

Total Stations

Prof. Mohammed Taleb Obaidat
Civil Engineering Department
Jordan University of Science and Technology (JUST)
Irbid-Jordan
E-mail: mobaidat@just.edu.jo
Home-Page: www.just.edu.jo/mobaidat

TOTAL STATION

■ Basic Principle

A total station integrates the functions of a theodolite for measuring angles, an EDM for measuring distances, digital data and a data recorder. Examples of total stations are the Sokkia Set4C and the Geodimeter 400 series.

- All total stations have similar constructional features regardless of their age or level of technology, and all perform basically the same functions.

□ Introduction:

➤ Measurements Capabilities:

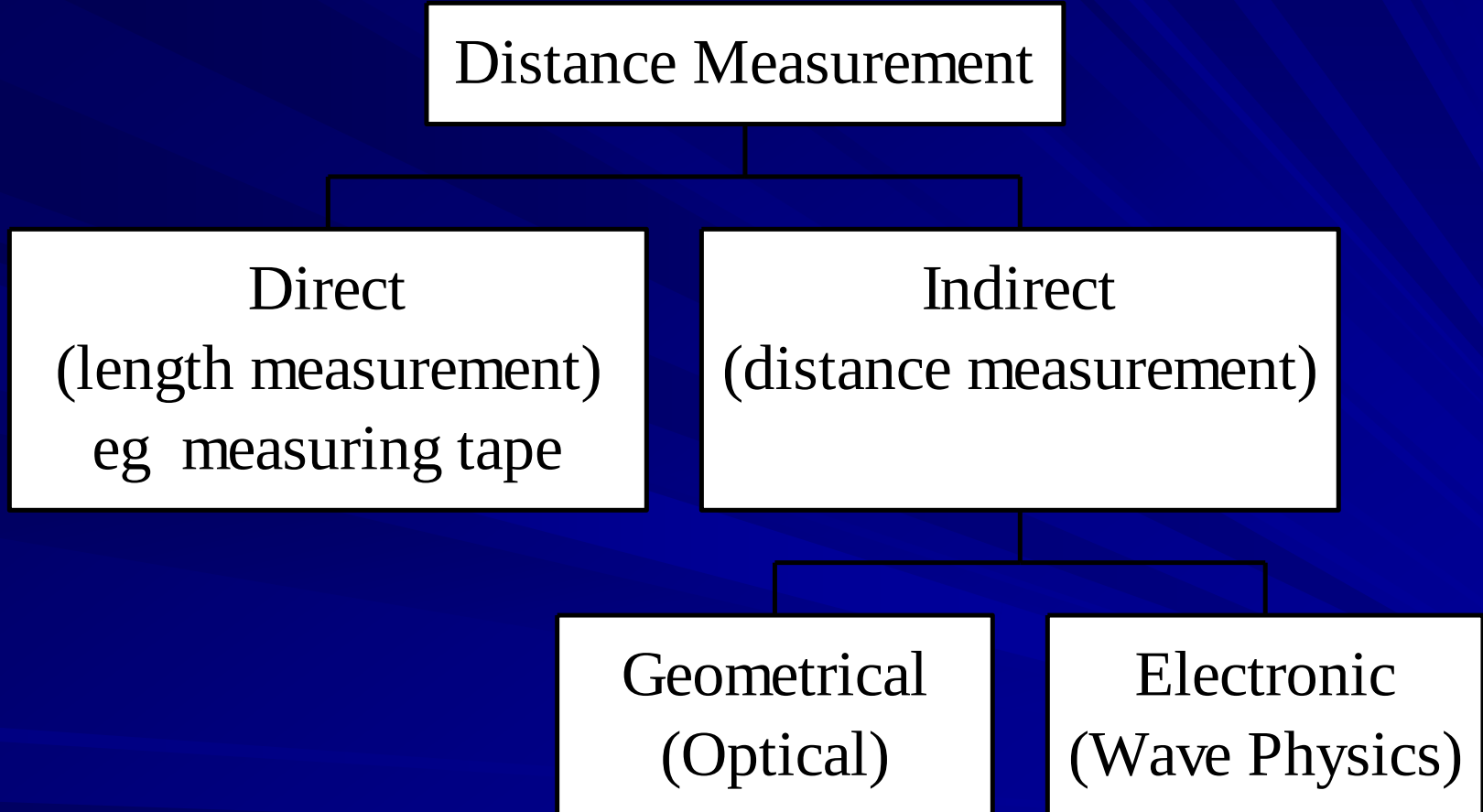
- Distances (H, V , S)
- Angles (H, V)
- 3-D Coordinates: with the aid of trigonometry the angles and distances may be used to calculate the coordinates of actual positions (X, Y, and Z or northing, easting and elevation) of surveyed points, or the position of the instrument from known points, in absolute terms.

- The data may be downloaded from the theodolite to a computer and application software will generate a map of the surveyed area.
- Some total stations also have a GPS
- The best quality total stations are capable of measuring angles down to 0.5 arc-second. Inexpensive "construction grade" total stations can generally measure angles to 5 or 10 arc-seconds.
- Measurement of distance is accomplished with a modulated microwave or infrared carrier signal, generated by a small solid-state emitter within the instrument's optical path, and bounced off of the object to be measured.

- Most total stations use a purpose-built glass prism as the reflector for the EDM signal, and can measure distances out to a few kilometers, but some instruments are "reflectorless", and can measure distances to any object that is reasonably light in color, out to a few hundred meters.
- The typical Total Station EDM can measure distances accurate to about 0.1 millimeter or 1/1000-foot, but most land surveying applications only take distance measurements to 1.0 mm or 1/100-foot.

❑ Some modern machines are 'robotic' allowing the operator to control the machine from a distance via remote control. This eliminates the need for an assistant staff member to hold the reflector prism over the point to be measured. The operator holds the reflector him/herself and controls the machine from the observed point.

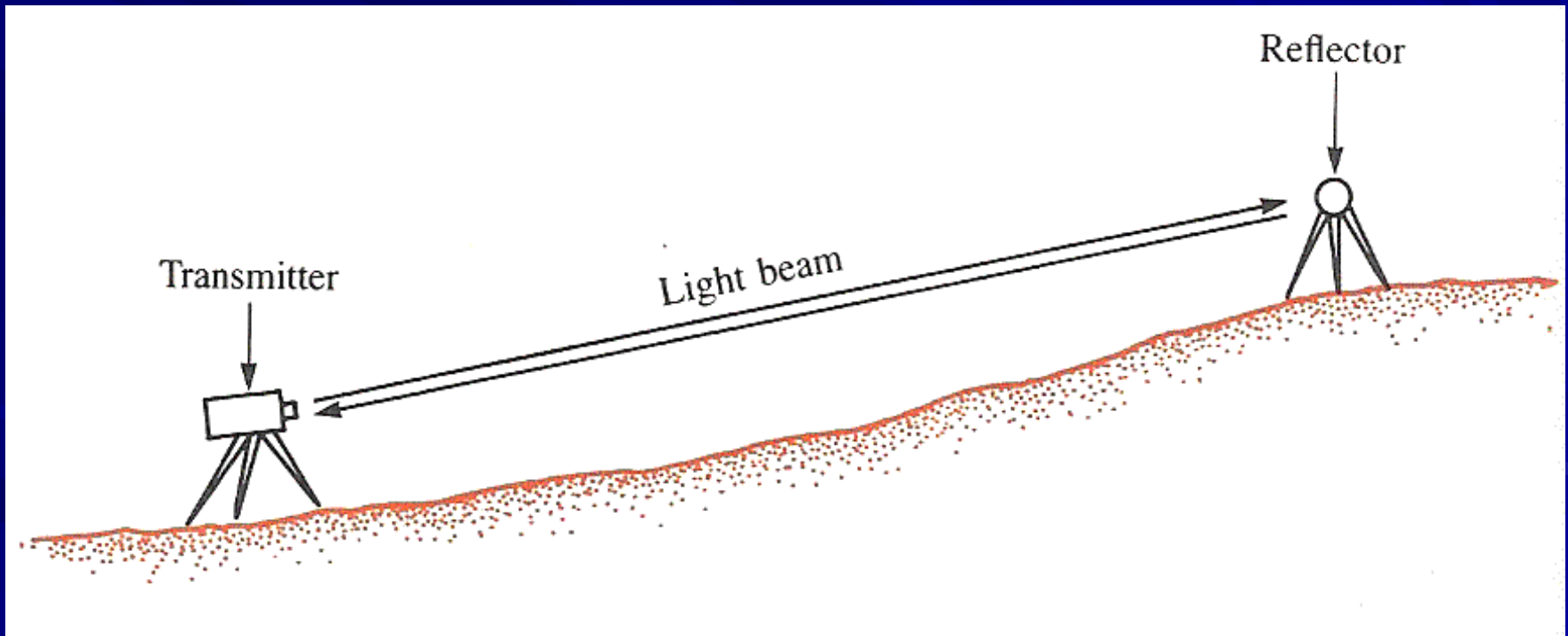
EDM Electro-Optical Distance Measurement



❑ Principle of operation:

Velocity = distance / time

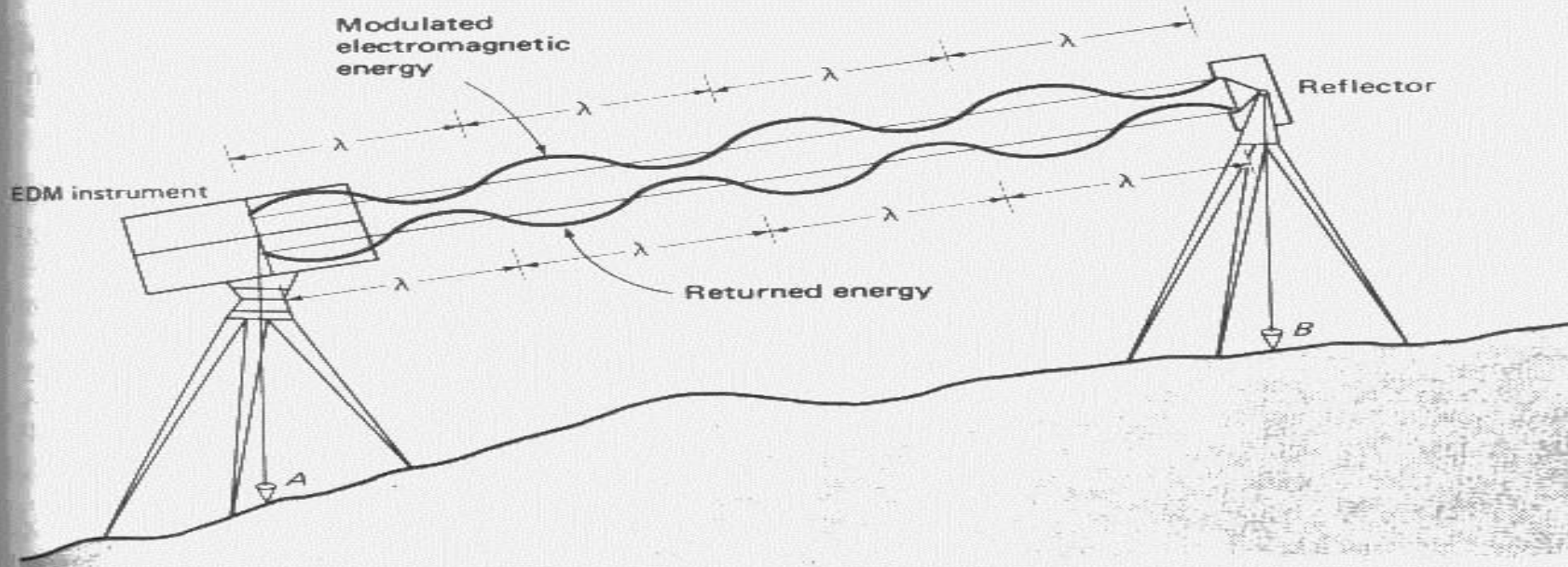
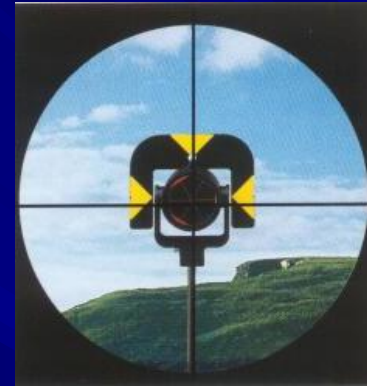
- EDM is very useful in measuring distances that are difficult to access or long distances.
- It measures the time required for a wave to sent to a target and reflect back.

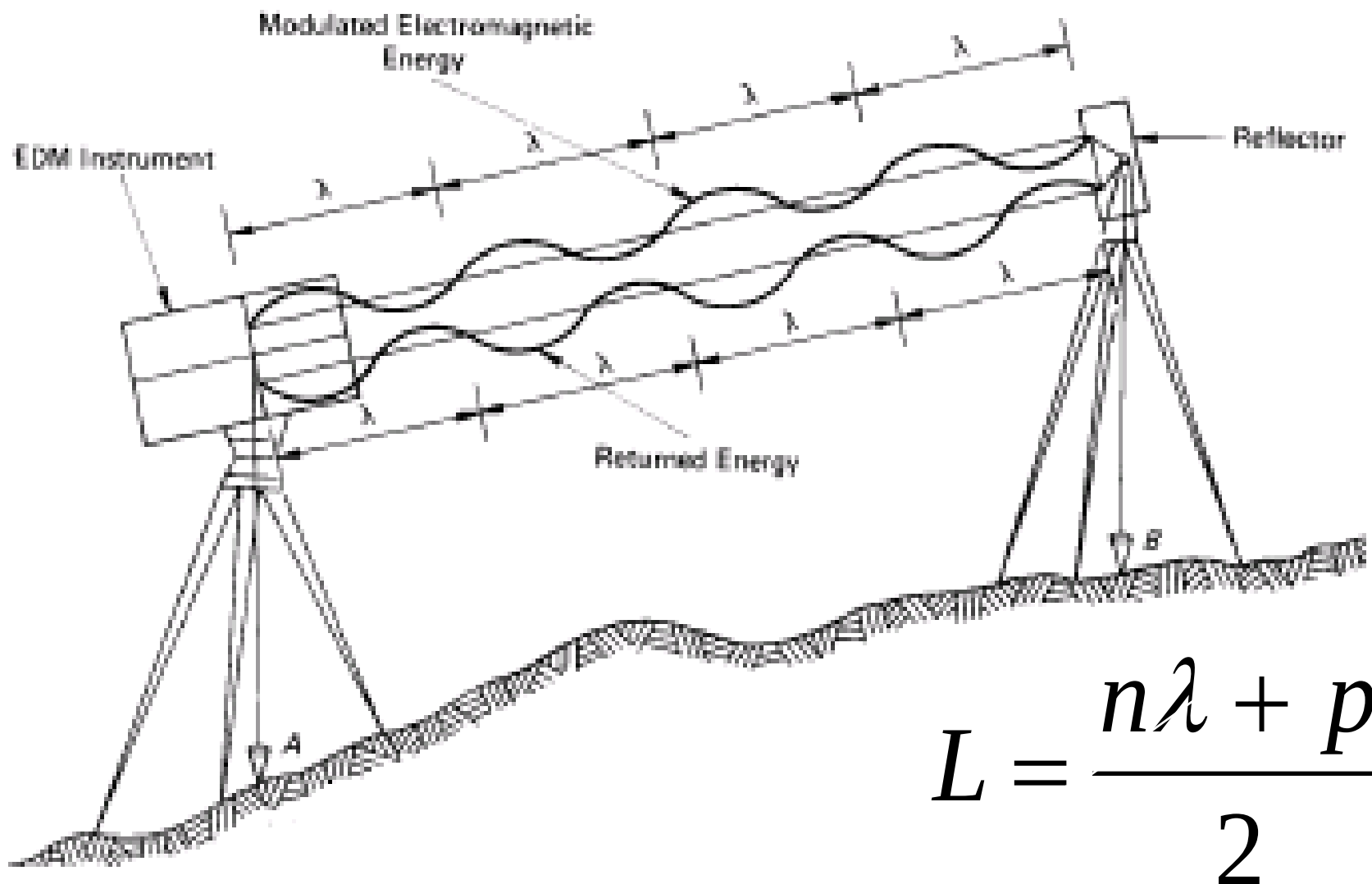


Principles of EDM measurement

❑ Operation:

❑ A wave is transmitted and the returning wave is measured to find the distance traveled.





Principles of EDM measurement

- Distances determined by calculating the number of wavelengths travelled.

$$L = \frac{n\lambda + \phi}{2}$$

- Errors are generally small and insignificant for short distances.
- For longer distances they can be more important.
- Errors can be accounted for manually, or by the EDM if it has the capability.

Velocity of light can be affected by:

Temperature

Atmospheric pressure

Water vapor content

EDM

EDM = Electronic Distance Measuring

- First introduced in the late 1950's
- At first they were complicated, large, heavy, and suited primarily for long distances
- ❑ Current EDM's use either infrared (lightwaves) or microwaves (radio waves)
- ❑ Microwaves require transmitters/receivers at both ends
- ❑ Infrared use a transmitter at one end and a reflecting prism at the other and are generally used more frequently.
- ❑ They come in long (10-20 km), medium (3-10 km), and short range (.5-3 km).
- ❑ They are typically mounted on top of a theodolite, but can be mounted directly to a tribrach.



*EDM Properties *

Ranges

- Long (10-20 km),
- Med (3-10),
- Short (.5-3).
- Range limits up to 50 km



← Total station

The Total Station



☐ Measures and Records:

Horizontal Angles
Vertical Angles
and
Slope Distances

☐ Calculates:

Horizontal Distance
Vertical Distance
Azimuths of Lines
X,Y,Z Coordinates
Layout, Etc.

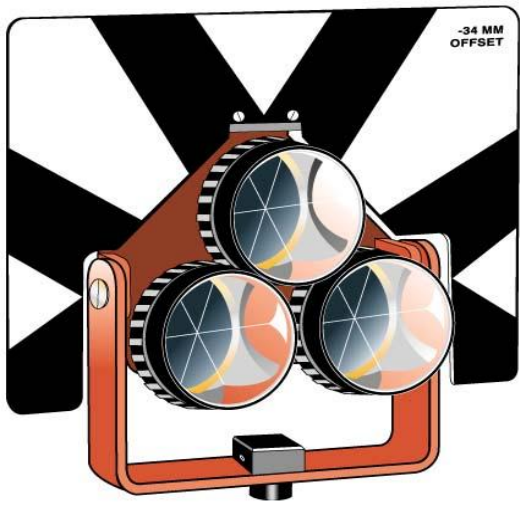


EDM Characteristics

- 750-1000 meters range
- Accurate to $\pm 5\text{mm} + 5 \text{ ppm}$
- Operating temperature between -20 to +50 degrees centigrade
- 1.5 seconds typical for computing a distance, 1 second when tracking.
- Slope reduction either manual or automatic.
- Some average repeated measurements.

Signal attenuation.

- battery operated and can perform between 350 and 1400 measurements.



