

‘fundamentals of surveying’
Lecture-2
Coordinate system,
measurements, and errors

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Outline

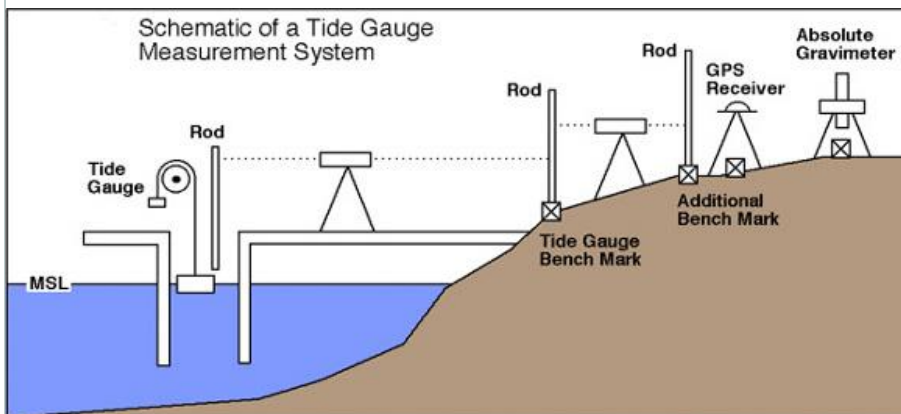
- ✓ **Reference surface**
- ✓ **Coordinate system**
- ✓ **Establishment of an assumed coordinate system**
- ✓ **Measurements and errors**
- ✓ **Types of measurements**
- ✓ **Types of errors**

Reference surfaces:

- Ellipsoid is the reference surface of horizontal measurement, for (x,y) in horizontal plane.
- Geoid is used for determination of (z) height.
- A point must be determined with zero elevation.
- This can be determined by observation to the tide for a long period (5-7) years, the average of the minimum levels is considered to be zero elevation and it's called Mean Sea level (M. S. L.)

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Tide Gauge



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Coordinate System

Coordinate systems are means for determination of location of points on the earth surface.

There are different coordinate systems.

Scientists are agreed upon:

Equator is divided to 360 units, each unit is called degree divisions are made starting from zero point Eastward (0-180°E) westward (0 – 180°W).

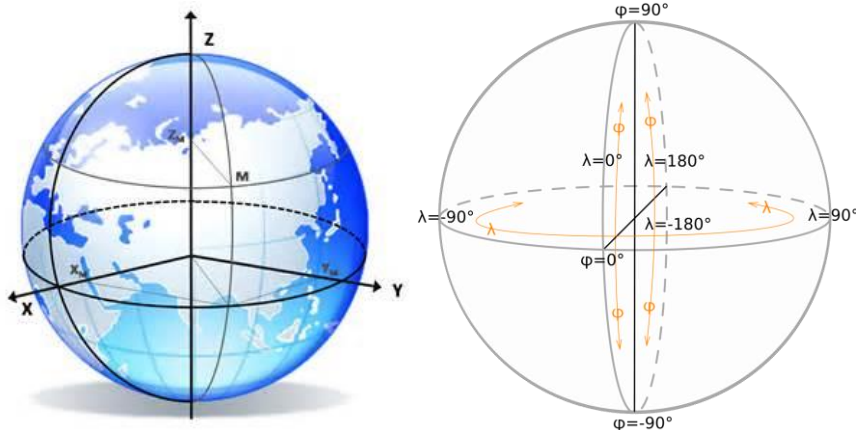
Vertical great circle is divided into:

90° North (from the equator towards north pole).

90° South (from the equator towards south pole).

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Coordinate system



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There are many kinds coordinate systems:

Geographic coordinate system:

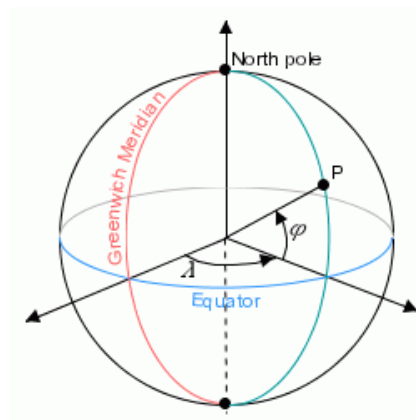
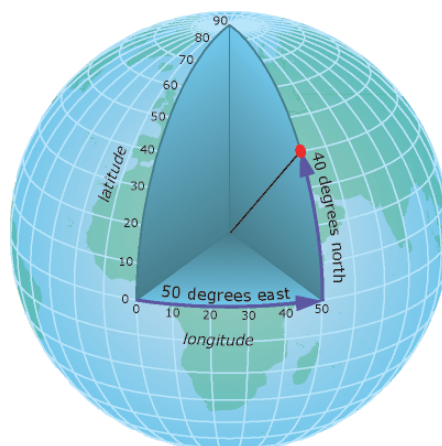
Longitude (λ): it's the horizontal angle measured at the center of the earth on the horizontal plane of equator from Greenwich meridian to the point.

Latitude (ϕ): it's the vertical angle measured from the plane of the equator to the point.

Height (H): it's the height above reference surface (ellipsoid).

