The basic **surface instruments** at any meteorological observatories are

- Mercury Barometer
- Four Thermometers i.e. Dry Bulb, Wet Bulb, Maximum and Minimum fixed inside the Thermometer screen (Stevenson screen).
- Raingauge and Measure glass.
- Wind instruments – Wind vane and Anemometer.

Meteorological elements:

The following meteorological elements are generally observed at observatories.

1. **Barometric Pressure**: -The pressure of air that is measured with the barometer.
2. **Dry Bulb temperature**: - Temperature of the air as measured by the dry bulb thermometer, kept inside the Thermometer Screen, at the time of observation.
3. **Wet Bulb temperature**:- Which gives in conjunction with the dry bulb temperature, the humidity of the air inside the thermometer screen and its dew point temperature.
4. **Maximum temperature**:- The highest temperature of the air indicated by the maximum thermometer in the thermometer screen since its last setting.
5. **Minimum temperature**:- The lowest temperature of the air indicated by the minimum thermometer in thermometer screen since its last setting.

Mercury Barometer:-

There are two types of mercury barometers are use at meteorological stations. They are the Fortin and the fixed cistern (or Kew pattern) barometers. The **kew pattern barometers** are being used in the India Meteorological Department.

Its essential parts are (1) Glass tube of about 90cm long closed at the top and open below (2) a cup or cistern (3) a brass scale. The glass tube is filled with mercury and its open end is dip in the mercury in the cistern, which prevent air from entering the tube. There is vacuum above the mercury column in the tube. Presence of air in minute quantity will affect the readings of the instrument. **The mercury column in the tube is supported by the pressure of the air on the surface of the mercury in the cistern.** This is the basic principle on which the barometer is constructed.

As the mercury in the barometer tube rises or falls due to changes in the atmospheric pressure, the mercury level in the cistern changes in the opposite direction. This change of level in the cistern is taken into account in the graduation of the scale itself.

In the **Fortin Barometer** the level of mercury in the cistern can be adjusted to bring it into contact with a fixed ivory pointer. The top of this pointer is at the zero of the barometer scale.

Aneroid Barometer: -

An aneroid barometer consists of a flexible sealed metal chamber. It is completely or partly evacuated and the distance between the centers of its opposite walls changes with atmospheric pressure.

A strong spring system prevents the chamber from collapsing due to the external atmospheric pressure. At any given pressure there will be an equilibrium position in which the force due to spring balances that of the external pressure.

One end of the cell is fixed, while the other is coupled to a pointer which move over a dial mark with pressure values. The coupling magnifies the movement of the pointer.

An aneroid barometer must be calibrated against the mercury barometer.

Advantages:

i. It is compact and portable and
ii. Convenient to use at sea or in field.

Disadvantage:

(i) Source of error due to incomplete compensation for temperature.

(ii) Weakening of spring with increasing temperature, which causes high pressure indicated by the instrument.

(iii) Elasticity error also occur due to the variation of temperature, which will affect true pressure.

Thermometer:-

Temperature of a body is the condition, which determines its ability to communicate heat to other bodies or to receive heat from them. Meteorologist is interested in the temperature of the air, of the soil and of water bodies. Temperature is measured by means of a thermometer.
Thermometer consists of a glass bulb containing mercury or spirit connected with the glass tube of very small bore closed at the top. The rise or fall of mercury or spirit in tube due to expansion or contraction of mercury or spirit is measured by calibrating the tube with standard temperatures. The temperature measured by thermometer is in degree Celsius.

Why mercury is used in Thermometer?

(i) It is shining, silvery white, which can be seen easily from outside the glass.
(ii) It does not stick to the glass.
(iii) Its expansion is fairly uniform over a wide range of temperature.

(iv) Its freezing point is -39ºc and boiling point is 357ºc whereas alcohol thermometers are used to measure between -125ºc to about 50ºc.

Maximum Thermometer: -

The maximum thermometer is mercury in glass thermometer with a constriction in the bore below the lowest graduation. When the temperature falls after reaching the maximum value the mercury does not return to the region below the constriction, provided that the stem of the thermometer is approximately horizontal.

The maximum thermometer rests bulb downwards at an angle of about 2º to the horizontal. The reason for the slight slope is to prevent the mercury column from drawing away from the constriction.

Minimum Thermometer: -

The liquid inside the minimum thermometer is spirit in which is immersed a dumb bell-shaped index. When the temperature falls, the spirit drags the index along with it towards the bulb end; but when the temperature rises the spirit expands and runs past the index without disturbing it. Thus, the end of the index farthest from the bulb gives the lowest temperature attained by the instrument. To set the minimum thermometer, remove it from its supports and tilt it slowly, bulb upwards, until the index touches the end of the spirit column.

Dry bulb Thermometer: -

Dry bulb thermometers have usually small bulbs, which may be round or cylindrical. The surface air temperature refers to the free air at a height of between 1.25 and 2m above ground level. It is necessary to read thermometer as rapidly as is consistent with accuracy, in order to avoid the changes in the temperature due to presence of the observer. The end of mercury column is curved and this surface is known as the meniscus. The air temperature is read to the nearest tenth of a degree.

