



Surveying

Basic Introduction

What is Surveying?

Surveying is the technique and profession of determining the positions of points and the distances and angles between them. In mining, surveying is used to establish the exact position of things and exactly where to mine:



Total Station

Surveying is done most commonly these days using an instrument called a **total station**. A **total station** is an optical instrument commonly used in surveying for measuring horizontal angles, vertical angles and distance. A total station is a type of **theodolite**. A theodolite is a surveying instrument with a rotating telescope for measuring horizontal and vertical angles. Total stations are much more advanced and modern than normal theodolites and have extra features such as electronically storing information captured which can then be instantly imported into a computer for analysis.



Pegs

Surveying uses objects called **pegs** to make measurements and establish positions. **Pegs** mark a known point in space. Measurements are taken using these pegs to find out the positions of unknown points. The unknown points will be a place where some one has decided they need to find out about and they will place a peg there which will then be surveyed with the help of the already surveyed pegs to establish its exact position.

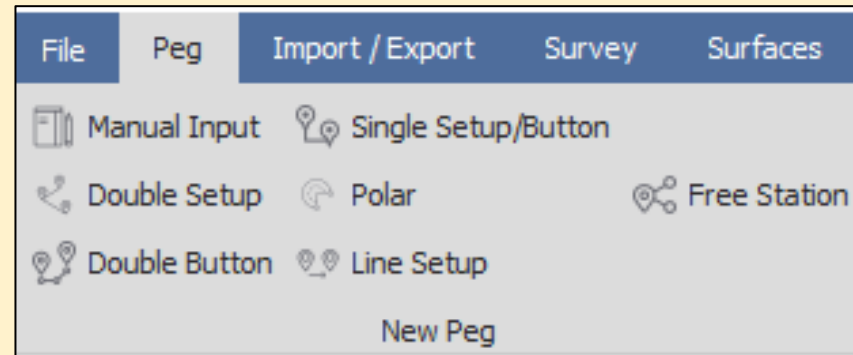


Why Surveying?

The reason surveying is used in mining, particularly underground mining, is that unlike on the surface of the earth where there is a clear view of the sky and GPS can be used to establish the location of points, underground this is not the case and so the techniques of surveying are used to establish locations and ensure the mining moves in the right direction.

Surveying Techniques

In surveying, there are a number of different types of surveys you can do. I will give a few of them in the following pages with an explanation.



Double Setup

Survey station positioned under the setup peg measuring 2 angles and distances to the backsight and foresight(new) pegs. Then the survey station is setup under the foresight peg measuring 2 angles and distances to the original setup peg. (The 2 angles and distances measured are the horizontal and vertical. Vertical distance is referred to as *slope distance*.)

Set-up = The point where the total station is set up and from which observations are taken, also called 'station'.

Station = The point where the total station is set up and from which observations are taken.

Setup peg = The peg from which observations are being taken. In underground mines, pegs are placed in the ceiling so as not to be in the way, so the survey station will be positioned under the peg.

Backsight = A 'sight' in surveying is an observation taken with a surveying instrument to ascertain an exact position or direction. A 'backsight' is a sight directed backward to a previous station. This backsight done is referred to as a 'back check' since the surveyor does it to ascertain that he is at the exact correct location at the set-up peg before he starts surveying the new peg.

Foresight = A 'foresight' is an observation made towards a forward point. This will be the new point that is being surveyed.

Double Button

Survey station positioned under the setup peg measuring 2 angles and distances to the foresight peg of each button(reflector) hanging from it.

