



Senior 3 General Science (New curriculum)

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Senior 3

Term 2

THEME: SCIENCE FOR HEALTH AND SAFETY

TOPIC 3: INFECTIONS AND DISEASES

Competency: The learner appreciates the communicable and non-communicable diseases in society and how they can be minimized.



Disease

A disease is an abnormal state in which the body or part of it fails to function properly due to infection, malfunction, or deficiency.

Communicable Diseases

These are diseases that **can be transmitted** from one person to another, or from animals and the environment to humans.

Causes

Pathogens: bacteria, viruses, fungi, or parasites.

Transmission routes: air, water, food, direct contact, or vectors (like mosquitoes).

Examples

Disease	Cause	Mode of Transmission
Malaria	Plasmodium parasite	Mosquito bite
Tuberculosis (TB)	Bacteria	Airborne droplets
HIV/AIDS	Virus	Sexual contact, blood
Cholera	Bacteria	Contaminated water
Influenza	Virus	Airborne droplets
Gonorrhea	Bacteria	Unsafe sex

Prevention

- (i) Maintain **good hygiene** and **sanitation**.
- (ii) Use **insect repellents** and **mosquito nets**.

- (iii) Get **vaccinated**.
- (iv) Avoid sharing sharp objects.
- (v) Safe sex

Non-Communicable Diseases

These are diseases **not spread** from person to person. They develop due to **genetic, lifestyle, or environmental factors**.

Causes

- (i) Poor diet and lack of exercise.
- (ii) Tobacco and alcohol use.
- (iii) Genetic inheritance.
- (iv) Environmental pollution or stress.

Examples

Disease	Cause/Factor	Effect on Body
Diabetes	High blood sugar	Damages organs
Hypertension	High blood pressure	Heart strain
Cancer	Abnormal cell growth	Organ failure
Obesity	Overeating, inactivity	Metabolic disorders
Sickle-cell anemia	Genetic	Reduced oxygen transport

Prevention

- (i) Eat a **balanced diet**.
- (ii) Exercise regularly.
- (iii) Avoid **smoking and alcohol**.
- (iv) Go for **regular health check-ups**.

Comparison Table

Feature	Communicable	Non-Communicable
Spread	Person-to-person or via vectors	Not spread between people
Cause	Pathogens (bacteria, viruses, etc.)	Genetic, lifestyle, environment
Examples	Malaria, TB, HIV/AIDS	Diabetes, cancer, hypertension
Prevention	Hygiene, vaccination	Healthy living, regular check-ups

Key Insight: Communicable diseases are **infectious and preventable through hygiene and immunization**, while non-communicable diseases are **chronic and prevented through healthy habits and early screening**.

Exercise 3.1

- (a) Give three example each of communicable and non-communicable diseases.
- (b) Explain 3 ways each of preventing communicable and non-communicable diseases

Challenges of people with HIV/AIDS and how to overcome them

People living with HIV/AIDS face medical, social, and economic challenges such as stigma, treatment adherence, opportunistic infections, and poverty. These can be overcome through consistent antiretroviral therapy (ART), community support, education, and integration of HIV care with broader health and social services.

Medical Challenges

- ❖ **Treatment adherence** → Interrupting ART increases risk of drug resistance, opportunistic infections, and death.
- ❖ **Opportunistic infections** → Tuberculosis remains the leading cause of death among HIV patients.
- ❖ **Drug resistance** → Emerging resistance threatens effectiveness of first-line regimens.
- ❖ **Comorbidities** → Aging patients face hypertension, diabetes, and cancers alongside HIV.

Solutions:

- ❖ Ensure uninterrupted ART supply.
- ❖ Regular monitoring of viral load and CD4 counts.
- ❖ Integrate HIV care with TB and non-communicable disease services.
- ❖ Expand access to second-line and third-line drugs.

Social Challenges

- ❖ **Stigma and discrimination** → Leads to isolation, loss of employment, and reluctance to seek care.

- ❖ **Gender inequality** → Women and girls face higher infection rates due to unequal power dynamics.
- ❖ **Mental health issues** → Depression and anxiety reduce adherence to treatment.

Solutions:

- ❖ Community education to dispel myths about HIV transmission.
- ❖ Legal protections against discrimination.
- ❖ Counseling and psychosocial support groups.
- ❖ Empower women through education and safe-sex negotiation programs.

Economic Challenges

- ❖ **Poverty** → Limits access to nutritious food and healthcare.
- ❖ **Unemployment** → Stigma reduces job opportunities.
- ❖ **Healthcare costs** → ART is free in Uganda, but transport and related costs remain barriers.

Solutions:

- ❖ Government and NGO support programs for food and transport.
- ❖ Vocational training and microfinance for people living with HIV.
- ❖ Integration of HIV services into primary healthcare to reduce costs.

Summary Table

Challenge	Impact	Solution
Treatment adherence	Risk of resistance, infections	Continuous ART, monitoring
Opportunistic infections	TB leading cause of death	Integrate TB & HIV care
Stigma	Isolation, reduced care-seeking	Education, legal protection
Gender inequality	Women more vulnerable	Empowerment, safe-sex programs
Poverty	Poor nutrition, limited access	Support programs, microfinance

Uganda Context

- ❖ Uganda has made progress with **95-95-95 targets** (95% diagnosed, 95% on ART, 95% virally suppressed).
- ❖ Challenges remain in rural areas where stigma, poverty, and transport costs hinder access.
- ❖ Community-based programs like **Village Health Teams** and NGOs (e.g., TASO) play a vital role in overcoming barriers.

Key Insight: Overcoming HIV/AIDS challenges requires a **holistic approach** — medical treatment, social support, and economic empowerment. With consistent ART, stigma reduction, and integrated care, people living with HIV can lead long, healthy lives.

Exercise 3.2

Explain five main challenges of people with HIV/AIDS and their solutions

Deficiency diseases

Deficiency diseases occur when the body lacks essential nutrients such as vitamins, minerals, or proteins. These nutrients are vital for growth, immunity, and proper functioning of organs.

Definition

A deficiency disease is a disorder caused by the **lack of specific nutrients** in the diet, leading to impaired body functions.

Types of Deficiency Diseases and Examples

Nutrient Deficiency	Disease	Symptoms
Protein	Kwashiorkor	Swollen belly, stunted growth, weakness
Vitamin A	Night blindness	Poor vision in dim light, dry eyes
Vitamin D	Rickets	Soft/bent bones, delayed growth
Vitamin C	Scurvy	Bleeding gums, weak immunity
Iron	Anemia	Fatigue, pale skin, dizziness
Iodine	Goiter	Swelling of the neck (thyroid gland)
Calcium	Osteoporosis	Weak, brittle bones

Causes of Deficiency Diseases

- (i) Poor diet lacking variety.
- (ii) Poverty and food insecurity.
- (iii) Malabsorption (body cannot absorb nutrients properly).
- (iv) Excessive alcohol or drug use.

- (v) Certain medical conditions.

Prevention

- (i) Eat a **balanced diet** with proteins, vitamins, and minerals.
- (ii) Use **fortified foods** (e.g., iodized salt, fortified flour).
- (iii) Take supplements when prescribed.
- (iv) Educate communities on nutrition.
- (v) Improve food security and access to healthcare.

Everyday Insight

In Uganda and many parts of Africa, **protein-energy malnutrition (Kwashiorkor and Marasmus)** and **micronutrient deficiencies (Vitamin A, Iron, Iodine)** are common among children due to poverty and limited diets. Public health programs focus on **nutrition education, supplementation, and food fortification** to combat these diseases.

Key Insight: Deficiency diseases are preventable. A **balanced diet, fortified foods, and awareness** are the strongest tools to protect individuals and communities from malnutrition.

Exercise 3.3

Write three causes of deficient diseases and how to prevent them

Hereditary diseases

Hereditary diseases are illnesses passed from parents to children through **genes**. They result from mutations or abnormalities in DNA and can affect body functions across generations.

Definition

A hereditary disease is a disorder **inherited genetically** from one or both parents due to defective genes.

