpendicular to the surface of the submerged object.

Since the force is equal to the weight of the water then we can write pressure as,

$$P = \frac{F}{A}$$

$$P = \frac{mg}{A}$$

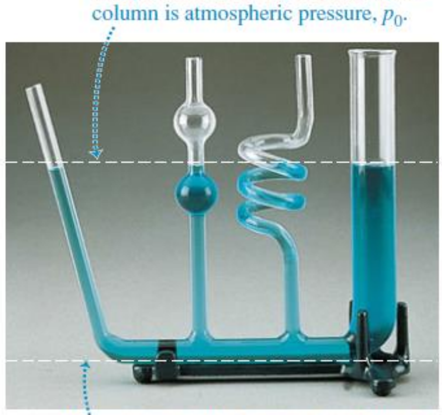
But since $m = \rho V$ and $V = Ah$ then,

$$P = \frac{\rho A h g}{A}$$

$$\boldsymbol{P = \rho g h}$$

From the above equation, it shows that fluid pressure depends on three (3) things only: density (ρ), acceleration due to gravity (g) and height of the fluid or depth (h). This means that fluid pressure does not depend on the shape or size of the container.

The pressure at the top of each liquid column is atmospheric pressure, p_0.



The pressure at the bottom of each liquid column has the same value p.

The difference between p and p_0 is $\rho g h$, where h is the distance from the top to the bottom of the liquid column. Hence all columns have the same height

E. Absolute pressure and gauge pressure

If the pressure inside a car tyre is equal to atmospheric pressure, the tire is flat. The pressure has to be greater than atmospheric pressure to support the car. So, when the gauge pressure reading is 32 psi (lbs/in^2), this means that it is 32 psi more than the atmospheric pressure. The sum of gauge pressure and atmospheric pressure is called **absolute pressure**.

$$\boldsymbol{P = P_0 + \rho g h}$$

Where P_o is the atmospheric pressure and is equal to 1.01×10^5 Pa **(at sea level)**. **Atmospheric pressure** is due to the weight of the air above the earth acting on its surface. As altitude increases, atmospheric pressure decreases.

The SI unit of pressure is N/m^2 or Pascal (Pa). However, there are several common units for pressure.

Units of Pressure

Unit	Atmospheric Pressure
Pascal (Pa); kilopascal (kPa)	$1.01325\text{x}10^5$ Pa; 101.325 kPa
Atmosphere (atm)	1 atm
Millimeters of mercury (mmHg)	760 mmHg
Torr	760 torr
Pounds per square inch (psi or lb/in^2)	14.7 lb/in^2
Bar	1.01325 bar

At sea level standard atmospheric pressure equals 1013.2 milli-bars or 14.69 psi or 1.01×10^5 or 760mm Hg at 15°C.

Example 4

Water stands 12.0 m deep in a storage tank whose top is open to the atmosphere. What are the gauge and absolute pressures at the bottom of the tank?

a.) Gauge pressure, $\rho gh = (1000kg/m^3)(9.8m/s^2)(12.0m)$
$= 1.18 \times 10^5 Pa\ or\ 1.16\ atm$

b.) $P = P_0 + \rho gh$
$P = 1.01 \times 10^5 + 1.18 \times 10^5 Pa$
$P = 2.19 \times 10^5 Pa$ or 2.16 atm

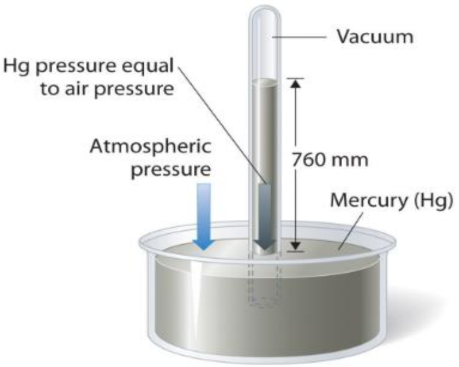
F. Measurement of pressure (gauging)

Devices that measure pressure are referred to as Manometers and manometers which measure atmospheric pressure are called Barometers.

The two most common types of barometer used to measure atmospheric pressure are the mercury and aneroid types.

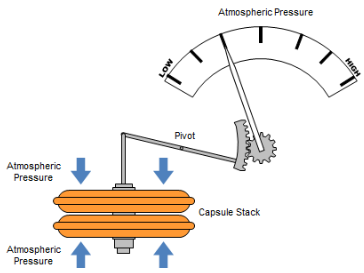
1) Mercury barometer

The simplest type of mercury barometer is illustrated in the figure at the right.
It consists of a mercury-filled tube, which is inverted and immersed (dipped) in a reservoir of mercury.
The atmospheric pressure can be calculated from the height of the column of the mercury.



2) Aneroid Barometer:

They are widely used in portable instruments and in aircraft altimeters because of its smaller size and convenience. It contains of a flexible-walled evacuated capsule, the wall of which deflects with changes in atmospheric pressure. This deflection is coupled mechanically to an indicating needle.



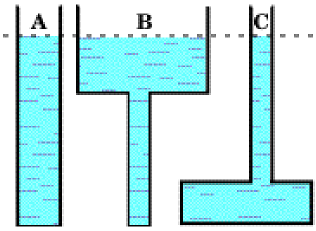
Class Activity 2

Choose the correct answer:

1. **Which of the following statements is TRUE if the gauge pressure of the tyre is 35 psi?**

    a) The absolute pressure is less than 35 psi.
    b) The atmospheric pressure is equal to 35 psi.
    c) The absolute pressure is greater than 35 psi.

2. **From the given pictures below, how do you compare the fluid pressure at the bottom of the containers?**



    a) Pressure in C is the highest
    b) Pressure in A is greater than B
    c) Pressure in A, B and C are all the same

3. **At a certain place, the reading on the mercury barometer is 745 mm Hg. This means it is located at _________.**

    a) Sea level
    b) Above sea level
    c) Below sea level

Problem Solving

1. Find the approximate pressure at a depth of 15 m under water surface in a dam.

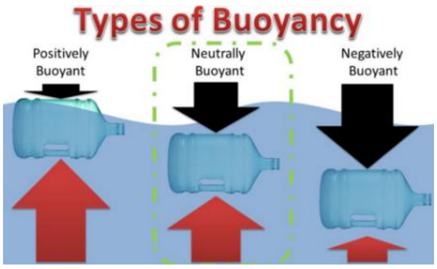
2. A vertical tube of radius 1 cm, open at the top to the atmosphere, contains 2 cm of oil floating on 3 cm of water. What is the gauge pressure at the bottom? [$\rho_{oil} = (0.82)*\rho_{water}$]

G. Buoyancy and Archimedes' principle

Buoyancy

Buoyancy is the apparent loss of weight of a submerged object due to the upward force exerted by the fluid called **buoyant force**.

1. The body will float--if the buoyancy is positive.
2. The body will sink--if the buoyancy is negative.
3. The body will be stuck--if the buoyancy is neutral, in this case the body neither sinks nor floats.



Buoyant Force is basically defined as the difference between weight of object in air and weight of object in fluid. Mathematically, we can write it as

$$B.F = W_{air} - W_{fluid}.$$

Similarly, the buoyant force (B.F) has been found to be the same as the weight of the displaced fluid. It is known as the Archimedes' Law.

Archimedes' law:

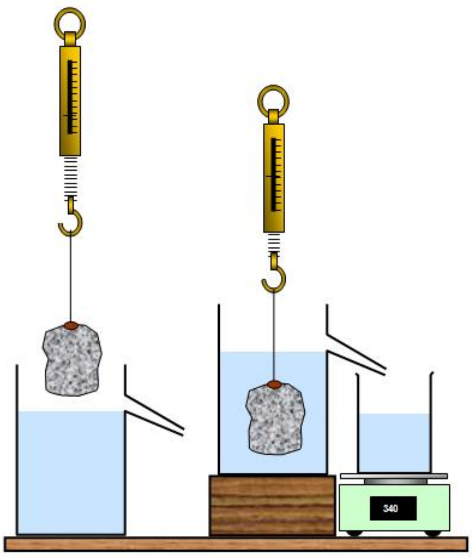
Archimedes' Principle states that" when an object is submerged in a liquid, the object displaces a volume of liquid equal to its volume and is supported by an upward force equal to the weight of the liquid displaced". Mathematically, we can write this as

$B.F = W_{displaced\ fluid} = mg$, But since $m = \rho V$, then

$$B.F = \rho g V_{displaced\ fluid}.$$

Likewise, $V_{displaced\ fluid} = V_{submerged\ object}$ then

$$B.F = \rho g V_{submerged\ object}$$



Volume of displaced water = volume of stone

If one can design an object that can displaces large amount of water, then there will be large amount of buoyant force acting on that object. This explains why boats made of steal don't sink in water.

Apparent weight[1] = weight of object - weight of displaced fluid[2]

1. If the weight of object is less than the weight of displaced water i.e. apparent weight < 0 then object will float.
2. If weight of object is more than the weight of displaced water i.e. apparent weight > 0 then object will sink.

This up thrust or buoyant force can be explained in terms of the forces acting on the body due to pressure acting on each surface of the body.

[1] The same as weight of the object in fluid (W_{fluid})

[2] This is also equal to the buoyant force ($B.F$)

Example 5:
A sample of an unknown material weighs 300 N in air and 200 N when submerged in an alcohol solution with a density of 0.70 x 10^3 kg/m^3. What is the density of the material?

Solution:
$B.F = W_{air} - W_{alcohol}$
B.F = 300 N – 200 N = 100 N
Also, $B.F = \rho g V_{submerged\ object}$

$100 = 700 \times 9.8 \times V_{submerged\ object}$

$V_{submerged\ object} = 0.0146\, m^3$

$W_{air} = m \times g$

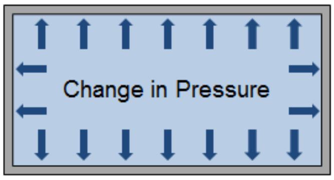
$300 = m \times 9.8$

$m = 30.61\ kg$

$$\rho_{submerged\ object} = \frac{m}{V} = \frac{30.61}{0.0146} = 2100\ kg/m^3$$

H. Pascal's law

Any change in the pressure on the fluid in an enclosed container is transmitted equally and undiminished to all of the enclosing walls of the container, and it acts at right angles to the walls.

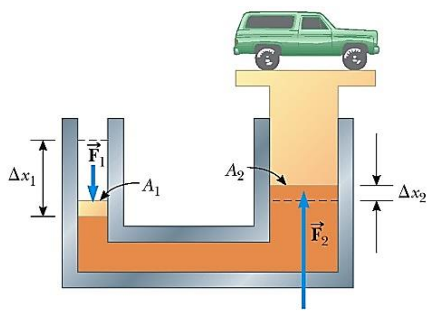


Enclosed Container

Bramah's law

Under a given load, the smaller the area it acts upon, the greater the pressure produced and the greater the area under pressure, the greater the force available.

Pascal's law states that when a pressure is applied to an enclosed fluid, this pressure is transmitted equally in all directions.



An application of the use of fluid pressure to hydrostatic system can be found in the **hydraulic press**, often referred to as **Bramah's press**. This is the principle behind hydraulic (fluid) systems, where a mechanical input force drives a pump, creating pressure which then acts within an actuator, so as to produce a mechanical output force.

In a hydraulic press, the area in which the input force is applied, is smaller than the other one. By applying Pascal's law,

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Now, since pressure must be equal at all points and $A_1 < A_2$, then $F_2 > F_1$.This makes hydraulic press lift heavy objects.

Example 6:

The small piston of a hydraulic lift has an area of 0.20 m^2. A car weighing 1.2×10^4 N sits on a rack mounted on the large piston that has an area of 0.90 m^2. How much force must be applied to the small piston to support the car?

Solution:

$F_1 / A_1 = F_2 / A_2$

$F_1 = [F_2 / A_2] \times (A_1) = (1.2 \times 10^4 \text{ N} / 0.90 \text{ m}^2) \times 0.20 \text{ m}^2$

$F_1 = 2.7 \times 10^3$ N

Class Activity 3

Choose the correct answer:

1. The magnitude of buoyant force acting on a body depends upon…
a) Weight of the immersed body
b) Density of the fluid and mass of the fluid
c) Density of the fluid and volume of the immersed body

2. A stone weighs 50 N in air and has apparent weight of 40 N in water. The buoyant force acting on the stone is…
a) 90 N
b) 10 N
c) 200 N

3. An object of weight 500 N is floating in a liquid. The magnitude of buoyant force acting on it is...
a) 200 N
b) 300 N
c) 500 N

Problem Solving

1. A stone weighs 450 N in air and has apparent weight of 200 N in water. Compute the volume of stone.

2. The small piston of a hydraulic lift has a cross-sectional area of 3.00 cm^2, and its large piston has a cross-sectional area of 200 cm^2. What force must be applied to the small piston for the lift to raise a load of 15.0 kN?

9.2. Fluid dynamics

Fluid dynamics is the branch of applied science that is concerned with the movement of fluids (liquids and gases). In this section, we are going to study static and dynamic behavior of fluids.

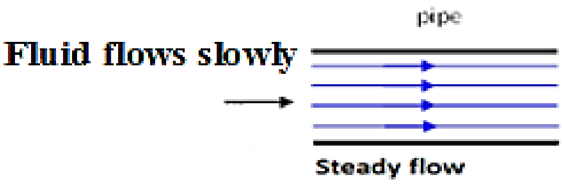
Dynamic pressure: Dynamic pressure P_d is the pressure of a fluid that results from its motion.

$P_d = \frac{\rho v^2}{2}$ where ρ and $\boldsymbol{v}$ are the density and the velocity of the fluid, respectively

A. Types of fluid flow

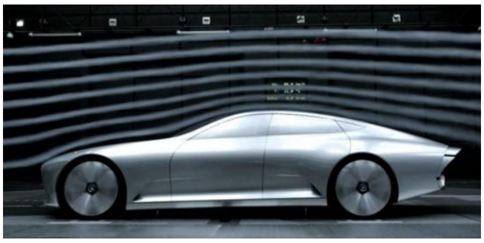
There are two types of fluid flow:

Steady or laminar flow: This is smooth flow of the fluid. (Velocity is constant).