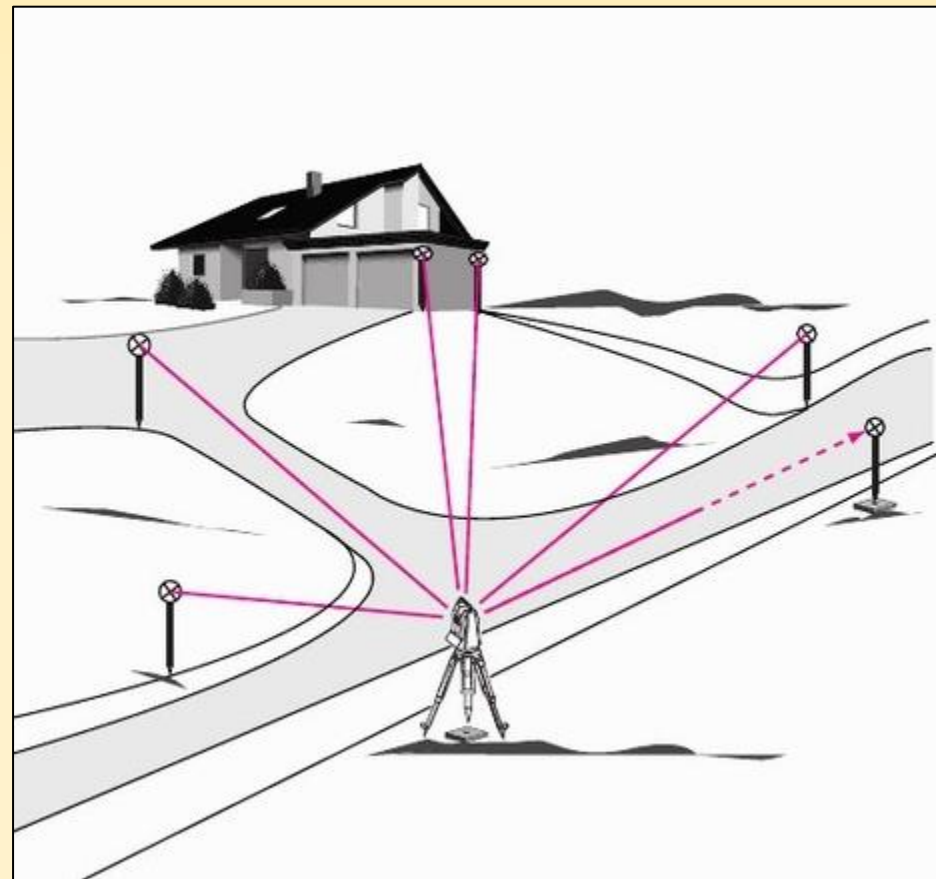
More on buttons: Reflectors are used on the pegs because when surveying the total station sends out a laser which then reflects off the buttons and comes back to the total station and this assists in measuring the distance of the peg from the total station. These reflectors are a special type of reflector called an optical survey prism which reflects the beam directly back to the source.

Single Setup/Button

Survey station positioned under the setup peg measuring 2 angles and distances to the foresight peg of the one button(reflector) hanging from it.

Polar

Survey station at setup peg using a bearing and distance to a new peg.



Line Setup

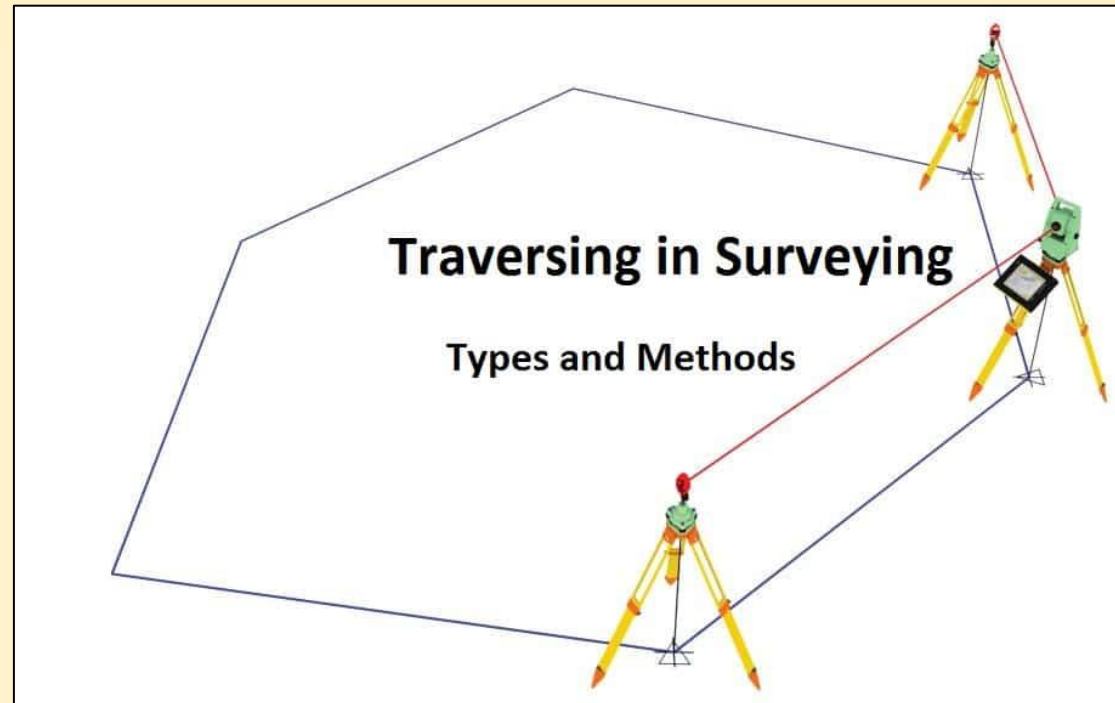
Survey station setup to take usual measurement of backsight peg then usual measurements of all foresight pegs.