Wet bulb Thermometer: -

This helps to find out the relative humidity of the surrounding air. The Wet bulb thermometer is as similar as dry bulb thermometer. The bulb is always kept wet by means of a muslin sheath, fed by water from a bottle through a wick. The diameter of muslin is 3cm (circular). For the wick, take four strands of darning cotton and loop them round the neck of the bulb over the muslin in the form of the noose, so that 8 tips of the thread will be dipped in the bottle filled with distill water. Cloth and thread should be changed every fortnight.

The bottle must have a small neck so that air inside the S.S. may not be moistened by evaporation of water in it. The bottle must not be placed below the wet bulb but a little on one side of it away from the dry bulb; otherwise, the thermometer may read too high. The part of the wick exposed to the air should be about 10 to 15 cm in length and must not form any loop so that water will not drip out.

Stevenson's Screen: -
It is used for keeping Hygrograph/Thermograph/thermometer to prevent them from direct solar heat and wind speed. It is made up of wooden rectangular box with its sides and door double louvered and with a double-layered roof with air space in between. The upper roof projects 5cms beyond the sides of the screen and slopes from front to back. Due to white paint, effect of heating of wood by solar radiation is avoided. The height of the top of the support from ground is 1.25 m. The thermometer screen is to be erected on four stout wooden posts with its door opening to the north and at such a height that the bulbs of the wet and dry bulb thermometer shall be between 1.30 and 1.40 meters above the ground.

Wind Instruments

Wind:- Wind is defined as air in motion and is expressed in terms of direction and speed. Wind direction is regarded as the direction from which it blows and speed as the rate of movement of air in its instantaneous direction.

Wind vane:- The wind direction is given by an instrument called the windvane. It is a balanced lever, which turns freely about a vertical axis. The one end of the lever exposes a broad surface to the wind, while the other end is narrow and points to the direction from which the wind blows. Wind direction is determined with reference to 16 points of compass. Wind speed is measured in knots or kilometers per hour.

In an open site it can be installed on a steel or wooden lattice tower or mast 6 meters high and well guyed within observatory enclosure. When obstructed by trees or building or a high mast so that it is higher by at least 3meter than the highest obstacle in the immediate vicinity. When both the anemometer and wind vane are fixed on the same platform, they should be at least 2meters apart.

Maintenance of wind vane: -

(1) Lubrication: - Lubrication is done every fortnight. Lubricate the ball bearings with few drops of spindle oil. For this remove the horizontal arm after taking out the top nut. Take out the screw and put a few drops of oil into the hole and replace it.

(2) Overhauling: - Keep the instrument clean. Examine the four set screws once in a month and tighten them if necessary. Once every six months examine carefully all the parts of the instrument and wash them thoroughly in kerosene oil, clean, dry then lubricate.

Anemometer: - The wind speed is measured by an instrument called the Anemometer.

Principle: - The instrument consists of three large semi-conical cups with beaded edges fixed at the ends of three rods. The cups are mounted symmetrically about a vertical axis so that the diametral plane of each cup is vertical. As the force on the concave side of any cup, due to the wind is greater than that on a convex side in a similar position, the cup wheel rotates.

The cups are attached to a central spider, which is mounted on a spindle carrying a worm. The worm engages with a gear wheel and drives a revolution counter mounted in a water proof aluminum housing. To obtain the run of the wind in kilometers and tenths over a given period, the counter is read at the beginning and end of a period, and the difference noted. The mean wind speed during this given period is obtained by dividing the difference in counter reading by the time interval in minutes.

Exposure: - The standard exposure of wind instruments over level, open terrain is 10 meters above the ground. Open terrain is defined as an area where the distance between the anemometer and any obstruction is at least 10 times the height of the obstructions. The standard exposure is especially important at airports. The ideal exposure will rarely be obtainable in practice, but great care should be taken to ensure that the site actually chosen be best possible.

When there is any obstruction by trees etc the instrument may be erected on a building or high mast, so that it is higher by at least three meters than the highest obstacle in the immediate vicinity.

Maintenance of anemometer: - The instrument suitable lubricated and no lubrication is required soon after installation. However, the instruments should be inspected, cleaned and lubricated at intervals of three months according to the following routine: -

(a) Place the instrument on a clean bench, remove the cap nut and lift the cup wheel with spider off spindle. If the cup wheel is stuck to the spindle, loosen the cap nut but do not remove it; support the cup wheel in one hand and strike the cap nut smartly with a mallet or the wooden handle of a screwdriver.
(b) Clean the cup wheel thoroughly checking that cup retaining nuts are light and that the cups are not loose in their arms.
(c) Clean thoroughly the exterior of the housing and spindle tube.
(d) Undo the five screw screws, which held the lid of housing and lift the lid and spindle assembly off the housing. Clean the inside of the housing and dry it thoroughly, if damp. Clean the glass cover of the window. Grease the threaded socket at bottom, which goes over 13mm pipe.
(e) Put a drop one or two of clock oil in the worm and over the teeth of the gear wheel.
(f) Similarly, put a drop of spindle oil down the inside of the spindle, projecting out at top. The oil will go down the spindly through the top bushing and will lubricate the ball bearing below it.
(g) Apply a drop of clock oil below the worm and gear where the lower thrust bearing is just visible in the slot of the tube. This will lubricate the lower thrust bearing.
(h) Now re-assemble the anemometer.