Prisms



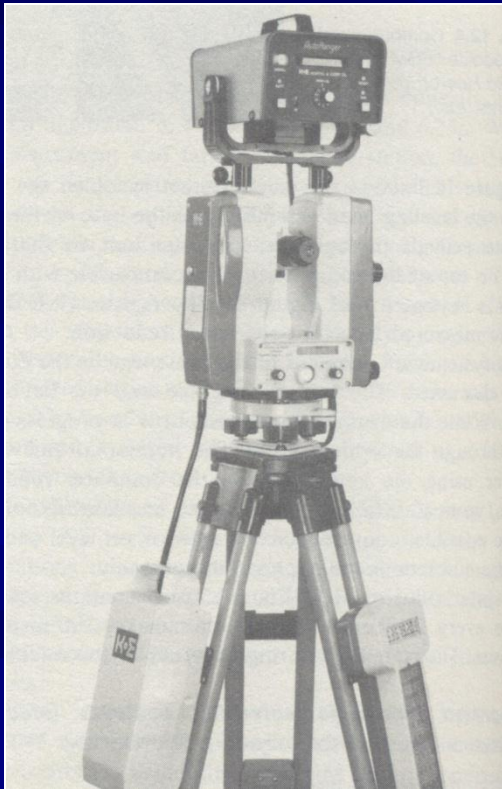
- Made from cube corners
- Have the property of reflecting rays back precisely in the same direction.
- They can be tribrach-mounted and centered with an optical plummet, or they can be attached
- to a range pole and held vertical on a point with the aid of a bulls-eye level.

EDM Accuracy

Distance (ft)	Error (ft)	Linear Precision	PPM
10	0.0164	1:600	1670
25	0.0165	1:1,500	670
50	0.0166	1:3,000	330
100	0.0167	1:6,000	170
300	0.0173	1:17,000	60
500	0.0179	1:28,000	35
1,000	0.0194	1:50,000	20
2,000	0.0224	1:90,000	10
4,000	0.0284	1:140,000	7
6,000	0.0344	1:170,000	6

Table 1: EDM Error Tabulated Over Distance Where Error is $\pm(5 \text{ mm} + 3 \text{ PPM})$

Advances
In
Computers,
Lasers
&
Batteries

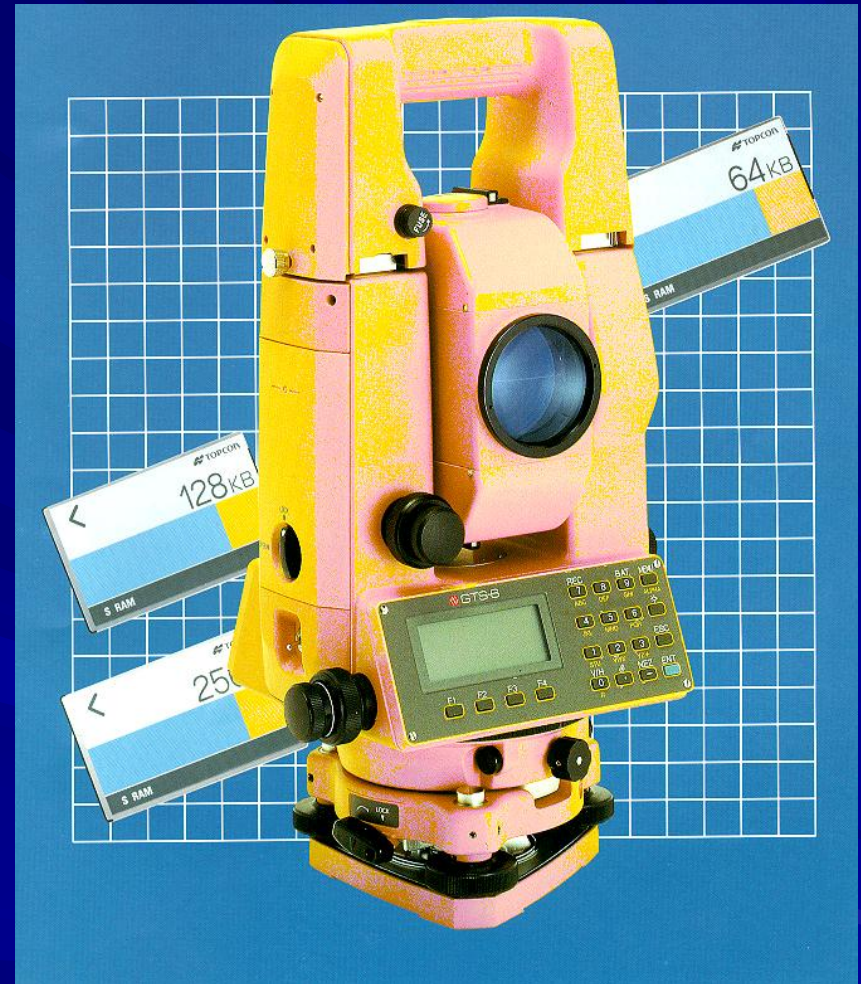




More advanced instrument

Total station

- Theodolite, EDM, data processor & display unit combined
- Instant data conversion into 3-D coordinates
- Interface with computers



**Total station with
memory cards**



Total Stations

- Leica
- Topcon
- Sokkia
- Pentax



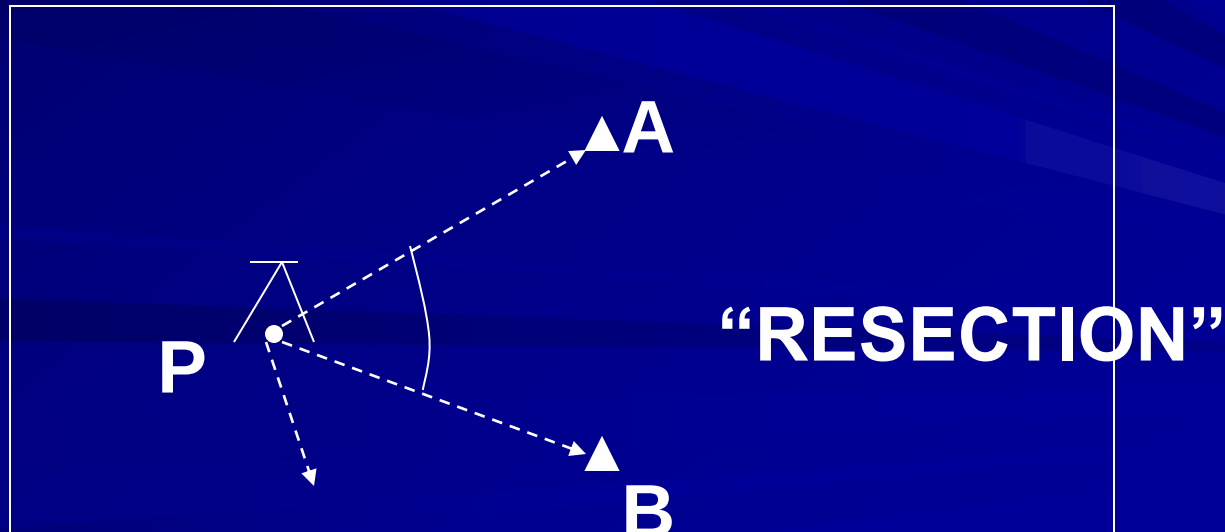
Components of a Total Station

- EDM
- Electronic theodolite
- On-Board Micro-processor
- Data Collector (built in or separate unit)
- Data Storage (internal or memory card)
- Prisms



Micro-processor

- **Averages multiple angle** measurements
- **Averages multiple distance** measurements
- Computes **horizontal** and **vertical distances**
- **Corrections** for temp, pressure and humidity
- **Computes** inverses, polars, resections
- **Computes X, Y and Z coordinates**



Specifications

Range

Reflectorless → 3 – 70 meters

Single Prism → 1 – 2000 m

Triple Prism → 1 – 2200 m

Accuracy

Angles → 1 - 5"

Distance → 3mm + 2ppm (prism)

→ 4mm + 3ppm (reflectorless)

Data Storage

2000 – 4000 points



Field to Finish Operation

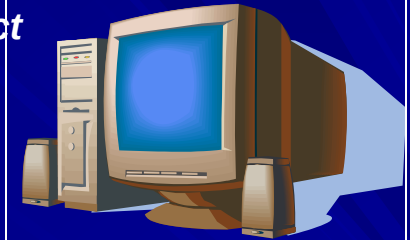


• *Automatic target recognition*



• *Memory card
USB and Compact
Flash*

• *Transfer remotely
(radio/cell
phone)*



• **Control/operation
(robotic)**

• **Measurement
and basic comps**

• **Final Comps,
checks and
outputs**

Continuing Evolution of Measurement Technologies

Leica Smartstation



Topcon Imaging TS



Merging TS and GPS

Merging TS and Lidar

Broadcast of
Real-Time
Corrections

Terrestrial Photogrammetry?

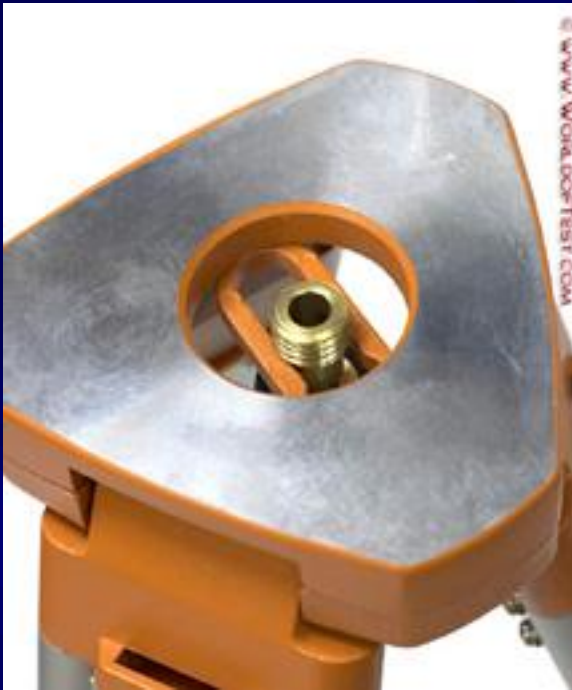
GoogleEarth

High Resolution Satellite Imagery

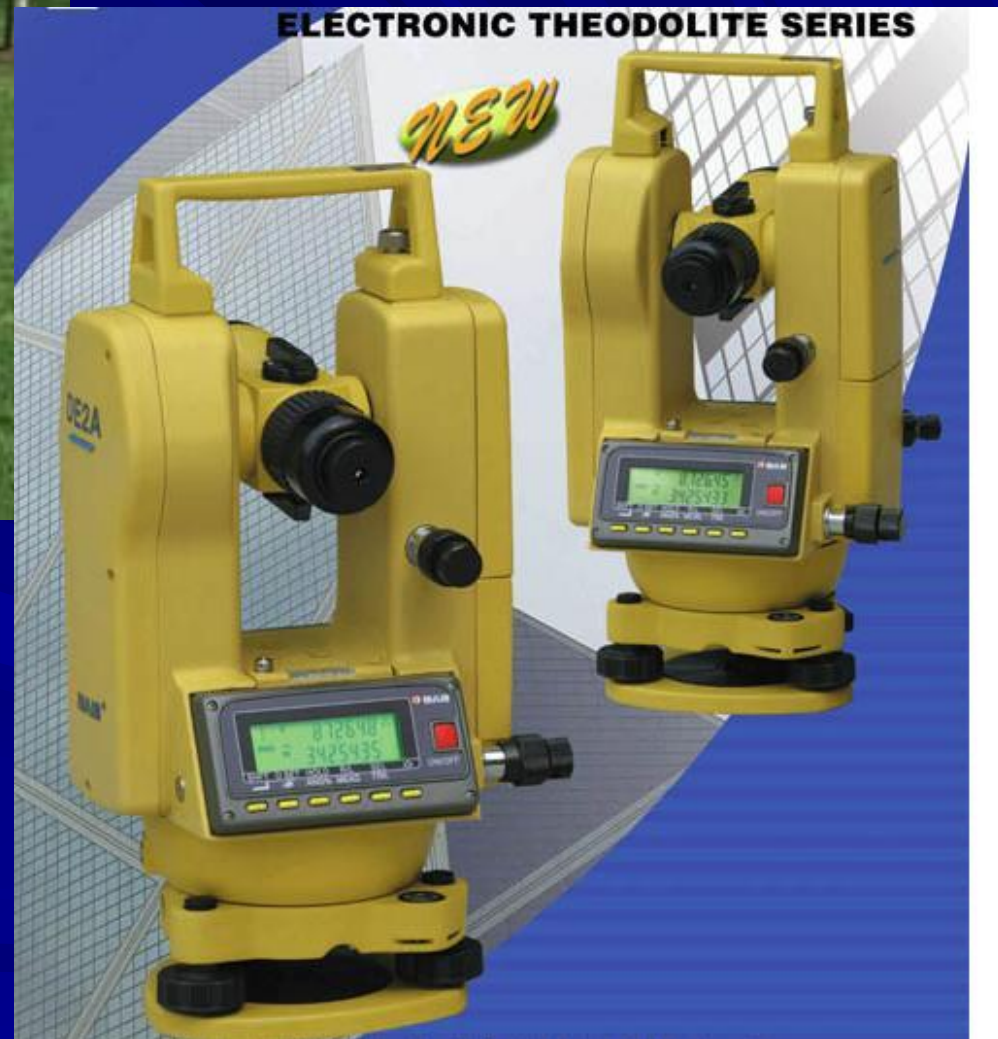












Features:-

- Total solution for surveying work,
- Most accurate and user friendly,
- Gives position of a point (x, y and z) w. r. t. known point (base point),
- EDM is fitted inside the telescope,
- Digital display,



- On board memory to store data,
- Compatibility with computers,
- Measures distance and angles and displays coordinates,
- Auto level compensator is available,
- Can work in lesser visibility also,
- Can measure distances even without prismatic target for lesser distances,
- Is water proof,
- On board software are available,
- Can be used for curve layout after feeding data.

- New **total stations** have atmospheric correction, and auto-focus. In addition, these series incorporates a quick distance measuring mode and a high data storage capacity for increased productivity.
- The new **Total station** gives the unique opportunity for long range distance monitoring of up to 9000m to a single prism. Using the scan functionality of software allows fully automated monitoring of the prism in direction of the line of sight.

USES:-

Total Stations can be used for:

- General purpose angle measurement
- General purpose distance measurement
- Provision of control surveys
- Contour and detail mapping
- Setting out and construction work

Factors influencing the use of Total Stations:

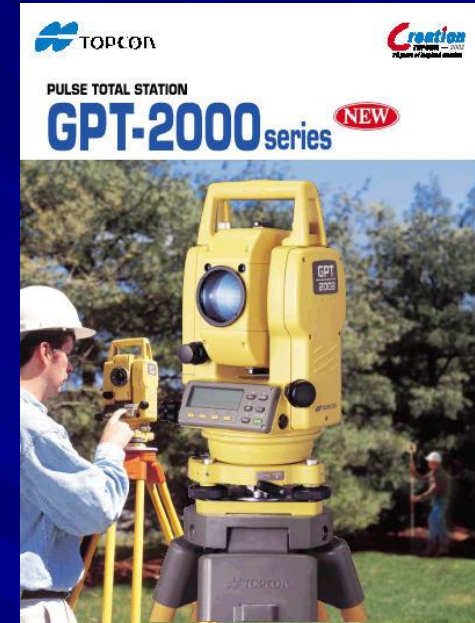
- A clear line of sight between the instrument and the measured points is essential.
- The precision of the instrument is dependent on the raw repeatabilities of the direction and distance measurements.
- A well defined measurement point or target/prism is required to obtain optimal precision and accuracy.
- The accuracy of direction and distance measurement is subject to a number of instrumental errors and the correct field procedures.

Auxiliary Equipment Required

- Targets or Prisms to accurately define the target point of a direction measurement.
- A data recorder if one is not integrated into the total station.
- A download cable and software on a PC to capture and process the captured digital data to produce contour and detail maps.

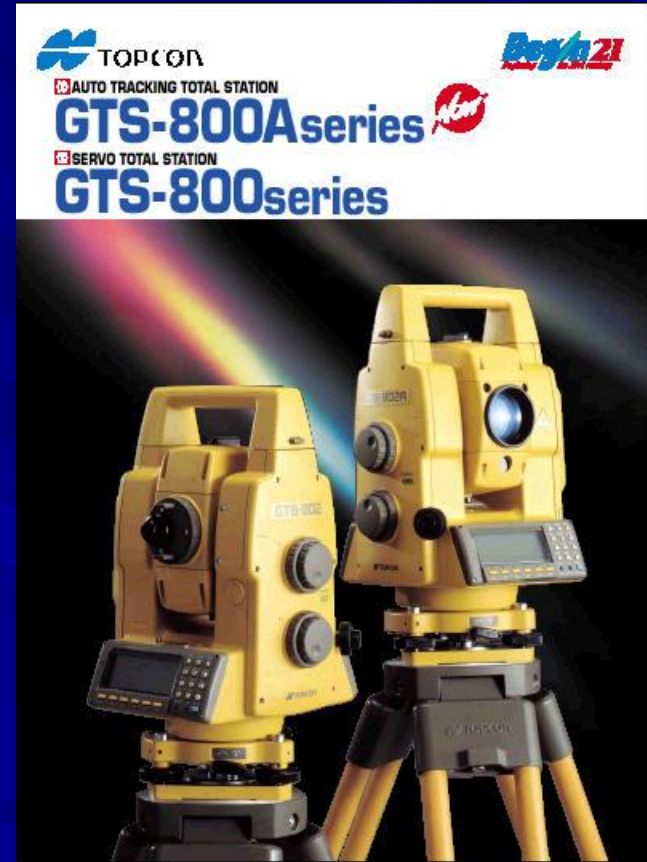
Topcon: Pulse Total Station GPT-2000 series

- Using pulse laser technology
- Support both prism/non-prism mode
- High accuracy:
 - Millimeter accuracy in distance measurement (5mm+2ppm xD in non prism mode; 3mm+2ppmxD in prism mode)
 - 1"/ 5" (H & V) angle measurement accuracy
- Fast data acquisition:
 - 0.3 sec tacking mode
 - 1.2 second fine mode
- Long range:
 - Prism: 7,000m
 - Non prism: 150m
- All weather operation: water /dust proof
- Large data storage: 8000 points
- Laser plummet



Total Station GTS-800/800A series from Topcon

- Motorized & automatic tracking – high speed rotation (up to 50° /sec) and high speed auto-tracking (up to 5° /sec)
- Remote control through radio link or optical remote controller – enables one man operation
- Flexible data management: Huge data storage – 2Mb memory plus PCMCIA card, space for data and software
- User friendly
 - Large graphic display
 - Built-in MS-DOS OS
 - Compact and light weight
 - Water / dust resistant
 - Handheld data collector
 - TDS Survey Pro software allows more functions: job classification, stake out, etc.