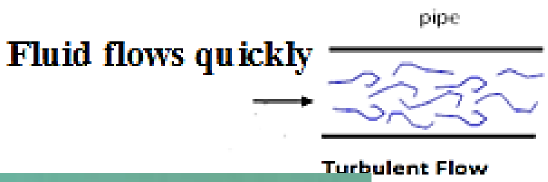


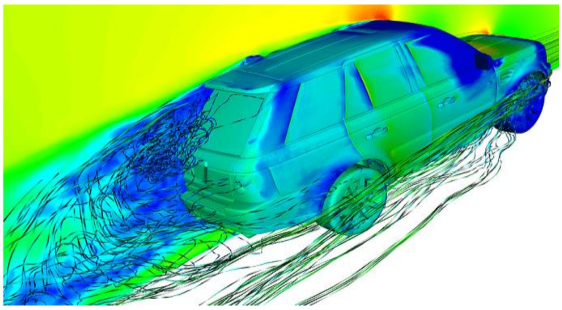
Streamlining

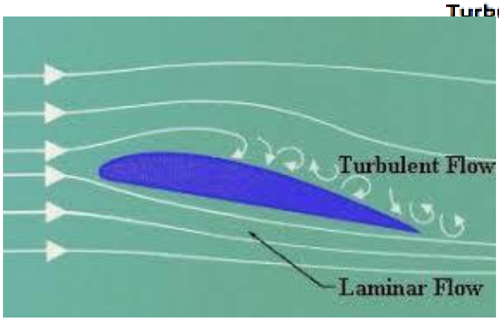
- Flowing steadily over a smooth surface, narrow layers of it follow smooth paths that are known as streamlines.
- If fluid flows slowly along a pipe, the flow is streamline.
- If flow is very fast and exceeds a certain critical speed, the flow will become turbulent.



Turbulent flow: If laminar flow encounters obstructions, the streamline will break and become irregular or **turbulent.** (Velocity changes).







Computer simulation of turbulent air flow for a car (left) and an airfoil (right)

B. Viscosity

Viscosity is the property of a fluid (a liquid or gas) that describes its ability to flow. Viscosity is basically a measure of how thick and "sticky" a fluid is. It is also known as thickness or internal friction.

High-viscosity fluids resist flow (flows slowly), and low-viscosity fluids flow easily. For example, the viscosity of water is less than the viscosity of honey. Therefore, water flows faster than honey.

A few typical values of viscosity are given in the Table below. Note that viscosities for all fluids are dependent on temperature, increasing for gases and decreasing for liquids as temperatures rise.

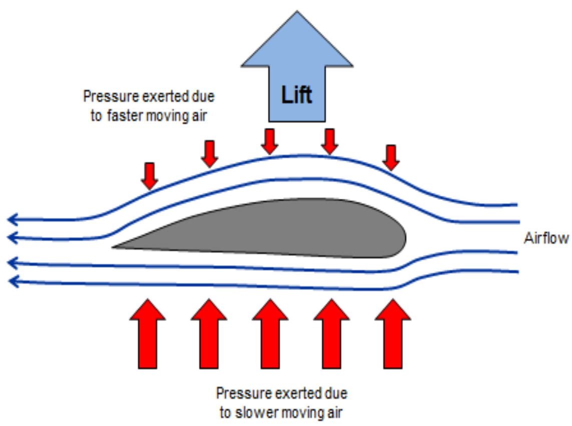
Temperature °C	Castor oil (poise) (i.e. Pa.s x 10 -1)	Water (centipoises) (i.e. Pa.s x 10 -3)	Air (micropoise) (i.e. Pa.s x 10-7)
0	53	1.792	171
20	9.86	1.005	181
40	⇑ 2.31	⇑ 0.656	⇓ 190
60	0.08	0.469	200
80	0.30	0.357	209
100	0.17	0.284	218

Typical Values of Viscosity

C. Bernoulli's principle & its applications

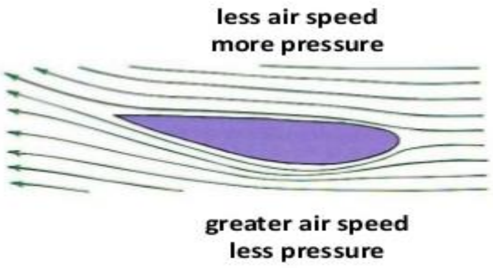
Bernoulli's principle states that the **sum** of the **pressure, kinetic energy per volume** and **potential energy per volume** at any point in steady flow calculated per unit mass or per unit volume is constant. In this section, we will treat fluids as an ideal fluid. An ideal fluid is an incompressible fluid that flows smoothly (laminar flow) and with zero viscosity.

$$P + \frac{\rho v^2}{2} + \rho g h = \text{constant}$$



Cross section of the wing of an aircraft.

This principle is used in the design of aircraft wings to create lift from the flow of air over the wing profile. It is also used in the design of the spoilers installed at the rear end of sports cars in the purpose of producing a downwards force to stabilize more the car and get better traction.



Spoilers installed at the rear end of a sports car

Example 7:

A water tank has a spigot near its bottom. If the top of the tank is open to the atmosphere, determine the speed at which the water leaves the spigot when the water level is 0.5 m above the spigot.

$P_1 = P_{atm} = 1.01 \times 10^5$ Pa $= P_2$ (both are open to atmosphere)

$v_1 = 0$ (negligible); $h_1 = 0.5$ m and $h_2 = 0$ m

Solution:

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

$$P_1 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2$$

$$v_2 = \sqrt{2gh_1} = \sqrt{2 \times 9.81 \times 0.5} = 3.13\ m/s$$

Equation of continuity

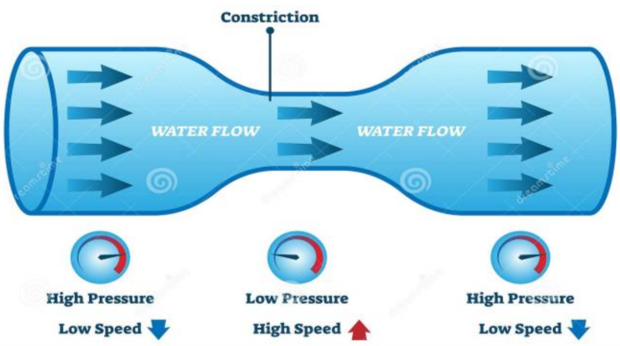
This equation is coming from the conservation of mass. It states that the volume per unit time is constant at all points. It can be written as,

$\frac{V_1}{t_1} = \frac{V_2}{t_2} = constant$ but since *V=Ah* and *v=h/t* then

$\frac{A_1 h_1}{t_1} = A_1 v_1$. Therefore,

$$\boldsymbol{A_1 v_1 = A_2 v_2}$$

Application of Bernoulli's Theorem and continuity equation: Venturi effect



The Venturi effect is the phenomenon that occurs when a fluid that is flowing through a pipe is forced through a narrow section (constricted section), resulting in a pressure decrease and a velocity increase. This phenomenon can be mathematically described through theBernoulli's and continuity equation and can be observed in both nature and industry.

Example 8:

Water enters a typical garden hose of diameter 1.6 cm with a velocity of 3 m/s. Calculate the exit velocity of water from the garden hose when a nozzle of diameter 0.5 cm is attached to the end of the hose.

Solution

First, find the cross-sectional areas of the entry (A_1) and exit (A_2) sides of the hose.

$$A_1 = \pi r^2 = \pi(0.008m)^2 = 2\times10^{-4}m^2$$

$$A_2 = \pi r^2 = \pi(0.0025m)^2 = 1.96\times10^{-5}m^2$$

Next, apply the continuity equation for fluids to solve for the water velocity as it exits the hose (v_2).

$$A_1v_1 = A_2v_2$$

$$v_2 = \left(\frac{A_1}{A_2}\right)v_1 = \left(\frac{2\times10^{-4}m^2}{1.96\times10^{-5}m^2}\right)(3\,m/s) = 30.6\,m/s$$

Example 9: Water enters a horizontal pipe of non-uniform cross section with a velocity of 0.4m/s and leans the other with a velocity of 0.6m/s. The pressure at the first end is 1500 Pa. What is the pressure at the other end?

Solution:

$$v_1 = 0.4\frac{m}{s}\ ;\ v_2 = 0.6\frac{m}{s}\ ;\ P_1 = 1500Pa$$

$$\rho = 1000\frac{kg}{m^3}\ ; P_2 = ?$$

According to Bernoulli's theorem,

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

But since $h_1 = h_2$ *then,*

$$P_1 + \frac{\rho v_1^2}{2} = P_2 + \frac{\rho v_2^2}{2}$$

$$\Rightarrow\ P_2 = P_1 + \frac{\rho}{2}\left[v_1^2 - v_2^2\right] \Rightarrow \quad P_2 = 1500 + \frac{1000}{2}\left[0.4^2 - 0.6^2\right] = 1400Pa$$

<u>Class Activity 4</u>

<u>Choose the correct answer:</u>

1. Equation of continuity is related to…

a) Conservation of mass
b) Conservation of energy
c) Conservation of momentum

2. If a liquid enters a pipe of diameter d with a velocity v, what will it's velocity at the exit if the diameter reduces to 0.5d?
a) v
b) 2v
c) 4v

3. If you blow air between these two balloons, the pressure between the balloons would…

a) Remain the same
b) Increase
c) Decrease

4. Bernoulli's principle is applicable only for
a) Compressible and viscous flow
b) Viscous and turbulent flow
c) Non-viscous and steady laminar flow

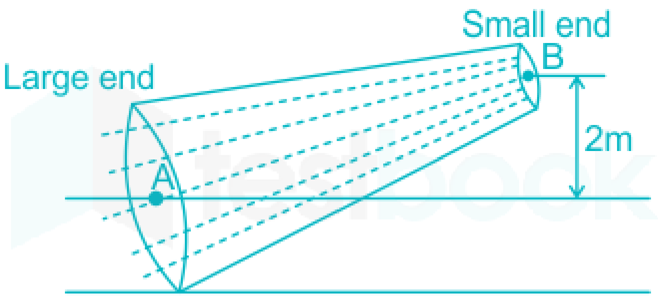
5. The upward force or lift force on flying aircrafts is based on the ___________.
a) Bernoulli's principle
b) Newton's third law
c) Conservation of mass

Problem Solving

1. A non-viscous liquid flows through a hose. Liquid enters with velocity 6.4 m/s and leaves at 2.5 m/s. What is the ratio of the radii of the hose where the liquid enters and where it leaves?

2. The pressure of water in a pipe when water is not flowing is $3 \times 10^5 Pa$ and when the water flows the pressure falls to $2.5 \times 10^5 Pa$. Find the speed of flow of water.

3. A pipe is placed as shown in the figure below. The velocity of the fluid at the large end is 2 m/s and the velocity at the smaller end is 8 m/s. Calculate the pressure difference required between the ends of the pipe to make water to flow.



Worksheet-9

Circle the correct answer:

1. The S.I unit of density is

a) kg m^3
b) kg /m^3
c) m/ kg^3

2. Clouds float in the atmosphere because of ________

a) their high temperature
b) their low viscosity
c) their low density

3. A 40 cm tall glass is filled with water to a depth of 30 cm. The absolute pressure at the bottom of the glass is…

a) 2.9×10^3 Pa
b) 1.04×10^5 Pa
c) 3.03×10^4 Pa

4. Bernoulli's principle is based on the law of conservation of…

a) Mass
b) Energy
c) Momentum

5. Air is streamlining past a $10\ m \times 2m$ long horizontal airplane wing such that its speed is 120 m/s over the upper surface and 90 m/s at the lower surface. If the density of air is 1.3 kg/m^3 then the difference of pressure on the two sides of the wing is…

a) 40.95 Pa
b) 4095 Pa
c) 409.5 Pa

Choose whether True / False:

1) Dynamic pressure depends on the motion of liquids. (True / False)

2) Pascal is the unit of pressure. (True / False)

3) If fluid flows slowly along a pipe, the flow is streamline. (True / False)

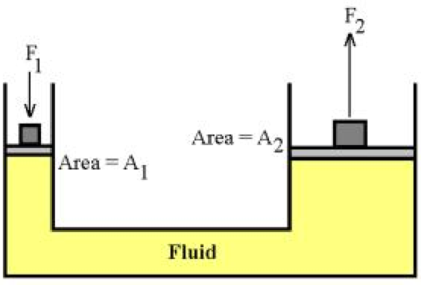
4) If the temperature of the air increases, then its viscosity increases. (True / False)

5) At the constriction of a Venturi tube, the pressure is high. (True / False)

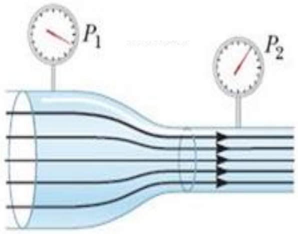
Problem Solving:

1. What volume of water is displaced by a submerged 2.0 kg cylinder made of solid aluminum? (aluminum density = 2.7×10^3 kg/m^3 and water density = 1.0×10^3 kg/m^3)

2. A force of 500 N is applied to the small cylinder hydraulic press, the smaller cylinder has a cross sectional area of 10 cm^2. The large cylinder has a cross sectional area of 180 cm^2. What load can be lifted by the larger piston?



3. Water enters a horizontal pipe of non-uniform cross section with a velocity 4 m/s and leaves the other with a velocity of 12 m/s as shown in the figure below. Pressure at the first end is 1200 kPa. What is the pressure at the other end?

$v_1 = 4\ m/s$  $v_2 = 12\ m/s$

4. Water circulates throughout a house in a hot water heating system. If the water is pumped at a speed of 0.50 m/s through a 4.0 cm diameter pipe in the basement under a pressure of 3.03×10^5 Pa, what will be the velocity and pressure in a 2.6 cm diameter pipe on the second floor 5.0 m above?

Chapter 10: Thermodynamics

Introduction:

The branch of physics that deals with the relationship between heat and other forms of energy is known as thermodynamics.