Free Station

In surveying, free stationing (also known as resection) is a method of determining a location of one unknown point in relation to known points. There is a zero point of reference called a total station. The instrument can be freely positioned so that all survey points are at a suitable sight from the instrument.

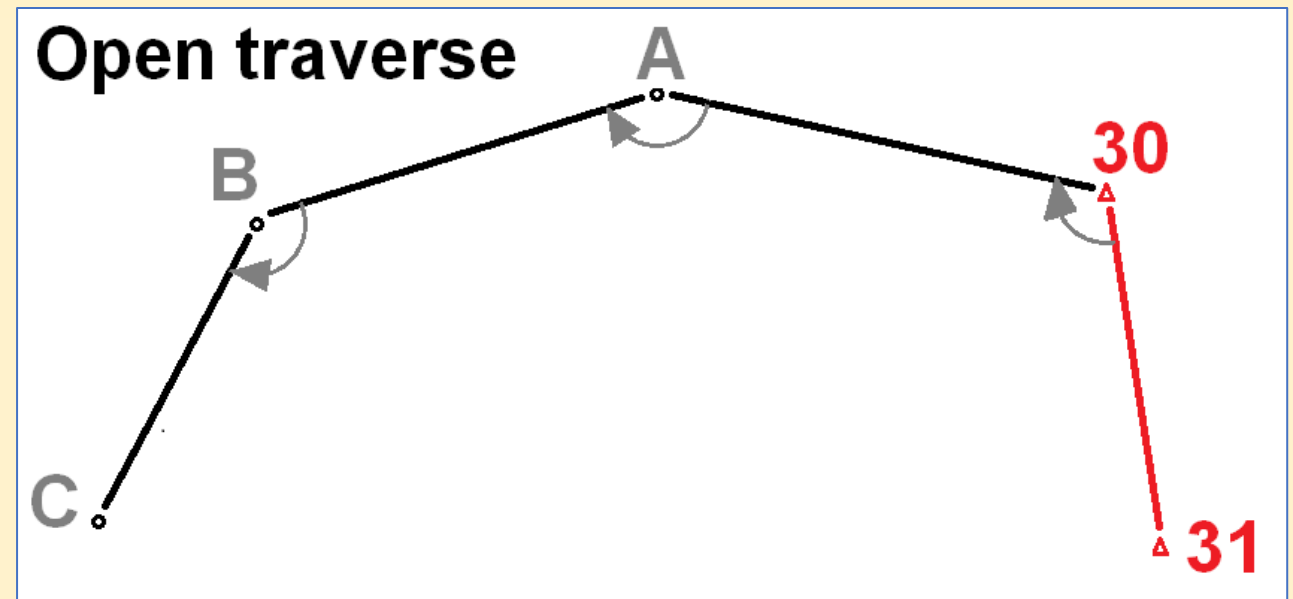
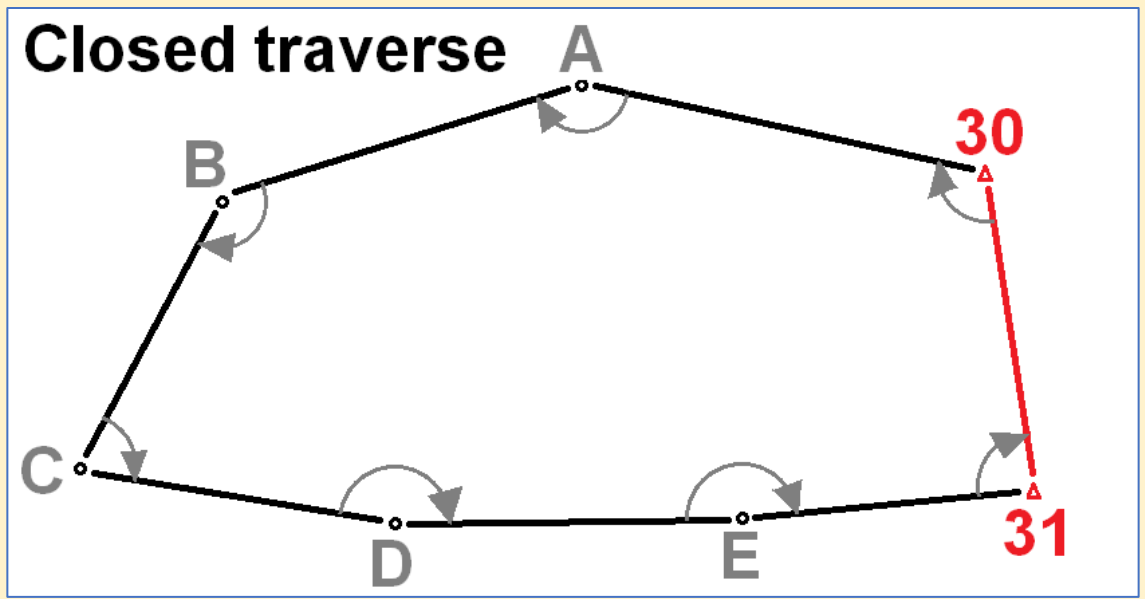
Traverse