Leica TCRA1100 series Total Station

- Motorized, automatic target recognition, reflectorless and remote control
- Accuracy:
 - Angle measurement: from 1.5" to 5"
 - Distance measurement: 3mm+2ppm w/o reflector; 2mm+2ppm w/ reflector
- Range: 200m (w/o reflector) to 7.5 km (w/reflector)
- Time
 - 1sec w/ reflector
 - 3 sec w/o reflector
- Data storage: PCMCIA card or export via RS232
- Software supports:
 - computations of area, height, tie distance etc.
 - stake outs
 - Exchange data between instrument and PC
 - Create code list



Competitive Comparison

- Motor drive performance and compensation range is similar to competing models



	SOKKIA SRX	Leica TPS1200	Trimble S6	Trimble 5600	Topcon GPT-8200A	Topcon GPT-9000A
Maximum Speed	45° / sec	45 / sec	115 / sec	?	50 / sec	85 / sec
Trigger Key	Y	N/A	Y	N/A	N/A	N/A
Compensator	Dual-axis	Dual-axis	Dual-axis	Dual-axis	Dual-axis	Dual-axis
Working range	+/- 4'	+/- 4'	+/- 6'	+/- 6'	+/- 4'	+/- 6'

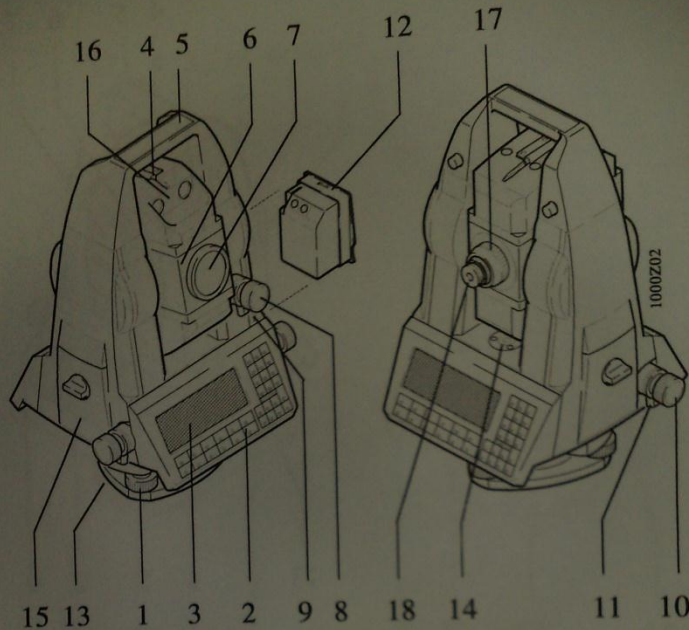
SRX

- Sokkia SRX is a completely new, revolutionary, next-generation Robotic Total Station
 - Stress-free Complete Remote Control
 - RED-Tech EX Enhanced Reflectorless EDM
 - IACS Technology RAB-code angle encoder
 - Bluetooth Wireless Technology
 - Multiple Data Interfaces

New Features

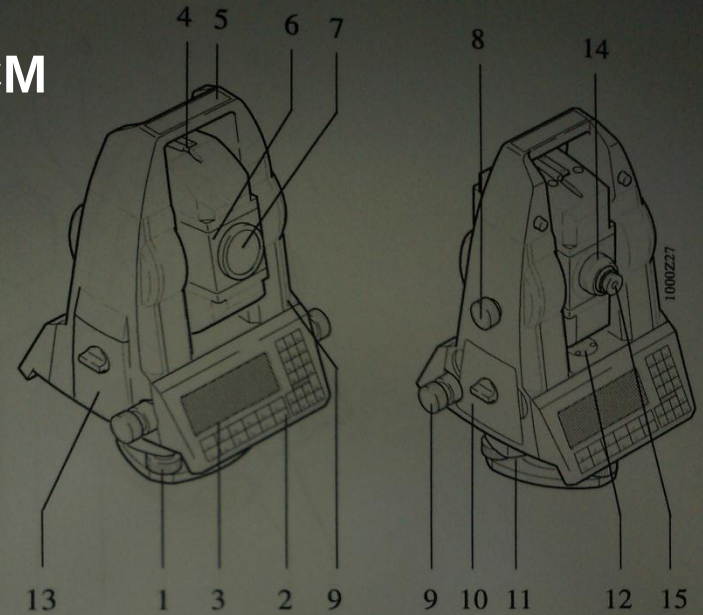
- Completely new environmental-friendly design
- New motors and jog dials for precise positioning and accurate aiming
- Side mounted trigger key
- New precise and reliable absolute encoders
- New dual-mode Auto-pointing and Auto-tracking
- New enhanced On-Demand Remote Control System
- Integrated long-range Bluetooth wireless technology
- New Enhanced EXtended reflectorless technology
- New touch screen color display
- Windows CE 5 operating system
- New On-board software
- Compact Flash Card support (up to 1GB) and USB ports
- Serial data/power port.
- Flexible power system
- Dust proof and waterproof construction even when external devices are connected

TC

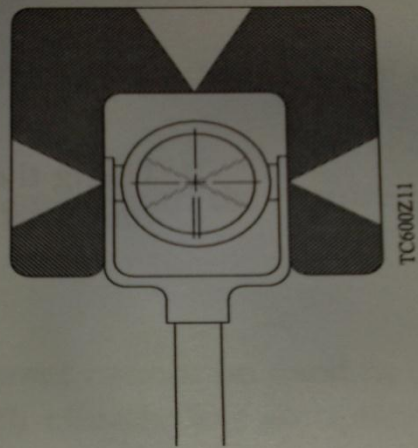


- | | |
|--|--------------------------------|
| 1 Footscrew | 10 Horizontal drive screw |
| 2 Keyboard | 11 Horizontal clamp |
| 3 Display | 12 Battery housing |
| 4 Optical sight | 13 Tribrach securing knob |
| 5 Carrying handle | 14 Bull's-eye bubble |
| 6 Telescope with integrated EDM | 15 Memory card housing |
| 7 Coaxial optics for angle- and distance measurement | 16 EGL1 Guide light (optional) |
| 8 Vertical drive screw | 17 Focusing ring |
| 9 Vertical clamp | 18 Interchangeable eyepiece |

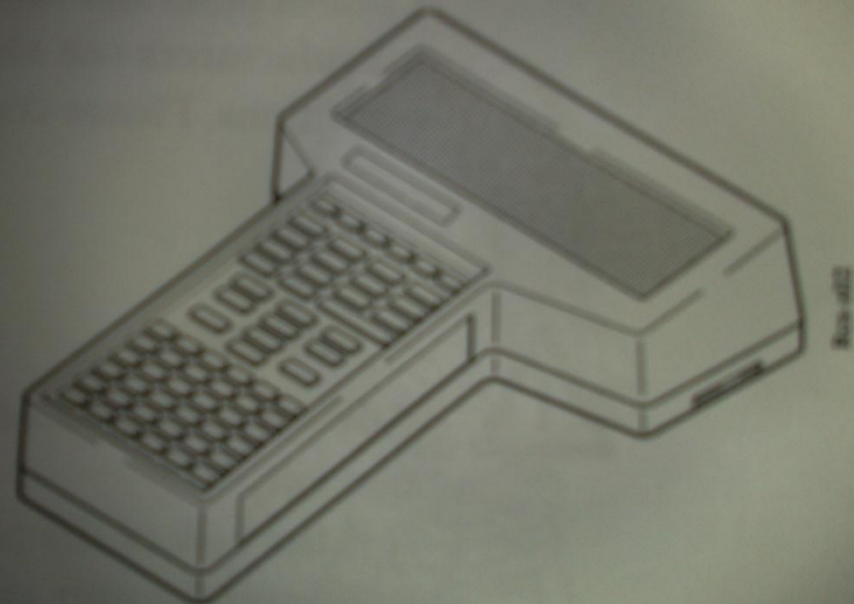
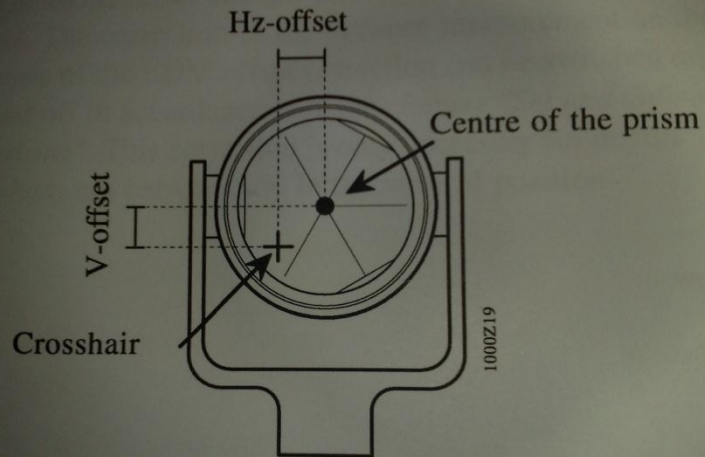
TCM



- | | |
|--|-----------------------------|
| 1 Footscrew | 8 Vertical drive screw |
| 2 Keyboard | 9 Horizontal drive screw |
| 3 Display | 10 Battery housing |
| 4 Optical sight | 11 Tribrach securing knob |
| 5 Carrying handle | 12 Bull's-eye bubble |
| 6 Telescope with integrated EDM | 13 Memory card housing |
| 7 Coaxial optics for angle- and distance measurement | 14 Focusing ring |
| | 15 Interchangeable eyepiece |



GPH1 prism holder with GZT4 target plate



Total Stations

- ❑ **TPS: Total Positioning System**
- ❑ **Motorized version: Automatic target recognition system.**
- ❑ **Regular version: manual target recognition system**
- ❑ **Advantages:**
 - ❑ **More functionality and flexibility**
 - ❑ **Improve comfort and productivity**
 - ❑ **Enhance display capabilities (LCD)**
 - ❑ **High accuracy (0.5" angles, 1mm±ppm distances)**

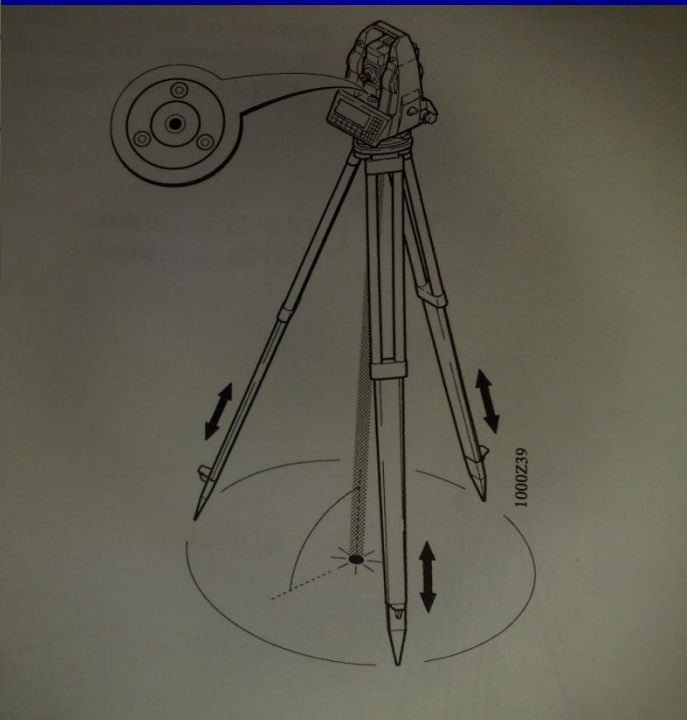
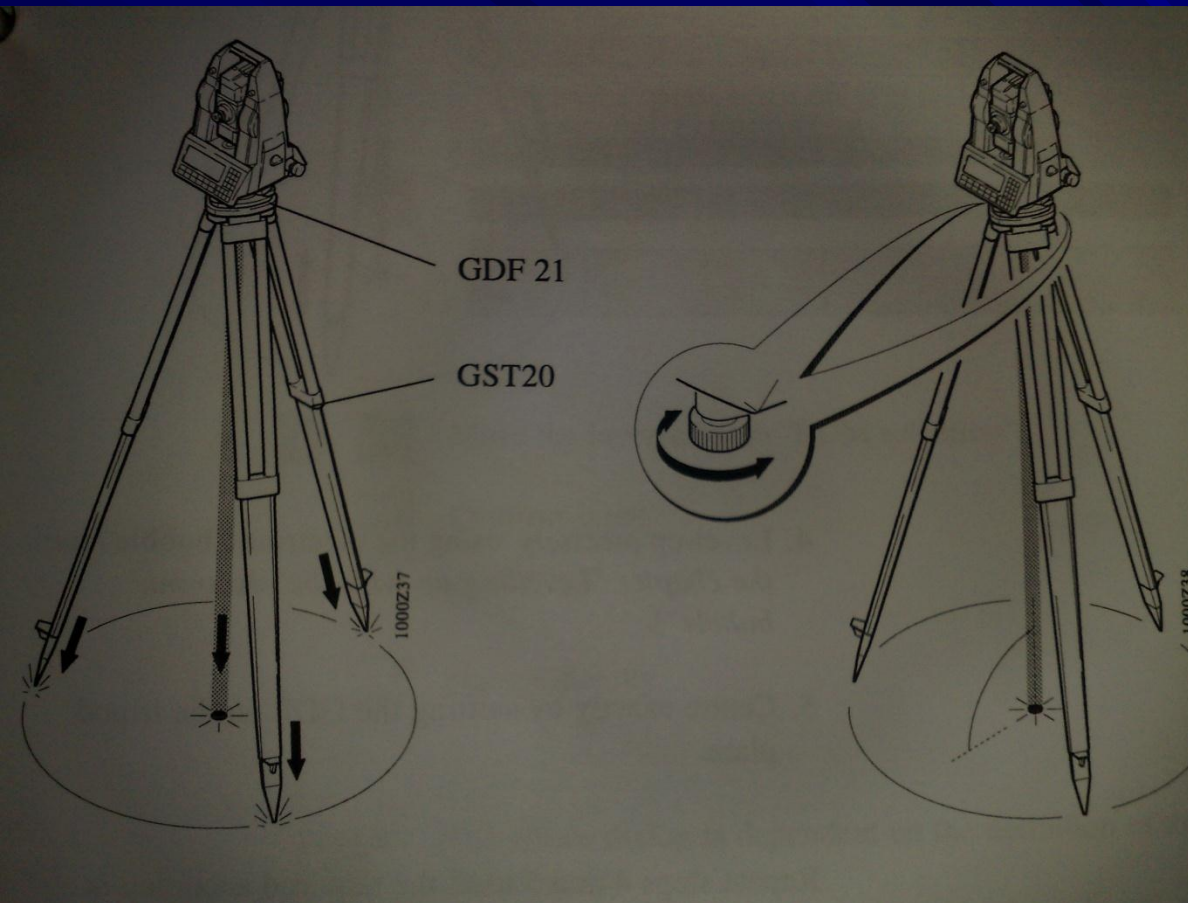
Available Total Stations in the Laboratory

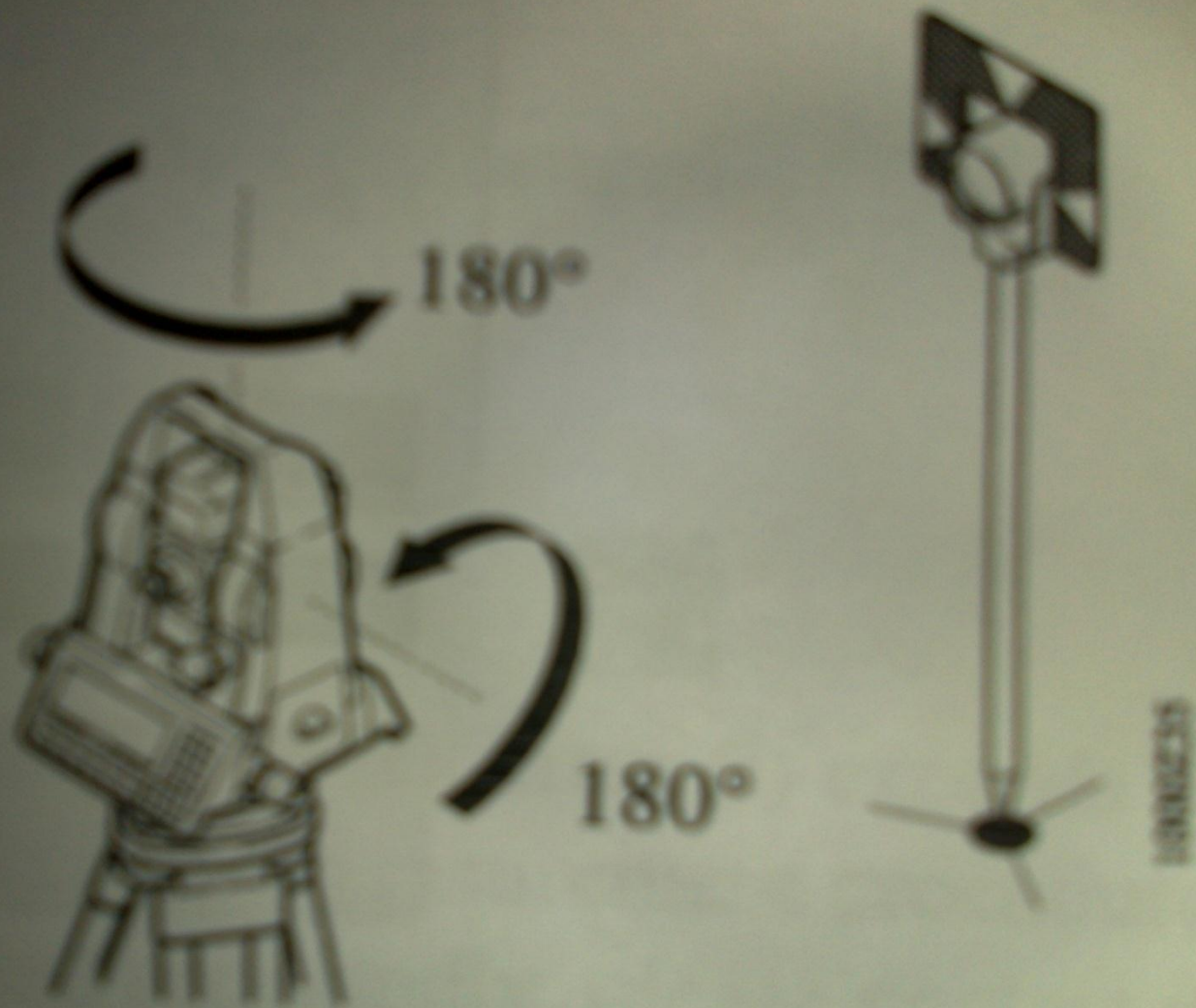
- ❑ TC 1200: Non-motorized (Manual)
- ❑ TCM 1800: Motorized Leica Total Station

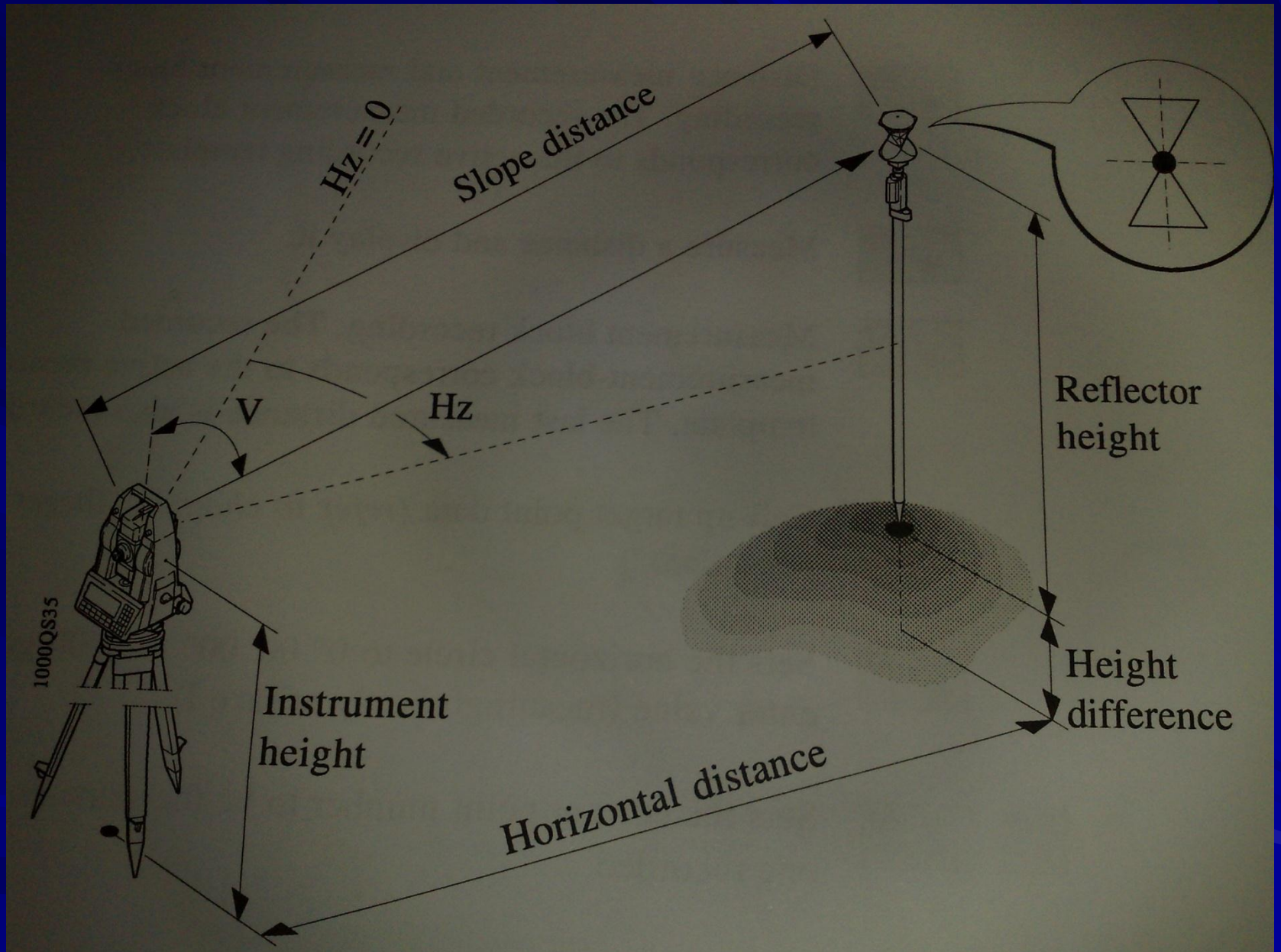
- ❑ Setup:
 - ❑ Centering: Laser plummet or optical one;
 - ❑ Leveling: legs and screws.