10.1. Heat, Temperature (T) and Temperature Scales

Temperature (T) is the measurement of relative hotness or coldness of a body and its units are Fahrenheit (°F) or (T_F), Celsius (°C) or (T_C), Kelvin (K) or (T_K), Rankine (°R) or T_R.

The process by which energy is exchanged between objects because of temperature difference is called heat.

Note:

1. SI unit of temperature is Kelvin (K)
2. K = °C + 273.15
3. °F = (°C × 9/5) + 32 = 1.8 °C + 32
4. Temperature is a degree of hotness or coldness.
5. The temperature at -273°C = 0 K is known as the absolute zero of temperature.
6. Absolute zero (0 K) is the temperature at which the internal energy of any system is at the lowest possible value.
7. Another absolute temperature scale based on the Fahrenheit scale is the Rankine scale. Absolute zero on the Rankine scale is -460° F. Thus $T_R = T_F + 460°$.

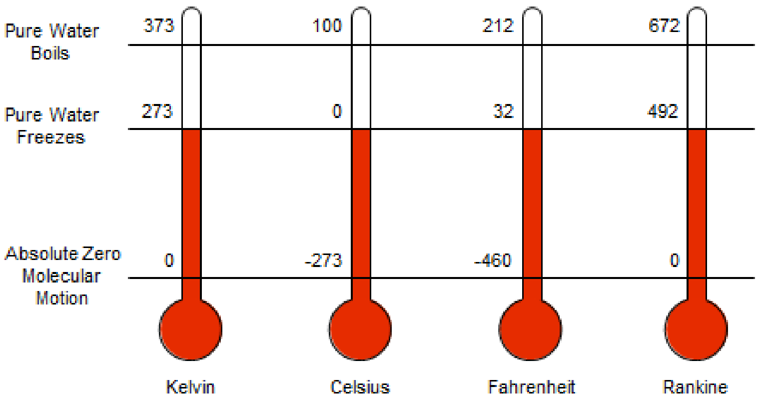


Fig-10.2, Temperature scale comparisons

Fig-10.1, Change in internal energy

8. The internal energy of a system is the sum of kinetic and potential energies of the molecules of the system (U=KE+PE). Example of change in internal energy:

- The tea heats the spoon, so the internal energy of the spoon increases.
- The spoon cools the tea, so the internal energy of the tea decreases.

9. At absolute zero temperature the translational kinetic energy of the molecules becomes zero but the substance still has internal energy due to the vibrational motion of the atoms within the molecules.

Example 1: Find the temperature that is the same on both Fahrenheit and Celsius scales.

Solution: $T_F = T_C$

$1.8\ T_C + 32 = T_C$

$T = -40^0\ C$

Thermometers are devices used to measure the temperature of an object or a system.

Different types of thermometers:

1. **Mercury thermometer** is an example of a common thermometer. Its range is from -30ºC to 330ºC.
2. **Clinical thermometer**: It is mercury thermometer used to measure the temperature of the human body. Its range is normally from 35ºC to 43.3ºC.
3. **Alcohol Thermometer**: Alcohol freezes at -130ºC and boils at 78ºC. Its range is from -130ºC to 78ºC.
4. **Radiation pyrometer:** It is used to measure very high temperatures like the temperature of the sun and furnaces. Its range is normally from 800 ºC to 4000 ºC.

Fig-10.2.1, a) Mercury thermometer; (b) Radiation thermometer; (c) Thermocouple thermometer; (d) Clinical mercury thermometer; (e) Alcohol thermometer

<u>Class Activity-1</u>

<u>Choose the correct answer:</u>

1. The internal energy of a gas depends on …
a) potential energy of its molecules.
b) kinetic energy of its molecules.
c) both potential and kinetic energy of its molecules.

2. The boiling point of water can be measured using:
a) Alcohol Thermometer
b) Clinical Thermometer
c) Mercury Thermometer

3. The temperature scale that has the same increments as the Fahrenheit scale is the:
a) Rankine scale
b) Kelvin Scale
c) Celsius scale

Problem solving:

1. Your normal body temperature is 310.15 K. What is it on Celsius scale?

2. Convert:

a) -45 °F = ______ K

b) 20 °C = ______ °R

10.2. Calorimetry

Heat (Q)

It is a form of energy due to the thermal agitation of atoms or molecules. The flow of heat between two bodies stops when their temperatures equalize.

The S.I. unit of heat is the Joule (J); however other units are sometimes used to describe heat energy, such as the calorie (cal) and the British thermal unit (BTU).

A. Heat Capacity (c)

It describes the amount of heat needed to raise the temperature of a given substance by 1°C or 1K.

Specific heat capacity (c)

The amount of energy required to raise the temperature of a substance of unit mass (1 kg) through 1°C

$$c = \frac{\Delta Q}{m\Delta T}, unit\ of\ c = \frac{J}{kg.K}$$

The specific heat capacity (**c**) depends on the nature of the substance and will be different for different substances. Water has highest specific heat (**c**) of 4200 J/kg.K.

Note-

- **British thermal unit (BTU)**: It is the amount of heat energy required to raise the temperature of 1lb. of water by 1 °F.
  1BTU= 1055 J
  1BTU/lb. = 2326 J/kg
- **Centigrade Heat Unit (CHU)**: It is the amount of heat energy needed to raise the temperature of 1lb of water by 1°C.
  1CHU= 1.8 BTU =1899 J

Specific heat capacities of some materials are shown in the table below:

Material	Specific Heat (J/kg. K)
Lead	127
Mercury	139
Zinc	386
Copper	389
Steel	481
Aluminum	908
Water	4200

B. Latent Heat (L)

Latent heat is the heat energy liberated or absorbed at constant temperature during a phase change of matter. It is mathematically written as,

$$\mathbf{Q = m\,L}$$

Here, **L** is the specific latent heat which unit is J/kg. It represents the amount of heat energy to change the state of 1 kg of substance. There are two types of specific latent heats depending on the type of phase change of the matter.

1) **Specific Latent Heat of Fusion-**The energy required to change one (1) kilogram of a substance from a solid to a liquid state at its melting point is commonly called as the heat of fusion.
2) **Specific Latent Heat of Vaporization-**The energy required to change one kilogram of a liquid into the gaseous state which occurs at temperatures at the boiling point is called the heat of vaporization.

Example 2: The latent heat of fusion (melting) of Ice is 330000J/kg. What is the energy needed to melt 0.65kg of Ice?

Solution: m= 0.65kg, L= 330000

$\Delta Q = mL_f = 0.65 \times 330000 = 214500$ J

Example 3: An immersion heater of 60W is used to heat water. In 5 minutes, the readings fall from 282g to 274 g of water. What is the latent heat of vaporization of water?

Solution: Power = 60W, Time=5 minutes=300s

$\Delta Q = Power \times time = 60 \times 300 = 18000J$

Mass of water evaporated= 282-274= 8g = $8\times10^{-3} kg$

$\Delta Q = mL_f$

$L_f = \frac{\Delta Q}{m} = \frac{18000}{8\times10^{-3}} = 2.3 \times 10^6 J/kg$

Example 4: 0.5 kg of water is heated from 10 °C to 100 °C. How much did its internal energy rise?

Solution: The specific heat (c) of water = 4200J/kg. K, m= 0.5kg, $\Delta T = 100℃ - 10℃ = 90℃$
$\Delta ℃ = \Delta K = 90℃$
$\Delta Q = mc\Delta T = 0.5 \times 4200 \times 90 = 189000J$

Thermal equilibrium
When a hot body and a cold body are in contact, heat will flow from the hot body to the cold body until both of them reach thermal equilibrium (they are at the same temperature).

Sensible Heat
The amount of heat when added or removed from a substance that causes a change in temperature without changing the state.

Changes of state: Phase change from Ice to Steam
Transitions between solid, liquid, and gaseous phases typically involve large amounts of energy compared to the specific heat. If heat is added at a constant rate to a mass of ice then its phase changes to liquid (water) and then to gas (steam). The energy required to accomplish the phase changes (called the latent heat of fusion and latent heat of vaporization) is represented in the temperature and heat graph fig-10.3. Freezing point of water or melting point of ice is 0°C and boiling point of water is 100°C.

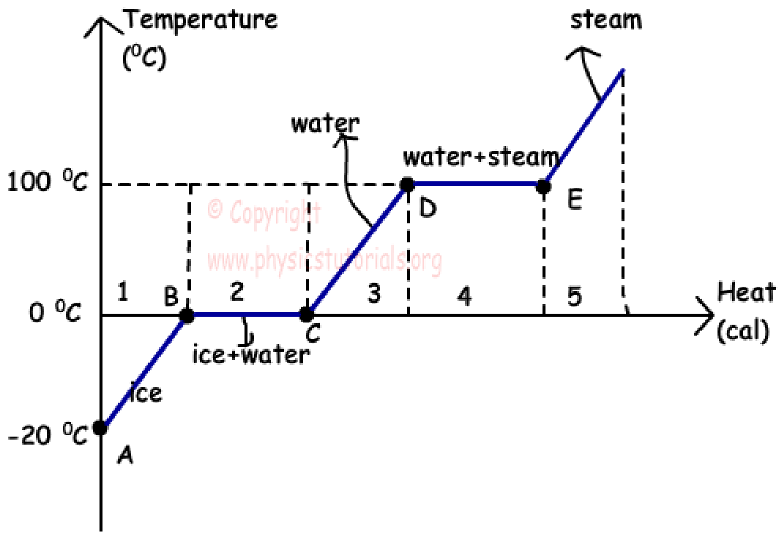


Fig-10.3, Phase change diagram of water

Example 5: Calculate the amount of heat required to convert 1.00 kg of Ice at – 20°C completely to steam (water vapour) at 100°C at normal pressure?

[Specific heat of Ice (c_{ice}) =2100J/kg.K; Specific latent heat of fusion of ice (L_f) =$3.36 \times 10^5 J/kg$; specific heat capacity of water (c_{water}) = 4200 J/kg.K; and Specific latent heat of vaporization (L_v) of water =$2.25 \times 10^6 J/kg$]

Solution:

a) Here, heat required to raise the temperature of ice from – 20°C to 0°C.
$\Delta Q_1 = mc_{ice}\Delta T = 1 \times 2100 \times (0 - (-20)) = 42000\ J$

b) Heat required to melt ice to water 0°C
$\Delta Q_2 = mL_f = 1 \times 3.36 \times 10^5 = 336000J$

c) Heat required to raise the temperature of water from 0°C to 100°C.
$\Delta Q_3 = m \times c_{water} \times \Delta T = 1 \times 4200 \times (100 - 0) = 420000J$

d) Heat required to change water to water vapor at 100°C.

$\Delta Q_4 = mL_v = 1(2.25 \times 10^6) = 2250000J$

e) Total heat required= $\Delta Q_1 + \Delta Q_2 + \Delta Q_3 + \Delta Q_4 = 3027000\ J\ (or\ 3.027 \times 10^6\ J)$

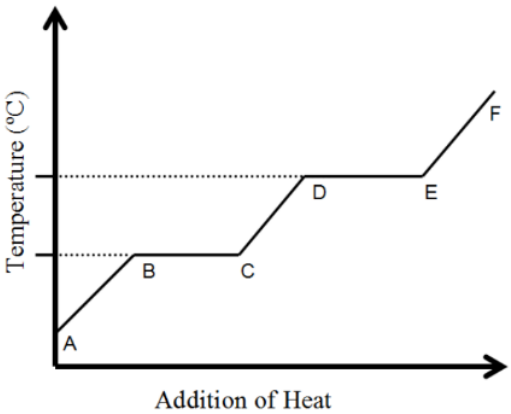
Class Activity-2

Choose the correct answer:

1. Specific heat of a substance depends on…
a) Mass
b) Temperature
c) Nature

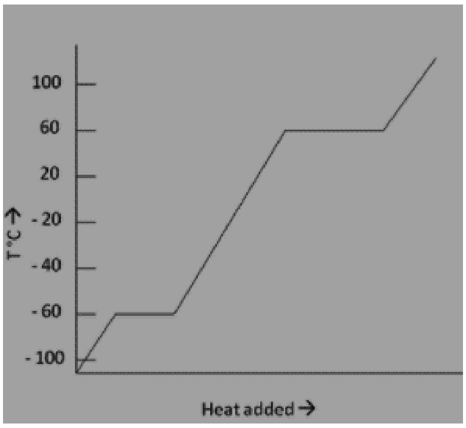
2. The temperature of land rises faster than that of the sea because…
a) The specific heat of soil is greater than water
b) The specific heat of soil is less than water
c) The specific heat of soil is equal to that of water

3. Which part of the graph represents only liquid state?



a) A-B
b) C-D
c) D-E

4. The heating curve of a substance is shown in the graph below. What is its boiling point?



a) -60°C
b) 60°C
c) 100°C

Problem Solving

1. A copper block of mass 70 g is heated till its temperature is increased from 30º to 60ºC. Find the heat supplied to the block. (Specific heat capacity of copper= 389 J/kg. K)

2. If 1 kg of wood absorbs 200kJ of heat energy and its temperature increases from 25ºC to 150ºC. What will be the specific heat capacity of wood?

3. A heat of 7.51×10^{10} J was required to change the phase of solid chocolate to liquid. If the latent heat of fusion of chocolate is 45 Jg^{-1}. Calculate the mass of chocolate used.

10.3. Types of Heat transfer

There are three methods by which heat is transferred from one place to another or from one substance to another, which are: Conduction, Convection and Radiation

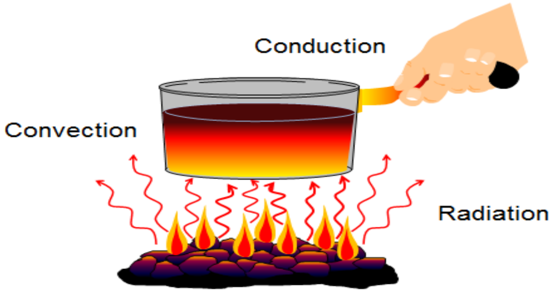


Fig-10.4 Types of heat transfer

1. **Conduction** is a process in which heat is transmitted from the hotter part of a body to the colder part without moving the particles in it.
eg: Heat transfer through solids

2. **Convection** is a process in which heat is transmitted from the hotter part to the colder part with movement of the particles of a fluid.
eg: Heat transfer through liquids and gases.