Sickle Cell Anemia

Cause: Mutation in the gene that produces hemoglobin.

Effect: Red blood cells become sickle-shaped, blocking blood flow.

Symptoms: Fatigue, pain crises, delayed growth, frequent infections.

Management: Regular medical checkups, blood transfusions, pain management, hydroxyurea therapy.

Hemophilia

Cause: Genetic defect in clotting factors (Factor VIII or IX).

Effect: Blood does not clot properly, leading to prolonged bleeding.

Symptoms: Excessive bleeding from minor cuts, internal bleeding in joints and muscles.

Management: Replacement therapy with clotting factors, avoiding injury, regular monitoring.

Color Blindness

Cause: Genetic mutation affecting cone cells in the retina.

Effect: Inability to distinguish certain colors (commonly red-green).

Symptoms: Difficulty differentiating colors, especially in learning or daily tasks.

Management: No cure, but special glasses or apps can help; education support for affected children.

Summary Table

Disease	Cause	Effect	Management
Sickle Cell Anemia	Hemoglobin gene mutation	Misshaped red blood cells	Blood transfusions, hydroxyurea
Hemophilia	Defective clotting factor gene	Poor blood clotting	Factor replacement therapy
Color Blindness	Mutation in cone cell genes	Difficulty seeing colors	Special glasses, learning support

Everyday Insight

- ❖ In Uganda and East Africa, **sickle cell anemia** is especially common and a major public health concern.
- ❖ **Hemophilia** is rarer but requires lifelong management to prevent dangerous bleeding.
- ❖ **Color blindness** is less life-threatening but can affect education and daily life.

Key Insight: Hereditary diseases are passed through genes and cannot be prevented, but **early diagnosis, medical care, and social support** help people live healthier, more productive lives.

Exercise 3.4

- Give three symptoms of anemia
- Suggest any three ways of managing sickle cell anemia

Physiological disease

Physiological diseases are disorders that affect the normal functioning of body organs and systems. They are often linked to lifestyle, environment, or genetic predisposition. Let's analyze the examples you gave: **bronchitis, cancer, diabetes, and blood pressure (hypertension)**.

Bronchitis

Cause: Inflammation of the bronchial tubes, often due to infection or smoking.

Effects: Persistent cough, mucus production, breathing difficulty.

Prevention/Management: Avoid smoking, reduce exposure to pollutants, seek medical treatment for infections.

Cancer

Cause: Uncontrolled growth of abnormal cells due to genetic mutations, lifestyle factors, or carcinogens.

Effects: Tumors, organ damage, spread (metastasis).

Prevention/Management: Healthy diet, avoiding tobacco/alcohol, regular screening, surgery, chemotherapy, radiotherapy.

Diabetes

Cause: Insufficient insulin production (Type 1) or poor insulin use (Type 2).

Effects: High blood sugar, fatigue, organ damage (kidneys, eyes, nerves).

Prevention/Management: Balanced diet, exercise, medication/insulin therapy, regular monitoring of blood sugar.

High Blood Pressure (Hypertension)

Cause: Narrowing of blood vessels, obesity, stress, high salt intake, genetics.

Effects: Strain on heart, risk of stroke, kidney damage.

Prevention/Management: Reduce salt intake, exercise, stress management, medication, regular checkups.

Summary Table

Disease	Cause	Effects	Prevention/Management
Bronchitis	Infection, smoking, pollution	Cough, mucus, breathing difficulty	Avoid smoking, treat infections
Cancer	Genetic mutations, carcinogens	Tumors, organ damage	Screening, surgery, therapy
Diabetes	Insulin issues	High blood sugar, organ damage	Diet, exercise, medication
Hypertension	Salt, stress, obesity, genetics	Stroke, heart strain	Lifestyle changes, medication

Everyday Insight

In Uganda and many developing countries, **diabetes and hypertension** are rising due to lifestyle changes, while **bronchitis** is common in areas with poor air quality. **Cancer** is increasingly diagnosed but often detected late due to limited screening.

Exercise 3.5

- State the causes of the various type of diabetes.
- Explain the management of diabetes.

Common Abnormalities of the reproductive system

Infertility

Inability to conceive after 12 months of unprotected intercourse.

Causes: blocked fallopian tubes, low sperm count, hormonal imbalance.

Management: medical treatment, assisted reproductive technologies (IVF).

Fibroids

Non-cancerous growths in the uterus.

Symptoms: heavy bleeding, pelvic pain, infertility.

Management: surgery, medication, lifestyle changes.

Endometriosis

Tissue similar to the uterine lining grows outside the uterus.

Symptoms: painful periods, infertility, pelvic pain.

Management: hormone therapy, surgery.

Polycystic Ovary Syndrome (PCOS)

Hormonal disorder causing irregular periods, cysts in ovaries, infertility.

Symptoms: weight gain, acne, excessive hair growth.

Management: lifestyle changes, medication to regulate hormones.

Prostate enlargement

Common in men over 50.

Symptoms: difficulty urinating, frequent urination.

Management: medication, surgery.

Sexually transmitted infections (STIs)

Examples: syphilis, gonorrhea, HIV/AIDS.

Effects: infertility, pelvic inflammatory disease, chronic pain.

Prevention: safe sex practices, regular screening.

Congenital abnormalities

Examples: undescended testes, abnormal uterus shape.

Effects: infertility, complications in pregnancy.

Management: surgery or medical correction.

Summary Table

Abnormality	Effect	Management
Infertility	Inability to conceive	ART, medical treatment
Fibroids	Heavy bleeding, pain	Surgery, medication
Endometriosis	Pain, infertility	Hormone therapy, surgery
PCOS	Irregular periods, infertility	Lifestyle changes, medication
Prostate enlargement	Urination problems	Medication, surgery
STIs	Infertility, chronic pain	Safe sex, screening
Congenital abnormalities	Infertility, pregnancy issues	Surgery, correction

Everyday Insight

In Uganda, **STIs and infertility** are among the most common reproductive health challenges.

Public health programs emphasize **safe sex education, early screening, and access to reproductive healthcare** to reduce these abnormalities.

Exercise 3.6

State the causes of infertility.

Healthy Lifestyles

- (i) **Balanced diet:** Eating fruits, vegetables, proteins, and whole grains strengthens immunity and reduces disease.

- (ii) **Regular exercise:** Keeps the body fit, lowers risk of diabetes, hypertension, and heart disease.
- (iii) **Adequate rest:** Improves mental health, productivity, and learning.
- (iv) **Good hygiene:** Prevents communicable diseases like cholera and typhoid.
- (v) **Avoiding harmful habits:** No smoking, limited alcohol, safe sexual practices.

Impact on society

- (i) Reduces healthcare costs.
- (ii) Increases productivity and economic growth.
- (iii) Builds stronger families and communities.
- (iv) Promotes longevity and quality of life.

Unhealthy Lifestyles

- (i) **Poor diet:** High sugar, salt, and fat intake leads to obesity, diabetes, and heart disease.
- (ii) **Physical inactivity:** Causes weak muscles, poor circulation, and chronic illness.
- (iii) **Substance abuse:** Alcohol, drugs, and smoking damage health and increase accidents.
- (iv) **Unsafe sexual practices:** Spread HIV/AIDS and other STIs.
- (v) **Stress and poor sleep:** Reduce concentration, increase mental illness.

Impact on society:

- (i) Higher healthcare burden.
- (ii) Loss of productivity due to illness.
- (iii) Increased poverty and dependency.

- (iv) Weakening of family structures.
- (v) Spread of preventable diseases.

Summary Table

Lifestyle	Examples	Effect on Society
Healthy	Balanced diet, exercise, hygiene	Strong workforce, lower healthcare costs
Unhealthy	Poor diet, smoking, unsafe sex	Disease burden, poverty, social instability

Everyday Insight

In Uganda, promoting **healthy lifestyles** through nutrition education, HIV prevention, and physical activity campaigns helps reduce the burden of **non-communicable diseases** and **communicable diseases** alike. Conversely, unhealthy habits like alcohol abuse and poor diet increase poverty and strain healthcare systems.

