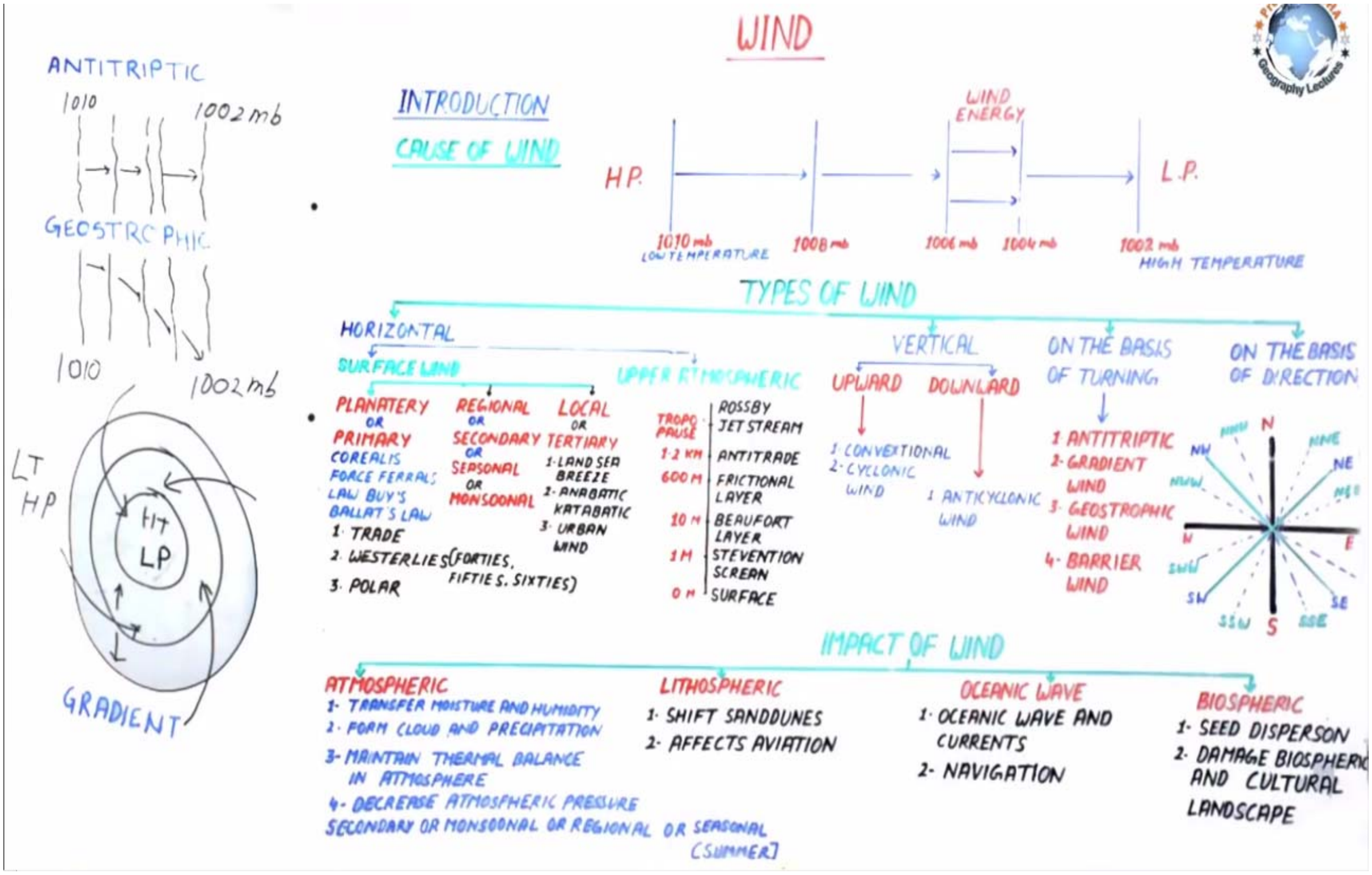
Wind



Introduction

Wind is air in motion. It is produced by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of various land and water formations, it absorbs the sun's radiation unevenly. Two factors are necessary to specify wind: speed and direction. The movement of wind is almost horizontal component. The vertical component is nearly always very small. The wind velocity is fully described by two quantities-its speed and its direction. The units of wind speed are the metre per second(m/s), mile per hour(mile/h) and the nautical mile per hour or knot(kn).

Wind direction is the direction from which the wind blows. It is well known that the wind velocity, both speed and direction, at any given place is continuously changing. Therefore, the velocity of any parcel of air as it moves over the earth's surface would also be continuously changing. The surface wind velocity is normally measured at a standard height of 10metres (33feet) above the ground.