3. **Radiation** is a process in which heat is transmitted one place to the other without any medium. It is transferred by electromagnetic waves.
eg: Heat transfer from sun to earth .

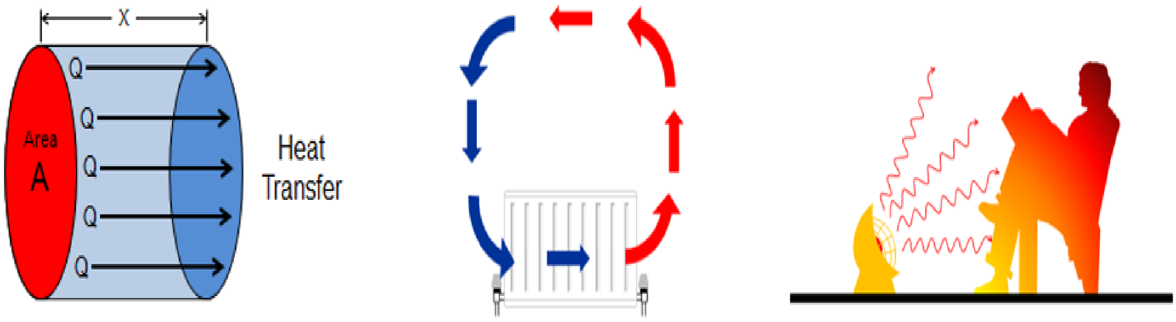
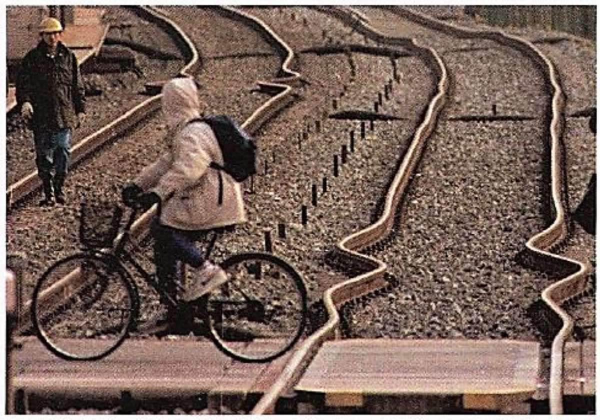


Fig-10.5, All three heat transfer methods modes, conduction, convection, and radiation.

10.4. Thermal Expansion



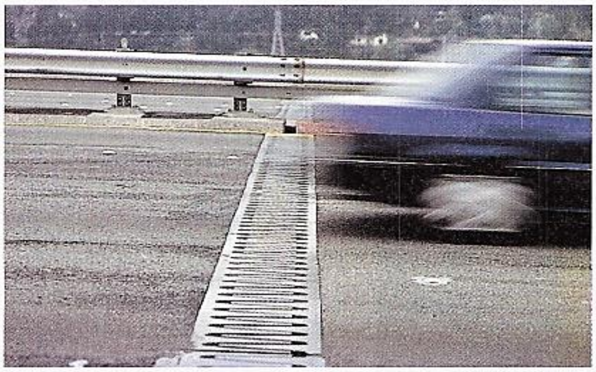
Most materials expand when heated. Rising temperatures make the liquid expand like in a liquid-type thermometer. Bridges made of iron and cement also expand during summer.

When substances expand or contract, their particles stay the same size. It is the space between the particles that changes:

The particles in a solid vibrate more when it is heated and take up more room.

The particles in a liquid move around each other more when it is heated, and therefore take up more space.

The particles in a gas move more quickly in all directions when it is heated and take up more space.



This gap in the roadway of a bridge is called an expansion joint; it allows the bridge to expand and contract. (Was this photo taken on a warm or a cold day?)

Fig-10.6.2, Thermal Expansion

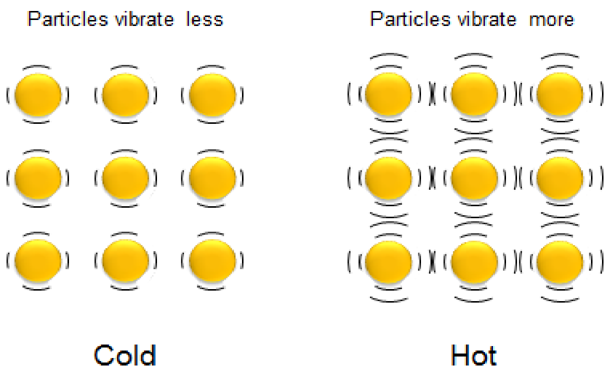


Fig-10.6.3 Particle vibration in hot and cold bodies

Note: Sign conventions

- Heat gained by a system- Positive
- Heat lost by a system- Negative

Expansion of Fluids: Fluids expand more than solids.
Expansion of Gas**:** For gases, volume and temperature changes are usually accompanied by pressure changes.

10.5. Laws of thermodynamics

A. First Law of Thermodynamics

Heat is a form of energy. Work is the conversion of one form of energy into another form. Thermodynamics is the study of the way that one does work with heat.
A very simple device that can convert heat into potential energy is a rubber band. Unlike most other substances, rubber contracts when heated. We can therefore lift an object by heating a rubber band. Heat is converted into gravitational potential energy.

If heat is supplied to a system which is capable of doing work, then the quantity of heat absorbed **Q** by the system will be equal to the sum of the external work done **W** by the system and the increase in its internal energy **ΔU**. The first law of thermodynamics is based on the law of conservation of energy.

$$Q = (U_2 - U_1) + W = \Delta U + W$$

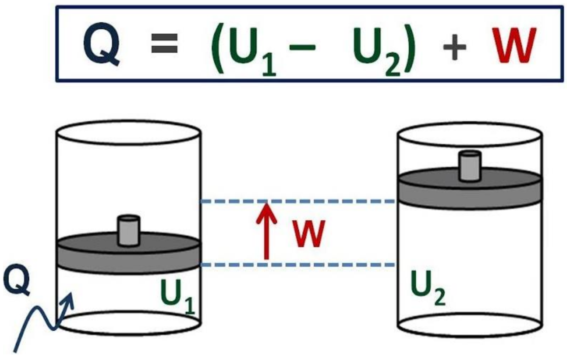


Fig-10.7. First Law of Thermodynamics

Note: Sign convention

- Work done by a system- Positive (work done by a gas that is expanding)
- Work done on a system- Negative (work done on a gas that is being compressed)

B. Second Law of Thermodynamics

Heat can only transfer from a high temperature region to a lower temperature region. It cannot naturally transfer the other way. The second law of thermodynamics is a profound principle of nature which affects the way energy can be used. Heat will not flow spontaneously from a cold object to a hot object.

10.6. Ideal Gas Laws

An ideal gas is a theoretical gas composed of many randomly moving point particles that are not subject to inter-particle interactions. For an ideal gas, the volume (V) is directly proportional the number of moles (n) and inversely proportional to absolute pressure (P). Also, pressure is directly proportional to absolute temperature (T). Mathematically, it is written as,

$$\boldsymbol{PV = nRT}$$

Where: P = pressure
V= volume
n = number of moles
T = temperature
R = 8.314 J/mol. K (ideal gas constant)

Boyle's Law (Isothermal process)

At constant temperature, the pressure of a given mass of a gas is inversely proportional to its volume

When Temperature is constant, $P \propto \frac{1}{V}$ or PV = constant or $P_1V_1 = P_2V_2$

Charles' Law (Isobaric Process)

At constant pressure, the volume of a given mass of a gas is directly proportional to the absolute scale of temperature.

When pressure is constant, $V \propto T$ or $\frac{V}{T}$ = constant or $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

Gay – Lussac's law (Isochoric Process)

Gay – Lussac's law states that if the volume of gas remains constant, then the absolute temperature of a gas is directly proportional to its absolute pressure.

When volume is constant, $P \propto T$ or P/T is constant or $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

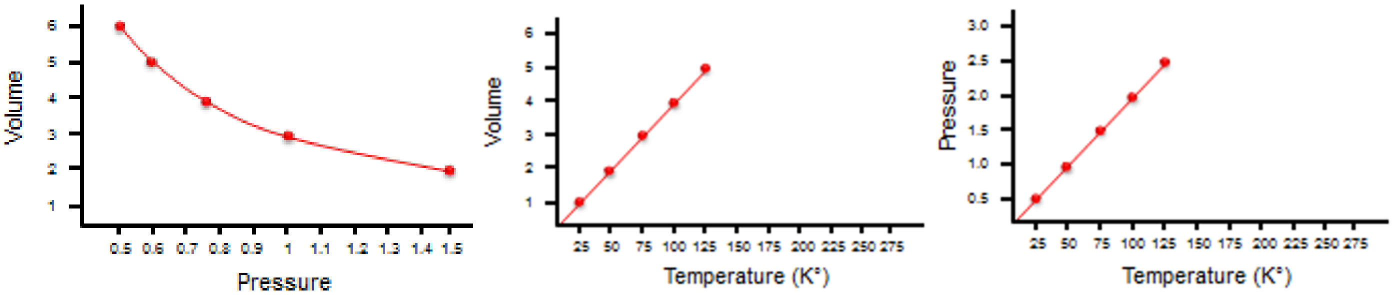


Fig-10.8, Gas Laws

General Gas Law

Combining the three gas laws, the following general gas law can be written:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Adiabatic process – In any system where no heat is added or taken away from it, this is known as adiabatic process.

In this process we use first law of thermodynamics (dQ = dU + dW) in which Q = 0, heat = zero, shows that all the change in internal energy is in the form of work done only.

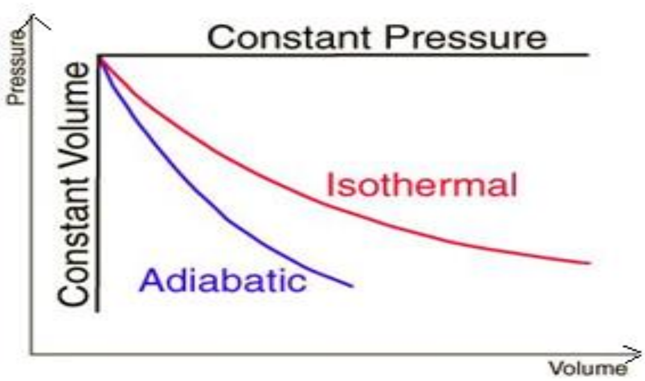
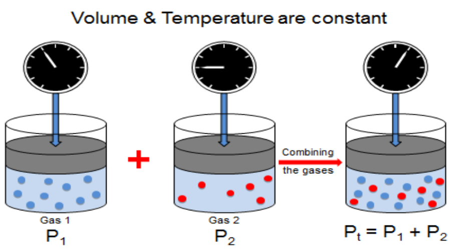


Fig 10.9, P-V diagram

Dalton's Law:

It states that in a mixture of non-reacting gases, the total pressure exerted is equal to the sum of the partial pressures of the individual gases.

$P_{total} = P_1 + P_2$



Heat Engine:

Heat engine is a system that performs the conversion of heat or thermal energy to mechanical work.

When energy is transformed from a hot reservoir to a cold reservoir, some of the energy is converted into work as shown in the Fig.

$Q_H = Q_C + W$

Q_H (work input) is the energy drawn from the hot reservoir

Q_C is the energy transferred to the cold reservoir

W (output) is the external work (work done by the system)

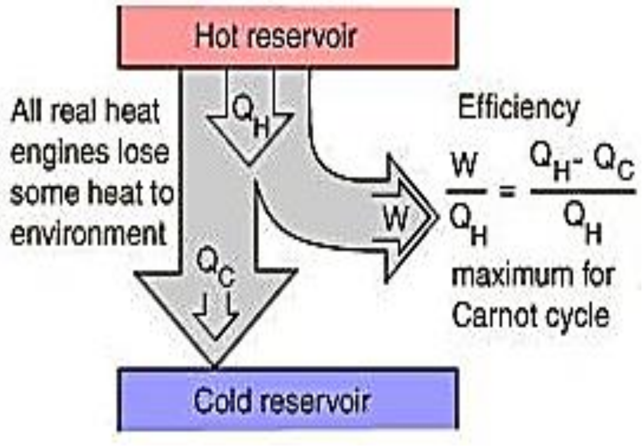
$$Heat\ Engine\ Efficiency\ (\eta) = \frac{work\ output}{work\ input}$$

$$= \frac{W}{Q_H}$$

$$\frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H} \times 100 = \frac{T_H - T_C}{T_H} \times 100\%$$

(expressed as a percentage)

Gasoline and diesel engines, jet engines, and steam turbines that generate electricity are all examples of heat engines



Heat Pumps and Refrigerators

Heat Pump

A heat pump is a device that transfers heat from a low temperature reservoir to high temperature reservoir with the help of external work. Heat pumps, refrigerators and air conditioners are reversed process of heat engines.

Heat pumps are usually used to pull heat out of the air to heat a building, or they can be switched into reverse to cool a building. Heat pumps and air conditioners operate in very similar ways.

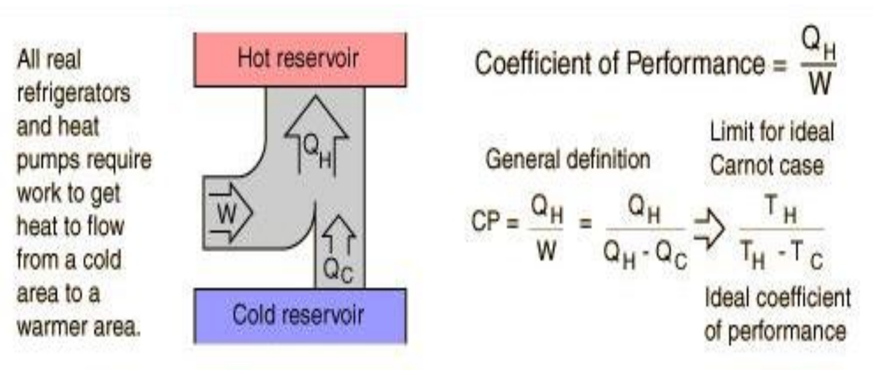
Refrigerator

A refrigerator is a special device meant for transfer of heat from low temperature medium to a high temperature medium with the help of work. Liquid evaporates inside the refrigerator to create cold temperature.

