Chapter – 9: Force and Pressure

- Daily activities – opening door, kicking football, opening drawer – require push or pull

Force

- External agent – push or pull
- Force – particular direction
- Amount of force – **magnitude of force**
- Direction – force applied – **direction of force**
- Pulling drawer out – force towards ourselves
- Pushing door close – force towards door
- International system of units – unit – Newton (N)
- Other units – dyne, kilogram force, pound force
- Force – interaction between 2 objects
- Long piece of rope – cannot move by itself – children – playing tug of war – ropes move in both direction
- Force – applied in different direction – resultant force – difference of magnitudes – direction of greater force – equal force – resultant force – 0
- Force – applied in same direction – resultant force – sum of magnitudes – same direction

Effect of force

- Force can change speed of moving object or move object at rest
    - Apply brakes – opposite direction of moving car – slows down car
    - Press accelerator – force applied – same direction – car speeds up
    - Playing cricket – stopping ball
    - Playing football – move stationary ball
- Force can change shape of object
    - Squeeze tomato – gets smashed
    - Squeeze toothpaste – shape of tube change
    - Change – temporary or permanent
    - Shape of sponge changes when pressed – shape of dough changes when pressed – shape of metal sheet changes when hammered
- Force can change direction of motion
    - Tennis racquet – change direction of ball
    - Change direction of motion – apply force in different direction

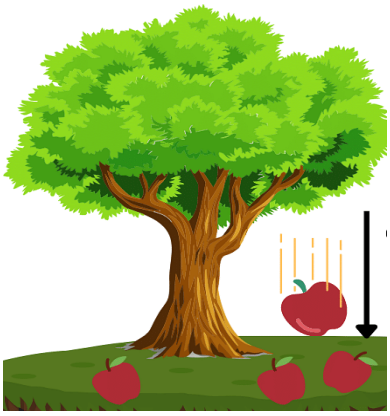
- Force – push or pull
- Changes – state of motion and/or shape of object
- State of motion – speed and direction

Types of force

- Force – push or pull – interaction between forces

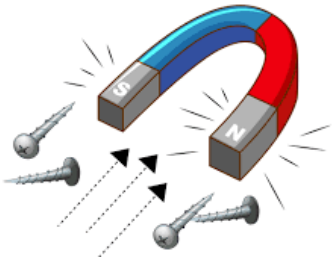
- Categorized as – **contact** and **non-contact**
  - Non-contact forces –
    - Interacting bodies – not in contact
    - Act from distance

    - **Gravitational force –**
      - Throw ball upwards – reaches a fixed height – falls down immediately
      - Reason – earth applies force – pulls ball back
      - This force – **gravity**
      - **Sir Isaac Newton** – observed earth's gravity – 1st time



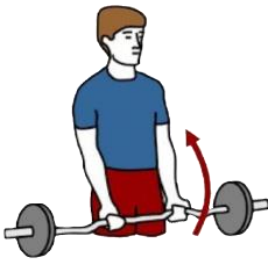
      - Every object – applies force on each other
      - Magnitude – depends – directly on product of masses – inversely on square of radius
      - Gravity of sun – all planets revolve around it
      - Mass – material of object – weight – force on object due to gravity
      - 3 kg apples – mass – same on earth and moon – weight – more on earth and less on moon
      - Weight – can be measured with spring balance
      - Hold a brick – after some time – hand feels heavy – gravity pulls the brick – muscles fight with gravity to keep holding it
    - **Electrostatic force –**
      - Comb your hair – hold the comb over your head – hairs stick to comb
      - Comb – gets electric charge – charged body – applies force – other charged on uncharged body
      - Charged comb – attracts piece of paper
      - Rub balloons on sweater – stick on the wall

    - **Magnetic force –**
      - Magnet – attracts other magnetic substances
      - Cranes – lift heavy objects, separate iron from garbage
      - Magnet – near iron fillings – attract them



- Contact forces –
  - Interacting bodies – always in contact
  - Different bodies – sliding against each other

  - **Muscular force –**
    - Applied by muscles of body
    - Kick football – muscles of leg
    - Lift school bag – muscles of arms
    - Oxen, camel – use muscles – pull carts with people and goods



  - **Frictional force –**
    - Stop peddling – cycle stops
    - Force applied on objects in contact – opposite to direction of motion – **friction**
    - Opposes the motion of objects

Pressure

- Effects of force – depends on – not only on magnitude – but also on area over which it acts
- Flat sandals – soft impressions – heels – deep impressions
- Force acting per unit area
- Pressure = force/area
- Less area – more pressure and vice-versa
- Stand on bed – bends more – lie on it – bends less
- Blunt knife – difficult to cut – sharp knife – easy to cut
- Blunt side – more area – less pressure – sharp side – less area – more pressure
- Women – carry mud pots – place cloth on head – increase area
- Men – carry luggage on stations – place cloth on head – increase area

- Nails – pointed end – less area – hammered easily

Unit of pressure

- SI system – force measured in Newton (N) – area measured in metre square (m^2)
- SI unit of pressure – Pascal (Pa)
- 1 Pa = 1 N/m^2