Key Insight: Healthy lifestyles **build strong societies**, while unhealthy lifestyles **drain resources and weaken communities**. The choice of individuals directly shapes the health and prosperity of nations.

THEME: SCIENCE FOR HEALTH AND SAFETY

TOPIC 4: SUBSTANCE / DRUG USE/ABUSE

Competency: the learner appreciates the different types of substance used as drugs in society and dangerous consequences that they have on life



Drug/substance use and abuse

Here's a clear distinction between **drug/substance use** and **drug/substance abuse**, and how each affects individuals and society:

Drug/Substance Use

Definition: The **controlled, moderate, and often legal use** of substances for medical or social purposes.

Examples:

- Taking prescribed medicine (antibiotics, painkillers) as directed.
- Drinking alcohol occasionally in moderation.
- Using caffeine to stay alert.

Effects:

- Can be beneficial when medically supervised.
- Minimal harm if used responsibly.
- Supports health and productivity when regulated.

Drug/Substance Abuse

Definition: The **excessive, harmful, or illegal use** of substances that damages health and disrupts life.

Examples:

- Overdosing on prescription drugs.
- Alcoholism (excessive drinking).

- Smoking marijuana or cocaine for recreation.
- Misusing painkillers or steroids.

Effects:

- Addiction and dependency.
- Physical harm (liver damage, brain impairment).
- Social problems (crime, unemployment, family breakdown).
- Increased burden on healthcare systems.

Comparison Table

Aspect	Use	Abuse
Definition	Controlled, moderate use	Excessive, harmful use
Legality	Often legal (prescribed or moderate)	Often illegal or misuse
Impact on health	Beneficial or neutral	Damaging, addictive
Impact on society	Supports productivity	Causes crime, poverty, family breakdown

Everyday Insight

In Uganda, **drug use** includes prescribed medicines and traditional herbs, which help communities stay healthy.

Drug abuse, however, is a growing problem among youth (alcohol, marijuana, narcotics), leading to crime, school dropouts, and health crises.

Key Insight: Drug use is **safe and beneficial when controlled**, while drug abuse is **dangerous and destructive**. Society thrives when substances are used responsibly but suffers when they are misused.

Common substances Abused in Uganda

(i) Alcohol

- Most widely abused substance (over 50% of treatment cases).
- Common among adults in rural and urban areas.
- Leads to liver disease, accidents, family breakdown, and poverty.

(ii) Cannabis (Marijuana)

- Popular among youth and urban residents.
- Associated with psychosis, poor academic performance, and crime.

(iii) Tobacco

- Widely available and socially accepted.
- Causes lung cancer, respiratory diseases, and heart problems.

(iv) Khat (Miraa)

- Chewed for stimulation, common in Eastern Uganda.
- Leads to addiction, insomnia, and social disruption.

(v) Prescription drugs

- Misuse of opioids, sedatives, and anticholinergics.
- Often linked to injection drug use and high risk of overdose.

(vi) **Illicit narcotics**

- Cocaine and heroin increasingly reported in urban centers.
- Associated with crime, severe addiction, and mental health crises.

Summary Table

Substance	Prevalence	Effects
Alcohol	Most common	Liver disease, accidents, poverty
Cannabis	Youth, urban	Psychosis, poor academics
Tobacco	Widespread	Cancer, respiratory illness
Khat	Eastern Uganda	Addiction, insomnia
Prescription drugs	10% of cases	Overdose, psychosis
Illicit narcotics	8–9% of cases	Crime, severe addiction

Risks to Society

- (i) **Health burden:** Increased cases of liver disease, cancer, and mental illness.
- (ii) **Economic impact:** Loss of productivity, unemployment, poverty.
- (iii) **Social disruption:** Family breakdown, crime, school dropouts.
- (iv) **Overloaded healthcare system:** Facilities like Butabika Hospital often exceed capacity due to substance abuse cases.

Uganda Context

Alcohol and cannabis dominate substance abuse patterns.

Youth in Kampala slums report high-risk alcohol use (16%) and illicit drug use (35%).

Government passed the **Narcotics and Psychotropic Substances Control Act (2023)** to regulate marijuana for medical use and impose strict penalties on illegal drug trade.

Key Insight: Tackling substance abuse in Uganda requires a **public health approach** — combining education, counseling, rehabilitation, and community support — rather than relying solely on criminalization.

Factors causing drug abuse

Drug abuse does not happen in isolation — it is driven by a mix of **personal, social, and environmental factors**. Let's break them down clearly:

Personal Factors

- **Curiosity and experimentation:** Young people often try drugs out of curiosity.
- **Peer pressure:** Friends influence others to fit in socially.
- **Stress and depression:** Drugs are used as an escape from emotional problems.
- **Ignorance:** Lack of knowledge about dangers of drugs.

Social Factors

- **Family problems:** Broken homes, neglect, or domestic violence push youth to drugs.
- **Cultural acceptance:** In some communities, alcohol or khat chewing is normalized.
- **Unemployment:** Idleness leads to drug use as a coping mechanism.
- **Media influence:** Music, movies, and social media glamorize drug use.

Economic Factors

- **Poverty:** Limited opportunities push people into substance abuse.
- **Cheap availability:** Alcohol, tobacco, and cannabis are easily accessible.
- **Drug trafficking:** Urban centers provide easy access to illicit substances.

Environmental Factors

- **Poor law enforcement:** Weak regulation allows drugs to circulate freely.
- **Urbanization:** Slums and crowded cities increase exposure to drugs.
- **Lack of recreational facilities:** Youth turn to drugs due to boredom.

Summary Table

Factor	Examples	Impact
Personal	Curiosity, stress, peer pressure	Addiction, poor health
Social	Family breakdown, cultural acceptance	Crime, school dropouts
Economic	Poverty, cheap drugs	Increased abuse, poverty cycle
Environmental	Urbanization, weak laws	Easy access, community breakdown

Uganda Context

Alcohol and cannabis are the most abused substances, especially among youth.

Unemployment and poverty drive many into drug abuse.

Peer pressure and slum life in Kampala contribute to rising cases.

Government has responded with the **Narcotics and Psychotropic Substances Control Act (2023)**, but community education and rehabilitation remain critical.

Key Insight: Drug abuse is caused by a **web of personal, social, economic, and environmental factors**. Tackling it requires **education, strong family support, law enforcement, and opportunities for youth**.

Prevention and control of drug abuse

Preventing and controlling **drug abuse** requires a mix of **education, strong family support, law enforcement, and rehabilitation services**. Let's break it down clearly:

Prevention Strategies

- (i) **Education and awareness:** Teach communities, especially youth, about the dangers of drugs.
- (ii) **Life skills training:** Help young people resist peer pressure and make healthy choices.
- (iii) **Parental guidance:** Strong family bonds reduce risk of drug experimentation.
- (iv) **School programs:** Integrate drug education into curricula.
- (v) **Community activities:** Sports, arts, and clubs provide alternatives to drug use.

Control Measures

- (i) **Law enforcement:** Strict regulation of drug production, sale, and trafficking.
- (ii) **Rehabilitation centers:** Provide counseling, detoxification, and therapy for addicts.
- (iii) **Health services:** Integrate drug abuse treatment into primary healthcare.

- (iv) **Support groups:** Encourage peer support and community reintegration.
- (v) **Government policies:** Enforce acts like Uganda's **Narcotics and Psychotropic Substances Control Act (2023)**.

Summary Table

Approach	Examples	Impact
Prevention	Education, parental guidance, sports	Reduces risk of initiation
Control	Laws, rehab, health services	Helps addicts recover, reduces supply

Uganda Context

- ❖ **Alcohol and cannabis** are the most abused substances.
- ❖ Government focuses on **law enforcement**, but NGOs like **TASO** and **Butabika Hospital** emphasize **rehabilitation and counseling**.
- ❖ Community-based approaches (sports clubs, youth groups) are vital in slum areas where drug abuse is rising.