The main purpose of the machine is to remove the heat from the cooled space.

Refrigerators are useful to preserve food items and chemicals at low temperature.The most common refrigerants are water, ammonia and Freon

When energy is transformed from cold reservoir to hot reservoir, some of the energy is taken in the form of work as shown in the Fig.



$Q_H = Q_C + W$

Q_H (work output) is the energy given to hot reservoir
Q_C is the energy drawn from the cold reservoir
W (input) is the workdone in transferring energy from cold reservoir to hot reservoir (work on the system)

$$Cold\ Engine\ Efficiency\ (\eta) = \frac{work\ output}{work\ input} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_C}$$

Class Activity-3

Choose the correct answer:

1. When heat is transferred from hot body to cold body, in a straight line, without affecting the intervening medium, it is referred to as…
a) Conduction
b) Convection
c) Radiation

2. Heat flowing from one object to another depends directly on…
a) Volume of objects
b) Specific heat of the objects
c) Temperature difference

3. First law of thermodynamics establishes relationship between
   a) Heat and work done
   b) Heat, work done and internal energy
   c) Heat and internal energy

4. A perfect gas at 27ºC is heated at constant pressure till its volume is doubled. The final temperature of the gas is…
   a) 54 ºC
   b) 327 ºC
   c) 108 ºC

5. A heat engine converts heat energy from fuel combustion or any other source into which type of work?
   a) Electrical work
   b) Mechanical work
   c) Pressure work

Problem Solving:

1. The pressure of the given mass of a gas at constant volume is 100 kPa at 127ºC. Calculate the pressure at 227ºC.

2. The internal energy of a gas changes from 10 cal to 8 cal when 12 cal heat is released by it. Calculate the work done.

3. If 100 g of water is heated from 50ºC to 100ºC then calculate the change in internal energy, assuming there is no work done on the system. (Specific heat of water = 4200 $Jkg^{-1}K^{-1}$).

4. If 3×10^6 J heat energy is required to convert ice at -20ºC completely into steam at 100ºC at normal atmospheric pressure then calculate the mass of ice.

5. A 20 cm^3 bulb contains 0.02 moles of ideal gas at a temperature of 27ºC.Calculate the pressure inside the bulb (Universal gas constant=8.314$JK^{-1}mol^{-1}$).

6. Calculate the efficiency of a heat engine working between 27ºC and 127ºC.

Worksheet-10

Multiple Choice Questions:

1) Which of the following liquids has the highest specific heat?
   a) Water
   b) Alcohol
   c) Petrol

2) Boyle’s Law holds true at constant:
   a) Volume
   b) Temperature
   c) Pressure

3) In a refrigerator heat is transferred from:
   a) Cold region to hot region
   b) Hot region to cold region
   c) Both the above cases

4) Heat transfer in Mercury takes place by the process of:
   a) Conduction
   b) Radiation
   c) Convection

5) If work is done on a gas, the volume of the gas is…
   a) Compressed
   b) Expanded
   c) Unchanged

Problem Solving

1. If the reading of a mercury thermometer in Celsius scale rises from 20ºC to 60ºC then in Fahrenheit scale to what value does the reading rise from 40ºF?

2. A change of 1ºF temperature is equal to how much change in Celsius scale?

3. Calculate the numerical value of temperature at which Celsius reading is twice that of Fahrenheit reading.

4. 500 cal heat is added to a gas and 200 cal work is also done on it. Calculate the change in internal energy.

5. Calculate the heat energy required to convert 1 kg ice at $-20^{0}C$ to water at $100^{0}C$.

6. A heat engine draws 1000 cal from the source. If its efficiency is 80% then calculate the heat rejected to the sink.

Chapter 11: Wave Motion and Sound

11.1. Wave

Periodic Motion: The motion of an object which repeats itself at regular intervals of time is known as periodic motion.

E.g: Motion of a planet around the sun, motion of moon around the earth,

Oscillatory Motion: The to and fro motion of an object relative to a fixed point is known as oscillatory motion.

E.g: Motion of child on a swing, Motion of the needle of a sewing machine, pendulum of a wall clock.

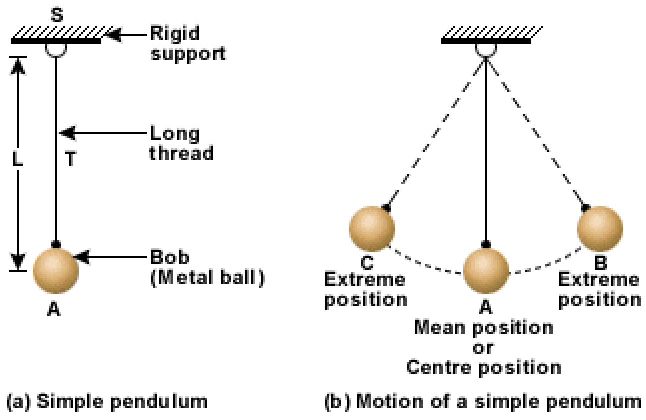


Fig-11.1- Simple pendulum in the wall clock

Simple Pendulum:

A simple pendulum (S.P) is defined as "a point mass (a bob) suspended by a torsion-less thread", when displaced, a pendulum will oscillate through its equilibrium point due to momentum in balance with the restoring force of gravity. It executes periodic- oscillatory motion.

The time period (T) can be measured from mean/equilibrium position, through to the next time that position is reached, with the motion in the original direction and 'L' is length of the simple pendulum.

Cycle: It corresponds to one complete back and forth movement (one full oscillation)

Time Period (T): Time taken to complete 1 cycle (oscillation). $T = 2\pi\sqrt{\frac{L}{g}}$

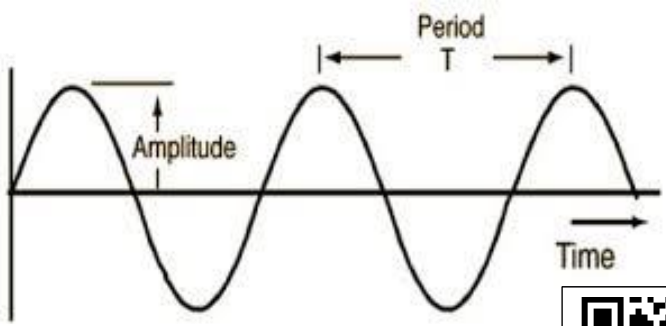
Frequency (f): The number of cycles occurring in 1 second. (Hertz – Hz) f=1/T

Amplitude (A): Maximum displacement of a body from its mean or rest position.

By finding the time period (T) using a stop watch and measuring the length (L) of the simple pendulum, we can calculate acceleration due to gravity at any given place, using the following equation. $g = \frac{4\pi^2 L}{T^2}$

A. Anatomy of Waves:

A wave can described as a disturbance or variation that travels through the medium transferring the energy from one point to another point without transporting matter.



A wave is characterized by:

1. Frequency: The frequency (f) is the number of waves (Oscillation) per second. It is measured in hertz (Hz). $\left(f = \frac{1}{T}\right)$

2. Period: The time for one oscillation is called the period (T). It is measured in seconds.

Period (T) = 1/ Frequency (f)

3. Wavelength: Wavelength (λ) is the distance between successive **crests or troughs** of a wave (S.I unit is m).

4. Amplitude: Amplitude is the maximum distance about its mean position on Y-axis.

5. Velocity: One of the properties of a wave is that the velocity of a wave is related to its frequency and wavelength by the following equation.

Velocity of a wave (v) =Frequency (f) × wavelength (λ)

B. Types of Waves

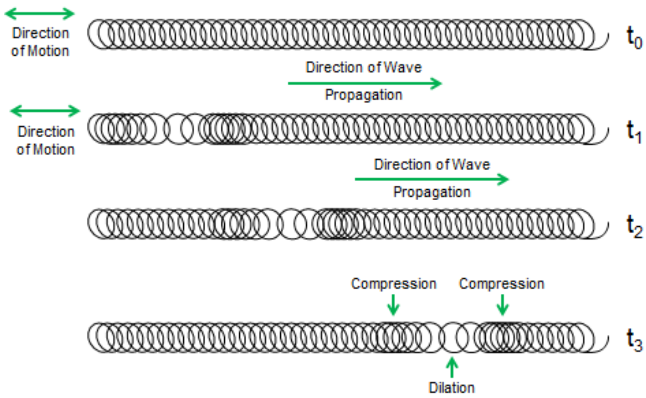
Categorizing waves based on their **ability or inability to transmit energy through a vacuum** (i.e., empty space) leads to two notable categories:

Electromagnetic waves: are produced by the vibration of charged particles and are capable of transmitting energy through a vacuum (i.e., empty space). Light and Radio waves are examples of electromagnetic waves.

Mechanical waves: are waves that are not capable of transmitting their energy through a vacuum. Mechanical waves require a medium to transport their energy from one location to another. A sound wave is an example of a mechanical wave.

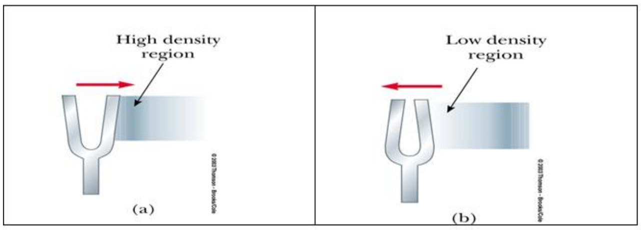
In terms of direction of propagation, we can classify the waves in to two categories:

Longitudinal waves: The particles of the medium vibrate ***parallel*** to the direction of wave motion is called longitudinal wave.
Example: Sound waves are longitudinal in nature.

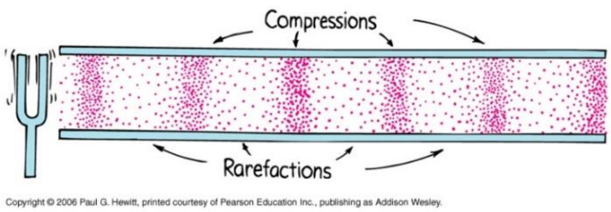


Compression: A region of high molecular density and high air pressure is called compression.

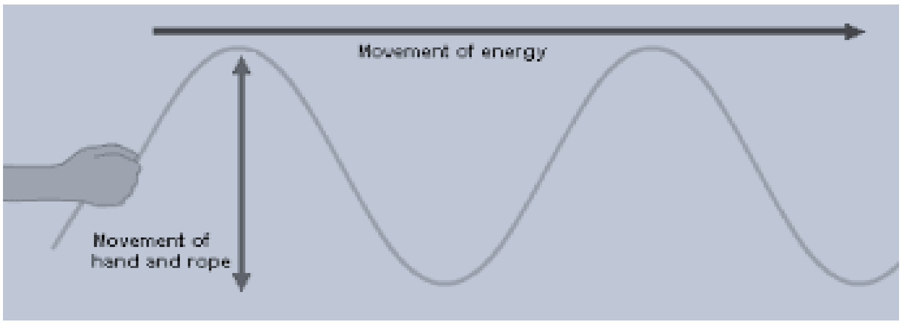
Rarefaction: A region of lower-than-normal density is called rarefaction.



Example: The tuning fork shown in the figure below is a device which produces pure musical notes. A tuning fork consists of two metal prongs or tines which vibrate when struck.
As the tines vibrate, they disturb the air near them forcing the molecules closer together. This produces both a region of high molecular density and high air pressure called **compression**, and a region of lower-than-normal density called **rarefaction**.

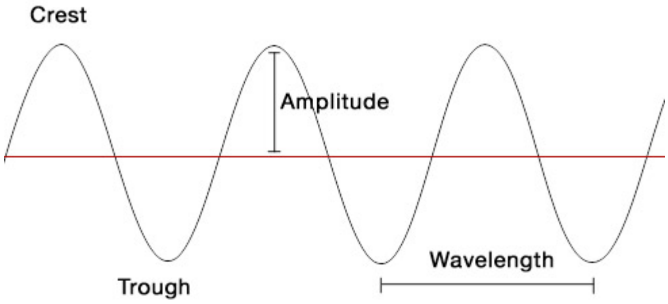


Transverse wave: The particles of the medium vibrate in a direction ***perpendicular*** to the direction of wave motion is called a transverse wave.
The example below shows a transverse wave in a rope as a **transverse mechanical wave.**



Light is also an example of transverse wave.

Parts of transverse wave:



Crest – is the highest point of the wave

Trough – is the lowest point of the wave.

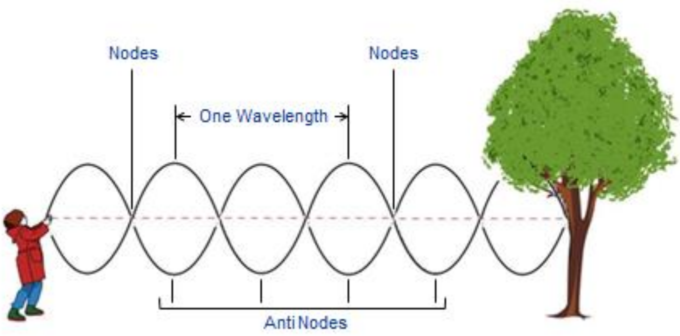
Amplitude – is the displacement from the equilibrium position to crest or trough.

Wavelength – is the distance of one complete cycle.

11.2 Stationary wave

A stationary wave, also called a standing wave, is a combination of two waves moving in opposite directions, with the same amplitude and frequency. When a progressive wave hits a barrier, reflects back and creates constructive interference with the incoming wave, it produces standing wave. A stationary wave is characterized by **nodes** and **anti-nodes**.

When two progressive waves of the same amplitude and frequency travel in opposite directions this forms stationary wave.



Note:

(i) **Antinode**: An antinode is a point along a standing wave where the wave has maximum amplitude.

(ii) **Node**: A node is a point along a standing wave where the wave has minimum amplitude.

(iii) The **distance** between **two adjacent nodes** or two **adjacent antinodes** is always equal to $\lambda/2$.

