Chapter 6: Pressure, Winds, Storms, and Cyclones

1. Introduction to Force and Wind

- **Effects of Wind:** When strong winds blow, they can cause fallen leaves to rise and swirl, make trees sway or bend, slam doors, rattle windows, and flutter clothes.
- **The Cause:** These effects happen because the force exerted by the wind creates wind pressure.

2. Understanding Pressure

- **Concept of Pressure (Megha and Pawan Example):** Carrying a heavy bag with narrow straps hurts the shoulders more than carrying an identical bag with broad straps.
- **Why Straps Matter:** The weight of the bag with narrow straps acts on a smaller area of the shoulders. Conversely, broad straps spread the same weight over a larger area, reducing the pressure and making it more comfortable to carry.
- **Definition:** Pressure is defined as the force acting per unit area (specifically, force acting perpendicular to the surface).
- **Formula:** $Pressure = \frac{Force}{Area}$.
- **SI Unit:** The SI unit of force is the newton (N) and area is $metre^{2}$ (m^{2}). Therefore, the SI unit of pressure is newton/$metre^{2}$ (N/m^{2}), which is also called a pascal (Pa).
- **Example Calculation:** If a force of 100 N is applied on a 2 m^{2} area, the pressure is $\frac{100~N}{2~m^{2}} = 50~N/m^{2}$.
- **Everyday Applications of Pressure:**
    - **Driving a nail:** It is easier to drive an iron nail into wood using its pointed end rather than its flat head because the smaller area at the point creates higher pressure.
    - **Cutting:** An apple is easier to cut with a sharp edge than a blunt edge due to the smaller surface area exerting higher pressure.
    - **Carrying Loads:** People carrying heavy pots or baskets on their heads place a round piece of cloth underneath to increase the area of contact, thereby reducing the pressure on their heads.
    - **Buckets:** Lifting a water bucket with a broad handle feels easier than one with a narrow handle.

3. Pressure Exerted by Liquids

- **Pressure Depends on Height (Activity 6.1):** If two pipes of different diameters are filled with water to the same height, identical rubber balloons attached to their bottoms will bulge to the exact same extent.
- **Conclusion:** The bulge is caused by the pressure of the water column. Liquid pressure at the bottom of a vessel depends directly on the height of its liquid column, not on the diameter or total weight of the water.
- **Overhead Tanks:** Water tanks are placed at a height (e.g., on building rooftops) to increase the height of the water column. This increases the pressure, resulting in a powerful stream of water from the taps below.
- **Pressure on Walls (Activity 6.2):** If holes are made at the same height around the sides of a plastic bottle filled with water, the water spurts out equally from all holes.
- **Conclusion:** Liquids exert pressure not just on the bottom, but also on the sides of the container. In fact, liquids exert pressure in all directions.
- **Dam Construction:** The base of a dam is built much broader than its top. This broad base is necessary to withstand the immense horizontal water pressure near the bottom, which increases with the depth of the stored water.

4. Pressure Exerted by Air (Atmospheric Pressure)

- **The Atmosphere:** The envelope of air surrounding the Earth is called the atmosphere, extending many kilometres above the surface. It contains gases like nitrogen, oxygen, argon, and carbon dioxide.
- **Paper Plate Experiment (Activity 6.3):** Lifting an inverted paper plate is much harder when covered with a large, unfolded chart paper compared to a smaller folded piece. Because the unfolded paper has a larger area, the air exerts a greater total force on it, making it harder to lift.
- **Definition:** The pressure exerted by the air around us is known as atmospheric pressure.
- **Pressure in all directions:** When blowing into a balloon, it inflates and expands in all directions because the air inside exerts pressure on the walls.
- **Magnitude of Atmospheric Pressure:** The force exerted by the atmosphere on a 15 cm × 15 cm area is nearly equal to the force of gravity on a 225 kg object (2250 N).

- **Why aren't we crushed?** We are not crushed by this massive weight because the pressure inside our bodies (caused by the movement of fluids and gases in tissues and organs) equals and balances the external atmospheric pressure.
- **Units of Air Pressure:** While the SI unit is pascal (Pa), practical units include the millibar (mb) and hectopascal (hPa), both of which equal 100 Pa.
- **The Sucker Example (Activity 6.4):** A rubber sucker pressed firmly against a smooth surface sticks to it because the air inside is pushed out, reducing internal pressure. The higher atmospheric pressure outside holds it firmly in place.