Key Insight: Prevention stops people from starting drug use, while control helps those already affected. Together, they protect individuals, families, and society from the destructive impact of drug abuse.

Exercise 4

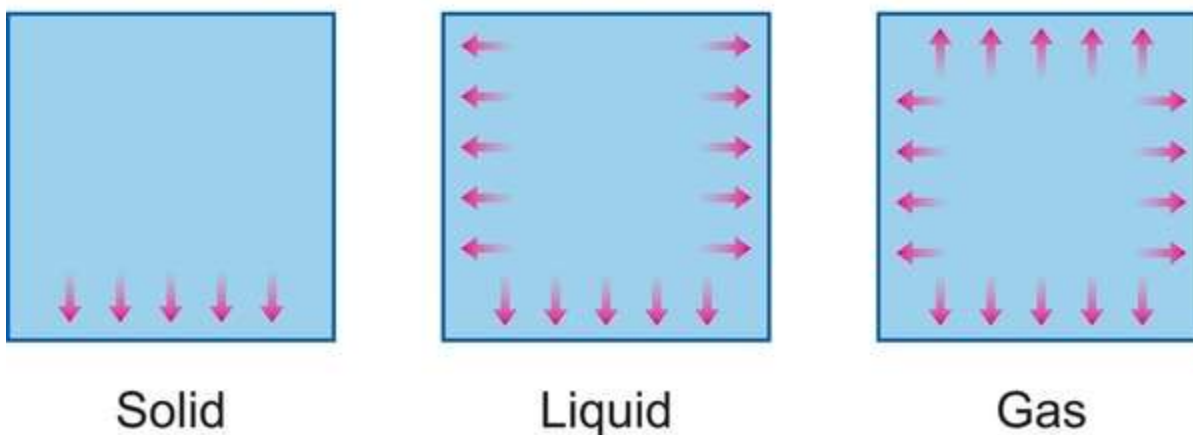
- (a) what is drug abuse
- (b) list cause of drug abuse
- (c) how can drug abuse be controlled

THEME: SCIENCE AND TECHNOLOGY

TOPIC 5: PRESSURE IN SOLIDS AND FLUIDS

Competency: The learner investigates pressure in in solids and its implications in everyday life.

Exertion of Pressure



Pressure in solids

Pressure is force per unit area. i.e.

$$\text{Pressure} = \frac{\text{Force (N)}}{\text{Area (m}^2\text{)}} \text{ Nm}^{-2} \text{ or Pascal, Pa}$$

Pressure is thus inversely proportional to the area. For a given amount of force, the smaller the area of contact between two bodies the greater the pressure exerted.

Example 1

A metallic block of mass 50kg exerts a pressure of 20Nm^{-2} on a surface. Find the area of contact between the block and the surface.

$$\text{Pressure} = \frac{\text{Force (N)}}{\text{Area (m}^2\text{)}}$$

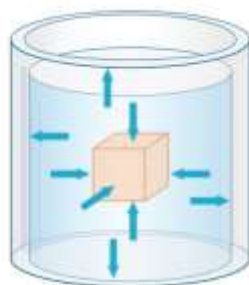
$$\text{Area} = \frac{\text{Force (N)}}{\text{Pressure}} = \frac{50 \times 10}{20} = 25\text{m}^2$$

Exercise 5.1

- (a) A metallic block of weight 100N rests on a surface. Find the pressure exerted on the surface if the area of contact between the block and the surface is
- (i) 0.1m^2 [1000Pa]
 - (ii) 0.01m^2 [10,000Pa]
- (b) A cuboid of dimensions 4m x 3m x 2m weights 480N. Calculate the maximum and minimum pressures it exerts on a table. [80Pa, 40Pa]
- (c) A rectangular block as sides 5.0cm by 10.0cm by 20cm. It is made of material of density 2.5gcm^{-3} . Find the maximum pressure in NM^{-2} it exerts when resting with one of its faces on horizontal surface. [5000N]

Pressure in fluids

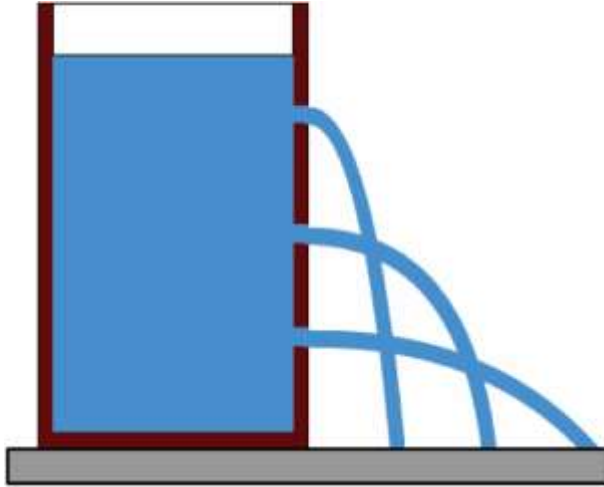
Fluids (liquids and gases) exert pressure on surfaces and objects in contact with them but unlike solids, pressure in fluids acts in all directions as shown below.



Pressure in fluids = $h\rho g$

where h = depth, ρ = density of the fluid and g = acceleration due to gravity

Experiment to show that pressure in liquids increases with depth



- (i) **Make holes:** Use the nail to carefully poke three holes in a vertical line on the side of the bottle—one near the top, one in the middle, and one near the bottom. Make sure they're the same size and evenly spaced.
- (ii) **Seal the holes:** Temporarily cover the holes with tape or your finger.
- (iii) **Fill the bottle:** Pour water into the bottle up to the top.
- (iv) **Unseal:** Remove all seals at once and observe the water jets.

Observation:

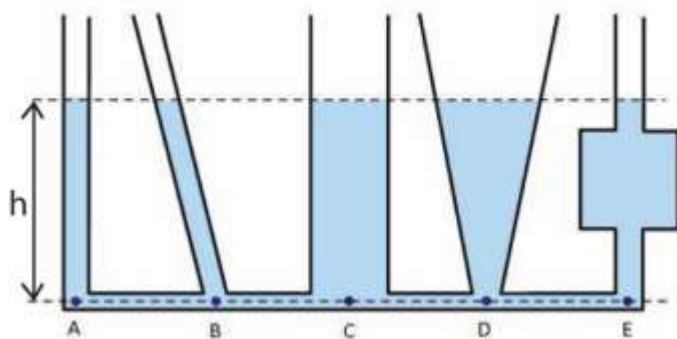
- The top hole releases a short, weak jet of water.
- The middle hole's stream goes farther.
- The bottom hole shoots water the farthest.

Conclusion:

This shows that **liquid pressure increases with depth**. The deeper the hole, the more pressure the water exerts, and the farther it shoots out.

Experiment to show that static fluid pressure does not depend on the shape and cross-section area of the container

Water is filled in differently shaped containers A, B, C, D, E as shown in the diagram below



Observation

A constant height h is maintained for each of the containers indicating that pressure at points A to E is the same and independent of the shape of and cross-section of the containers.

Example 2

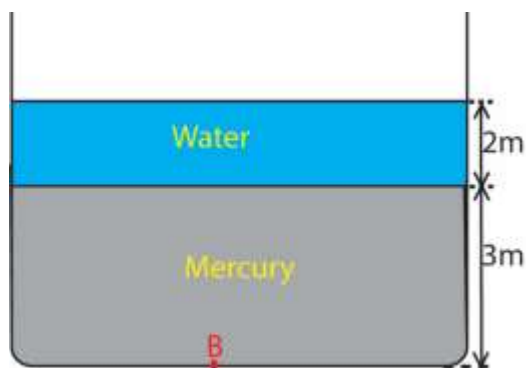
- (a) Find the pressure exerted 1,500m below the surface of the lake. Given that the density of water is 1000kgm^{-3} .