Laser Plummet









GPT2000 series Display



Prism Mode



Non-Prism Mode

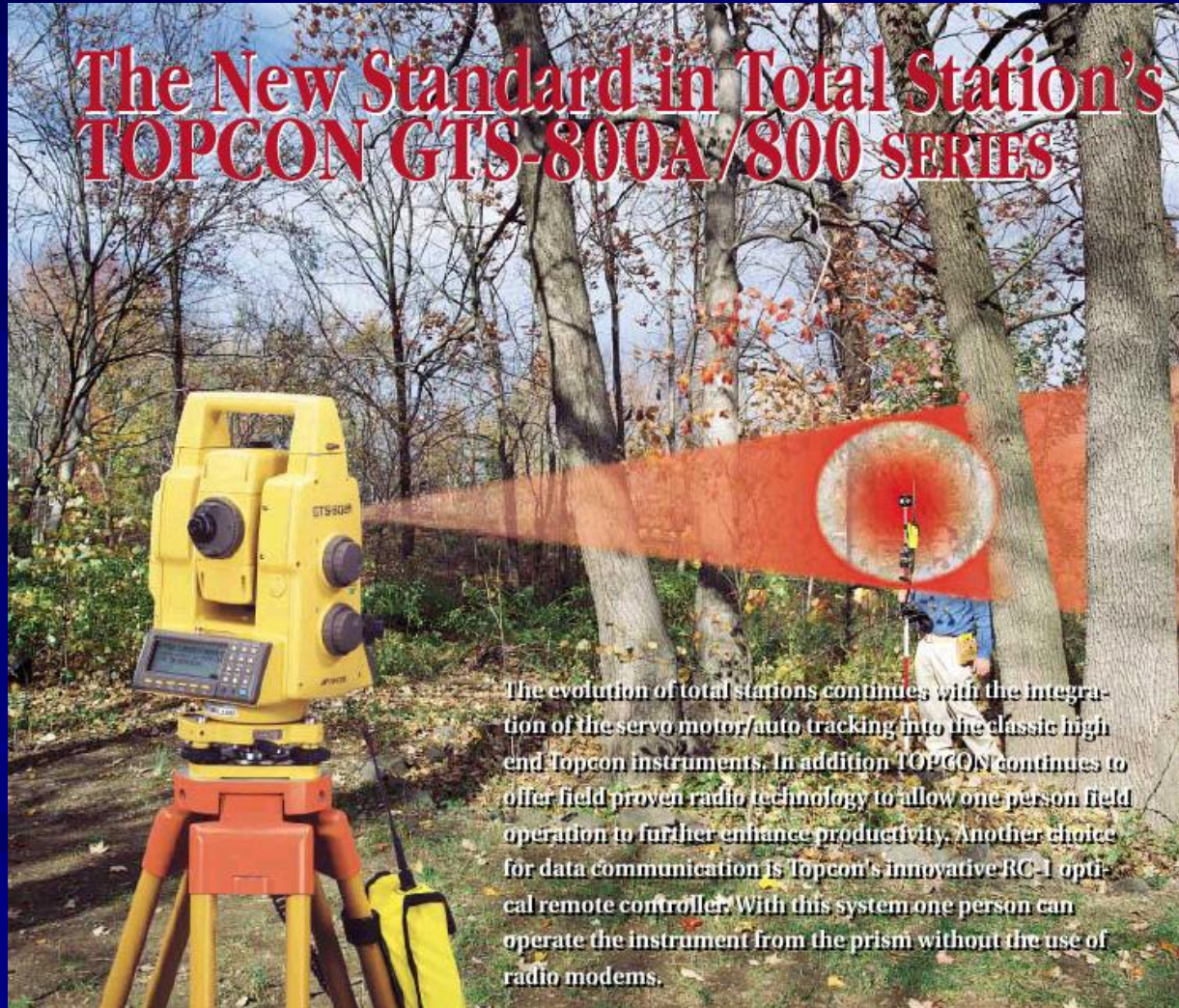


Leica TCRA1100 series Range

☐ Range-Reflector	☐ 3 km (circular prism)
	☐ 1.5 km (360 degree prism)
☐ Reflectorless - standard range	☐ 80m (without reflector)
	☐ 5 km (circular prism)
☐ Reflectorless - eXtended Range	☐ 200m (without reflector)
	☐ 7.5 km (circular prism)



GTS800A Series

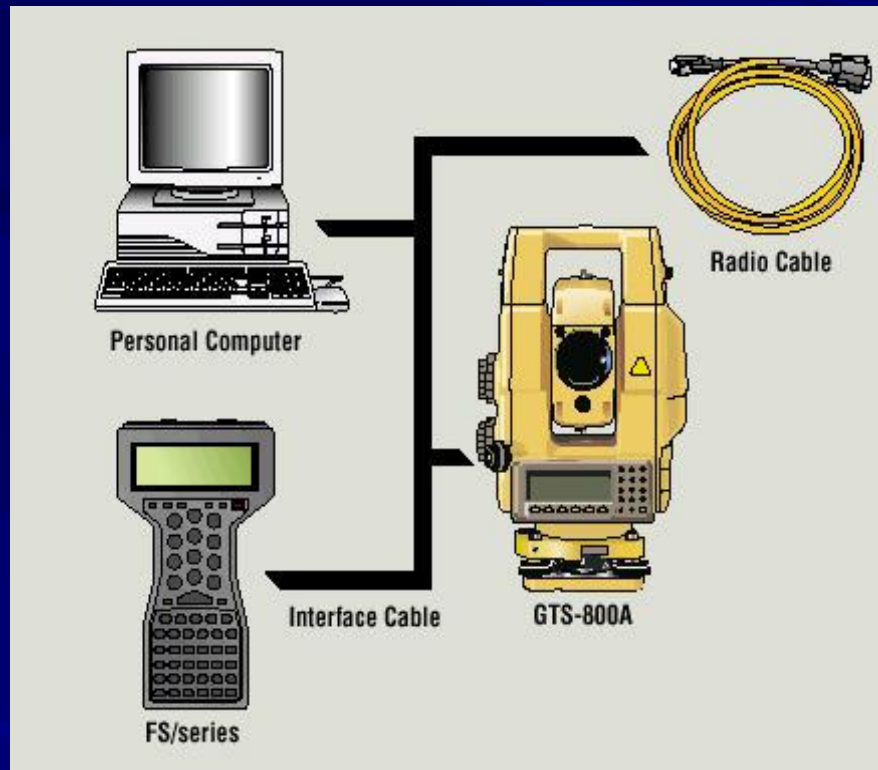


**The New Standard in Total Station's
TOPCON GTS-800A/800 SERIES**

The evolution of total stations continues with the integration of the servo motor/auto tracking into the classic high end Topcon instruments. In addition TOPCON continues to offer field proven radio technology to allow one person field operation to further enhance productivity. Another choice for data communication is Topcon's innovative RC-1 optical remote controller. With this system one person can operate the instrument from the prism without the use of radio modems.



External Interface

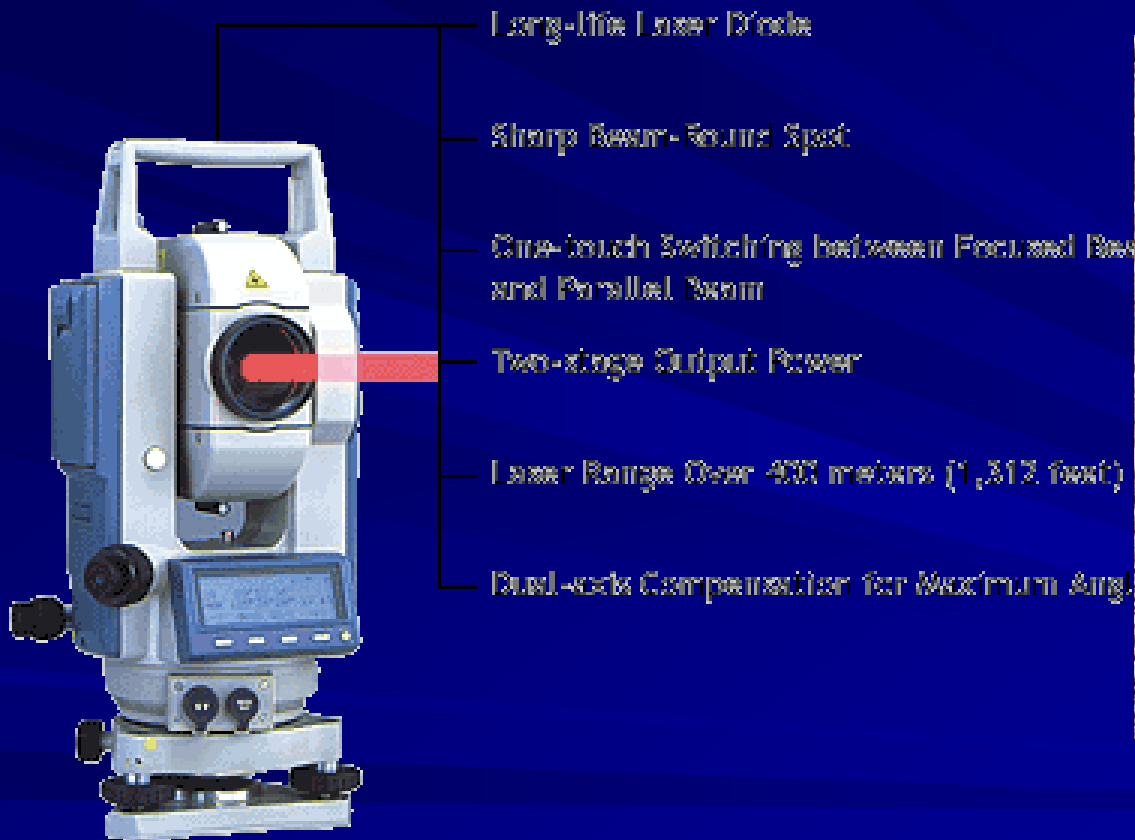


❑ The external interface provides a way for the instrument to communicate with a PC, a laptop, a palm or a data logger. All the models here have this ability



The laser total station

LDT50 - Laser Digital Theodolite

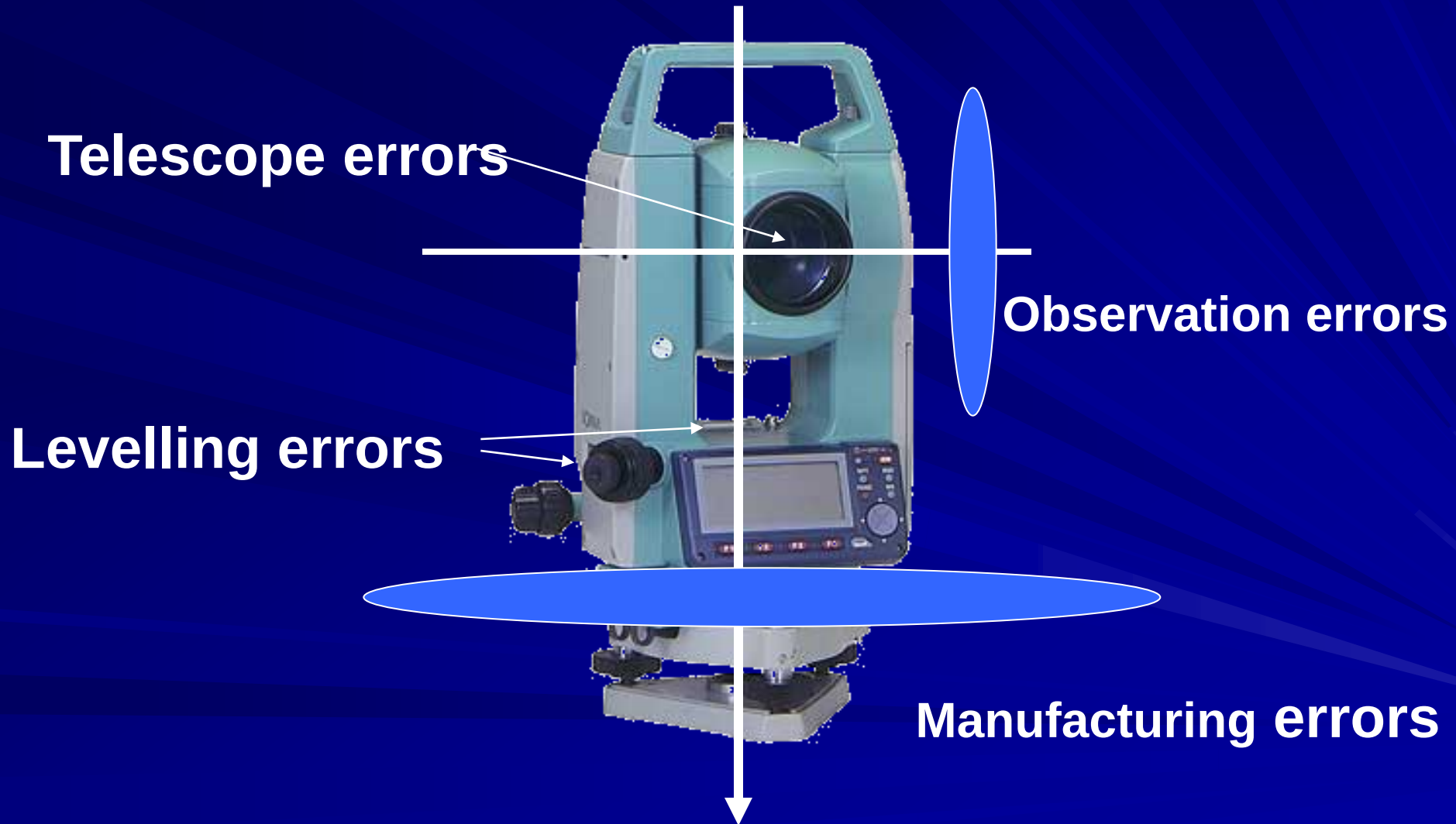


- The laser total station combines a laser based distance measuring device with a highly accurate device to measure angles (vertical and horizontal)
- The total station can convert all field observations into a data file which can be downloaded directly into a computer mapping application.



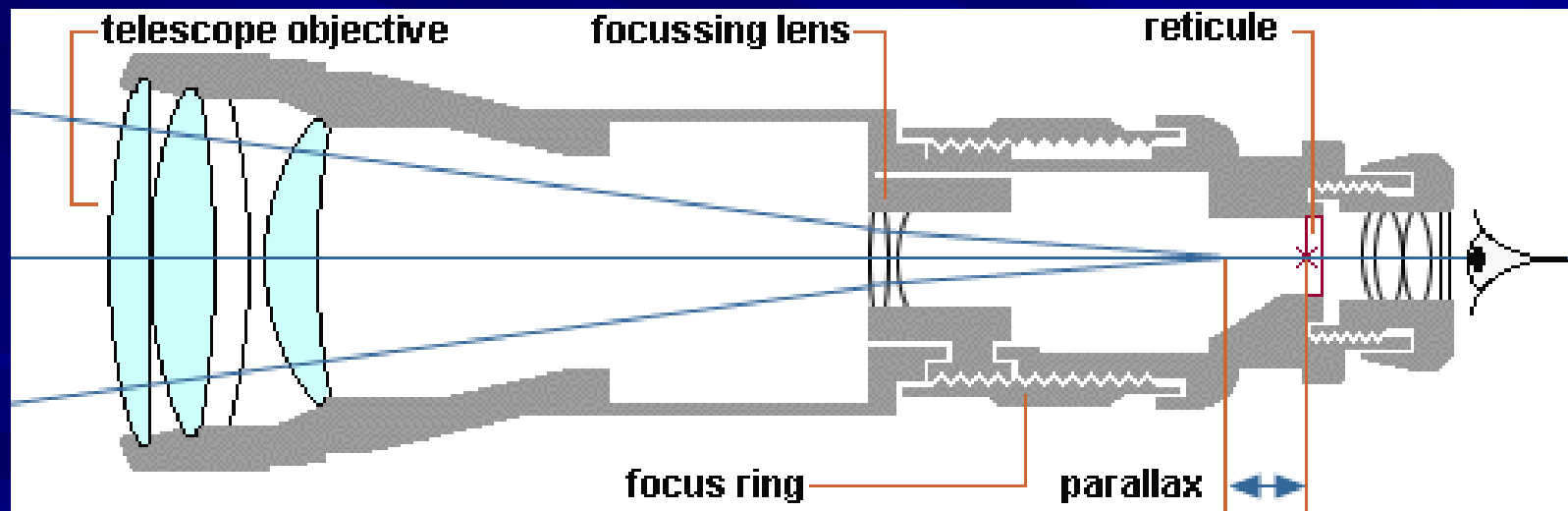
□ Smart Total Stations

Jigger Errors



The Telescope

- Parallax error
- Collimation error



Total Station

■ Components

- Head
- Data Collector
- Tri-pod
- Survey Rod with prism (adjustable height from .25ft to 25ft)

Total Station

- Components
 - Head



Total Station

- Components
 - Data Collector



Total Station

■ Components

- Tri-pod



Total Station

- Components
 - Survey Rod with prism



Application

- Widely in use
- Good for every type of scene
- Accesses points that are hidden behind objects
- Can be used at night and in moderately foul weather conditions
- Setup is about 5 minutes
- Can be used while emergency crews are on scene

Manpower Requirements

- One operator and one person for each prism. At least one prism is necessary.
- There are systems that can be operated by one person.
- Once the data is collected, it must be uploaded onto a computer to process

Different Types of Usage

- May be used during the on-scene investigation
- May be used after the scene is cleared by having the evidence marked
- May be used again to add points not previously collected.
- The data may be merged onto an aerial view of the scene. Combining Total Station and Photogrammetry



Typical Application

- If used during the on-scene investigation, the investigator would place the prism at each point of reference and a “shot” would be taken. This would be repeated for each point of reference, the vehicles, roadway evidence, and traffic control. The dimensions of the roadway may also have be referenced.