Knowledge of winds at levels well above the ground is of the greatest importance to aircraft navigation; it is also important to the study of the development of depressions and anticyclones. Clearly, they cannot be measured by anemometers and wind vanes, except perhaps in the first 300 metres above the ground where the instruments then be mounted on a tower.

Pressure gradient force

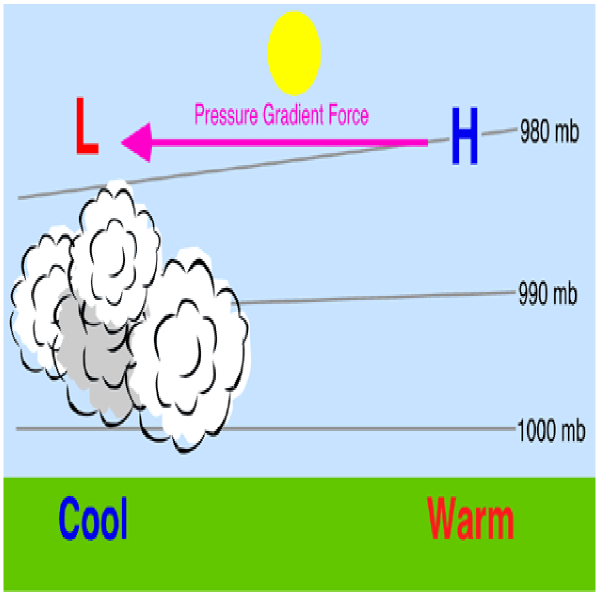
The force caused by the pressure variation is the pressure gradient force.

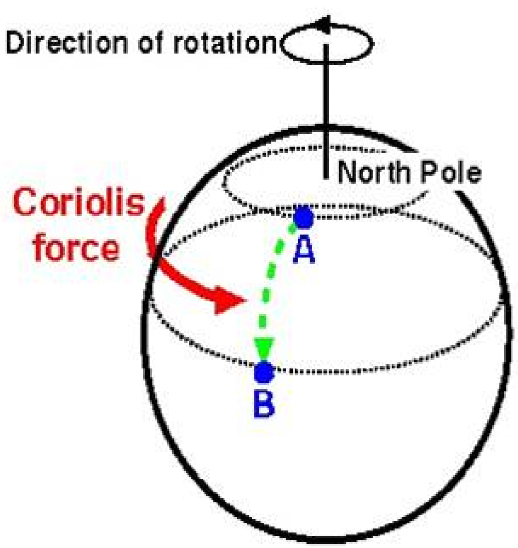
Isotach

A line connecting points of equal wind speed.

Coriolis force

Once air has been set in motion by the pressure gradient force, it undergoes an apparent deflection from its path, as seen by an observer on the earth. This apparent deflection is due to coriolis force that is a result of the earth's rotation. As air moves from high to low pressure in the northern hemisphere, it is deflected to the right by the coriolis force. In the southern hemisphere, air moving from high to low pressure is deflected to the left by the coriolis force. The amount of deflection the air makes is directly related to both the speed at which the air is moving and its latitude. Therefore, slowly blowing winds will be deflected a small amount, while stronger winds will be deflected more. Likewise, winds blowing closer to the poles will be deflected more than winds at the same speed closer to the equator.