Traverse networks involve placing survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point. There are two types of traverses, an open traverse and a closed traverse, an open traverse does not end at a known point, a closed traverse does end at a known point which is the point at which it started, and this forms a circuit.



Bowditch Correction

The start and end of a closed traverse are supposed to match up and don't for some reason. Bowditch's Method looks to average out this error over the course of the whole traverse to fix it up. The end result will be a closed traverse. Bowditch's Method works graphically.



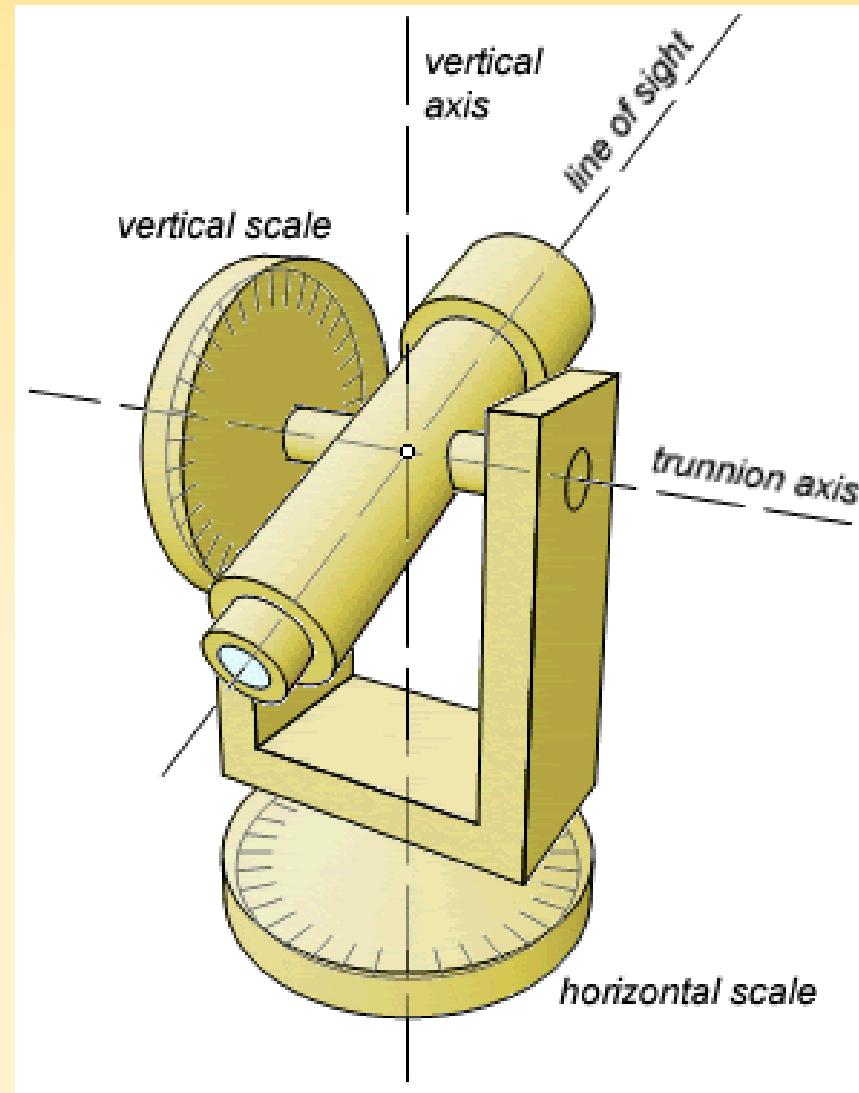
Some Terms You Will Encounter

Left and Right: Referring to *Face Left* and *Face Right*, this is a situation where the vertical circle of the theodolite is on the left side.

Measurements are taken with it like this, then the instrument is rotated 180 degrees about its horizontal axis and then turned 180 degrees about its vertical axis so that the vertical circle is now on the right side, measurements are then taken with it like this. The reason the measurements are taken like this is so that any error in alignment along the line of sight of the telescope is cancelled out. Any time an angle is measured it will be done with both Face Left and Face Right. The average of these two measurements is then gotten and is called the **Face Mean**.