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Geographic Coordinate system



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Cartesian Coordinate System:

Center of the earth is the origin

$x = 0, y = 0$ (0,0) at the origin

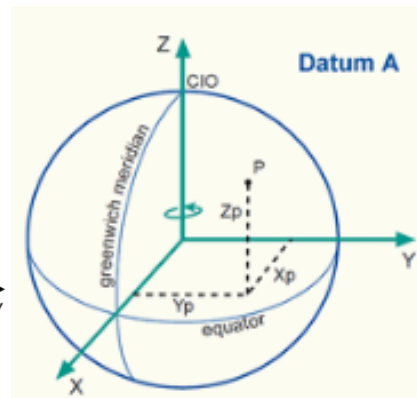
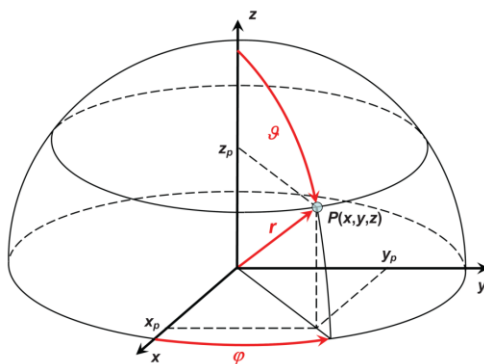
- **Z-axis** is coincided with axis of rotation of the earth
- **X-axis** is the axis from the center of the earth to the intersection point of the great horizontal and great vertical circle.
- **Y-axis** is the axis perpendicular to x-axis at the center of the earth.

For any point on the ellipsoid has coordinates of x, y, h . Units of these coordinates are units of length (m).

Z is the height above the ellipsoid.

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Cartesian Coordinate system



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To establish an (assumed coordinate system):

- Create a horizontal reference (horizontal datum) for x,y measurements.
- Create a vertical reference (vertical datum) for z measurements.

How to establish the coordinate system;**For horizontal datum:**

The origin of the system must be at the left and south of the area, therefore all the area will be located in the first quadrant (all coordinated positive).

For vertical plane

- Any value for (z) may be used unless their will not be negative values of z.
- Elevation is always (+) only if it was lower than sea level, then it become (-).

Measurements and Errors

In surveying measurements are made of

1. Field Surveying:

Distance using tape

Angle using theodolite

Elevation using level

Coordinate using total station, GPS, UAV, Laser scanning

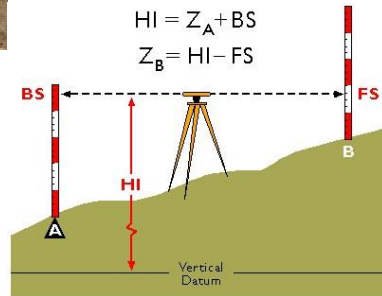
Field surveying



Distance using tape



Angle using theodolite



Elevation using level

Field surveying



Total Station

GPS



Laser Scanning



UAV

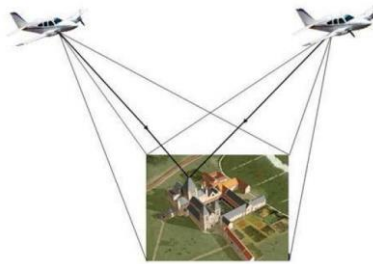
2. Digital Camera ----- on the ground

From the air

Satellite imagery – produced from electromagnetic energy.



On the ground



From the air



Satellite imagery

All measurements must be processed before using them for special purpose because all measurements contain error.

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Methods of Processing

➤ Measurements must be processed statistically to assess their values whether they are acceptable or not.

If yes ---- ok

If not ---- rejected and to be repeated

➤ Adjust the measurements to conform with geometric condition.

What is measurement?

It is the art of making quantitative comparison between pre-defined standards and unknown magnitude.

Measurements require:

- There must be a standard for magnitude.
- A procedure and an instrument for the measurement.

(e.g. distance measurement --- tape_s—m)

Types of measurements:

1. **Direct measurement:** applying an instrument and taking the readings on it's scale
2. **Indirect measurement:** it is required coordinate to derive their measurements (angle, distance).

Facts about measurements:

1. No measurement is exact
2. Every measurement contains error.
3. The true value of a measurement is never known
4. The true error is never known too

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Error: is the difference between measured value and the true value of the quantity.

$$e = x - x'$$

e: error

x: measured value of the quantity

x': is the true value of the quantity

residual: is the different between measured value and most probable value (mpv), (mean value) of the quantity.

$$r = x - x'$$

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Sources of errors

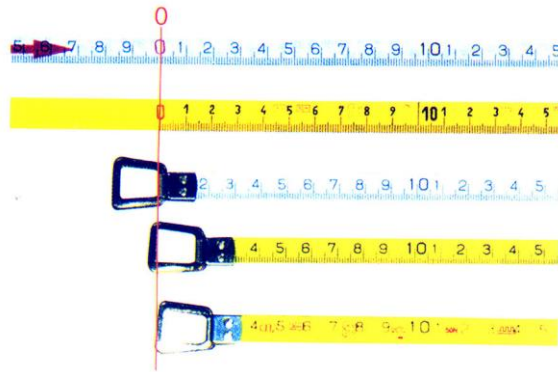
1. **Instrumental error:** due to imperfection of manufacturing the instrument.
2. **Natural errors:** it's due to variation in the condition of the environment surrounding the instrument (ex. Temperature, pressure gravity,.....).
3. **Personal errors:** it is from the person who makes the measurement.

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Types of errors

1- Systematic errors: they are happening according to physical law. They are constant magnitude in each measurement step condition. Also called cumulative errors or biases.

They may be corrected mathematically or by changing the procedure of the measurement.



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2- Random error (accidental error): are errors remaining in the measurements after the corrections of systematic errors and mistakes (gross-errors). Usually they are of small magnitude and its (negative and positive) signs.

Random errors are also called compensating errors. Since they tend to partially cancel themselves in a series of observations. Their effect is minimized by adjustment methods.

3- Mistake (blunders/gross errors): they happen in measurements due to confusion and carelessness of the observer.

They are corrected by repeating the measurement.

Ex. 169.78 196.78

Measured writing