Chapter 6: Pressure, Winds, Storms, and Cyclones

Exercises — Keep the Curiosity Alive

Q1 Choose the correct statement.

(i) Look at Fig. 6.21 carefully. Vessel R is filled with water. When pouring of water is stopped, the level of water will be ____.

(a) the highest in vessel P
(b) the highest in vessel Q
(c) the highest in vessel R
(d) equal in all three vessels

(ii) A rubber sucker (M) is pressed on a flat smooth surface and an identical sucker (N) is pressed on a rough surface:

(a) Both M and N will stick to their surfaces.
(b) Both M and N will not stick to their surfaces.
(c) M will stick but N will not stick.
(d) M will not stick but N will stick.

(iii) A water tank is placed on the roof of a building at a height 'H'. To get water with more pressure on the ground floor, one has to

(a) increase the height 'H' at which the tank is placed.
(b) decrease the height 'H' at which the tank is placed.
(c) replace the tank with another tank of the same height that can hold more water.
(d) replace the tank with another tank of the same height that can hold less water.

(iv) Two vessels, A and B contain water up to the same level as shown in Fig. 6.22. PA and PB is the pressure at the bottom of the vessels. FA and FB is the force exerted by the water at the bottom of the vessels A and B.

(a) PA = PB, FA = FB
(b) PA = PB, FA < FB
(c) PA < PB, FA = FB
(d) PA > PB, FA > FB

SOLUTION

(i) Answer: (d) equal in all three vessels.

Fig. 6.21 shows vessels P, Q, and R connected at their bases (communicating vessels). In communicating vessels, liquid always finds its own level — regardless

of the shape or width of individual vessels, the water surface rises to the same height in all connected vessels when equilibrium is reached. This is because pressure at every point on the same horizontal plane at the base must be equal.

(ii) Answer: (c) M will stick but N will not stick.
A rubber sucker works by evacuating air when pressed firmly against a surface. The atmospheric pressure outside then holds the sucker in place. On a flat smooth surface, sucker M makes a complete seal, expelling all air — atmospheric pressure holds it firmly. On a rough surface, sucker N cannot form a complete seal because the surface irregularities leave tiny gaps through which air re-enters. Without a pressure difference, no net force holds N in place.

(iii) Answer: (a) increase the height 'H' at which the tank is placed.
Pressure due to a liquid column is given by $P = \rho gh$, where h is the height of the liquid above the point where pressure is measured. To get more pressure at the ground floor, the height H of the water tank above the ground must be increased. The volume or capacity of the tank does not affect pressure (only the height of the water column matters).

(iv) Answer: (b) PA = PB, FA < FB.
From Fig. 6.22, both vessels A (narrow) and B (wide) contain water up to the same level. Since pressure at the bottom depends only on the height of the liquid column ($P = \rho gh$) and the height is identical, PA = PB.
However, Force = Pressure × Area. Vessel B has a wider base area than vessel A. Since PA = PB but Area_B > Area_A, the force on the bottom of B (FB) is greater than the force on the bottom of A (FA). Therefore FA < FB.

Answer: (i) (d) equal in all three vessels — communicating vessels reach the same level. (ii) (c) M will stick but N will not — smooth surface allows a complete seal; rough surface lets air back in. (iii) (a) increase the height H — pressure $P = \rho gh$ depends on height. (iv) (b) PA = PB, FA < FB — same water height gives equal pressure, but wider base of B gives larger force.

Q2 State whether the following statements are True [T] or False [F].
(i) Air flows from a region of higher pressure to a region of lower pressure.
(ii) Liquids exert pressure only at the bottom of a container.
(iii) Weather is stormy at the eye of a cyclone.
(iv) During a thunderstorm, it is safer to be in a car.

SOLUTION

(i) True [T].
Air (and all fluids) flows from a region of higher pressure to a region of lower pressure. This pressure difference is the driving force behind winds and air movement.

(ii) False [F].
Liquids exert pressure in all directions — at the bottom, on the walls, and on any surface in contact with the liquid. The pressure at any point inside a liquid acts equally in all directions (Pascal's principle). The bottom experiences the greatest pressure because it supports the full height of the liquid column above it, but the liquid also exerts lateral pressure on the walls.

(iii) False [F].
The eye of a cyclone is actually a region of calm weather — it has low wind speed, clear skies, and relatively light winds. The stormy, violent weather (heavy rain, strong winds) occurs in the eye wall, the ring of clouds surrounding the eye.