FL: Face Left

FR: Face Right



(*Trunnion axis* is the horizontal axis)

Arc Mean: *Arc* is the horizontal angle measurement made, it is called this as the total station is moved in an arc while making the measurement. The *Arc Mean* is the average of the *Face Mean* of the two horizontal angular measurements made in the case of a Double Setup or Double Button for example.

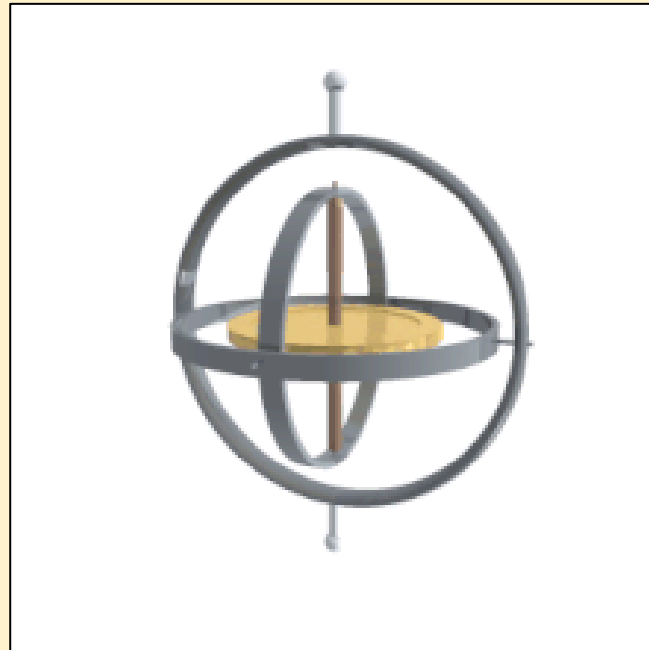
Grade elevation: The incline of the tunnel where surveying is being done, it is indicated by a line drawn along the wall, and the height from the floor where you are set up to that line is the grade elevation.

Bob height: The height of the *bob* which is the hanging peg from the ceiling which you are taking measurements on.

DMS: Degrees, Minutes, Seconds. Degrees - a unit of measurement of angles; Minutes - any of the 60 parts that the degrees of any angle are divided into; Seconds - the smallest unit used for measuring an angle)

Chain length: A *chain* is a distance-measuring device consisting of a chain of 100 links of equal length, having a total length of 66 feet (20 meters). It is also a unit of length equal to one of these (20 meters).