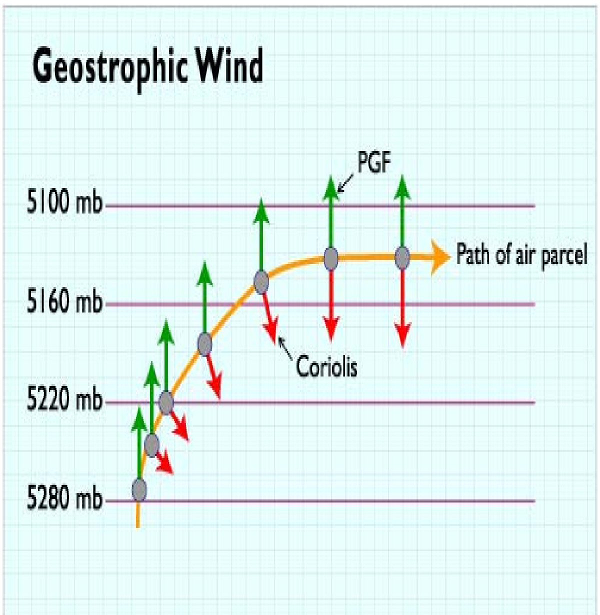


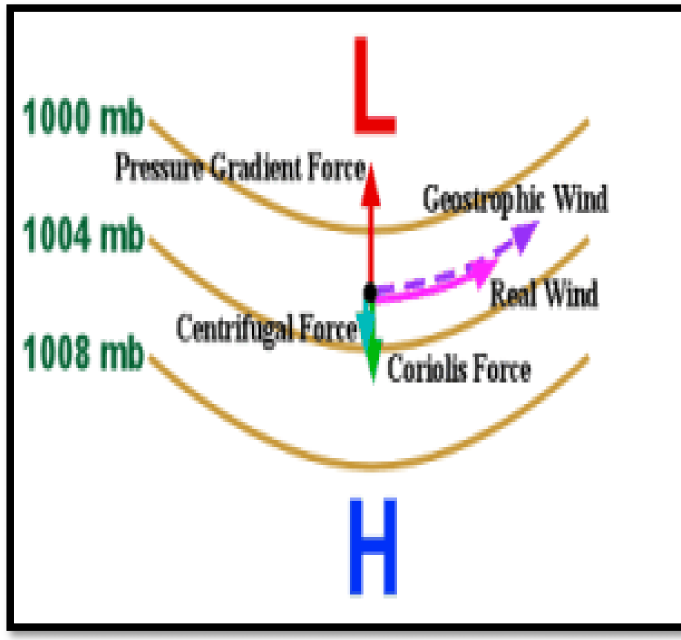
Geostrophic wind

It is a steady motion of the wind where pressure gradient force (PGF) is exactly balanced by the coriolis force.

Gradient wind

The force caused by the pressure variation is the pressure gradient force. The gradient wind is the balanced flow along a curved path under the influence of coriolis force, pressure gradient force and centrifugal force. For anticyclonic curvature, the coriolis force must be greater than the pressure gradient force, but for cyclonic curvature, the coriolis force is less than the pressure gradient force.





Surface wind flow

The diurnal variation of the surface wind is largely controlled by diurnal changes of stability of the turbulent layer near the ground. In stable air, as may be found during a clear night, mixing is inhibited and the frictional force is large; but when it is unstable, mixing is extensive and friction is reduced. Maximum speed therefore occurs in the early afternoon and the minimum in the early morning. Correspondingly, the direction is least backed in the afternoon and most in the early morning. The wind nearly always shows some gusts. These are caused by,

Turbulence-when they are on a small scale, with extreme gust speeds approximately in excess by one-third above the mean speed.

Convection-when they are very irregular in size and timing and there is a marked diurnal variation, as is to be expected, with the strongest gusts in the afternoon.

Squalls

A sudden increase of wind speed reaching 24kt or more and lasting a minute or more is termed a squall.

Gale

Persistent strong winds over 33kt, generally occurring with cyclones are called gales.

Hurricane wind

The violent winds associated with severe cyclonic storms exceeding 63kt are known as hurricane winds.

Vertical motion

Vertical motion is generally small in the atmosphere, of the order of a few centimeters per second, compared to the horizontal motion of several meters per second. In atmospheric systems such as cyclones, vertical motion occurs on a large area over a period of days. Convergence takes place when there is horizontal flow and accumulation of air over a region. Air is then transported upwards. This type of uplift of air occurs in troughs, lows depressions and cyclones, leading to cloud formation and weather development. In the ridges and highs there is downward motion or subsidence at the higher levels with net outflow of air or divergence at the lower levels and the surface. The subsided air is comparatively warm and dry giving rise to more or less settled weather.

When two air streams with marked temperature and density contrast meet, a discontinuity or front develops. The warmer and lighter air ascends along a sloping surface with the cooler air underneath. The ascent of air results in clouding and weather. When an air stream encounters a range of mountains more or less perpendicular to it, forced ascent of air takes place. Air cools during this orographic ascent and when moist, gives rise to clouding and rain or thundershowers.

Factors Affecting Wind Motion:

Since pressure differences are mainly caused by unequal heating of the earth's surface, solar radiation may be called the ultimate driving force of the wind. If the earth were stationary and had a uniform surface, air would flow directly from high pressure areas to low pressure areas. Because none of these conditions exist, the direction and speed of wind are controlled by a number of factors. These are pressure gradient, the Coriolis effect, the centripetal acceleration and friction.

1. Pressure Gradient Force:

This is the force generated due to the differences in horizontal pressure, and it operates from the high pressure area to a low pressure area. Since a closely spaced gradient implies a steep pressure change, it also indicates a strong wind speed. The wind direction follows the direction of change of pressure, i.e. perpendicular to the isobars.