Pressure in fluids = $h\rho g$

$$= 1500 \times 1000 \times 10$$

$$= 1.5 \times 10^7 \text{Nm}^{-2}$$

- (b) The tank shown below contains mercury and water. Given that the density of mercury and water are 13600kgm^{-3} and 1000kgm^{-3} respectively. Find the pressure at B



Pressure in fluids = $h\rho g$

$$\text{Pressure due to water} = 2 \times 1000 \times 10 = 20,000 \text{Nm}^{-2}$$

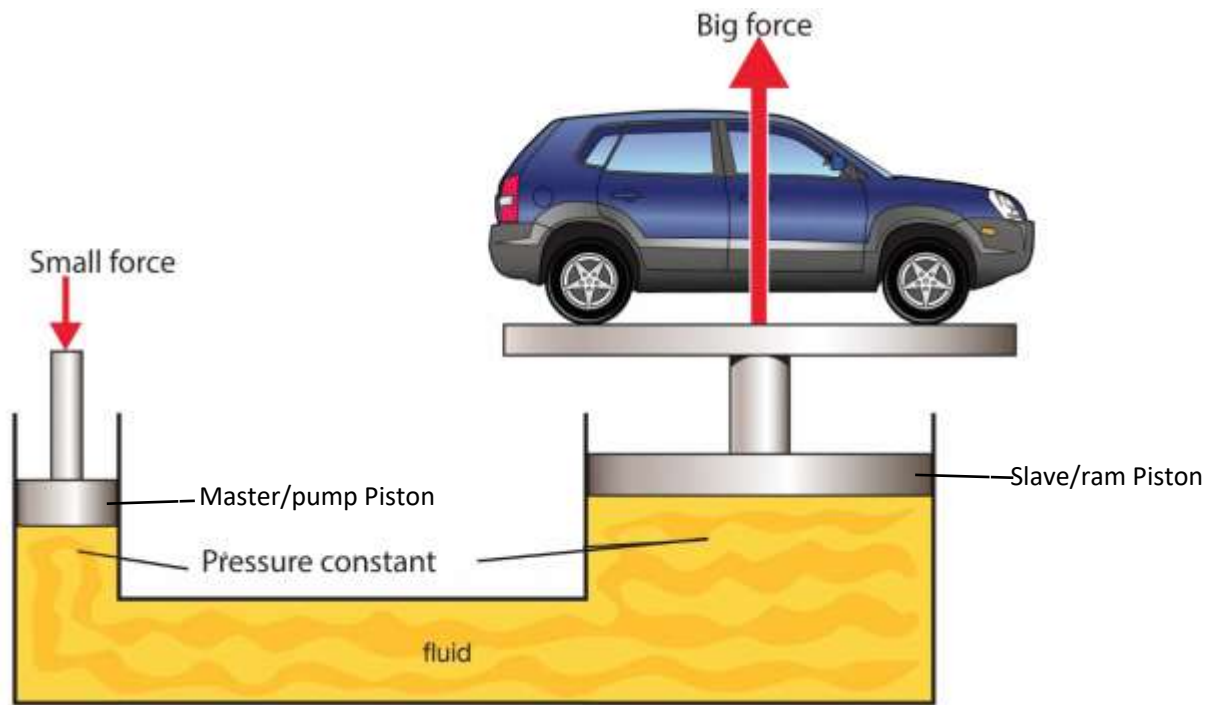
$$\text{Pressure due to mercury} = 3 \times 13600 \times 10 = 408,000 \text{Nm}^{-2}$$

$$\text{Total pressure at B} = 20,000 + 408,000 = 428,000 \text{Nm}^{-2}$$

Exercise 4.2

The pressure at the bottom of mercury is 106,000Pa. How high is the mercury column?
Density of mercury is $13,600\text{kgm}^{-3}$. [0.78m]

Transmission of pressure in liquids



The **transmission of pressure in liquids** is explained by **Pascal's Principle**, which states:

Pascal's principle states that the pressure applied at a point in an enclosed fluid is transmitted equally to all parts of the fluid

This means that if you apply pressure to a confined liquid, that pressure is passed on uniformly to every part of the liquid and the walls of the container.

Real-Life Applications:

1. **Hydraulic Systems** – Found in car brakes, car jacks, and heavy lifting equipment. A small force applied at one point gets transmitted and magnified to move heavier loads at another.
2. **Dentist Chairs & Barber Seats** – Use hydraulics to smoothly raise or lower the chair with minimal effort.
3. **Hydraulic Presses** – Used in manufacturing to mold, press, or cut materials using transmitted pressure.

4. **Aircraft Landing Gear** – Hydraulic systems transmit pressure to extend and retract landing gear smoothly.

Example 3

- (a) The pistons of a hydraulic press have their areas given as A and $10A$ respectively. If the smaller piston is pushed down with force F , what is the force required to push the larger piston?

Let the force required to push the larger piston be F_2

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

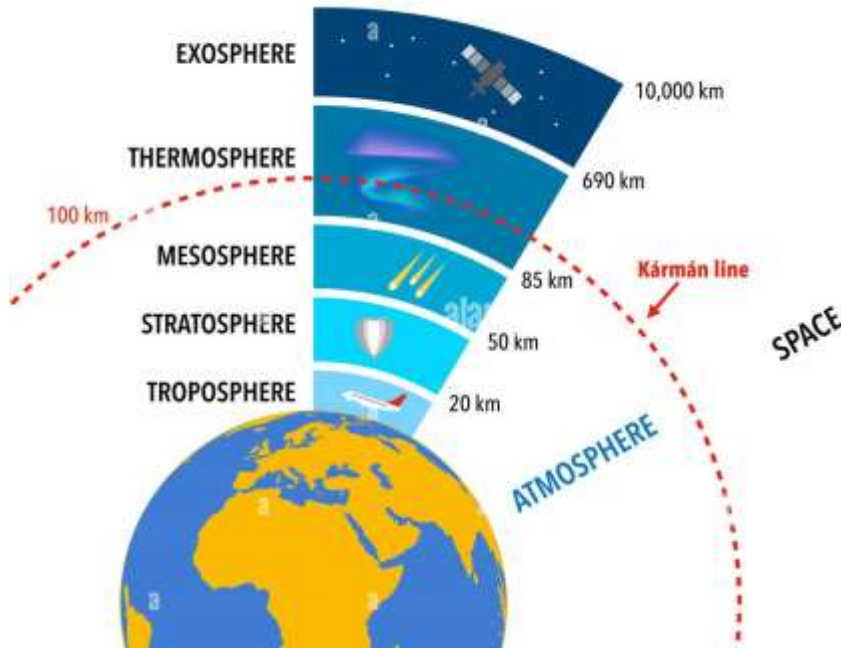
Since pressure is constant, then $\frac{F_2}{10A} = \frac{F}{A}$

Hence, $F_2 = 10F$

Exercise 4.3

- (a) The pistons of a hydraulic press have their areas given as $3.0 \times 10^{-2} \text{m}^2$ and $2.0 \times 10^2 \text{N}$ respectively. If the smaller piston is pushed down with force 120N , what is the force required to push the larger piston? [$8.0 \times 10^5 \text{N}$]
- (b) A force of 40N applied on the piston pump of area 2cm^2 to lift a load of 1000N placed on the ram piston. Calculate the
- (i) Pressure transmitted [$200,000 \text{Nm}^{-2}$]
 - (ii) The area of the ram piston in square centimeters [50cm^2]
- (c) (a) State Pascal's principle.
- (b) In a hydraulic press, a force of 200N is applied to master piston of area 25cm^2 . If the hydraulic press is designed to produce a force of 5000N , determine
- (i) The area of the slave piston in m^2 [0.0625m^2]
 - (ii) The radius of the slave piston in cm [14.1cm]

Atmosphere



The **atmosphere** is the invisible, protective blanket of gases that surrounds Earth. It is divided into **five main layers**, each with unique characteristics and roles that support life and protect the planet:

- (i) **Troposphere** occupies space from Surface to ~12 km. This is where *all weather* occurs—clouds, rain, storms. It contains about 75% of the atmosphere's mass and most of its water vapor. Temperature decreases with altitude here.
- (ii) **Stratosphere** is the second layer that occurs between 12 km to 50 km. it contains ozone layer, which absorbs harmful ultraviolet (UV) radiation from the sun. Unlike the troposphere, temperature increases with height due to ozone absorption of UV rays. Jet aircraft often cruise here for smoother flights.
- (iii) **Mesosphere** is the third layer occurring between 50 km to 85 km. It's the coldest layer, with temperatures dropping as low as -90°C .
- (iv) **Thermosphere** the fourth layer occurs between 85 km to 600 km. here temperatures soar up to 1500°C due to absorption of high-energy solar radiation.
- (v) **Exosphere** the fifth layer occurs between 600 km to 10,000 km. it is thin and contains hydrogen and helium. It gradually fades into the vacuum of space and is where many satellites orbit.