5. Formation of Wind

- **Air Moves Due to Pressure Differences (Activity 6.5):** If an inflated balloon is connected to an uninflated balloon via a straw, air flows from the inflated one to the uninflated one until they become the same size.
- **Rule of Wind:** Air always moves from a region of high air pressure to a region of low air pressure. The flow stops when the pressures equalize.
- **Link to Breezes:**
    - **Sea Breeze (Day):** Land heats faster than water, warming the air above it. The lighter warm air rises, creating a low-pressure area over land. High-pressure air from the sea blows towards the land.
    - **Land Breeze (Night):** Water stays warmer than land, creating low pressure over the sea. High-pressure air from the land blows towards the sea.
- **Wind Speed:** The greater the pressure difference between two areas, the higher the speed of the wind.

6. High-Speed Winds and Low Air Pressure

- **The Balloon Experiment (Activity 6.6):** Blowing air into the gap between two hanging balloons causes them to move *towards* each other.
- **The Principle:** Blowing creates a low-pressure area between the balloons. The higher air pressure on the outer sides pushes them together.
- **Conclusion:** High-speed winds are accompanied by reduced air pressure.
- **Blowing off Roofs:** When high-speed winds blow over houses, a low-pressure area is created above the roof. The higher pressure inside the house can push weak roofs up and blow them away.

- **Prevention:** Keeping doors and windows open during storms reduces the pressure difference between the inside and outside, helping prevent the roof from being blown off.

7. Storms, Thunderstorms, and Lightning

- **Formation of a Storm:**
    1. Land gets heated, warming the moist air above it, which becomes lighter and rises (creating low pressure).
    2. Cooler air rushes in to take its place, gets heated, and also rises, creating continuous wind circulation.
    3. As rising air expands, it cools, and its moisture condenses into water droplets to form clouds.
    4. These droplets merge into heavier drops and fall as rain, hail, or snow.
    5. The combination of strong winds and rain is called a storm (frequent in hot, tropical regions like India).
- **Formation of Lightning:**
    - Sometimes warm air rises to such extreme heights that low temperatures freeze the water droplets into ice particles.
    - Strong upward and downward winds cause ice particles and water droplets to rub against each other, generating static electric charges via friction.
    - Positively charged (lighter) ice particles accumulate at the top of the cloud, while negatively charged (heavier) water droplets gather at the bottom.
    - The negatively charged cloud base also induces a positive charge on the ground and nearby tall objects (trees, buildings).
    - When the charge build-up becomes massive, the insulating property of the air breaks down, resulting in a sudden flow of charges called a bright flash of lightning.
    - Lightning can happen within a single cloud, between two clouds, or between a cloud and the ground.
- **Thunder:** Lightning rapidly heats the surrounding air, causing it to expand violently and produce a loud sound called thunder. A storm with both lightning and thunder is a **thunderstorm**.

- **Local Names for Thunderstorms:**
    - *Kalboishakhi* (West Bengal, Bihar, Jharkhand).
    - *Bordoisila* (Assam).
    - *Mango Showers* (Kerala, Karnataka, Tamil Nadu - helps ripen mangoes and grow coffee).
- **Lightning Safety Precautions:** Stay away from tall objects, crouch down in a low-lying open area (do not lie flat), avoid metallic umbrellas, get out of water bodies, or take shelter inside a completely enclosed vehicle like a car or bus.
- **Lightning Conductor:** A metallic rod installed during building construction with a pointed top extending above the roof and the bottom buried deep into the ground. It protects the building by providing an easy path to safely transfer electric charges into the ground.

8. Cyclones

- **What is a Cyclone?** A large spinning storm that forms over warm ocean waters.
- **Formation Process:**
    1. Warm ocean water heats the moist air above it, making it rise.
    2. The water vapour condenses into raindrops, releasing immense heat back into the atmosphere.
    3. This released heat warms the air further, making it rise even faster and creating an area of extremely low pressure.
    4. Surrounding air rushes into this low-pressure center.
    5. The Earth's rotation causes these incoming winds to spin. This repeating cycle creates a spinning system of clouds, heavy rain, and high-speed winds known as a cyclone.
- **The Eye:** The exact center of the cyclone is called the "eye". It has the absolute lowest pressure and calm winds, while the region immediately surrounding the eye has the most violent winds and heaviest rainfall.
- **Dissipation:** Once a cyclone hits land, its source of warm, moist ocean air is cut off, causing it to gradually lose its strength.
- **Destruction Caused:**
    - Can generate peak wind speeds up to 270 km/h (like Cyclone Amphan in 2020).

    - Creates massive storm surges (walls of water 3-12 metres high) that flood coastal and inland areas.
    - Saltwater inundation contaminates drinking water and ruins soil fertility.
    - Heavy rains trigger river overflows and landslides.
    - Winds uproot trees, block roads, and cause severe power outages.
- **Protection & Monitoring:** We can protect ourselves by staying updated on weather reports and alerts issued by the India Meteorological Department (IMD). Modern weather monitoring satellites help track and predict cyclone paths to save lives and property. Keep emergency kits ready and move to designated cyclone shelters when warned.