(iv) True [T].
During a thunderstorm, it is safer to be inside a car than in the open. A car's metal body acts like a Faraday cage — if lightning strikes the car, the electrical charge travels along the metal exterior and dissipates into the ground, leaving the occupants inside unharmed (as long as windows are closed and metal parts are not touched).

Answer: (i) T — air flows from high to low pressure. (ii) F — liquids exert pressure in all directions, not just at the bottom. (iii) F — the eye of a cyclone is calm; stormy weather is in the eye wall. (iv) T — a car's metal body acts as a Faraday cage, protecting occupants from lightning.

Q3 Fig. 6.23(a) shows a boy lying horizontally, and Fig. 6.23(b) shows the boy standing vertically on a loose sand bed. In which case does the boy sink more in sand? Give reasons.

SOLUTION

The boy sinks more in sand when standing vertically (Fig. 6.23b).

Reason: Pressure = Force / Area.
The weight (force) of the boy is the same in both cases. However, the area of contact with the sand is very different:
— When lying horizontally (Fig. 6.23a), the boy's entire body surface (back area) is in contact with the sand. This is a very large area, so the pressure exerted on the sand is low.
— When standing vertically (Fig. 6.23b), only the soles of the boy's feet are in contact with the sand. This is a very small area, so the same weight is distributed over a much smaller area, resulting in much greater pressure.

Since pressure is greater when standing, the sand cannot support the boy as easily and he sinks more. This is why sharp-heeled footwear sinks into soft ground while flat-soled footwear does not.

Answer: The boy sinks more when standing vertically (Fig. 6.23b). Standing concentrates his weight over the small area of his feet, creating much greater pressure on the sand than when lying flat (large contact area, low pressure).

Q4 An elephant stands on four feet. If the area covered by one foot is 0.25 m², calculate the pressure exerted by the elephant on the ground if its weight is 20000 N.

SOLUTION

Given:
Weight of elephant (Force) = 20000 N
Area of one foot = 0.25 m²
Number of feet = 4

Total area of contact = 4 × 0.25 = 1.0 m²

Pressure = Force / Area
Pressure = 20000 N / 1.0 m²
Pressure = 20000 Pa (or 20000 N/m²)

Answer: Pressure = 20000 N ÷ 1.0 m² = 20000 Pa (20000 N/m²).

Q5 There are two boats, A and B. Boat A has a base area of 7 m², and 5 persons are seated in it. Boat B has a base area of 3.5 m², and 3 persons are seated in it. If each person has a weight of 700 N, find out which boat will experience more pressure on its base and by how much?

SOLUTION

Given:
Boat A: base area = 7 m², number of persons = 5
Boat B: base area = 3.5 m², number of persons = 3
Weight per person = 700 N

Total weight on Boat A = 5 × 700 = 3500 N
Pressure on Boat A = Force / Area = 3500 / 7 = 500 N/m²

Total weight on Boat B = 3 × 700 = 2100 N
Pressure on Boat B = Force / Area = 2100 / 3.5 = 600 N/m²

Comparing: 600 N/m² > 500 N/m²
Boat B experiences more pressure by 600 − 500 = 100 N/m².

Answer: Boat B experiences more pressure (600 N/m²) than Boat A (500 N/m²) by 100 N/m².

Q6 Would lightning occur if air and clouds were good conductors of electricity? Give reasons for your answer.

SOLUTION

No, lightning would NOT occur if air and clouds were good conductors of electricity.

Reason: Lightning occurs because of a large build-up of electric charge in clouds — positive charges accumulate near the top of the cloud and negative charges near the bottom. Between the cloud and the ground (or between clouds), there is an insulating layer of air that prevents immediate discharge.

When the charge difference (potential difference) becomes very large, it overcomes the insulating resistance of air, causing a sudden massive discharge — this is lightning.

If air and clouds were good conductors, charge would flow continuously and

smoothly without accumulating. There would be no build-up of a large potential difference, and therefore no sudden massive discharge. Lightning is essentially the result of charge being unable to flow gradually — it is forced to discharge explosively when the insulating barrier (air) is finally overcome.

Answer: No. Lightning requires a large build-up of charge in clouds. If air and clouds were good conductors, charge would flow continuously rather than accumulate, so no large potential difference would develop and no sudden lightning discharge would occur.

Q7 What will happen to the two identical balloons A and B as shown in Fig. 6.24 when water is filled into the bottle up to a certain height? Will both the balloons bulge? If yes, will they bulge equally? Explain your answer.

SOLUTION

From Fig. 6.24, two identical balloons A and B are attached through tubes to the two sides of a bottle at the SAME height, near the bottom of the bottle.