Harmful human activities to the atmospheres

Humans have had a profound impact on the atmosphere—some of it beneficial, but much of it harmful. Here are some of the most damaging activities:

- (i) **Burning Fossil Fuels:** Cars, factories, and power plants release **carbon dioxide (CO₂)** and **methane (CH₄)** into the air. These greenhouse gases trap heat, leading to global warming and climate change.
- (ii) **Deforestation:** Cutting down forests reduces the number of trees that absorb CO₂. It also disrupts ecosystems and contributes to increased atmospheric carbon.
- (iii) **Industrial Emissions:** Factories emit pollutants like **sulfur dioxide**, **nitrogen oxides**, and **particulate matter**, which can cause acid rain and respiratory problems.
- (iv) **Use of CFCs:** Chlorofluorocarbons (CFCs), once common in aerosols and refrigerants, have damaged the **ozone layer**, which protects us from harmful UV radiation. Though largely banned, their effects linger.
- (v) **Agricultural Practices:** Fertilizers release **nitrous oxide**, another potent greenhouse gas. Livestock farming also produces large amounts of methane.
- (vi) **Urbanization:** Expanding cities increase energy use, vehicle emissions, and heat retention (urban heat islands), all of which strain the atmosphere.

How to mitigate the negative effects of human activities on atmosphere

Mitigating the negative effects of human activities on the atmosphere requires both individual action and systemic change. Here are some powerful strategies:

- (i) **Switch to Clean Energy:** Using renewable sources like solar, wind, and hydroelectric power reduces reliance on fossil fuels, cutting down greenhouse gas emissions.
- (ii) **Reforest and Protect Green Spaces:** Trees absorb carbon dioxide and release oxygen. Reforestation and preventing deforestation are among the most effective ways to combat climate change.
- (iii) **Adopt Sustainable Transportation:** Walking, biking, using public transit, or switching to electric vehicles can significantly reduce air pollution and carbon emissions.
- (iv) **Reduce, Reuse, Recycle:** Minimizing waste and reusing materials helps lower the energy and emissions involved in production and disposal.
- (v) **Improve Energy Efficiency:** Insulating homes, using energy-efficient appliances, and turning off unused electronics can reduce energy consumption and emissions.
- (vi) **Support Climate-Friendly Policies:** Advocating for environmental regulations, clean energy investments, and sustainable urban planning can drive large-scale change.

- (vii) **Educate and Inspire Others:** Spreading awareness and encouraging others to take action multiplies the impact. Collective effort is key to reversing environmental damage.

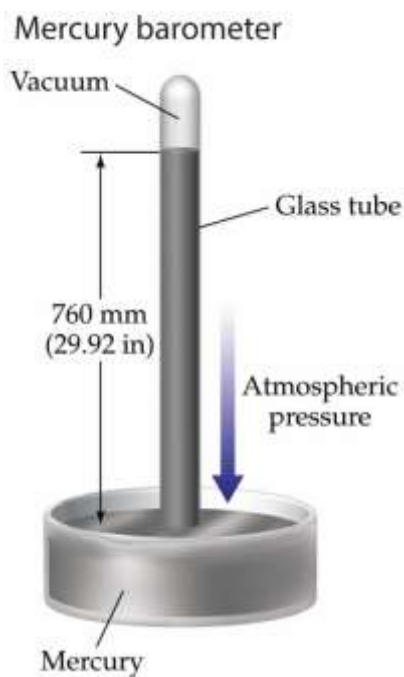
Exercise 4.4

Explain the mitigation on negative effect of human activities to atmosphere

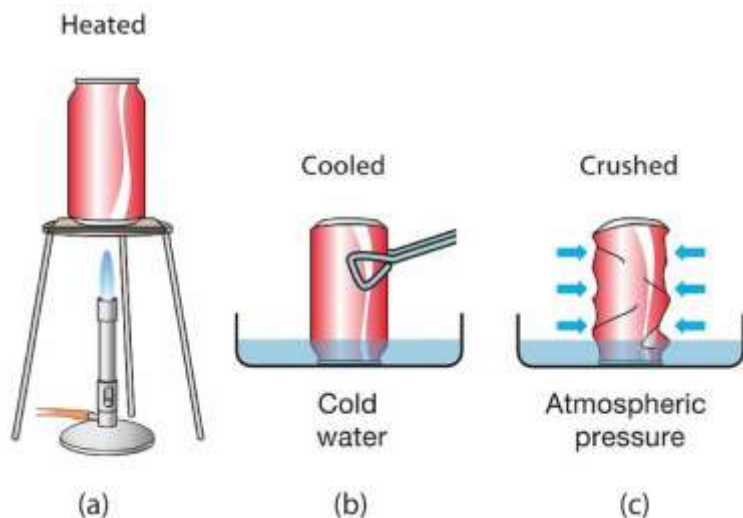
Atmospheric pressure

Atmospheric pressure is the force per unit area exerted on a surface by the weight of the air above it in the Earth's atmosphere. At sea level, atmospheric pressure is about **101,325 Pascals (Pa), 1 atmosphere (atm) or 760 mmHg**. It decreases with altitude because there's less air above you.

Atmospheric pressure is measured by mercury barometer or aneroid barometer shown below



Experiment to demonstrate atmospheric pressure



- (a) Heat a little water in a can until it boils.
- (b) Close the opening of the hot can and place it in cold water.
- (c) Observations: the can collapses.

Explanation

- (i) Boiling water fills the can with steam, displacing the air.
- (ii) When the can is flipped into cold water, the steam rapidly condenses back into liquid, creating a partial vacuum inside.
- (iii) With little to no internal pressure, the **atmospheric pressure outside crushes the can**.

Applications of atmospheric pressure

- (i) **Drinking with a Straw:** When you suck air out of a straw, you lower the pressure inside it. The higher atmospheric pressure on the drink's surface pushes the liquid up into your mouth.
- (ii) **Syringes and Droppers:** Pulling the plunger or releasing the bulb reduces internal pressure, allowing atmospheric pressure to push liquid into the device.
- (iii) **Vacuum Cleaners:** They create a low-pressure zone inside, and atmospheric pressure forces air (and dust) into the machine.
- (iv) **Rubber Suckers (Suction Cups):** Pressing them against a surface expels air, creating a partial vacuum. Atmospheric pressure then holds them firmly in place.

- (v) **Lift Pumps:** Used to draw water from wells—atmospheric pressure pushes water up when air is removed from the pump cylinder.
- (vi) **Can Crushing Experiment:** Heating and then rapidly cooling a can cause's internal pressure to drop. Atmospheric pressure outside crushes the can—dramatic proof of its strength!
- (vii) **Weather Forecasting:** Barometers measure atmospheric pressure to predict weather changes—falling pressure often signals storms.

Exercise 4.5

- (a) Demonstrate atmospheric pressure.
- (b) Give five applications of atmospheric pressure

Daily Variation in Atmospheric Pressure

Definition: Pressure changes within 24 hours due to heating and cooling of the atmosphere.

Typical Range: 2–3 hPa at sea level, larger at higher altitudes.

Causes:

- Solar heating during the day reduces air density → lower pressure.
- Cooling at night increases density → higher pressure.
- Local factors like humidity, wind, and terrain also play a role.