2. Coriolis Force:

Due to the earth's rotation, winds do not cross the isobars at right angles as the pressure gradient force directs, but get deflected from their original path. This deviation is the result of the earth's rotation and is called the Coriolis Effect or Coriolis force. Due to this effect, winds in the northern hemisphere get deflected to the right of their path and those in the southern hemisphere to their left, following Farrel's Law. The Coriolis force changes wind direction but not its speed. This deflection force does not seem to exist until the air is set in motion and increases with wind velocity, air mass and an increase in latitude.

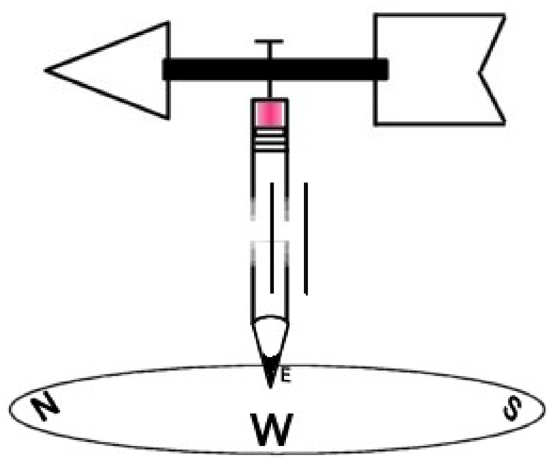
Frictional Force:

The irregularities of the earth's surface offer resistance to the wind motion in the form of friction. This force determines the angle at which air will flow across the isobars, as well as the speed at which it will move. It may also alter wind direction. Over the relatively smooth ocean surface, the friction is minimum, so the air moves at low angles to the isobars and at a greater speed. Over uneven terrain, however, due to high friction, the wind direction makes high angles with, isobars and the speed gets retarded.

WIND INSTRUMENTS

Wind Vane:

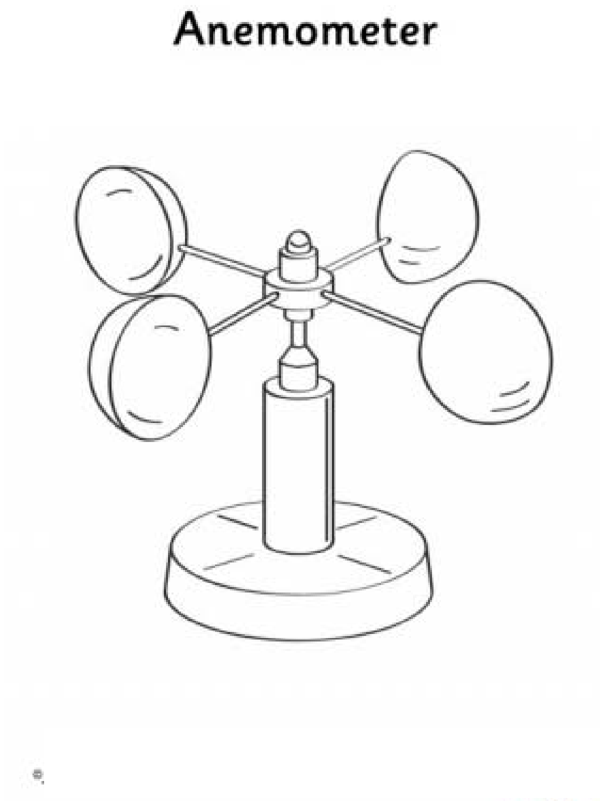
A very old, yet reliable, weather instrument for determining wind direction is the **wind vane**. Most wind vanes consist of a long arrow with a tail, which is allowed to move freely about a vertical post. The arrow always points into the wind and, hence, always gives the wind direction. Wind vanes can be made of almost any material. At airports, a cone-shaped bag opened at both ends so that it extends horizontally as the wind blows through it sits near the runway. This form of wind vane, called a *wind sock,* enables pilots to tell the surface wind direction when landing.



WIND VANE

Anemometer:

The instrument that measures wind speed is the **anemometer.** Most anemometers consist of three (or more) hemispherical cups *(cup anemometer)* mounted on a vertical shaft. The difference in wind pressure from one side of a cup to the other causes the cups to spin about the shaft. The rate at which they rotate is directly proportional to the speed of the wind. The spinning of the cups is usually translated into wind speed through a system of gears, and may be read from a dial or transmitted to a recorder.



The wind-measuring instruments described thus far are “ground-based” and only give wind speed or direction at a particular fixed location. But the wind is influenced by local conditions, such as buildings, trees, and so on. Also, wind speed normally increases rapidly with height above the ground. Thus, wind instruments should be exposed to freely flowing air well above the roofs of buildings. In practice, unfortunately, anemometers are placed at various levels; the result, then, is often erratic wind observations.