 **DWBROOKE**
9,900+
AYSON

466-3608



Typical Application

- The base would be placed and marked so it could be used again if necessary.
- Using the system while the on-scene investigation is being made extends the time on-scene. Whether this is best for the situation depends on the roadway and traffic conditions.





Typical Application

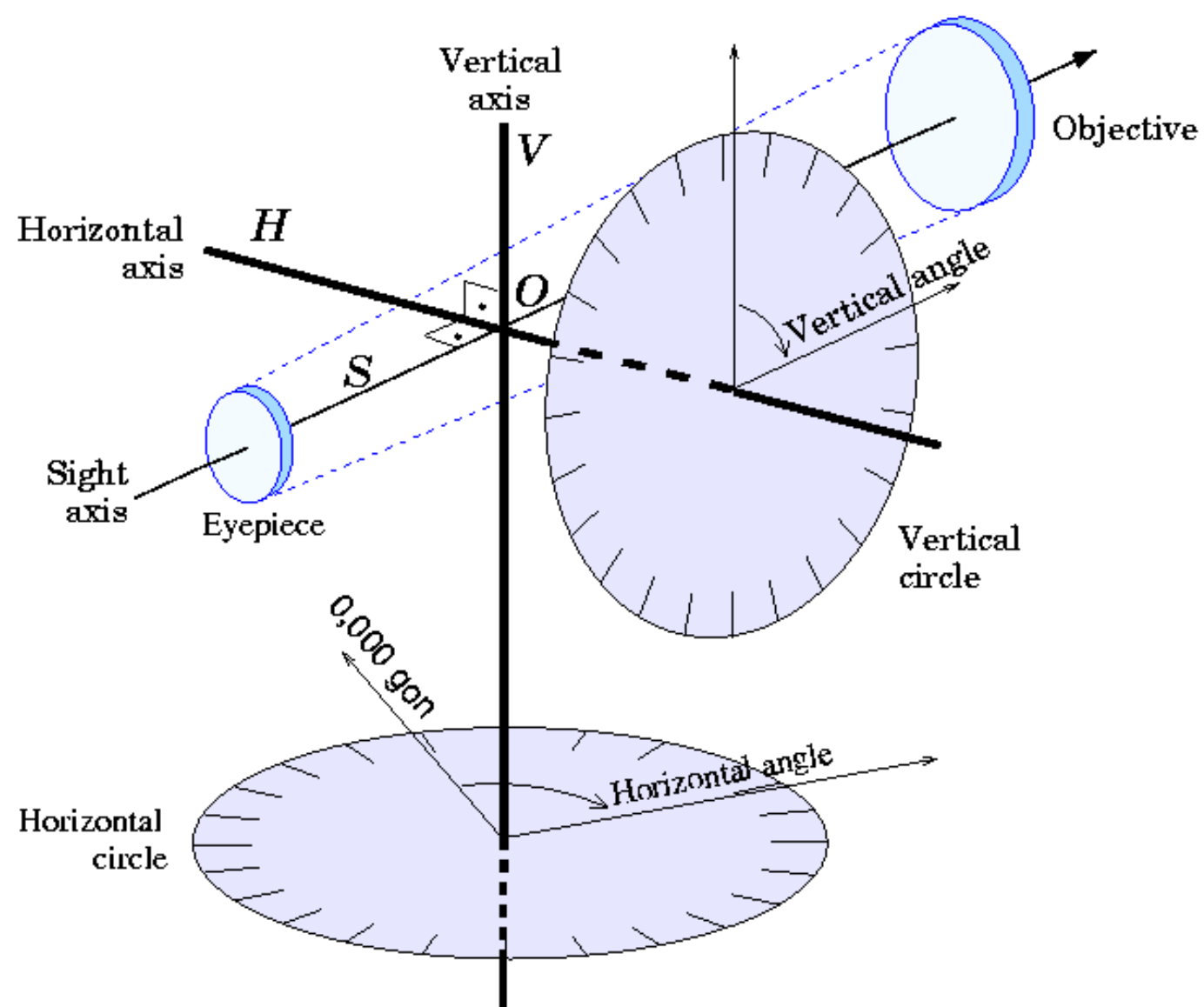
- If the evidence is marked, the scene can be “shot” on a better date and time for the traffic conditions. All the obstructions would be gone and the traffic can be controlled with better planning and appropriate manpower.





Setup :

- ✓ Leveling
- ✓ Centering



□ Some Geometrical Concepts

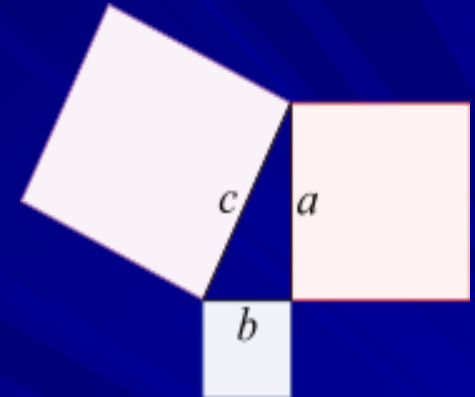
Offsets [perpendicular lines]

- 3 - 4 - 5 [pythagorion theorem] .
- Minimum distance .
- Arc method .
- Any instrument .

Offsets

3 - 4 - 5 [pythagorion theorem] :-

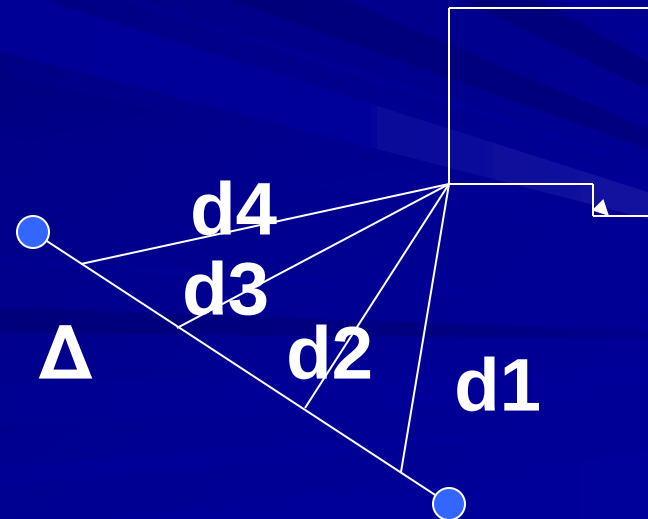
$$C^2 = a^2 + b^2$$



Minimum distance :-

If $d4 > d3 > d1 > d2$

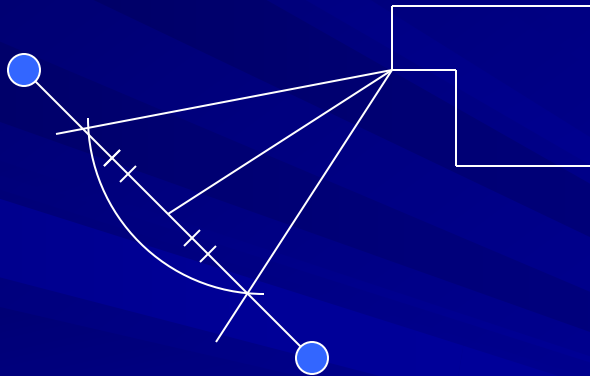
**d1 is
perpendicular**



If Δ is low then the accuracy increased .

Offsets

✓ Arc method



Offset

✓ instrument :-

1. Theodolite .
2. Compass .
3. Total station .
4. Tacheometer .

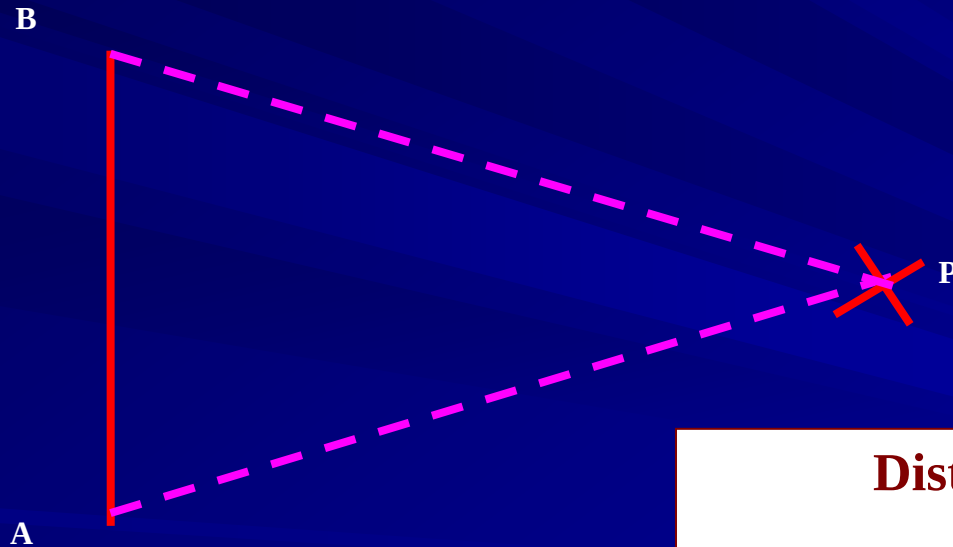


theodolite

Geometrical concept for surveying

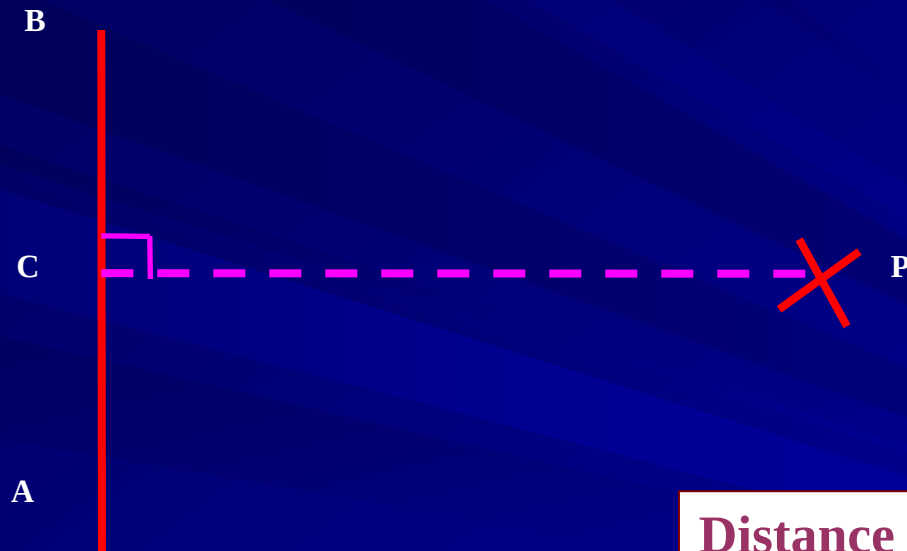
- Distance intersection .
- Angle intersection .
- Polar method .
- Offset method .
- Graphical method .

1- distance intersection



Distance AP and BP

2- Offset method

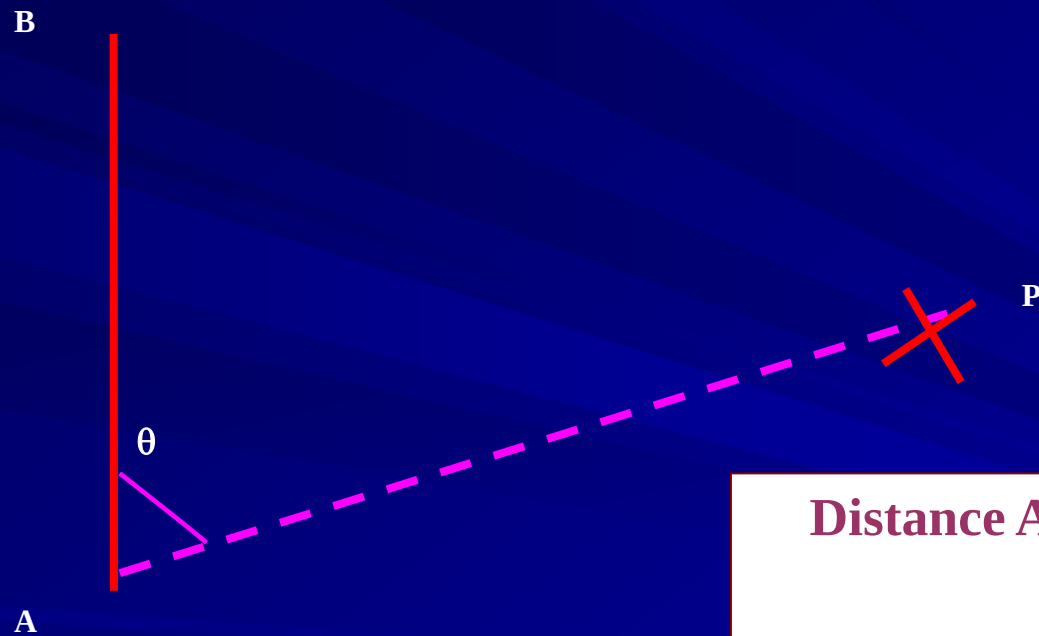


Distance CB or CA

Distance CP

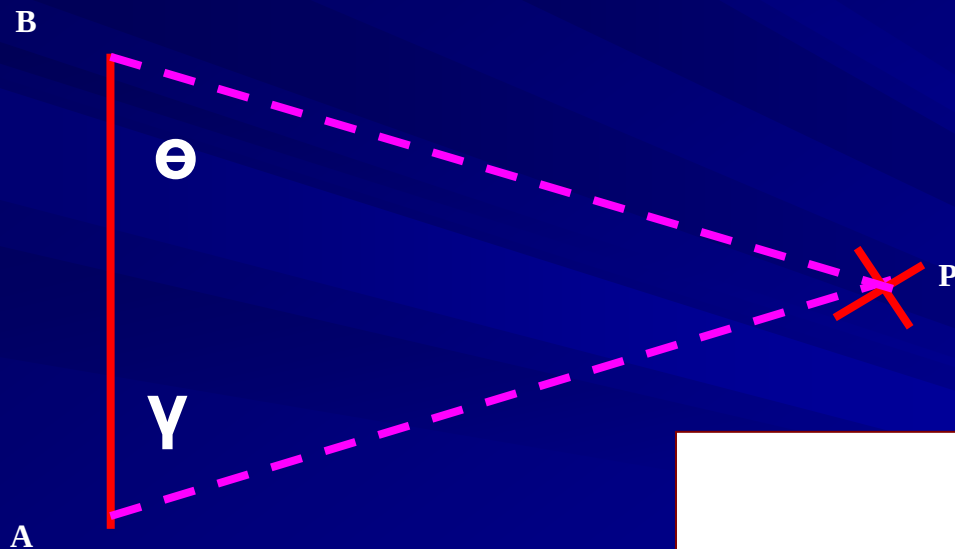
Angle C (90°)

3-Polar intersection



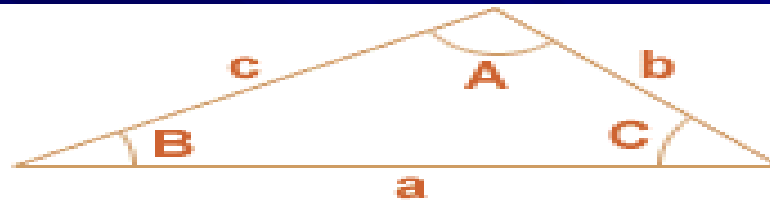
Distance AP & Angle θ

4- Angle intersection



Angle θ & γ

2- Triangle



$$A + B + C = 180^\circ$$

Sine Rule:

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Cosine Rule:

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$$

$$\text{Area} = \frac{1}{2} bc \sin A = \sqrt{s(s-a)(s-b)(s-c)}$$

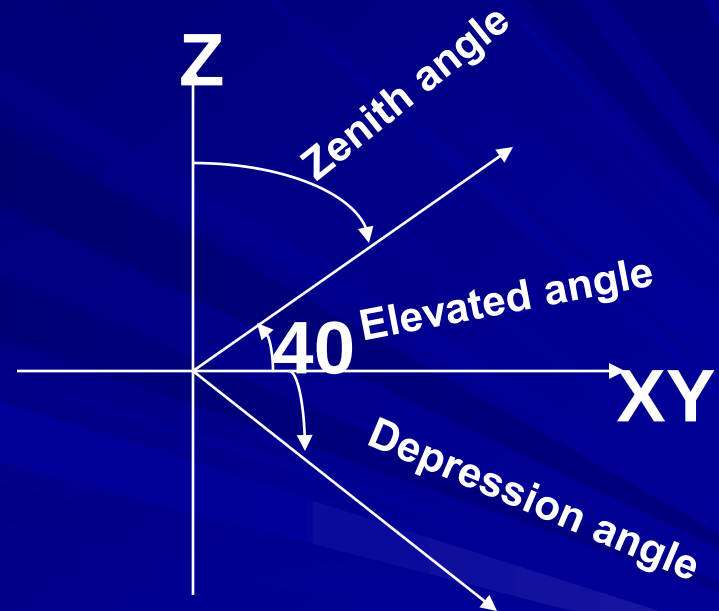
$$\text{where } s = \frac{a+b+c}{2}$$

Vertical angles

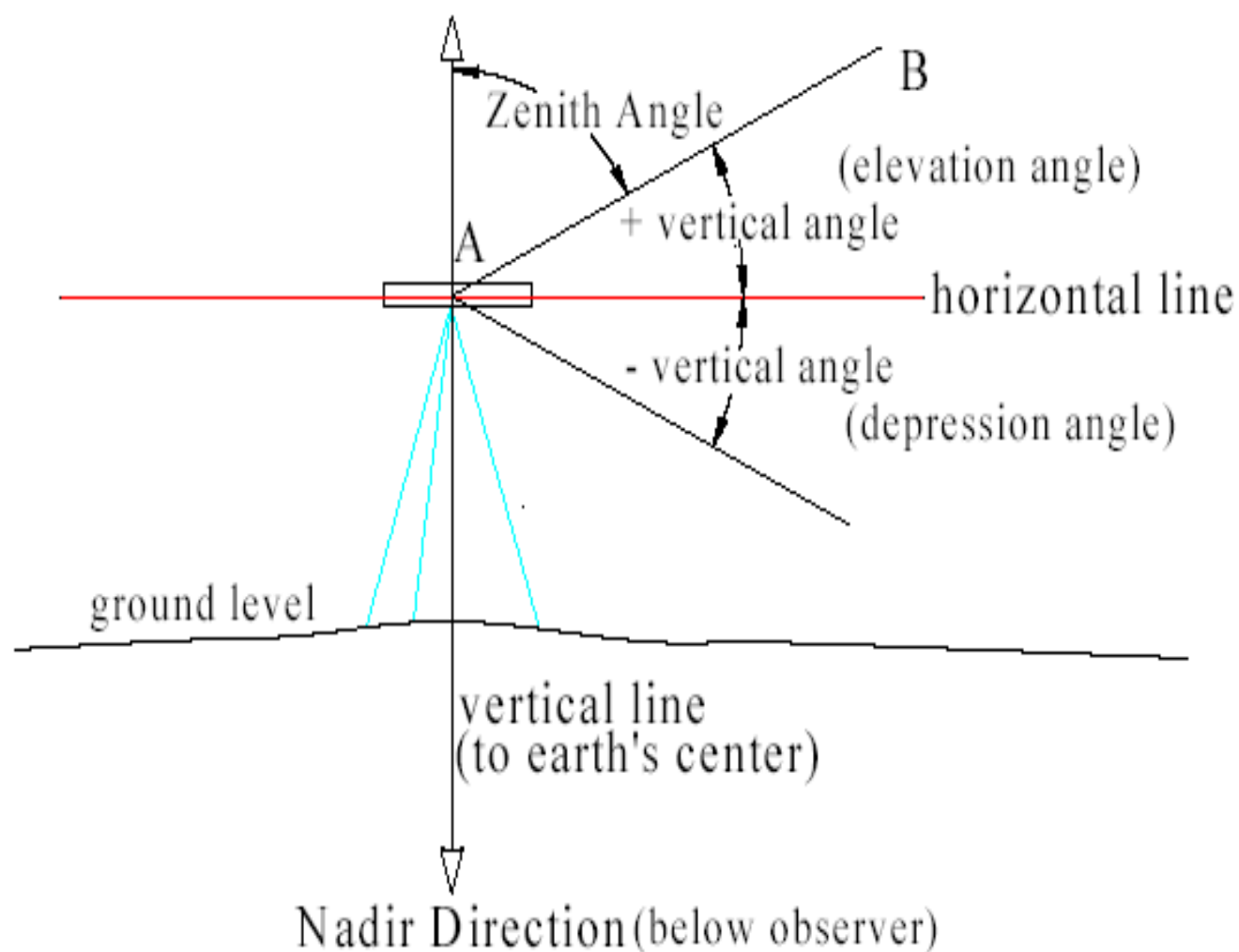
Zenith angle = $90 - \text{elevation angle}$