Effects on Weather

- (i) **High pressure (rising barometer):** Clear skies, dry weather, calm winds.
- (ii) **Low pressure (falling barometer):** Cloud formation, rainfall, storms.
- (iii) **Rapid drops in pressure:** Signal strong winds and heavy precipitation.

Effects on Climate

Long-term pressure patterns shape climate zones:

- **Equatorial low pressure:** Warm, wet, tropical climates.

- **Subtropical high pressure:** Dry deserts.
- **Polar high pressure:** Cold, dry climates.

Impact on High-Altitude Climbers

Reduced oxygen availability: At 5,500 m, pressure is ~500 hPa (half sea level).

Effects: Breathlessness, fatigue, risk of altitude sickness.

Adaptations: Acclimatization, supplemental oxygen, slower ascent.

Impact on Divers

Increased pressure underwater: Every 10 m depth adds ~1 atm (1013 hPa).

Effects: Nitrogen dissolves in blood → risk of decompression sickness (“the bends”).

Precautions: Controlled ascent, use of dive tables, breathing gas mixtures.

Summary Table

Context	Pressure Effect	Impact
Weather	Rising = clear, falling = rain	Predicts daily conditions
Climate	Long-term pressure zones	Defines deserts, tropics, polar regions
Climbers	Lower oxygen at altitude	Altitude sickness, need acclimatization
Divers	Higher pressure underwater	Risk of decompression sickness

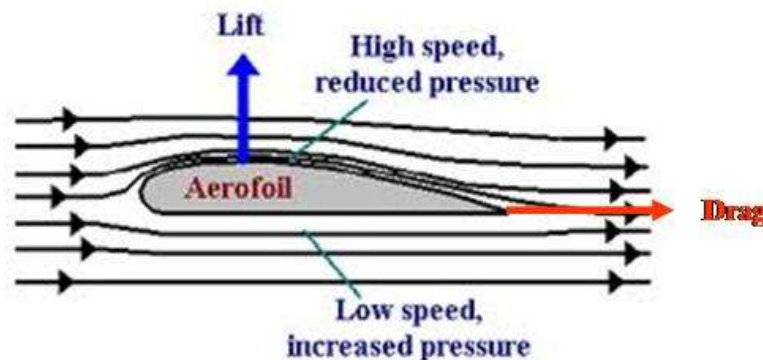
Key Insight: Daily pressure variations are small but crucial for **weather forecasting**, while extreme changes at altitude or underwater pose serious risks to **climbers and divers**.

Bernoulli's effect

The **Bernoulli effect** (or Bernoulli's principle) is a concept in fluid dynamics that explains how **fluid pressure decreases as the fluid's speed increases**.

Application of Bernoulli Effect

- (a) **Airplane Wings:** Air moves faster over the curved top of a wing than underneath, creating lower pressure above and lifting the plane.



- (b) **Spray Bottles:** Fast-moving air over a tube draws liquid upward due to lower pressure.
(c) **Chimneys:** Wind blowing across the top creates low pressure, helping smoke rise.

Exercise 4.6

Explain the following in relation to Bernoulli's Effect.

- (a) It is not advisable to stand close to the railway when a fast moving train is passing.
(b) Rifting of roofs from buildings during high speed wind.

Upthrust

Upthrust, also known as **buoyant force**, is the upward force exerted by a fluid (liquid or gas) on an object that is either fully or partially submerged in it.

Why It Happens:

When an object is placed in a fluid, the pressure at the bottom of the object is greater than the pressure at the top. This difference in pressure creates a net upward force—**upthrust**.

Archimedes' Principle:

Upthrust is equal to the **weight of the fluid displaced** by the object. So:

- If upthrust > object's weight → it floats
- If upthrust < object's weight → it sinks
- If upthrust = object's weight → it hovers or stays suspended

Law of floatation

The **law of floatation** states that: *A floating object displaces its own weight of the fluid in which it floats.*

Everyday Examples:

- A boat floating on water
- A helium balloon rising in air
- You feeling lighter when swimming

Example 4

(a) A boat of mass 150kg floats on water. Find

(i) The upthrust

$$\begin{aligned}\text{Upthrust, } F &= \text{Weight of the boat} \\ &= mg \\ &= 150 \times 10 \\ &= 1500\text{N}\end{aligned}$$

(ii) The mass of water displaced

From Archimedes' principle, the weight of water displaced is equal to upthrust.

$$\text{Mass of water} = \frac{\text{weight of water}}{10} = \frac{1500}{10} = 150\text{kg}$$

(iii) The maximum mass the boat can load if the volume of the boat at the safety level is 3.0m^3 .

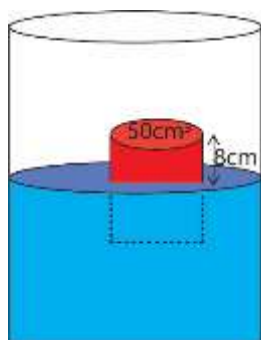
Upthrust, $F = \text{weight} = mg$

$$\begin{aligned}mg &= \rho vg \text{ since mass} = \text{density, } \rho \times \text{volume } v \\ &= 1000 \times 3 \times 10 = 30,000\text{N}\end{aligned}$$

$$\begin{aligned}\text{Maximum weight of the load} &= \text{weight sustained} - \text{weight of the boat} \\ &= 30,000 - 1500 \\ &= 28,500\end{aligned}$$

$$\text{Maximum mass of the load, } m = \frac{\text{weight of load}}{g} = \frac{28,500}{10} = 2,850\text{kg}$$

(b) The figure below shows a cylinder immersed in water. If the height of the cylinder is 20cm, and the density of water is 1000kgm^{-3} . Find the density of the cylinder in kgm^{-3} .



Volume of water displaced = $50 \times 12 = 600\text{cm}^3$

Mass of water = $600 \times 1 = 600\text{g}$ or $\frac{600}{1000} = 0.6\text{kg}$

Volume of the cylinder = $20 \times 50 = 1000\text{cm}^3$ or $\frac{1000}{1000000} = 0.001\text{m}^3$

Density = $\frac{\text{mass}}{\text{volume}} = \frac{0.6}{0.001} = 600\text{kg/m}^3$

Exercise 4.7

1. A metal of volume 0.3m^3 is held in water with a string. What is the tension in the string if the density of the metal = $8 \times 10^3\text{kgm}^{-3}$ and the density of water = $1 \times 10^3\text{kgm}^{-3}$. [14,000N]
2. The density and mass of a metal block are 5000kgm^{-3} and 4.0kg respectively. Find the upthrust which acts on the metal block when it is fully immersed in water. (The density of water = 1000kgm^{-3}) [8N]
3. A steel cable holds 120kg shark tank 3m below the surface of salt water. If the volume of water displaced by the shark is 0.1m^3 , what is the tension in the cable? Assume the density of salt water is $1,025\text{kgm}^{-3}$. [175N]

THEME: SCIENCE AND ENERGY

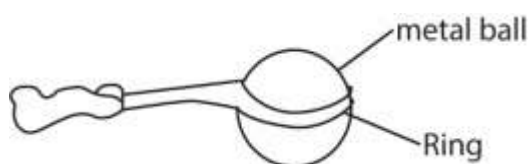
TOPIC 6: EXPANSION OF SOLIDS, LIQUIDS AND GASES

Competency: the learner explores the effect of heat on solids, liquids and gases in relation to their use in everyday life

Expansion

This is the increase in size of matter in all directions whenever matter is heated.

Expansion in Solid.



- (i) Before heating, the metal ball passes through the ring easily
- (ii) After heating the metal ball does not pass through the ring showing that when the metal ball (Solid) was heated, it expanded.
- (iii) When the metal ball cooled, it was found to pass through the ring. This indicated that on cooling the metal ball (Solid) contracted.

Metals expand by different amounts



When the bimetallic strip of Iron and Brass is heated, it bends with brass on the outside of the curve. This is because Brass expands more than Iron.

Bimetallic strips are useful in the following devices by completing the metallic circuit

- (i) ringing alarm bells
- (ii) thermostats

Linear Expansivity

Linear expansivity refers to the fractional increase in length of a material per unit length per degree rise in temperature. It is a key concept in thermal expansion, helping engineers and scientists predict how materials behave under temperature changes.