Example 1:

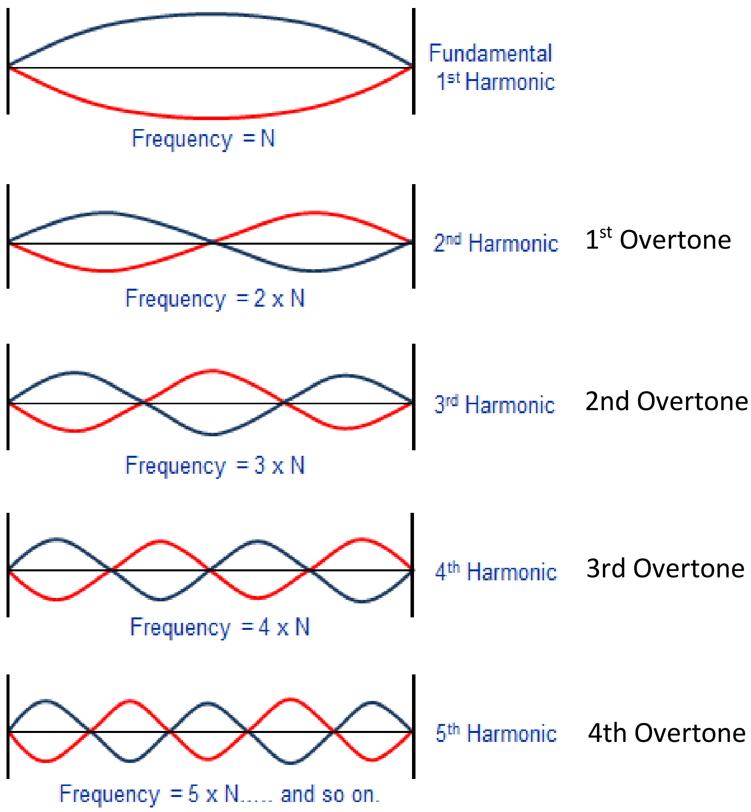
The velocity of waves on a string is 92 m/s. If the frequency of standing waves is 475 Hz, find the distance between two adjacent nodes.

Solution: The distance between two adjacent nodes is the half of wavelength.

Therefore: λ = v/f = 92/475 = 0.2 m

d = λ/2 = 0.1 m

11.3 Fundamental frequency and harmonics



The lowest resonant frequency of a vibrating object is called its fundamental frequency. Most vibrating objects have more than one resonant frequency and those used in musical instruments typically vibrate at harmonics of the fundamental. A harmonic is defined as an integer (whole number) multiple of the fundamental frequency.

The frequency of Nth harmonic = N × the fundamental frequency.

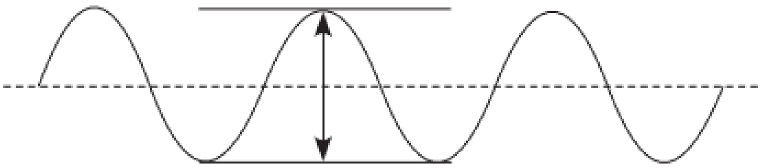
Class Activity-1

Choose the correct answer:

1. Sound wave in air is an example of

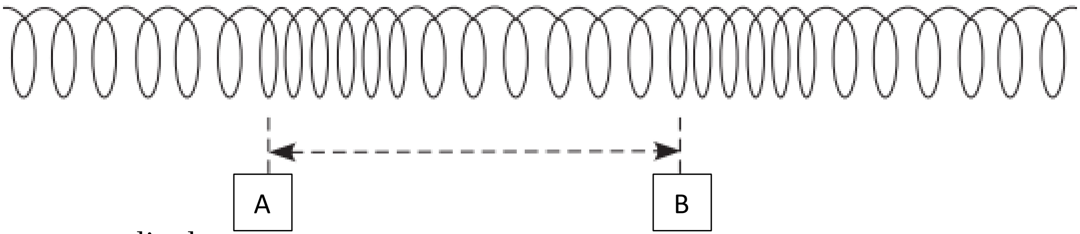
a) Transverse wave
b) Longitudinal wave
c) Disturbance that can travels in air and vacuum.

2. The diagram below shows a wave. The arrow is showing the distance from the top of the wave to the bottom of the wave. This arrow represents…



a) the amplitude
b) twice the amplitude
c) twice the wavelength

2. The diagram below shows a longitudinal wave. The horizontal distance AB shows…

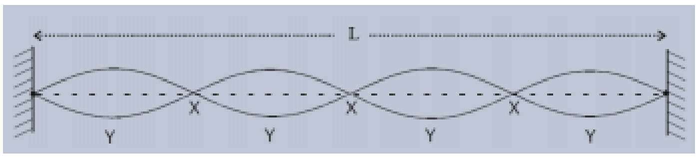


a) one amplitude
b) twice one wavelength
c) one wavelength

3. If the natural frequency of a string is 250 Hz, the wavelength of the sound wave produced (speed of sound = 340 m s^{-1}) will be ________

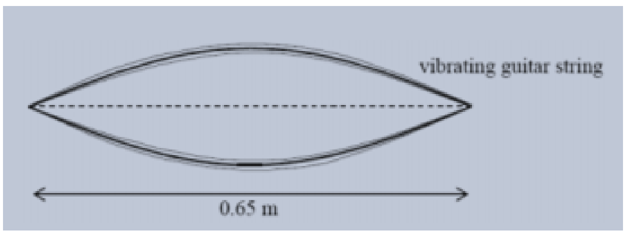
a) 2.48 m
b) 1.36 m
c) 3.40 m

4. How many wavelengths are contained in the distance marked **L** for the standing waves shown below?



a) 4
b) 2
c) 1

5. The diagram shows a guitar string stretched between supports 0.65 m apart. The string is vibrating at its first harmonic. The speed of sound in the string is 500 m s^{-1}. What is the frequency of vibration of the string?



a) 385 Hz
b) 340 Hz
c) 650 Hz

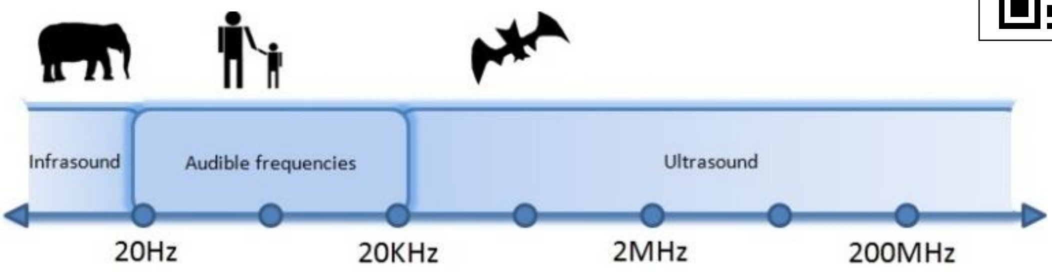
11.4 Sound Waves

Sound is a form energy created by vibrating body and causes sensation in the ear. It is a longitudinal mechanical wave.

As sound propagates in the **air** it produces compressions and rarefactions.

A. Categories of Sound Waves

Based on frequency, sound waves can be classified in 3 categories:



Infrasonic waves: Less than 20 Hz.

Examples: *Waves produced after a volcano explodes, some animals use infrasound to communicate like elephants and whales or to navigate like homing pigeons.*

Audible waves: Sound waves ranging in frequency from 20 Hz to 20 000 Hz, which can be heard by humans.

Example: Waves produced by the human voice.

Ultrasonic waves: Sound waves with frequency greater than 20000 Hz.

Uses of ultrasonic waves:

In Medicine:

Ultrasound is now widely used as diagnostic therapeutic and surgical tool in medicine.

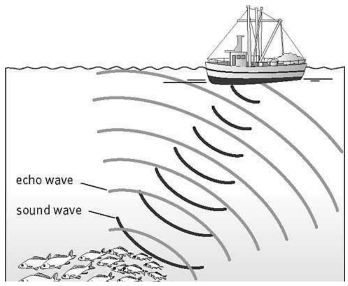
Ultrasound is preferred over x-rays due to safety.

In Industry:

To find cracks in metal structures.

In Technology:

Ultrasound is used in echo-depth sounding devices for determining depth of sea. (SONAR)



In General:

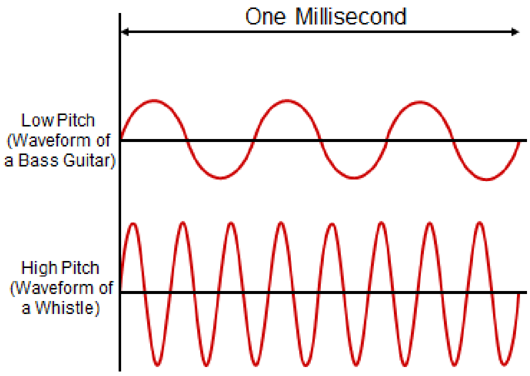
In guiding devices for blind persons.

B. Properties of Sound waves

i) **Pitch:** It is sensation on ear (Physical feeling) of a frequency. A high pitch has high frequency and a low pitch has low frequency of sound wave.

ii) **Loudness**: it depends on the amplitude of the sound wave.

iii) **Quality or Timbre:** The property of sound by virtue of which we can distinguish between two sounds of the same pitch and the loudness originating from two different musical instruments.



iv) **Speed of sound:** The speed of a sound wave depends on the properties of the medium through which it moves and the only way to change the speed is to change the properties of the medium.

The speed of sound is primarily affected by temperature, **the lower the temperature, the lower the speed of sound.**

The **speed of sound in air** also depends on the temperature of the medium as follow:

$v = (331 m/s)\sqrt{\frac{T(K)}{273K}}$; Where: 331 m/s is the speed of air at 0°C

Speed of Sound in Different Media at 20 degrees Celsius

Medium	Speed m/s)
Air	343
Helium	1,005
Water	1,482
Sea Water	1,522
Wood (oak)	3,850
Glass	4,540
Steel	5,200

The speed of sound is faster in liquids than in gases because molecules are more tightly packed. Sound travels fastest through solids. This is because molecules in a solid medium are much closer together than those in a liquid or gas, allowing sound waves to travel more quickly through it.

Mach number:

Speed of sound is of utmost importance in the study of aerodynamics, because it determines the nature and formation of shock waves. Because of this, aircraft speed is often compressed in relation to the speed to sound.

$$\frac{\text{True Airspeed of aircraft}}{\text{speed of sound (allowing for temperature)}} = \text{Mach N}^{o}$$

Example 2: If an aircraft travels with a speed of 780 ft/sec in air at 20°C along while it undergoes the compressibility effect, its Mach number will be calculated as follows:

The speed of body, v = 780 ft/sec = 237.7 m/s, speed of sound at 20 °C, a = 343 m/s

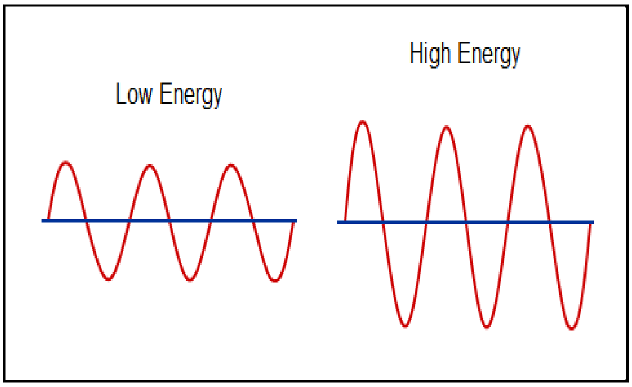
The Mach number is given by,
M = v/a = M = 237.7 /343

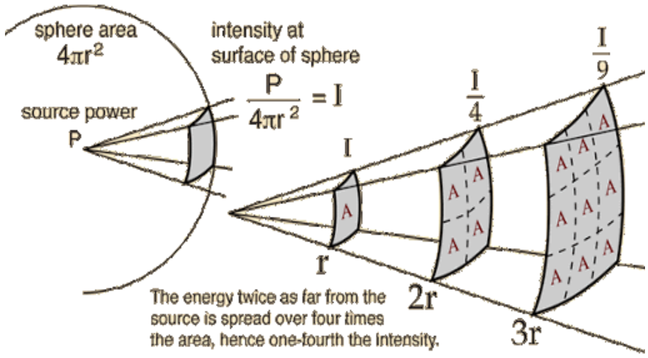
Hence, M = 0.69

Aircraft travelling at speeds less than Mach 1 are travelling at a subsonic speed and aircraft travelling above Mach 1 are travelling at supersonic speed.

C. Sound Intensity

The amount of energy which is transported past a given area of the medium per unit of time is known as the intensity of the sound wave. The greater the amplitude of the vibrations of the particles of the medium, the greater the rate at which energy is transported through it, and the more intense that the sound wave is.





Wave Intensity dependence on the amplitude of the wave and area of a medium

Intensity is the energy/time ×area; and since the energy/time ratio is equivalent to the quantity power, intensity is simply the power/area.

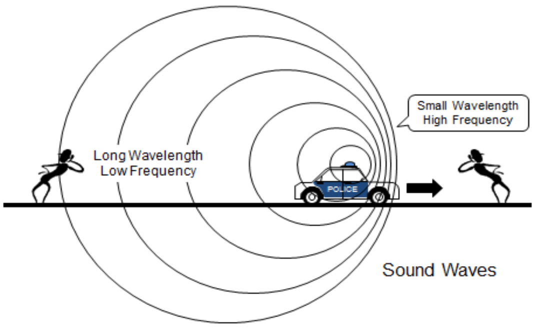
$$\textbf{Intensity} = \frac{\text{Energy}}{\text{Time x Area}} \quad \textbf{or} \quad \textbf{Intensity} = \frac{\text{Power}}{\text{Area}}$$

Typical units for expressing the intensity of a sound wave are Watts/meter^2 or decibel (dB).

The scale for measuring intensity is the decibel scale. Since the range of intensities which the human ear can detect is so large, the scale which is frequently used by physicists to measure intensity is a scale based on multiples of 10. This type of scale is sometimes referred to as a logarithmic scale.