Gyro calibration: Calibrating a gyrocompass to confirm angular measurements of pegs. A *gyrocompass* is a non-magnetic compass in which the direction of true north is maintained by a continuously driven gyroscope whose axis is parallel to the earth's axis of rotation. A *gyroscope* is a device consisting of a wheel that turns rapidly inside a frame and does not change position when the frame is moved. Gyroscopes are often used to keep ships and aircraft steady.



Gyroscope

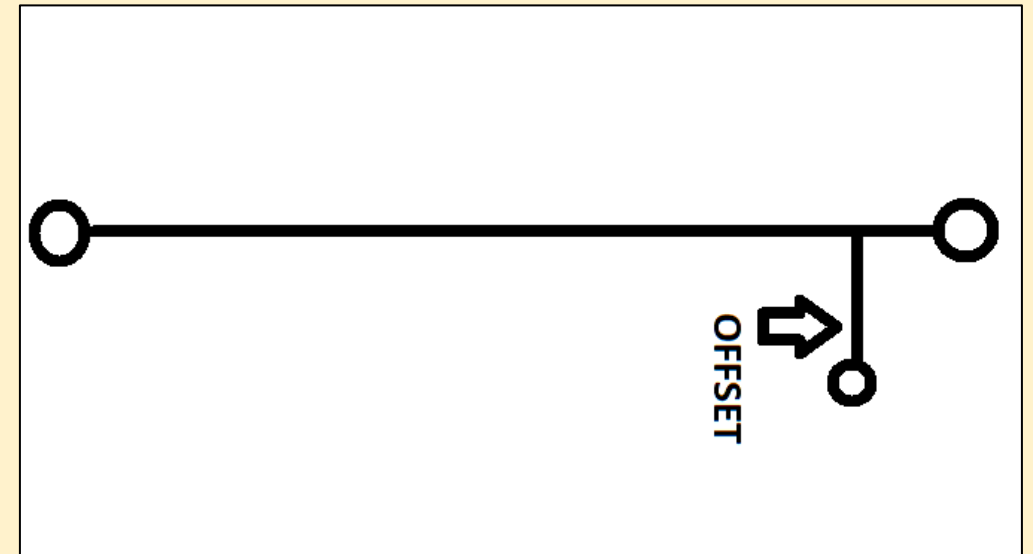
Schuler Means: A method for calibrating the gyrocompass.

Transit: 1) Another method for calibrating a gyrocompass.

2) *Transit* can also mean the action of rotating the telescope of an instrument like a theodolite 180 degrees towards the vertical plane. It can also refer to an instrument itself which can do this, such as a theodolite.

Tapes

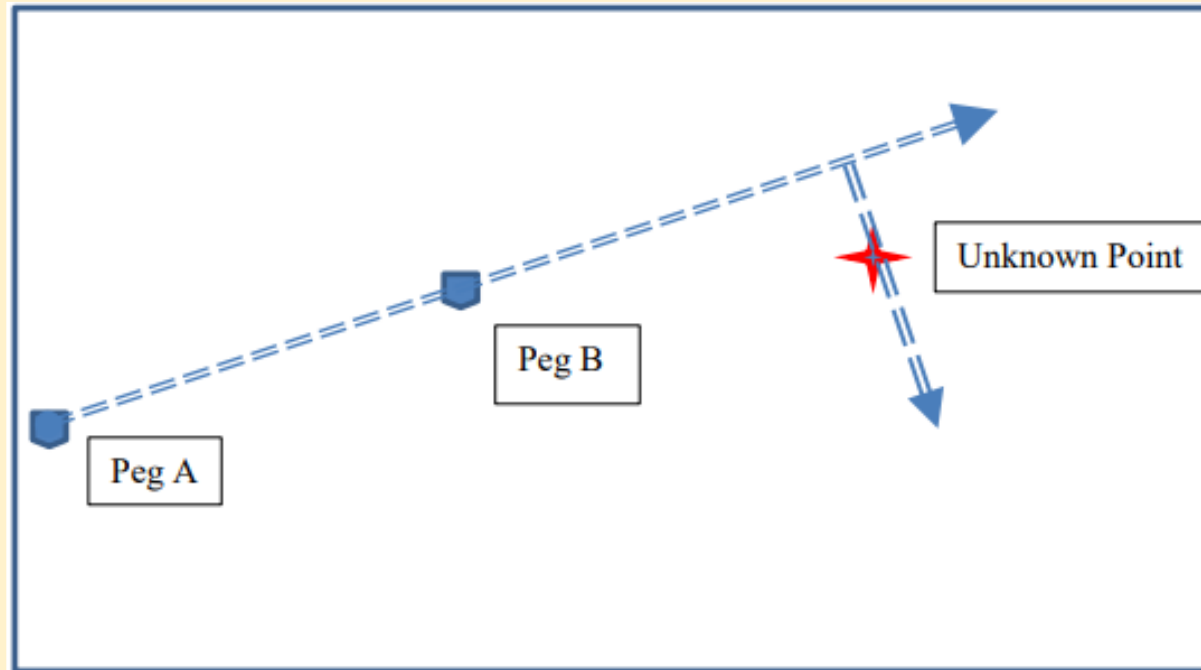
In surveying, sometimes **tapes** are used. Tapes are used in surveying to measure horizontal, vertical, and slope distances. They may be made of a ribbon or a band of steel, an alloy of steel, cloth reinforced with metal, or synthetic materials. Tapes are issued in various lengths and widths and graduated in a variety of ways. *Offsetting* can be done with tapes to ascertain the location of points. An *offset* is a short distance measured perpendicularly from the main line of measurement.