OR

Zenith angle = $90 + \text{depression angle}$

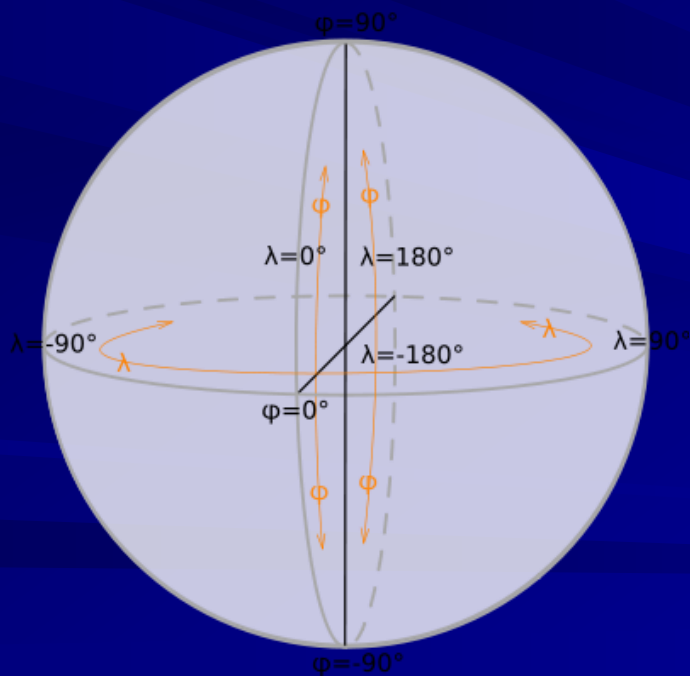


Zenith Direction (above observer)

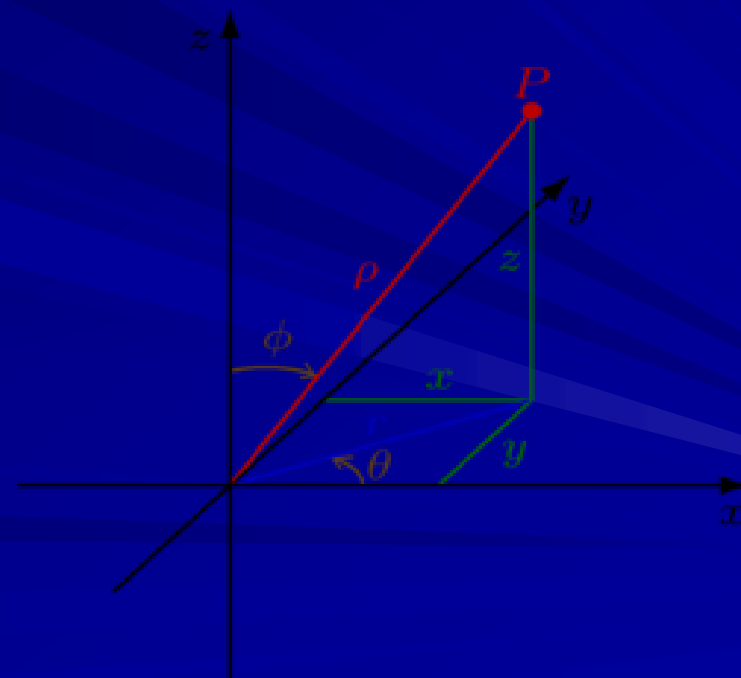


Coordinate Geometry

Global coordinate system



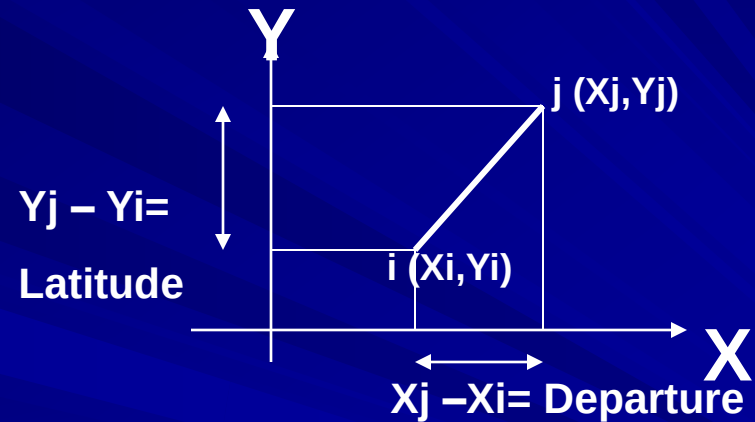
Rectangular coordinate system



$$d_{ij} = \sqrt{(X_j - X_i)^2 + (Y_j - Y_i)^2}$$

$$\tan(\alpha_{ij}) = (X_j - X_i) / (Y_j - Y_i)$$

$$\alpha_{ij} = \tan^{-1}((X_j - X_i) / (Y_j - Y_i)) = \tan^{-1}(\text{Departure} / \text{Latitude})$$



Case 1:

Given: (x_i, y_i)

Measured : d_{ij} , α_{ij}

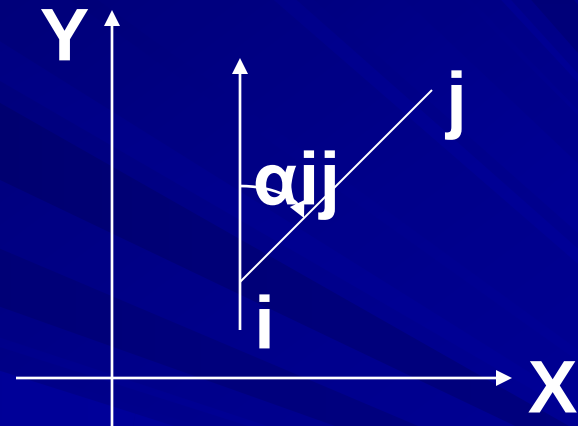
Required : (x_j, y_j)

Departure = $d_{ij} * \sin(\alpha_{ij})$

Latitude = $d_{ij} * \cos(\alpha_{ij})$

$x_j = x_i + \text{Departure} = x_i + d_{ij} * \sin(\alpha_{ij})$

$y_j = y_i + \text{Latitude} = y_i + d_{ij} * \cos(\alpha_{ij})$



Case 2: Polar method

Given: (X_i, Y_i) , (X_j, Y_j)

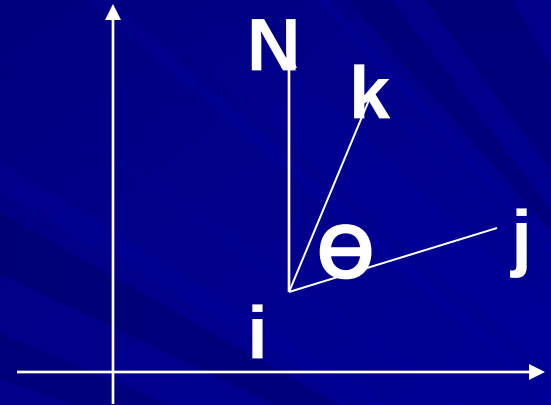
Measured : d_{ik} , Θ

Required : (X_k, Y_k)

$$\alpha_{ik} = \alpha_{ij} - \Theta$$

$$X_k = X_i + d_{ik} * \sin(\alpha_{ik})$$

$$Y_k = Y_i + d_{ik} * \cos(\alpha_{ik})$$



Case 3 : Angle intersection

Given: (X_i, Y_i) , (X_j, Y_j)

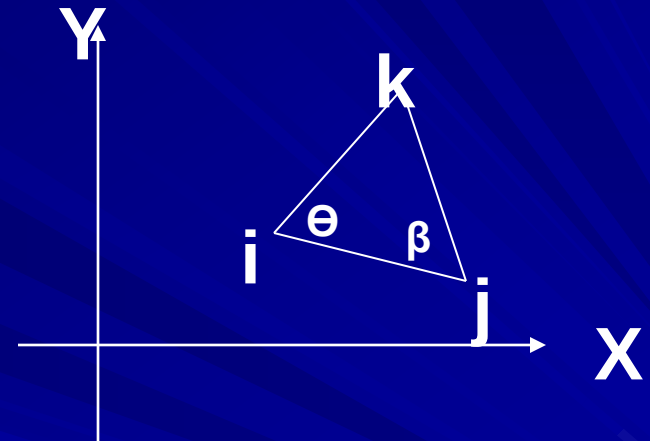
Measured : β , Θ

Required : (X_k, Y_k)

$$\alpha_{ik} = \alpha_{ij} - \Theta$$

Use sin law

$$\frac{d_{ik}}{\sin \beta} = \frac{d_{ij}}{\sin(180 - \Theta - \beta)}$$



$$X_k = X_i + d_{ik} * \sin(\alpha_{ik})$$

$$Y_k = Y_i + d_{ik} * \cos(\alpha_{ik})$$

4- Distance intersection

Given: (X_i, Y_i) , (X_j, Y_j)

Measured : d_{ik}, d_{jk}

Required : (X_k, Y_k)

$$d_{ij} = \sqrt{(X_j - X_i)^2 + (Y_j - Y_i)^2}$$

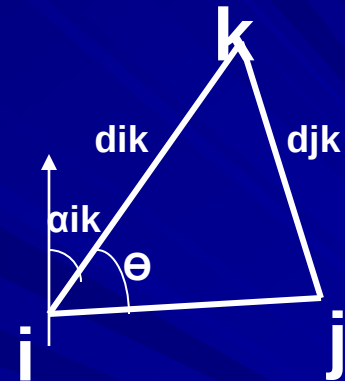
By using cosine law

$$d_{jk}^2 = d_{ik}^2 + d_{ij}^2 - 2d_{ik} * d_{ij} * \cos \theta$$

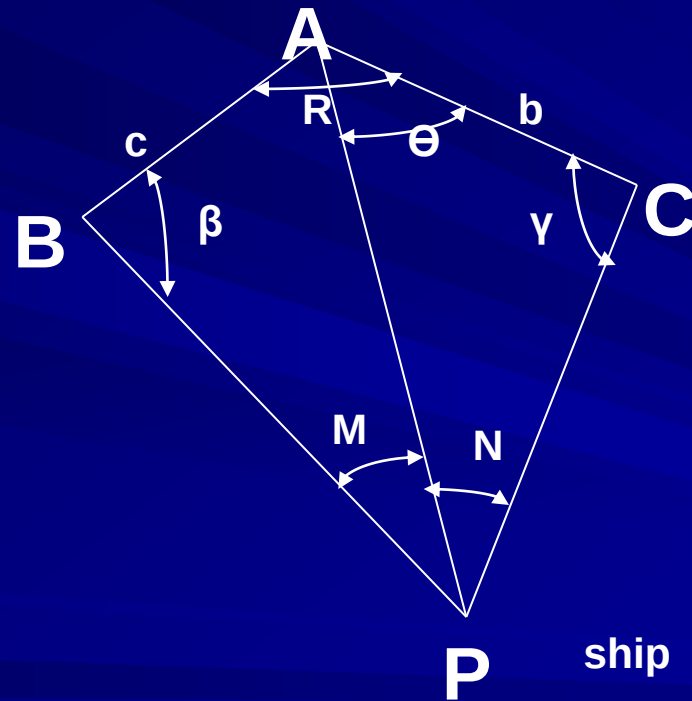
$$\alpha_{ik} = \alpha_{ij} - \theta$$

$$X_k = X_i + d_{ik} * \sin(\alpha_{ik})$$

$$Y_k = Y_i + d_{ik} * \cos(\alpha_{ik})$$



5- Resection

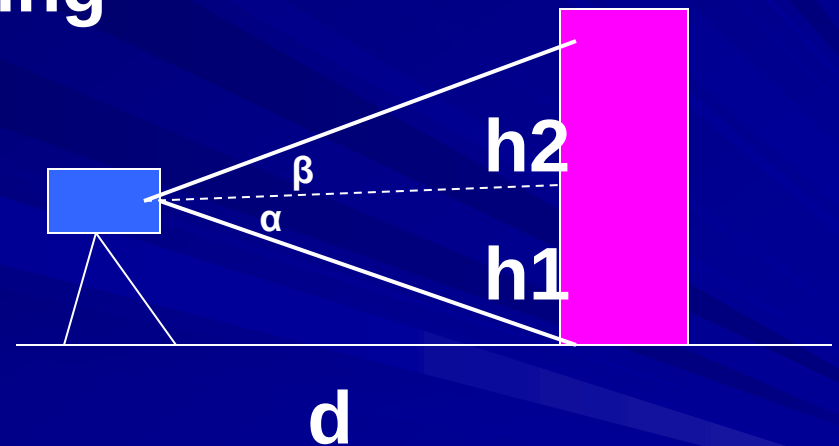


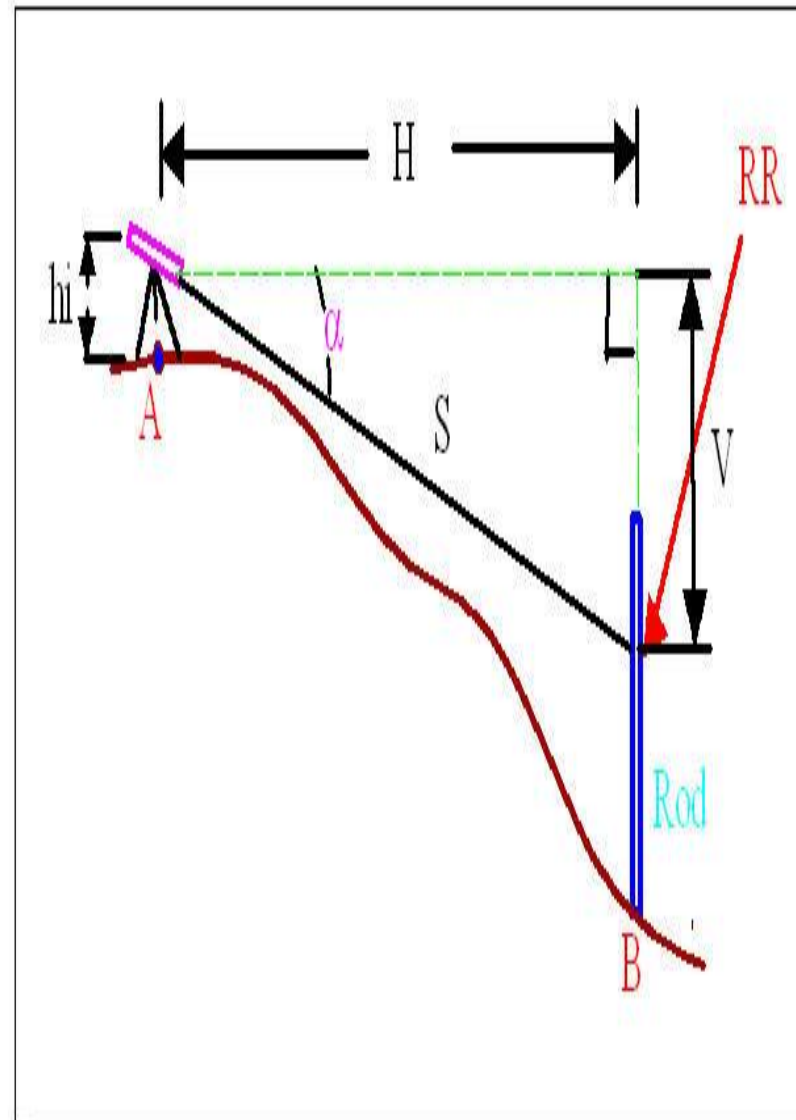
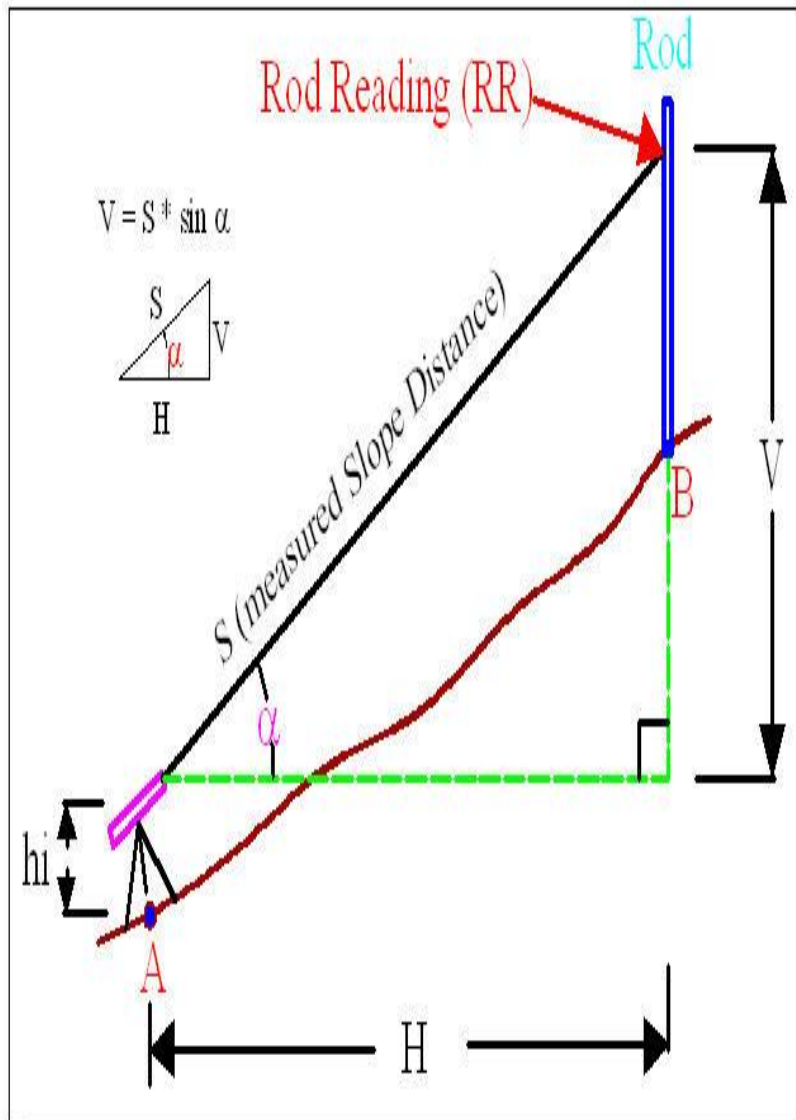
Trigonometry leveling