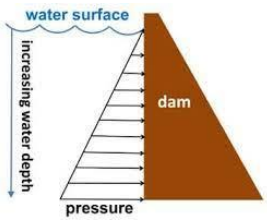
- Some things – high pressure – work well – scissors, bolt-cutters, knives
- Other things – low pressure – work well – tractors, vehicles that move over mud

Pressure exerted by air

- All fluids (liquids and gases) – exert pressure
- Fill balloon with air – it expands – pressure by air on the walls
- Keep filling it – at a stage, it bursts
- Pressure by atmospheric gases – **atmospheric pressure**
- Atmospheric pressure at sea level – **normal** or **standard pressure** – 100 kilo pascals (100 kPa)
- Pressure on our head – column of air over it – equal to force of gravity on 225 kg – 2250 N
- This pressure – too much – we don't feel it – pressure by blood in blood vessels – balances it
- High altitudes (heights) – low atmospheric pressure – same blood pressure – bleeding through nose and ears – blood vessels rupture
- Instrument – measure atmospheric pressure **- barometer**

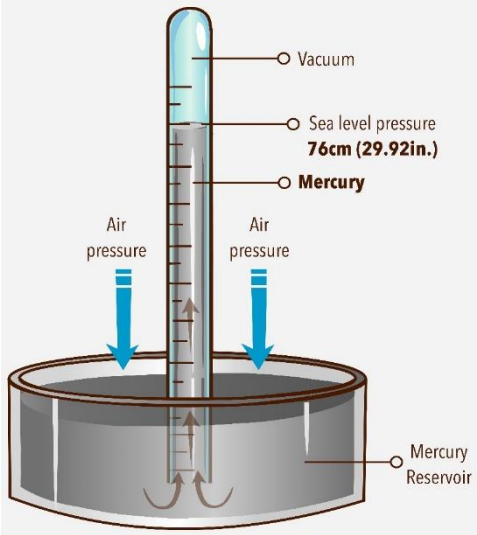
Pressure exerted by liquids

- Tie a balloon – end of hollow glass tube – fill it with water – balloon expands – **liquid exerts pressure in all directions**
- Take a jar – make a hole at bottom – attach a pipe – tie a balloon at the end – fill it with water – balloon expands – **liquid exerts pressure on walls**
- Take 2 jars – 1st – make holes at equal depths – 2nd – make holes at different depths – fill them with water – 1st – flow rate of water same at all holes – 2nd – flow rate of water different at different holes – more at lower holes – less on higher holes – **liquid exerts different pressure at different depths**
- Dams – store water – dam walls – built wider at bottom – more pressure by water



Measurement of pressure

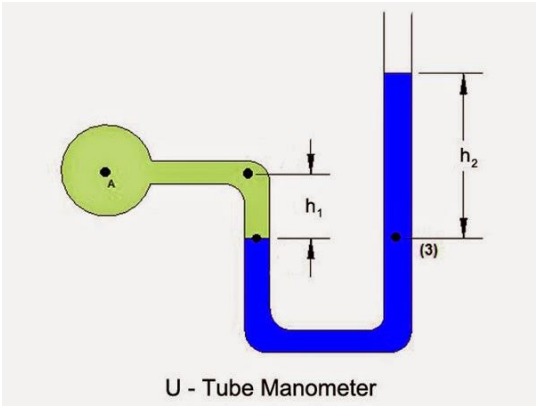
- Air pressure drops – tyres of vehicles – fill it up again – keep eye on machine – more air pressure – tyres may burst
- **Barometer** – measure atmospheric pressure
- Long tube (sealed at one end) – filled with mercury (Hg) – inverted into a tray of mercury
- Sea level – atmospheric pressure – pushes mercury in tray inside glass tube
- Height of mercury in the tube = atmospheric pressure
- Higher altitudes – less height – low pressure
- Standard – 760 mm of Hg



Can we use water instead of mercury?

- Water less dense – level of water – rise too much – very long glass tube required – barometer – bulky and impractical

- Another instrument – **U-tube manometer**
- Measure difference – pressure by atmosphere and pressure by other fluid
- Simple manometer – u shaped glass tube – filled with coloured water
- One end – open to atmosphere – other end – connected to container of fluid
- If atmospheric pressure > pressure of fluid – level of water in closed end – rise
- If atmospheric pressure < pressure of fluid – level of water in open end – rise
- If atmospheric pressure = pressure of fluid – level of water in both ends – same
- Pressure difference = $h_2 - h_1$



U - Tube Manometer

Application of pressure

- Pressure by liquids in blood vessels – blood moves throughout the body
- Rubber suckers – air inside them is sucked out – held against the wall by atmospheric pressure
- When juice is sucked through straw – air in straw goes to lungs – reduces pressure inside straw – liquid gets filled in straw
- Vacuum cleaner – switch on – low pressure inside it – sucks dirt inside it
- Squeezing of tooth paste, spray bottle, ketchup – work due to pressure difference