Formula:

The coefficient of linear expansion (α) is given by: $\alpha = \frac{\Delta L}{L_0 \Delta T}$

Where:

- ΔL = Change in length
- L_0 = Original length
- ΔT = Change in temperature

Application of expansion of solids

- Railway tracks:** Gaps are left between rails to accommodate thermal expansion, preventing warping and misalignment.
- Bridges and buildings:** Expansion joints allow structures to expand and contract with temperature changes, reducing stress.
- Electrical wires:** Overhead power lines are installed with slack to prevent breakage due to contraction in cold weather.
- Bimetallic strips:** Used in thermostats and temperature-sensitive devices, these strips bend due to different expansion rates of metals.
- Automobile engines:** Pistons and cylinders expand when heated, ensuring proper function and efficiency

Exercise 6.1

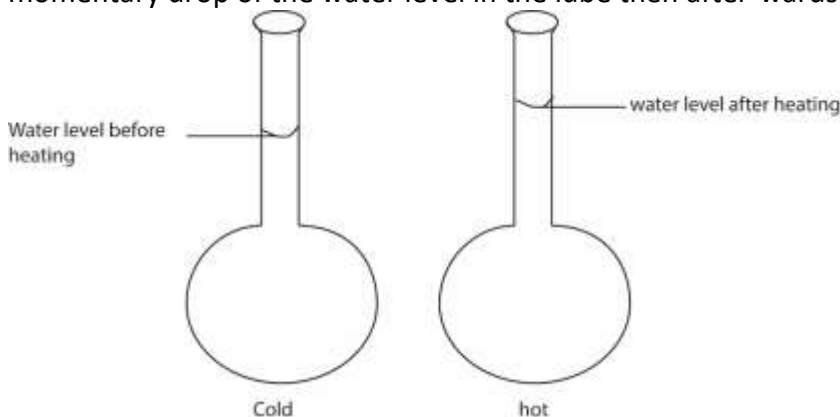
- Demonstrate expansion in solid.
- Explain any five applications of expansion in solids

Expansion of liquids

Liquids expand when they are heated. Different liquids expand by different amounts when equally heated. Liquids expand much more than Solids because according to the Kinetic theory, liquid molecules are far apart compared to those of solids and the intermolecular forces are weaker in liquids.

Experiment to demonstrate expansion of water

When the round bottomed flask is placed in hot water as shown, initially there will be a momentary drop of the water level in the tube then after-wards the level rises.



Explanation

When the flask is in hot water, the flask first receives heat before the water in it so the flask expands and its volume increases causing the slight fall in level. However, on receiving the heat, the water expands more than the increase in volume of the flask.

Applications of expansion of liquids

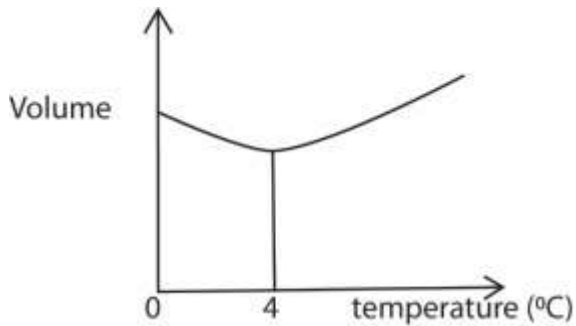
The **expansion of liquids** has several practical applications in daily life and industry. Here are some key examples:

- (i) **Thermometers:** Liquids like mercury and alcohol expand with temperature changes, allowing accurate measurement.
- (ii) **Car engine cooling systems:** Coolants expand when heated, helping regulate engine temperature.
- (iii) **Hot air balloons:** Heated air expands, reducing density and allowing the balloon to rise.
- (iv) **Cooking and food processing:** Liquids expand when heated, affecting boiling points and cooking efficiency.
- (v) **Industrial processes:** Liquid expansion is considered in chemical reactions, fuel storage, and hydraulic systems.

Anomalous expansion of water (Unusual expansion of water)

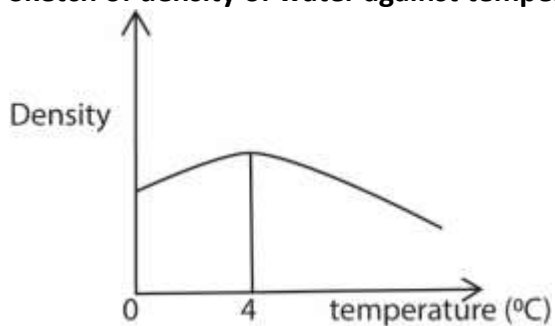
For all Solids except ice, when they melt to form liquids they expand just after melting but Ice which melts at 0°C to form water contracts until 4°C . Water is thus exceptional or anomalous in the range 0°C to 4°C

Sketch of volume against temperature



From the sketch it is noted that water has its minimum volume at 4°C

Sketch of density of water against temperature



Since density is mass/volume but mass is unaltered by warming. It is only volume which decreases from 0°C to 4°C. It follows that water has its maximum density at 4°C.

Biological Importance of abnormal expansion

Ice is less dense than water so it floats on water. Ice insulates water bodies during winter preventing further solidification of water. This protects aquatic organisms from freezing.

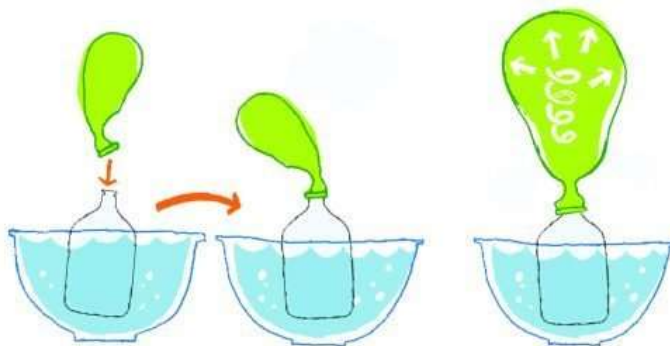
Exercise 6.2

- (a) Demonstrate expansion in liquids.
- (b) explain any five applications of expansion in liquids.

Expansion of gases

Like liquids and solids gases expand when heated although, the expansion of gases is far much greater. This is because molecules in gases have weak intermolecular forces, so they easily get broken when heated.

Experiment to demonstrate expansion in gases



- (i) Fill two bowls—one with **cold water** and the other with **hot water**.
- (ii) Place an **empty plastic bottle** in the cold water for a minute.
- (iii) Fit a **balloon** over the bottle's opening.
- (iv) Now, place the bottle into the hot water.
- (v) Watch the balloon **expand** as the gas inside the bottle heats up and expands.

Applications of expansion in gases

- (i) **Hot air balloons:** Heated air expands, reducing its density and allowing the balloon to rise.
- (ii) **Internal combustion engines:** Fuel combustion causes gas expansion, driving pistons and generating power.
- (iii) **Air conditioning and refrigeration:** Gases expand and contract to regulate temperature in cooling systems.
- (iv) **Weather phenomena:** Atmospheric expansion influences wind patterns, storms, and cloud formation.
- (v) **Jet propulsion:** Expanding gases in jet engines create thrust, enabling aircraft to fly.
- (vi) **Aerosol Sprays:** Compressed gas inside the can expands when released. This expansion forces the liquid product out as a fine spray.
- (vii) **Diving Equipment:** Compressed air tanks release gas that expands to match surrounding pressure. Regulators control expansion so divers can breathe safely underwater.
- (viii) **Meteorology:** Expansion of warm air causes it to rise, forming clouds and influencing weather patterns. This principle explains convection currents and storm formation.

- (ix) **Safety Valves in Pressure Vessels:** Expansion of gases increases pressure in boilers or cylinders. Safety valves release excess gas to prevent explosions.

Exercise 6.3

- (a) Describe an experiment to demonstrate expansion of air.
(b) Explain any five applications of the expansion of air

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Thank you

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