To find the location of a point we look for the nearest peg or pegs and then take measurements from the peg to then work out the new location.

This is often done using tape measures, or tapes for short.

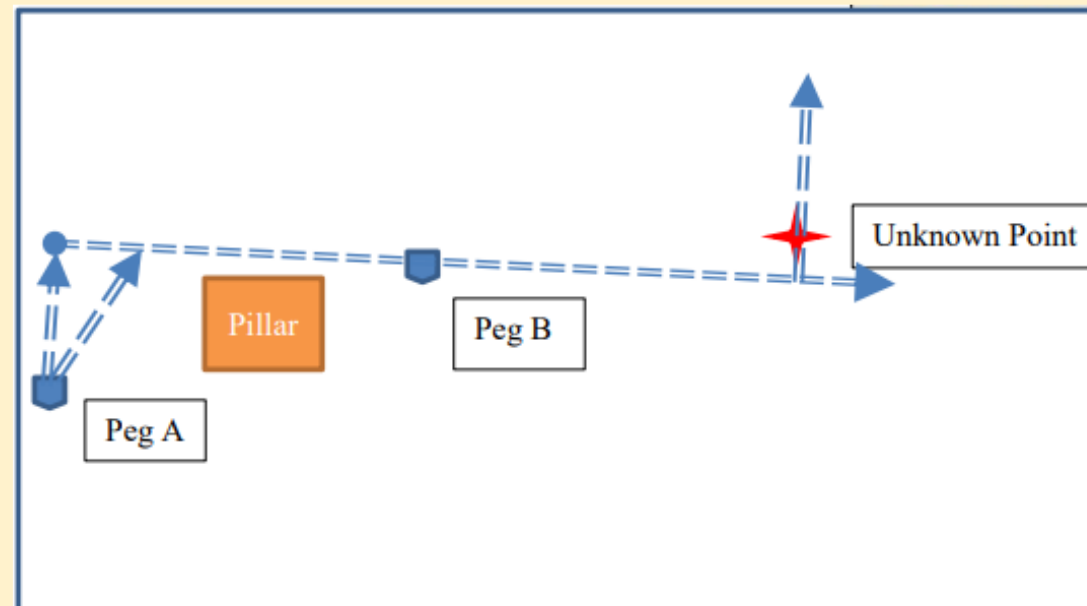
One typically finds two nearest pegs to a point and then puts a tape measure between and along the pegs:



And then another at right angles to the first tape. Then taking measurements along the tapes one can work out the unknown point from the two know peg points.

So in the above case we needed two tape measures to work out the location of the unknown point.

Sometimes however it is not possible to draw a tape straight across the two pegs as shown above, because of an intervening pillar. In this case one uses extra tapes called 'Ties' as follows:



The two extra tapes coming from peg A are referred to as ties.

Note that in more complicated scenarios we could even have ties coming from peg B. In any case using the measurements along the various tapes we can get the location of the unknown point.

So using pegs, tapes and even tie tapes we can get the location of points.