Yes, both balloons will bulge outward when water is filled into the bottle.

Both balloons will bulge EQUALLY.

Reason: The pressure exerted by a liquid depends on the height (depth) of the water column above the point ($P = \rho gh$), and at any given depth the liquid exerts pressure equally in all directions. Since both balloons are fixed at the same height below the water surface, the water column above each is the same, so both experience the same pressure and bulge to the same extent.

This is the same result seen in Activity 6.1 of the chapter — equal water-column heights produce equal bulges in the balloons, regardless of the width of the vessel.

Answer: Yes, both balloons bulge, and they bulge equally. In Fig. 6.24 both balloons are attached at the same height near the bottom of the bottle, so the water column (depth) above each is the same. Since liquid pressure depends only on depth ($P = \rho gh$) and acts equally in all directions, both experience the same pressure and bulge equally.

Q8 Explain how a storm becomes a cyclone.

SOLUTION

A cyclone develops from a storm through the following process:

1. Warming over the sea: Over warm tropical oceans, the sun heats the sea surface strongly, causing large amounts of water to evaporate. The warm, moist air rises rapidly, creating a region of low pressure near the sea surface.

2. Inflow of surrounding air: Cooler surrounding air rushes in to fill the low-pressure zone. As this air moves inward, the Earth's rotation (Coriolis effect) causes it to spiral — anticlockwise in the Northern Hemisphere.

3. Intensification: As the spiraling moist air rises, it cools and condenses, releasing heat. This released heat warms the surrounding air further, causing it to rise faster. More air rushes in from the outside — the cycle intensifies.

4. Eye formation: The intensifying rotation creates a calm, low-pressure centre called the eye of the cyclone. The surrounding eye wall has the most violent winds and heaviest rainfall.

5. Fully developed cyclone: As the process continues, wind speeds increase dramatically (often exceeding 120 km/h). The system now becomes a fully developed cyclone — a large rotating storm system with a distinct eye, capable of causing widespread destruction when it makes landfall.

Answer: A storm becomes a cyclone when warm moist air rising from the ocean creates a low-pressure zone; cooler air spirals in (Coriolis effect), intensifying as condensation releases heat — this self-reinforcing cycle builds rotating wind speeds into a cyclone with a calm eye at its centre.

Q9 Fig. 6.25 shows trees along the sea coast in a summer afternoon. Identify which side is land — A or B. Explain your answer.

SOLUTION

From Fig. 6.25, the trees along the sea coast are bent and leaning toward side B (their trunks and fronds are swept toward B).

Side B is the land side (and side A is the sea side).

Explanation: On a summer afternoon, the land heats up much faster than the sea (land has a lower specific heat capacity). The air above the land becomes warmer and rises, creating a low-pressure region over the land. The air above the sea

stays cooler and denser, so the pressure over the sea is relatively higher.

Air (the sea breeze) flows from the region of higher pressure to the region of lower pressure — that is, from the sea toward the land during the day. This wind pushes and bends the trees in the direction it blows, i.e. toward the land.

Since the trees are bent toward side B, the wind must be blowing toward B. So the wind is travelling from the sea (side A) to the land (side B).

Therefore: B is the land, A is the sea.

Answer: Side B is the land. On a summer afternoon, land heats faster than the sea, creating low pressure over the land. The sea breeze blows from the sea (side A, higher pressure) toward the land (side B, lower pressure), and this wind bends the trees toward B — the direction it is blowing.

Q10 Describe an activity to show that air flows from a region of high pressure to a region of low pressure.

SOLUTION

Activity: Inflated balloon demonstration

Materials needed: One inflated balloon, a pin (optional) or just the balloon's nozzle.

Procedure:
1. Inflate a balloon fully and hold its opening tightly closed so no air escapes.
2. The air inside the inflated balloon is at higher pressure than the surrounding atmospheric air outside.
3. Now slowly release the opening of the balloon (or observe what happens if you make a small hole).

Observation: Air rushes out of the balloon with force, moving from the inside (high pressure) to the outside (low pressure) until the pressures equalise.

Conclusion: This demonstrates that air always flows from a region of higher pressure to a region of lower pressure. The same principle drives winds — air moves from high-pressure regions to low-pressure regions in the atmosphere.

Alternative activity: Take two empty bottles. Heat one bottle (creating low pressure inside as hot air rises and escapes). Place both bottles mouth-to-mouth. As the heated bottle cools, it draws air from the other bottle into itself, showing air movement from the higher-pressure bottle to the lower-pressure bottle.