$h1 + h2 = \text{Height of building}$

$h1 = d \tan \alpha$

$h2 = d \tan \beta$



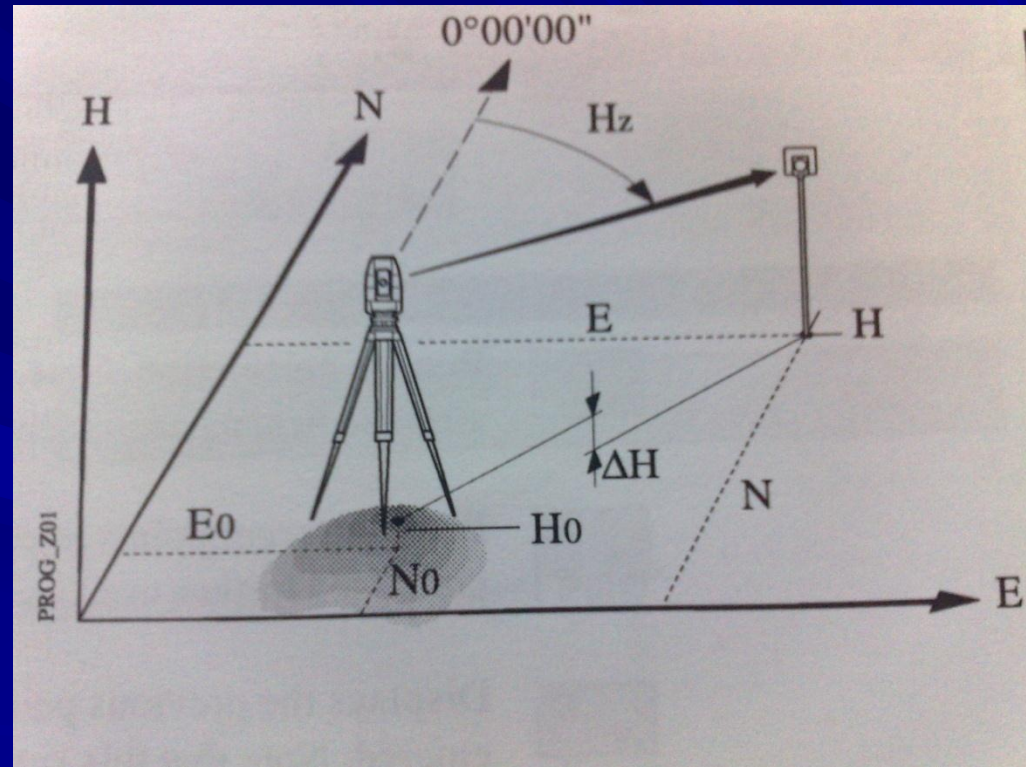


Leica Programs

- ☐ Orientation and height transfer
- ☐ Resection
- ☐ Tie distance
- ☐ Stakeout
- ☐ Free station
- ☐ Reference line
- ☐ Remote height
- ☐ Hidden point
- ☐ Area
- ☐ Sets of angles
- ☐ Traverse
- ☐ Local resection
- ☐ Road line and road plus
- ☐ COGO

Orientation and Height Transfer

- ❑ Set instrument at known point
- ❑ The program calculates an angular correction for the instrument's horizontal circle using reference points with known E and N
- ❑ Knowing height of instrument and reflector, station elevation could be found



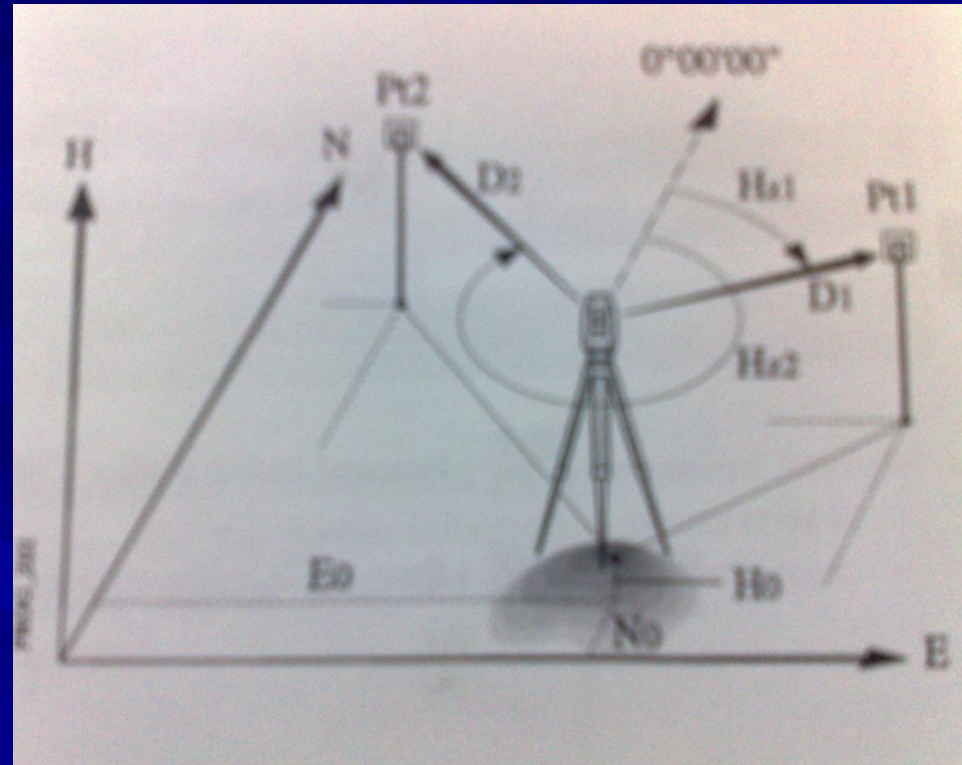
Modes of the Programs

- ❑ **Measure mode:** elevation, Easting, Northing, distances, etc.
- ❑ **Calculation mode:** orientation, elevation, standard deviation, etc.
- ❑ **Plot mode:** a plot showing the measurement configuration.

Resection

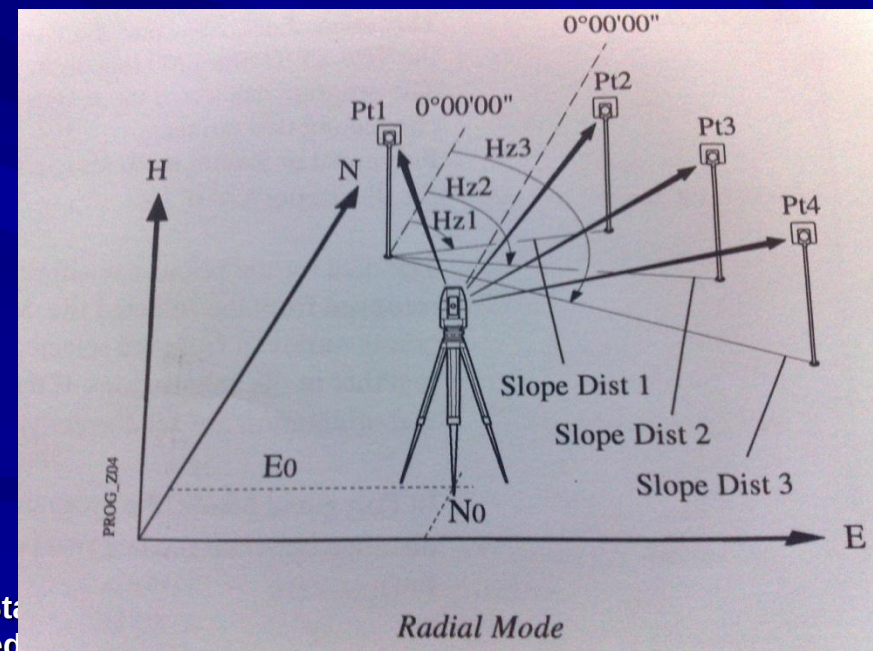
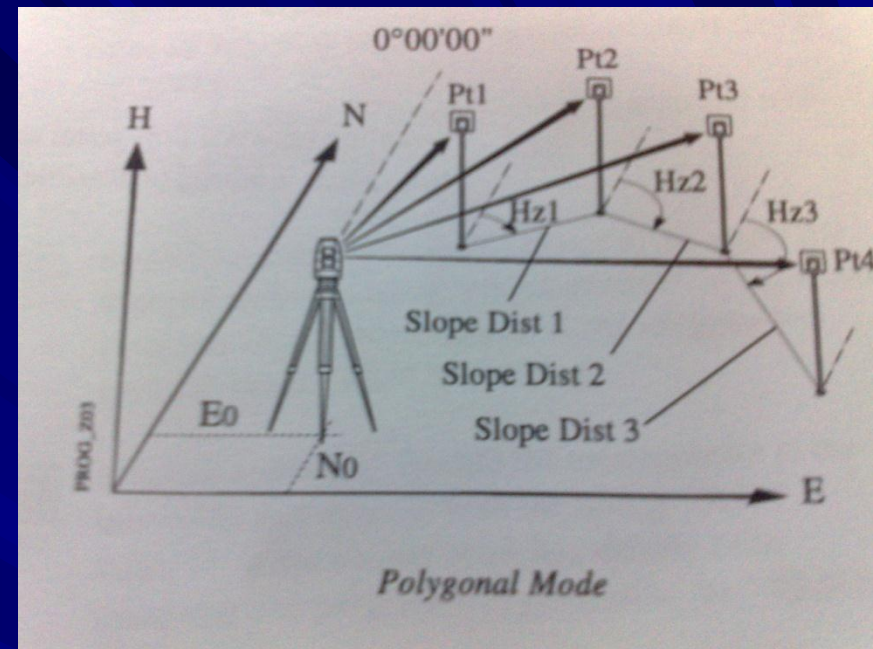
❑ Deduce the 3-D coordinates for the instrument station and the orientation of the horizontal circle from measurements of two target points of known E and N.

❑ For simultaneous determination of the station elevation, heights of the instrument and reflector must be known, and elevation of the target points.



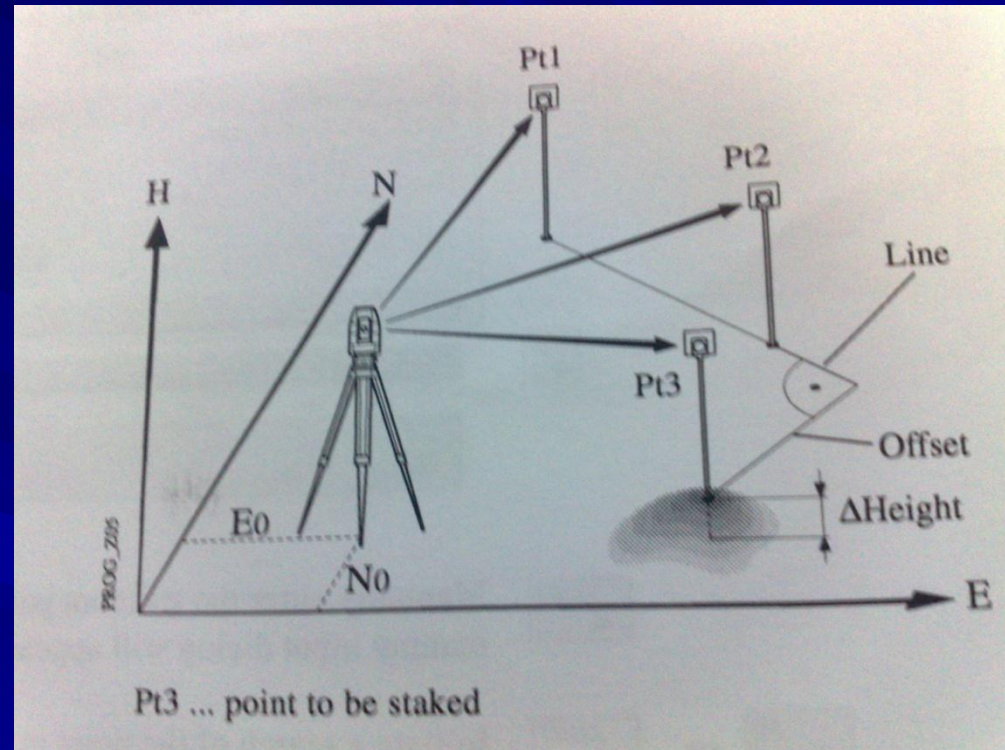
Tie Distance

- ❑ Calculates the length and azimuth of a line connecting two points.
- ❑ Polygonal mode: calculate the distance between the last two points measured.
- ❑ Radial mode: calculate the distance between the last point measured (radial point) and a fixed center point.



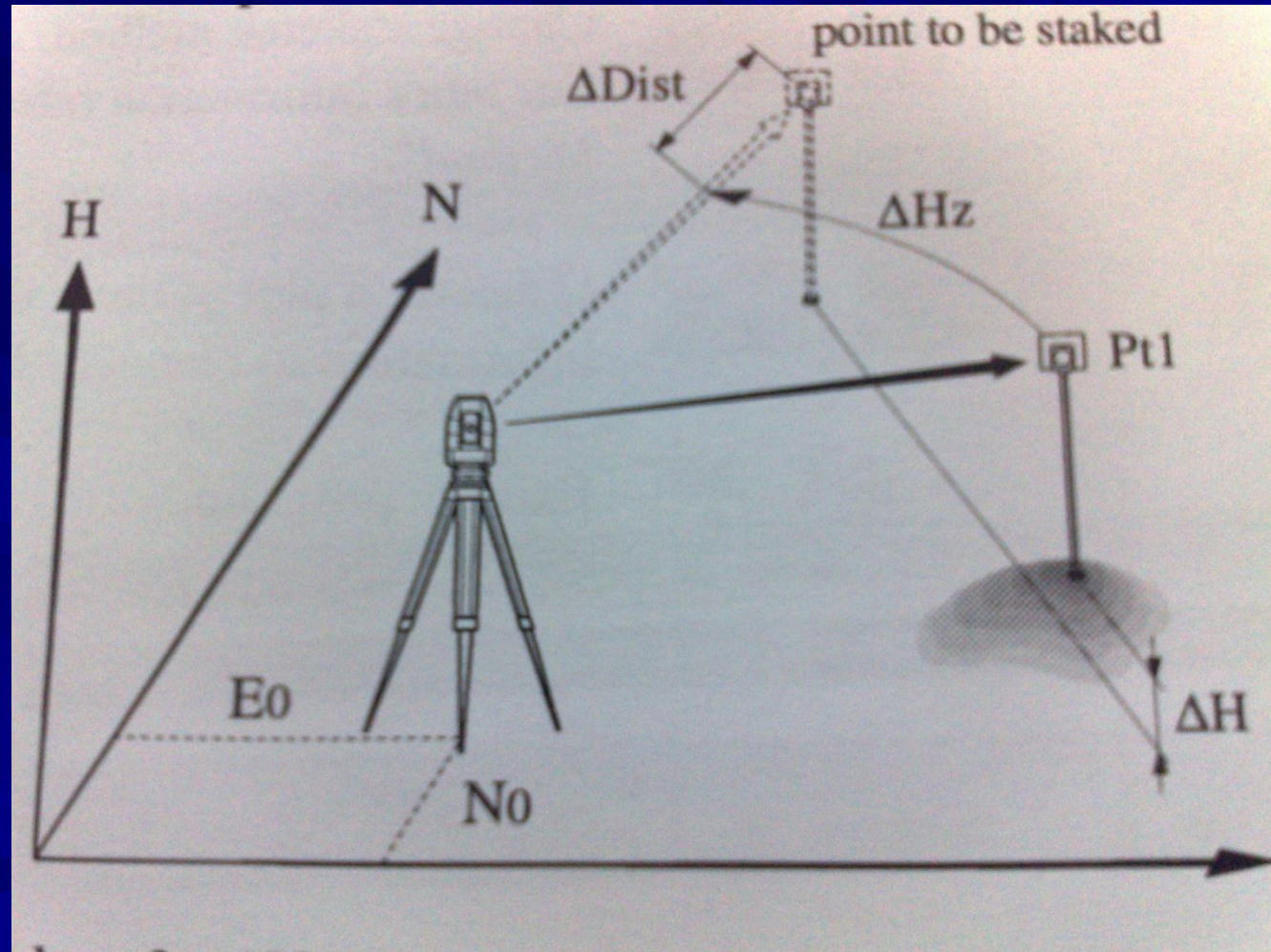
Stakeout

- ❑ Set instrument on a known point with the instrument orientation.
- ❑ The program allows points with known coordinates to be placed in the field.
- ❑ The program permits selection of either 2D or 3D stakeout modes.
- ❑ The stakeout values of each point are computed in relation to the base formed by the last two points.