Dust and other foreign matter may get into the instrument case and settle on the revolving parts. The bearings and gear also require thorough cleaning and lubrication once in while. The instrument should therefore be carefully inspected and all the bearings thoroughly washed, cleaned and lubricated at interval of six months (and especially after every dust storm).

Precipitation:

Precipitation is expressed as the depth to which it would cover a horizontal projection of the earth's surface, if there were no loss by evaporation, run-off or infiltration and if any part of the precipitation fall as snow or ice were melted.

Rainfall: - The simplest method of measuring precipitation is by setting up gauges with a horizontal circular aperture of known area, collecting and measuring at regular intervals the precipitation collected in them. It is assumed that the amount of precipitation collected in the gauge is representative of a certain area around the point where the measurement is made.

Measurement of Rainfall: - The amount of rainfall at a station is measured by a rain gauge. The recommendations of the World Meteorological organization for the use of Fibre Glass Reinforced Polyester (FRP) Rain gauges as the standard instruments at all raingauge station in the country.

The essential parts of a raingauge are (1) a collector with a gunmetal rim truly circular shape 100 or 200 sq.cm. area. (2) base (30 a polythene bottle and (4) a measure glass.

Both the collector and the base are made of fibre glass reinforced polyster. The collector has a deep-set funnel and the complete raingauge has a slight taper with the narrowest portion at the top. The collectors have their apertures so designed that the 100 and 200 sq cm area ones are interchangeable. The small collector has a diameter of 112.9mm corresponding to 100 sq.cm and the bigger one is of 159.6 mm diameter corresponding to 200 sq cm. There are also two types of interchangeable base, the small base being used for all types of receivers except the largest. The rainfall into the funnel collects in the bottle kept inside the base and is measured by means of special measure glass which is appropriate to the area of the aperture and which is graduated in the tenths of millimeter. This has usually a capacity of 20mm of rain.

Exposure of rain gauge: -

The amount of precipitation collected in a raingauge depends to a considerable extent on its exposure and great care must be exercised in selecting a suitable site. The raingauge should be set on a level ground away from trees, buildings and other obstructions and not upon a slope or terrace. The distance between raingauge and obstacles should be as far as possible 4 times the height of the obstacle. **In any case, the distance between the rain gauge and the nearest object should not be less than twice the height of the object above the rim of gauge.** (Subject to the above conditions, a position sheltered from wind is preferable to an exposed one.)

In order that the observations at different stations are comparable, the exposure must be as uniform as possible at all stations. The rim of the rain gauge should be exactly horizontal and remain at a height of 30cm, above the ground level. This rule must be strictly adhered to in the erection of the instrument. The site of the thermometer screen should be so chosen that the raingauge could be placed at the plot of ground at a distance of 3.6mtr from the screen to its south.

Erection of rain gauge: -

The rain gauge should be fixed on a masonry of concrete foundation 60X60X60 cm sunk into the ground. The base of the gauge should be embedded in the foundation, so that the rim of the gauge is exactly 30cm, above the surrounding ground level. The height is necessary to prevent more than a negligible amount of rain splashing into the gauge from the surrounding ground. If the height exceeds the 30cm limit, a positive correction to catch of the rain gauge will be necessary, since the catch decreases owing to wind eddies set up by the gauge itself.

The rim of the gauge should be kept perfectly level. The horizontally should be checked with a spirit level laid across the rim.

Care of the rain gauge and rain measures:

(1) It should be ensured that the collector of the rain gauge doesn't get chocked with dirt and the receiving bottle and additional cylinder, if any, are always clean. They should be emptied regularly of sediment or other material that may have fallen in to them and cleaned periodically.
(2) The outer surface of the visible portion of the raingauge should also be kept clean by wiping it occasionally with a wet cloth. The rain gauge doesn't need any painting and this should not be attempted any time.
(3) The collector, receiving bottle (and additional cylinder, if provided) and the base should be examined for leak regularly. If found to be leaking, they should be repaired either locally, if possible, with the aid of repair kit or replaced by refresh components.
(4) While replacing the collector on the base it should be ensured that the two locking rings have engaged properly. The locking ring fixed to the collector and base are delicate and should not be handled roughly.
(5) Care should be taken not be dent or deform the gun metal rim of the collector by rough handling.
(6) The rain gauge should always be kept locked for safety.
(7) The grass round the gauge should be kept short. No shrubs or plants should be allowed to grow round the gauge.
(8) Both the rain measures glasses should be kept spotlessly clean. They should be handled gently to avoid breakages and stored dry in a safe place when not in use. Always, wipe it dry before leaving it in the Thermometer screen after use. This is very important in freezing weather when there is risk that it may become frozen to the wood by any residual water left adhering to the base.