Answer: Inflate a balloon and release its opening — air rushes from inside (high pressure) to outside (low pressure). This shows that air flows from high-pressure regions to low-pressure regions, the same principle that drives winds.

Q11 What is a thunderstorm? Explain the process of its formation.

SOLUTION

A thunderstorm is a violent storm accompanied by thunder, lightning, heavy rain, and strong winds. It develops rapidly from cumulonimbus (thunder) clouds over a short period.

Process of formation:

1. Heating and updraft: On hot, humid days, the sun strongly heats the land surface. Air near the ground becomes warm, moist, and rises rapidly in powerful updrafts.

2. Cloud formation: As the warm moist air rises, it cools and condenses to form large cumulonimbus clouds that grow rapidly upward — sometimes reaching heights of 10–15 km.

3. Charge separation: Within the cloud, rising warm air carries water droplets and ice particles upward. Collisions between these particles cause charge separation — the upper part of the cloud becomes positively charged while the lower part accumulates negative charges.

4. Downdrafts and rain: As the cloud grows, heavy water droplets and ice form. These are too heavy to be supported and fall as heavy rain. Falling rain drags cold air downward (downdraft). The interaction of strong updrafts and downdrafts creates turbulent, violent conditions inside the cloud.

5. Thunderstorm activity: Lightning discharges occur (within the cloud or cloud-to-ground). The rapid heating of air by lightning causes it to expand explosively, creating the sound wave we hear as thunder. Strong gusty winds, heavy downpours, and sometimes hail accompany the storm.

Thunderstorms typically last 30 minutes to an hour and are most common in tropical regions in summer afternoons.

Answer: A thunderstorm is a violent storm with thunder, lightning, and heavy rain. It forms when hot humid air rises rapidly, creates tall cumulonimbus clouds, causes charge separation (positive top, negative bottom), and discharges electricity as lightning — rapid air expansion from lightning produces the thunder.

Q12 Explain the process that causes lightning.

SOLUTION

Lightning is caused by the discharge of accumulated electric charges in thunderclouds. The process is as follows:

1. Charge build-up: Inside a thundercloud (cumulonimbus), warm air currents carry small water droplets and ice crystals upward at high speed. Collisions between these particles cause charge separation:

— Lighter, positively charged ice crystals are carried to the upper parts of the cloud.

— Heavier, negatively charged water droplets and ice pellets accumulate near the lower part of the cloud.

2. Induction on ground: The large negative charge at the base of the cloud induces a positive charge on the ground below it (especially on tall objects like trees and buildings).

3. Electrical breakdown: As the potential difference (voltage) between the cloud base and the ground (or between two parts of the cloud) grows very large, the insulating resistance of air is eventually overcome.

4. Lightning discharge: A massive and nearly instantaneous flow of electric charge (a spark) occurs — either cloud-to-cloud or cloud-to-ground. This electrical discharge is what we see as lightning.

5. Thunder: The enormous electrical energy heats the air along the lightning channel to about 30,000°C almost instantly. This causes the air to expand explosively, creating a pressure wave that we hear as thunder.

Answer: Lightning is caused by charge separation in thunderclouds (positive charges at top, negative at bottom). When the potential difference becomes large enough to overcome air's insulating resistance, a sudden massive electrical discharge occurs between clouds or cloud-to-ground — this is lightning. The explosive heating of air by the discharge produces thunder.

Q13 Explain why holes are made in banners and hoardings.

SOLUTION

Holes are made in banners and hoardings to reduce the wind pressure exerted on them.

Explanation using Bernoulli's principle and pressure concept:
When wind blows against a large flat surface (banner or hoarding), the banner obstructs the airflow. The wind exerts a large force (pressure × area) on the banner. If the banner has no holes, it acts like a solid wall — all the kinetic energy of the wind is converted to pressure on the banner. This creates a very large force that can:
— Tear the banner,
— Break the supporting structure, or
— Topple the hoarding entirely.

When holes are made in the banner, wind passes through the holes instead of being completely blocked. This reduces the effective area facing the wind and allows air to escape through the openings, significantly reducing the net force (pressure × area) exerted on the banner.

As a result, the banner or hoarding can withstand strong winds without being damaged, making it safer and more durable.

This is the same principle used in wind breaks, sails, and parachutes — managing airflow through the material to control the force experienced.

Answer: Holes in banners allow wind to pass through, reducing the effective area obstructing the wind and thus lowering the net force on the banner (Force = Pressure × Area). Without holes, the full wind force could tear the banner or topple the hoarding structure.