Doppler's Effect

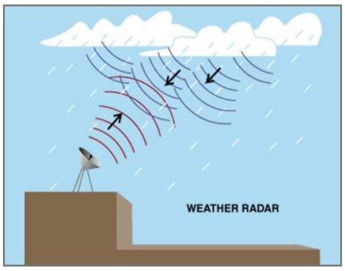
The Doppler Effect is the change in frequency of a wave for an observer (the man) moving relative to its source (the car). Or it is "The apparent change in the frequency of sound due to relative motion between the source and observer".

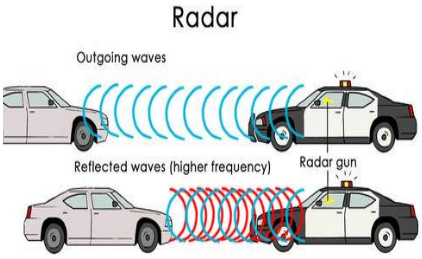


Doppler Effect for a moving sound source

Real Life Applications of Doppler Effect:

A Doppler radar is a specialized radar that uses the Doppler effect to produce velocity data about objects at a distance. It does this by bouncing a microwave signal off a desired target and analyzing how the object's motion has altered the frequency of the returned signal. This variation gives direct and highly accurate measurements of the radial component of a target's velocity relative to the radar. Doppler radars are used in aviation, sounding satellites, meteorology, radar guns, radiology and healthcare (fall detection and risk assessment, nursing or clinic purpose), and biostatic radar (surface-to-air missiles).





<u>Class Activity-2</u>

<u>Choose the correct answer</u>:

1. What is the speed of sound in air if the temperature is 309 K?

(Take: Speed of sound in vacuum = 330 m/s)

a) 330 m/s

b) 273 m/s

c) 352 m/s

2. The pitch of a note emitted by the siren of a fast moving ambulance appears to change as it passes a stationary observer. This is explained by

a) Doppler Effect

b) Resonance of sound

c) Archimedes' Principle

3. At a temperature of 0°C, an aircraft has a Mach 2 air speed. Its speed in m/s is equal to:

a) 2000 m/s

b) 200 m/s

c) 660 m/s

<u>Problem Solving</u>

1. A sound wave has a frequency of 700 Hz in air and a wavelength of 0.50 m. What is the temperature of the air?

2. The range of human hearing extends from approximately 20 Hz to 20 000 Hz. Find the wavelengths of these extremes at a temperature of 27°C.

3. The wavelength of a stationary wave is equal to 16 cm. what is the distance between two adjacent nodes?

4. Calculate the intensity of a wave if the power transferred is 10 W and the area through which the wave is transferred is 5 m^2.

Worksheet-11
Multiple Choice Questions:

1. In a stationary wave the amplitude at the node is:

a) Zero
b) Maximum
c) Infinity

2. If the wavelength of a stationary wave is λ then the distance between a node and adjacent anti-node will be:

a) λ/2
b) λ/4
c) λ/6

3. The SI unit of intensity of sound is:

a) Wm^{-1}
b) Wm^{-2}
c) Wm^{2}

4. A sound wave which frequency is 2000 kHz is in the range of:

a) Infrasonic waves
b) Ultrasonic waves
c) Audible waves

5. Whales communicate with the help of which waves?

a) Ultrasonic
b) Infrasonic
c) Radio

6. Light is an example of:

a) Transverse mechanical wave
b) Longitudinal mechanical wave
c) Transverse electromagnetic wave

7. The loudness of a sound wave depends on:

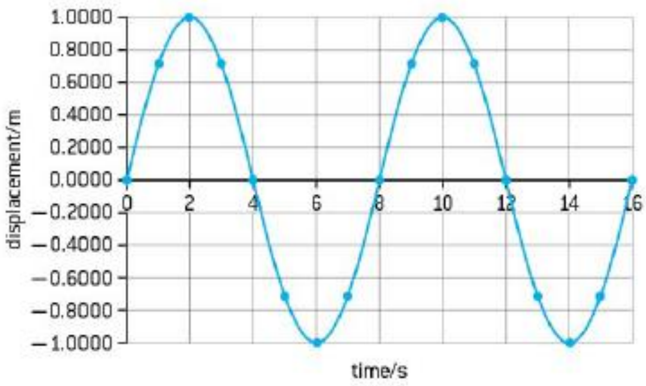
a) The amplitude of the wave
b) The frequency of the wave
c) The time period of the wave

8. Pitch of sound is characterized by:

a) Time period
b) Frequency
c) Wave length

Problem Solving

1) Determine **the period, amplitude, and frequency of the following wave:**



Solution

2) In a longitudinal wave if the first compression and third rarefaction are separated by 40 cm, then calculate the wavelength of the wave.

Solution:

3) In a transverse wave if the first and sixth crests are 4 ms apart then calculate the frequency of the wave.

Solution:

4) A Stationary wave of 10 loops is set up in a rope 10 m long. Calculate the wavelength of the wave.

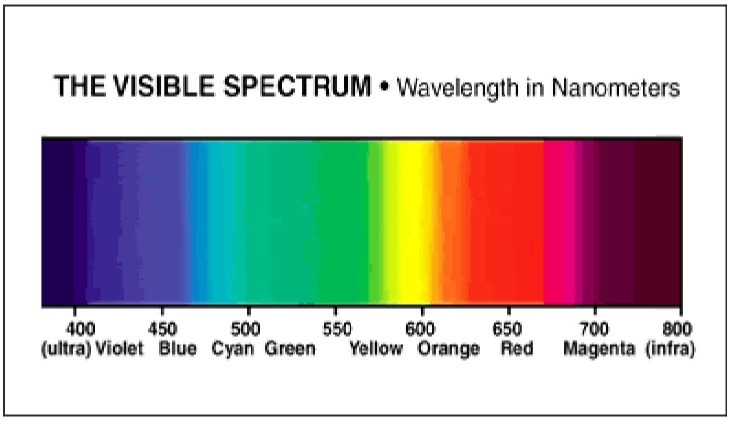
Solution:

Chapter 12: Optics

12.1. Introduction to Light

Light is a form of energy which causes the sensation of vision through the optic nerve.

It travels in the form of electro-magnetic wave of wavelength 400 nm (violet) to 700 nm (red) and travels with a speed of 3×10^8 m/s in free space (vacuum). Most of the phenomena, like reflection, refraction, interference, diffraction, polarization can be explained using the wave nature of light.



12.2. Laws of Reflection and Refraction

In geometric optics, we can make use of the following important property of light which is based on common experience:

Light travels in straight line path in homogeneous medium (medium of uniform density) unless it strikes a boundary separating the two media.

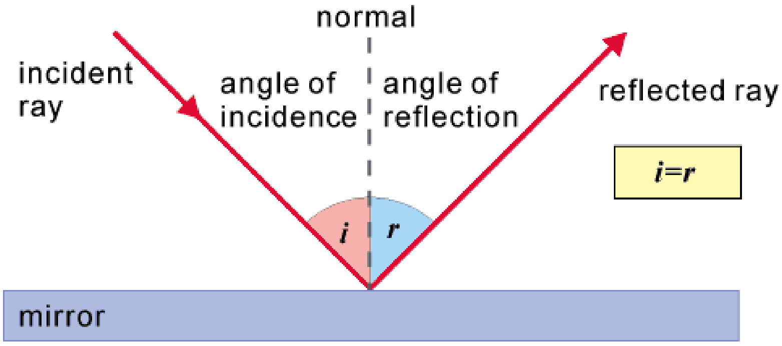
When a beam of light strikes such a boundary, it is either reflected in the same medium or crosses the boundary and enters the other medium. There is also a possibility that the light is partially reflected in the first medium and partially transmitted in the second medium.

Reflection:

When a light travel from one medium to other, if it comes back into the first medium, this phenomenon is called reflection. The phenomenon of reflection obeys the law of reflection.

Law of Reflection

"The angle of incidence (θ_i) is equal to the angle of reflection (θ_r)."



Refraction:

The phenomenon of bending of light when it travels from one medium to another medium is called refraction.

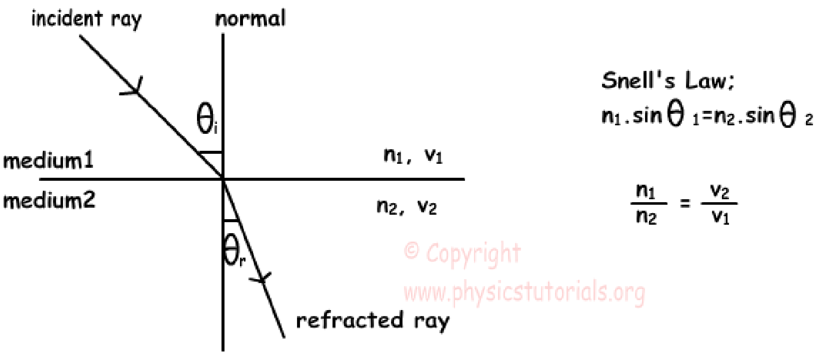
Law of Refraction:

The phenomenon of refraction takes place according to the following laws:

The incident ray, the refracted ray, and the normal to the refracting surface at the point of incidence all lie in the same plane.

The ratio of the sine of the angle of incidence to the sine of angle of refraction is constant for any two-given media. This is known as Snell's Law.

Thus, Snell's Law may be written as $\frac{n_2}{n_1} = \frac{sin\theta_i}{sin\theta_r}$



The absolute refractive index '*n*' of a medium can also be defined in terms of velocity of light as

$$n = \frac{c}{v}$$

Where '***c***' is the velocity of light in vacuum and 'v' is the velocity of light in medium respectively.

Thus, the refractive index (n_2) of medium 2 to the refractive index (n_1) of medium 1 can be written as follows.

$$\frac{n_2}{n_1} = \frac{v_1}{v_2}$$

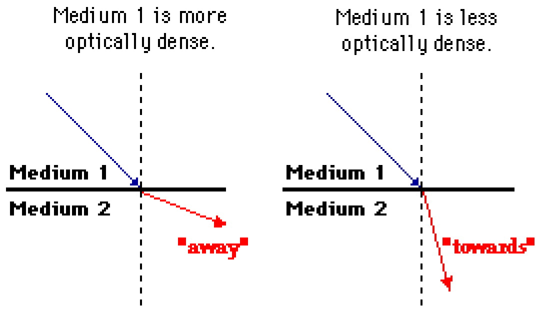
Where (v_1) is the velocity of light in medium 1 and (v_2) is the velocity of light in medium 2. But since $v = \lambda f$

Note: 'f' is the frequency of the light remains constant.

From the above relations, the refractive index and wavelength can be obtained as;

$$\frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2} = \frac{c/n_1}{c/n_2} = \frac{n_2}{n_1}.$$

- ✓ If the light is travelling from a **rarer to a denser medium**, the refracted ray will bend **towards the normal** line that separates the two media.
- ✓ If the light is travelling from a **denser to a rarer medium**, the refracted ray will bend **away from the normal**.



<u>Class Activity-1</u>

<u>Choose the correct answer:</u>

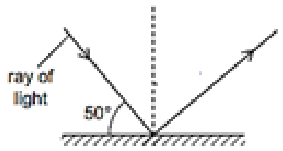
1. Which of the following is not true about light?

a) Light is a form of energy.

b) It is an electromagnetic radiation which is part of the electromagnetic spectrum.

c) Natural sources of light on earth are candles, flashlights and fluorescent lamps.

2. In the figure below, what is the angle of incidence?

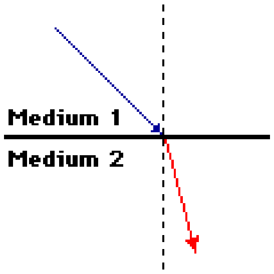


a) 100º
b) 50 º
c) 40 º

3. If the angle between the incidence ray and the reflected ray is 115°, what is the angle of incidence?

a) 25º
b) 65º
c) 57.5º

4. In the figure below, light travels from medium 1 to medium 2. Which statement is true?



a) Density of medium 1 >Density of medium 2
b) Density of medium 1 < Density of medium 2
c) Density of medium 1 = Density of medium 2

Problem Solving:

1. The refractive index of water is 1.33. What is the speed of light in water if speed of light is vacuum is $3 \times 10^8 m/s$?

2. A narrow beam of sodium yellow light (λ_0 = 589 nm) is incident from air on a smooth surface of water (n=1.33). Determine its wavelength in water.

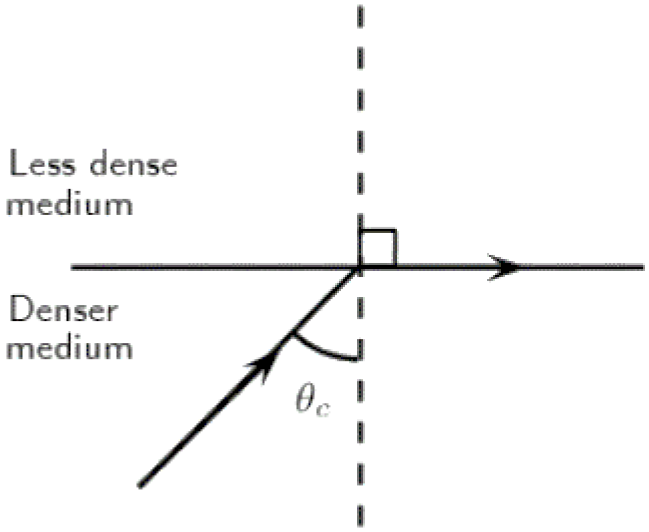
3. What is the angle of incidence on an air-to-glass boundary if the angle of refraction in the glass (n = 1.52) is 25º?

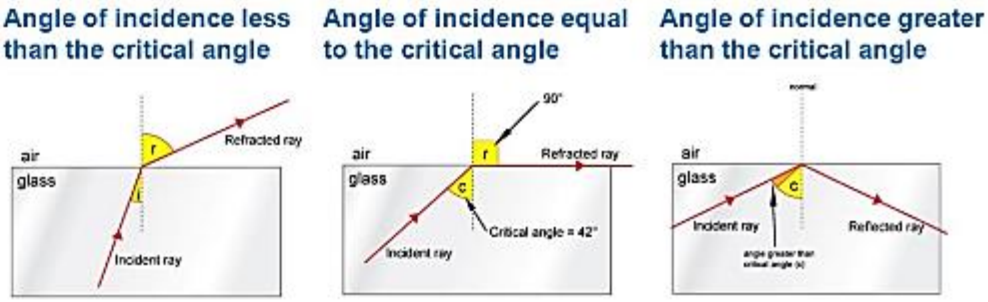
12.3. Critical Angle and Total Internal Reflection

If a ray of light enters from a denser to a rarer medium ($n_1 > n_2$), it bends away from the normal.
In this case, $\theta_r > \theta_i$.

Critical angle of incidence (θ_c):

As shown in the diagram below, on increasing the angle of incidence, the angle of refraction will also increase.
For a particular angle of incidence, the angle of refraction becomes 90^0 and the refracted ray passes grazing the surface. This particular angle of incidence for which the angle of refraction is 90^0 is called the Critical Angle and is denoted by θ_c





If we apply Snell's law for these angles then,

$$\frac{n_2}{n_1} = \frac{\sin\theta_C}{\sin 90^0}$$

If the second medium is air then $n_2 = 1$ and $\sin 90^o = 1$

then taking $n_1 = n$, we get

$$\sin\theta_C = 1/n$$

<u>Total Internal Reflection:</u>

If the angle of incidence further increases and becomes larger than the critical angle, then the angle of refraction would become > 90^0 and the ray will return back to the previous medium and we say that instead of refraction, the phenomenon of total internal reflection is observed.

Conditions for the Total Internal Reflection:

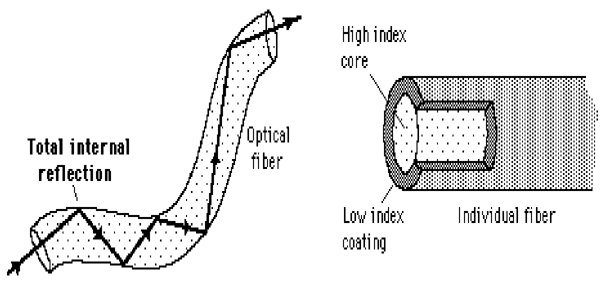
1. The ray should travel from denser medium to rarer medium
2. The angle of incidence should be greater than the critical angle.

One of the most **important** and interesting **applications of total internal reflection** is **optical fibers.**

12.4. Fiber Optics

- Depends upon the total internal reflection of light rays.

- Light can be trapped by total internal reflection inside a bent glass rod and travel along a curved path as in the diagram below. A single, very thin glass fiber behaves in the same way.

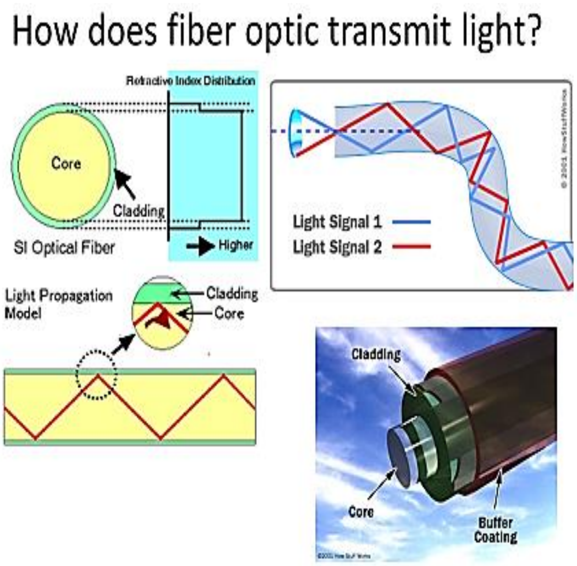


- They are small and so, once light is introduced into the fiber with an angle within the confines of the numerical aperture of the fiber, it will continue to reflect almost lossless off the walls of the fiber and thus can travel long distances in the fiber.

- If a bundle of parallel fibers is used to construct an optical transmission line, images can be transferred from one point to another.

Fibre optic imaging

- Principle: light striking at one end will be transmitted to the other end of the fiber.
- If the arrangement of fibers in the bundle is kept constant, then the transmitted light forms a mosaic image of the light which struck the end of the bundle.



Other uses of fiber optics:

1) Medical treatments (like endoscopes to view internal body parts)
2) Carrying high speed signals of internet, radio, T.V, telephones, because of less dispersion.

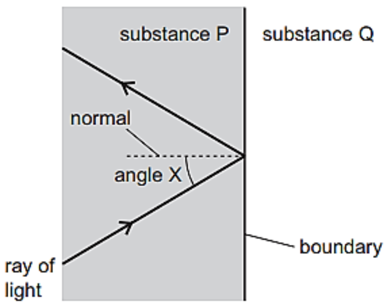
Class Activity-2

Choose the correct answer:

1. Which of the following will not occur when light moves from air to glass?

a) Total internal reflection
b) Reflection
c) Refraction

2. The diagram shows a ray of light travelling in a substance P. The ray reaches a boundary with a substance Q. Total internal reflection occurs at the boundary.



Which row contains correct statements about angle X and about the optical density of substance Q?

	angle X	substance Q
A	smaller than the critical angle	less dense than substance P
B	smaller than the critical angle	more dense than substance P
C	greater than the critical angle	less dense than substance P
D	greater than the critical angle	more dense than substance P

3. In an Optical fiber, total internal reflection takes place in:

a) Cladding
b) Core
c) Both A & B

Problem Solving:

1. A beam of light is incident from air on the surface of a liquid. If the angle of incidence is 30.0° and the angle of refraction is 22.0°, find the critical angle for the liquid when surrounded by air.

2. A fiber optic cable (n = 1.50) is submerged in water (n = 1.33). What is the critical angle for light to stay inside the cable?

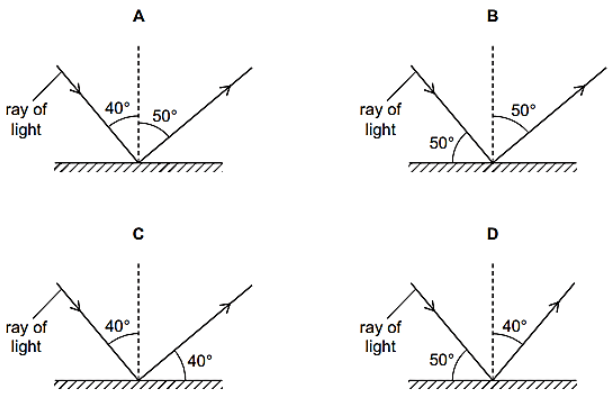
Worksheet-12

Multiple Choice Questions:

1. The speed of light in a glass block of refractive index 2 will be (in kms^{-1})
  a) 150,000
  b) 200,000
  c) 275,000

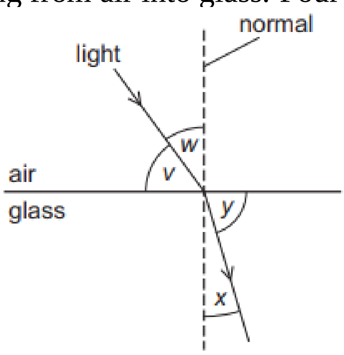
2. When a ray of light travels from one medium to the other then the physical quantity which always remains constant is:
  a) Speed
  b) Wavelength
  c) Frequency

3. Which diagram correctly shows a ray of light reflected by a plane mirror?



6. Sparkling of Diamond is due to which property of light?
  a) Refraction
  b) Total internal reflection
  c) Reflection

7. The diagram shows light travelling from air into glass. Four angles v, w, x and y are shown.



Which formula is used to calculate the refractive index n of the glass?

  a) n= sin v/sin y
  b) n= sin x/sin y
  c) n= sin w/sin x

Problem Solving:

1. If the critical angle of glass is 45° then calculate the refractive index.

2. A ray of light travelling in air is incident on a glass prism.

i) The speed of light in air is 3.0×10^8 m/s. Its speed in the glass is 2.0×10^8m/s. Calculate the refractive index of the glass.

ii) Show that the critical angle for the glass-air boundary is 42°.

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ARABIC TRANSLATION OF THE PHYSICS TECHNICAL TERMS IN THE PHYSICS WORKBOOK (PART III)

ترجمة المصطلحات الفيزيائية إلى اللغة العربية (الجزء الثاني)

CHAPTER 9

Absolute pressure: الضغط المطلق
Adhesion: الإلتصاق
Aerodynamic drag:السحب الديناميكي الهوائي
Aneroid Barometer: بارومتر معدني (لا سائلي)
Archimedes' law: قانون أرخميدس
Bernouilli's theorem: نظرية(مبرهنة) برنولي
Buoyancy: الطفو
Capillarity: الخاصية الشعرية
Capillary action: الفعل الشعري
Cohesion: التماسك
Continuity Equation: معادلة الاستمرارية
Density: الكثافة
Dynamic Pressure: الضغط الديناميكي
Effects: تأثيرات
Fluid dynamics: الموائع المتحركة
Fluid statics: الموائع السكونية
Fluids: موائع
Gauge pressure: ضغط المقياس
Induced drag: السحب المستحث
Laminar flow: التدفق (السريان) الرقائقي
Measurement of pressure: قياس الضغط
Mercury barometer: بارومتر زئبقي -مقياس
Parasitic drag: السحب الطفيلي
Pascal's law: قانون باسكال
Pressure in liquids: الضغط في السوائل
Relative Density: الكثافة النسبية
Skin friction: احتكاك سطحي
Steady flow : التدفق(السريان) الثابت
Streamlining: انسيابية
Surface tension: التوتر السطحي
Turbulent flow: التدفق(السريان) المضطرب
Venturi Effect:تأثير فنتوري
Viscosity: اللزوجة

CHAPTER 10

Absolute zero: الصفر المطلق
Adiabatic process: عملية ثابت الحرارة
Boyle's law: قانون بويل
British thermal unit: النظام البريطاني لوحدة الحرارة
Bulb: مصباح
Centigrade heat unit: النظام المئوي للحرارة
Changes of states: تغير الحالة
Charles' law: قانون تشارلز
Cold body: جسم بارد
Conduction: التوصيل الحراري
Convection: حمل حراري
Dalton's law: قانون دالتون
Decreases: تنقص
Exchanged: تبادل أو استبدال
Gay-Lussac's law: قانون جاي و لساك
Heat capacity: السعة الحرارية
Heat engine Processes: عمليات محرك الحرارة
Heat engine: المحرك الحراري
Heat pump and refrigerator: المضخة الحرارية
Heat pump: مضخة الحرارة
Hot body: جسم ساخن(حار)
Ice: ثلج
Ideal gas law: قانون الغاز المثالي
Internal energy: الطاقة الداخلية أو الطاقة الكلية
Latent heat of fusion: الحرارة الكامنة للانصهار
Latent heat of vaporization: الحرارة الكامنة للتبخير
Latent heat: الحرارة الكامنة
Radiation: الإشعاع الحراري
Refrigerator: براد(ثلاجة)
Sensible heat: حرارة ملموسة
Sign convention: مصطلح(اتفاقية) الإشارات
Specific heat capacity: السعة الحرارية النوعية
Steam: بخار
Thermal equilibrium: التوازن الحراري
Thermal expansion: التمدد الحراري
Thermometers: مقياس أو ميزان الحرارة
Types of heat transfer: أنواع نقل الحرارة
Vaporization: التبخر

CHAPTER 11

Adjacent:مجاور
Amplitude: السعة
Antinode: بطن
Apparent: ظاهر

Audible waves: موجات مسموعة
Categories of sound waves: فئات أو اقسام موجات الصوت
Compression: تضاغط أو انضغاط
Constructive interference: تداخل بناء
Crest: قمة
Cycle: الدورة
Destructive interference: تداخل هدام
Doppler's effect: ظاهرة دوبلر
Electromagnetic waves: الموجات الكهرومغناطسية
Frequency: التردد
Harmonic motion: الحركة التوافقية
Infrasonic waves: موجات تحت الصوتية
Intensity: شدة الصوت
Interference: تداخل
Light: الضوء
Longitudinal waves: الموجات الطولية
Loudness: قوة الصوت
Mechanical waves: الموجات الميكانيكية
Node: عقدة
Oscillatory motion: الحركة الاهتزازية
Periodic motion: الحركة الدورية
Phase difference: فرق الطور(الفرق بين الموجتين)
Pitch: النغمة
Propagation: الانتشار
Properties of sound waves: خصائص موجات الصوت
Quality or timbre of sound: نوعية الصوت
Rarefaction: تخلخل
Resonance: الرنين
Simple pendulum: البندول البسيط
Sound: الصوت
Stationary wave: موجة ثابتة
Time period: الزمن الدوري
Transverse wave: الموجات المستعرضة
Trough: قاع
Types of waves: أنواع الموجات
Ultrasonic waves: موجات فوق الصوتية
Wave motion and sound: حركة الموجات و الصوت
Waves: الموجات

CHAPTER 12

Absolute refractive index: معامل الإنكسار المطلق
Angle of incidence: زاوية السقوط
Angle of reflection: زاوية الإنعكاس
Blue: أزرق
Concave lens: عدسة محدبة
Cone: مخروط
Convex lens: عدسة مقعرة
Critical angle: الزاوية الحرجة
Cube: مكعب
Curved mirrors: مرايا منحنية
Cylinder: إسطوانة
Fiber optics: الألياف البصرية
Incident ray: شعاع ساقط
Law of reflection: قا نون الإنعكاس
Lenses: العدسات
Magnification: التكبير
Medium: وسط
Optical center: المركز البصري
Parabolic: قطعي
Phenomenon: ظاهرة
Plane mirrors: مرايا مستوية
Principal axis: المحور الأساسي
Principal focus: البؤرة
Real image: صورة حقيقية
Red: أحمر
Reflected ray: شعاع منعكس
Reflection: انعكاس
Refraction: انكسار
Refractive index: معامل الإنكسار
Spherical: كروي
Thins lens equation: معادلة العدسة الرقيقة (القانون العام للعدسات)
Total internal reflection: الإنعكاس الكلي الداخلي
Violet: بنفسجي
Virtual image: صورة وهمية
Visible: مرئي
Wavelength: الطول الموجي
Yellow: أصفر