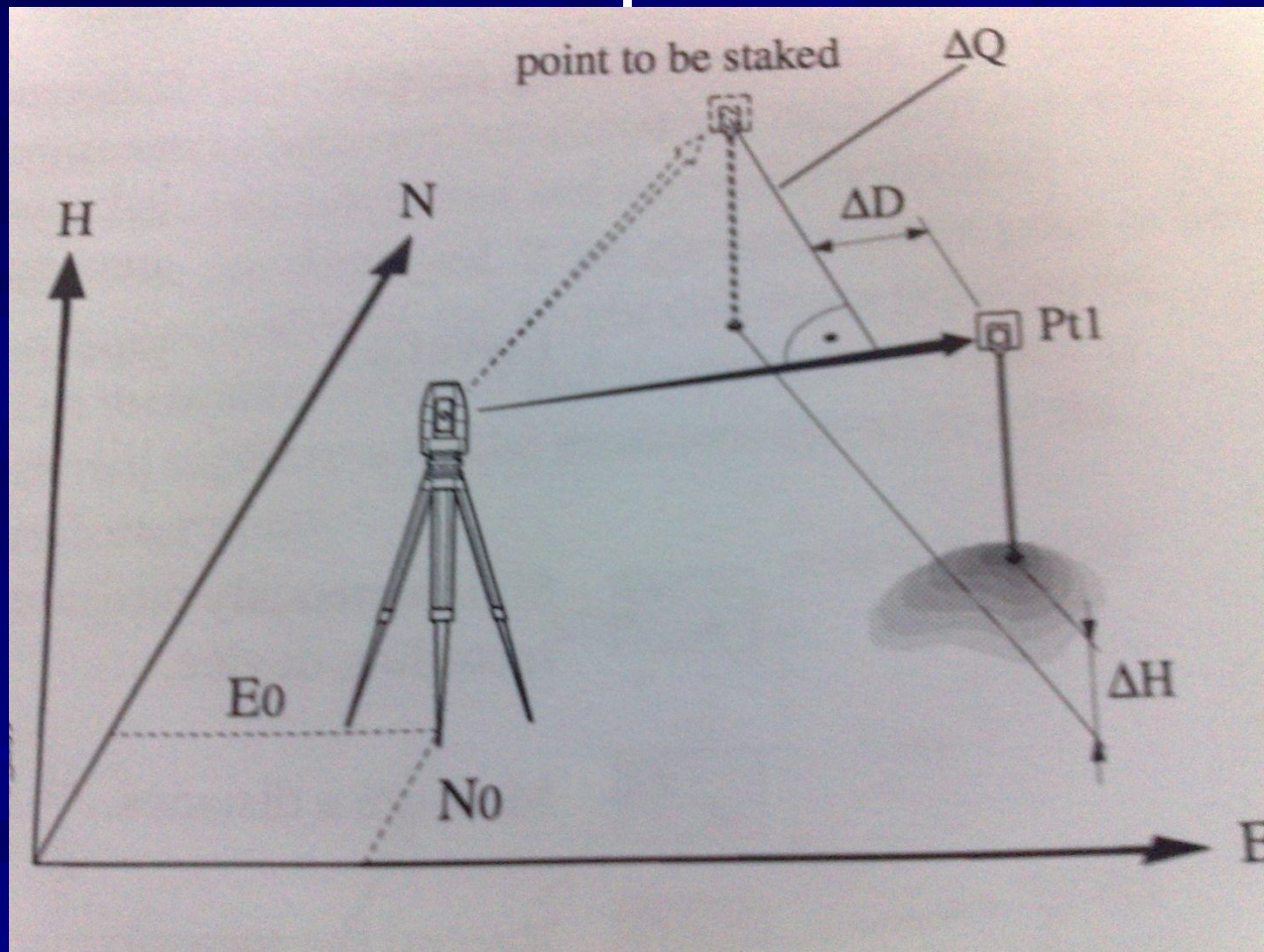
□ Types of Stakeout:

➤ Azimuth and distance (Polar method)



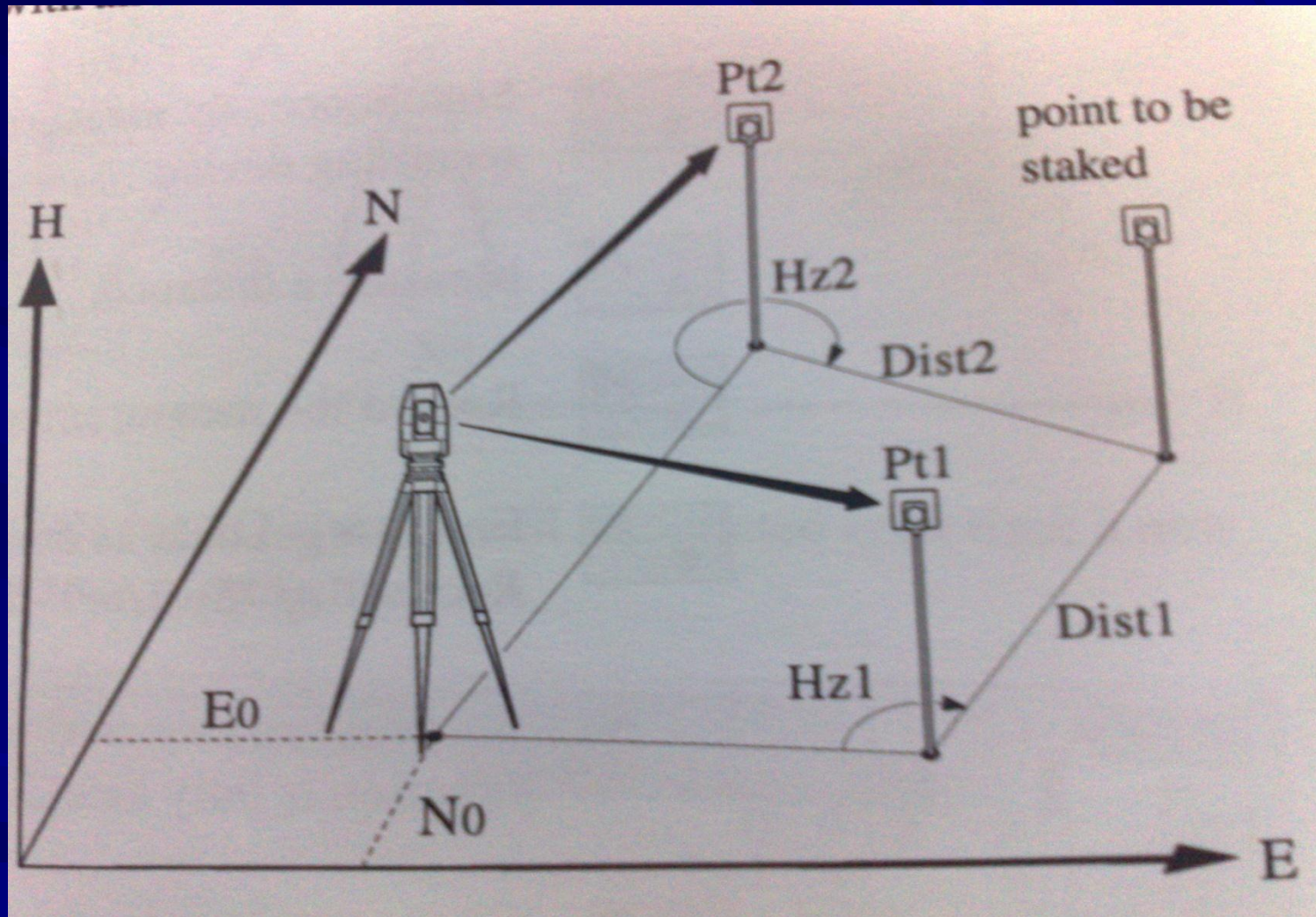
➤ Orthogonal Stakeout

❑ Orthogonal offsets are computed using the baseline between the last measured point and the instrument station

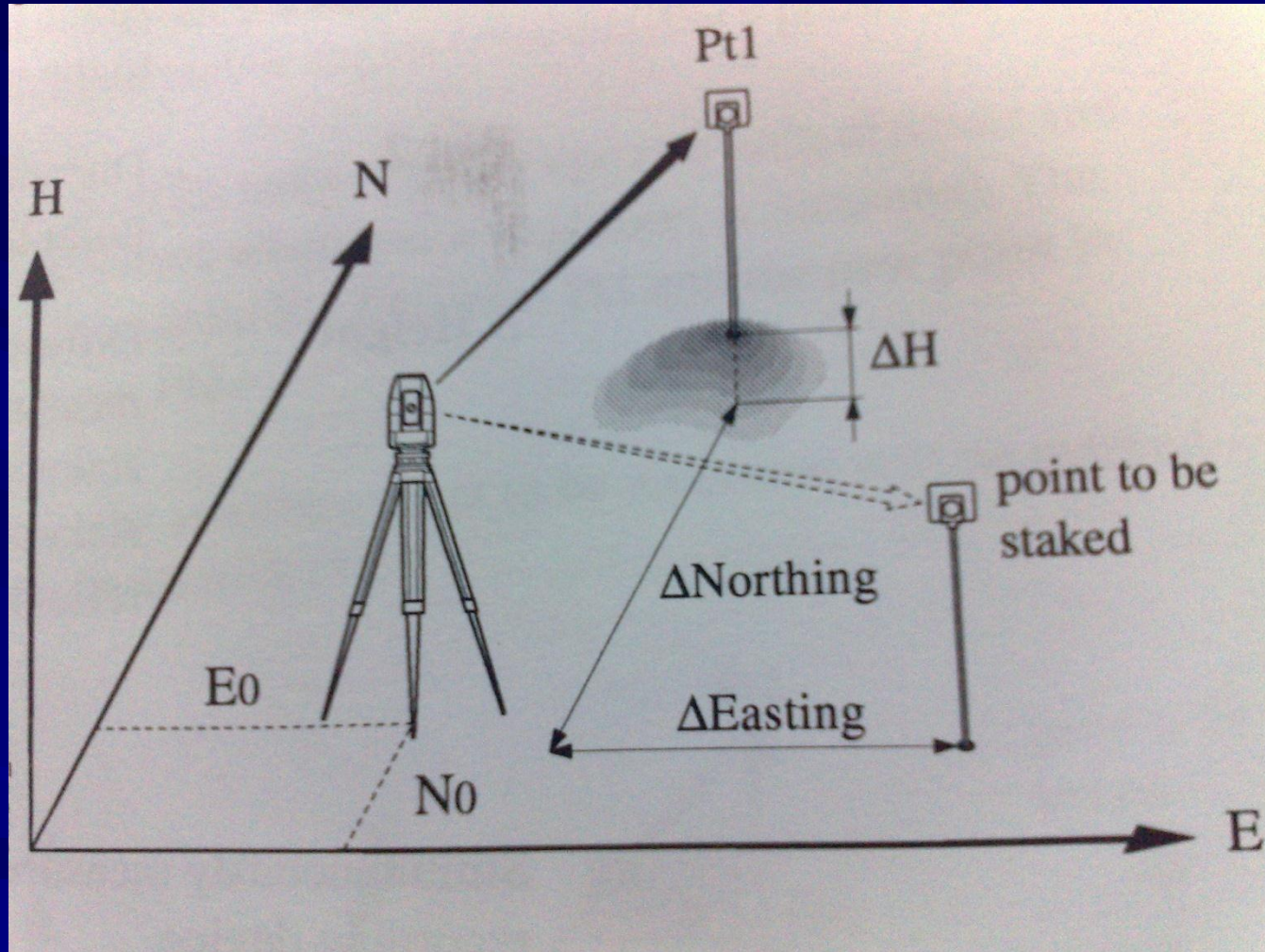


Total Stations

➤ Stakeout with auxiliary points

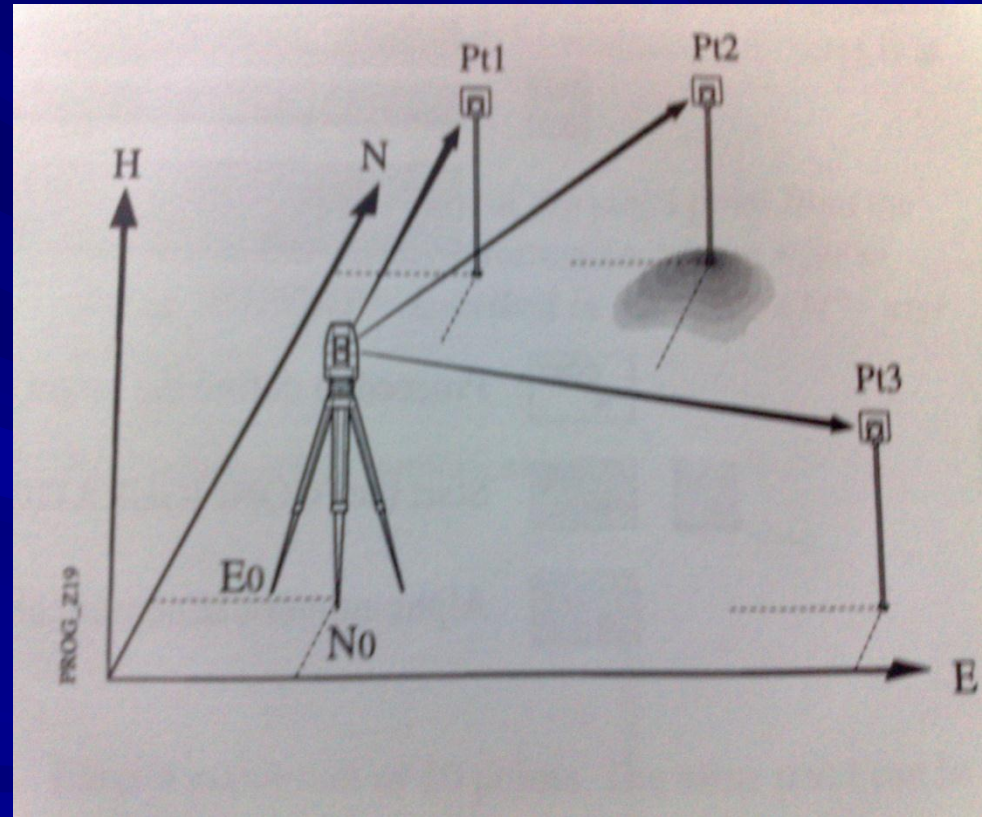


➤ Stakeout from coordinate differences (elevation differences measurements)



Free Station

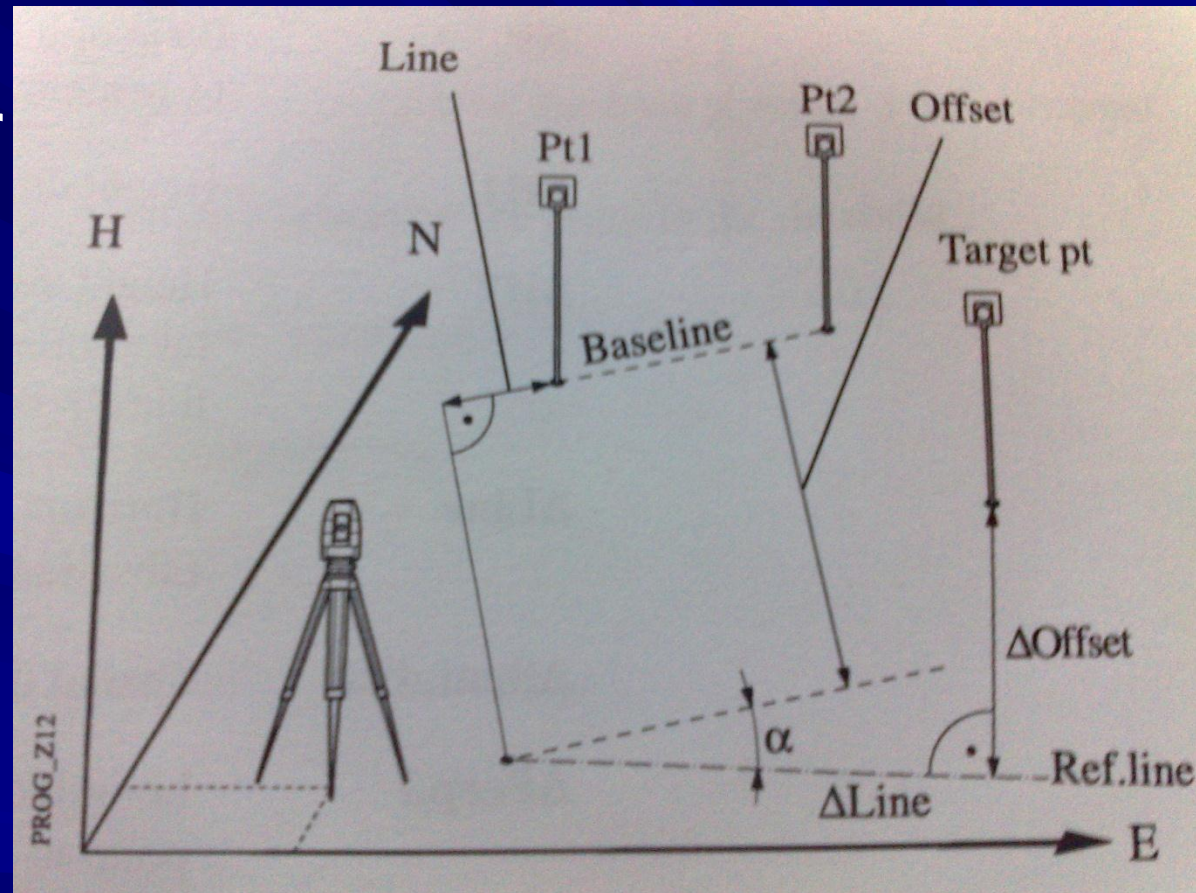
- ❑ Deduce the 3D coordinates for the instrument station and the horizontal orientation of it .
- ❑ For elevation measurement, heights of instrument and reflector, and target elevation must be known.
- ❑ Direction of target points can be determined as can any combination of direction and distance



Reference Line

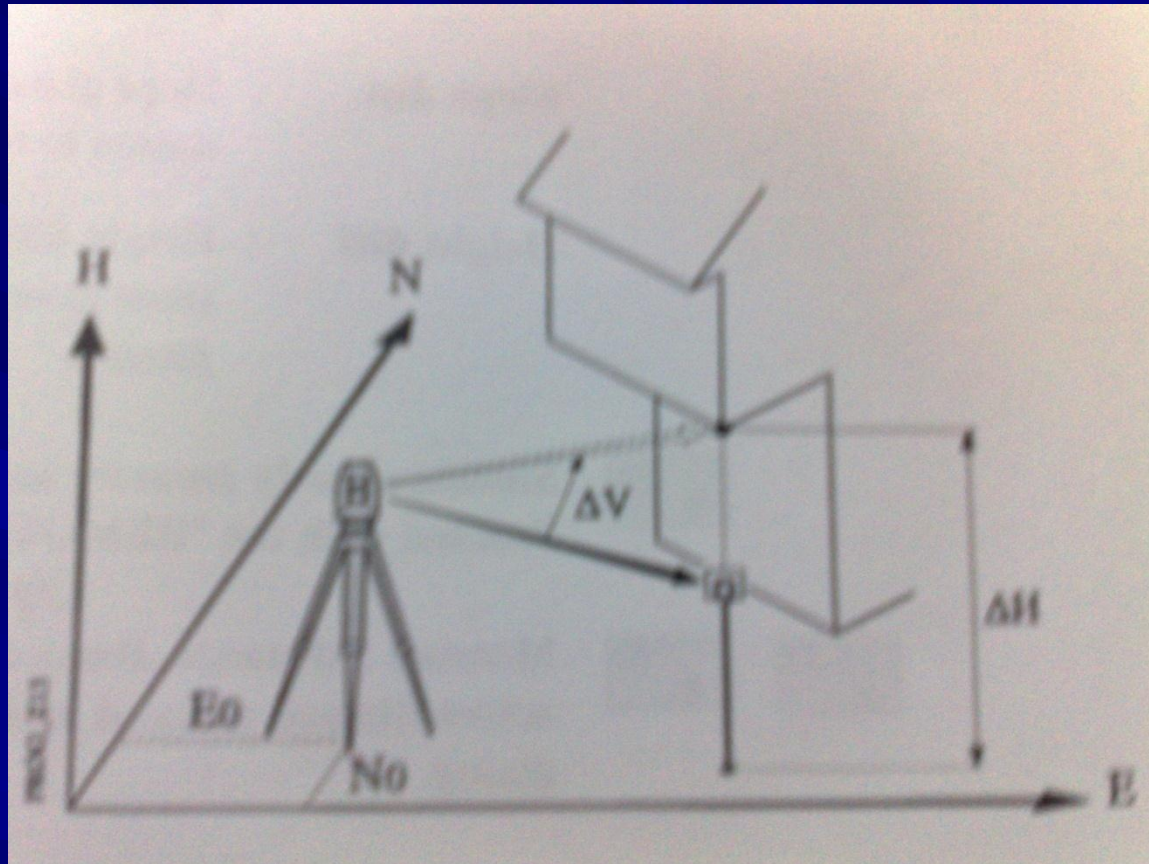
❑ Specialized form of stakeout used for construction and building alignment. It permits positioning of a point referred to a line.

❑ The distance and angle between two points is calculated



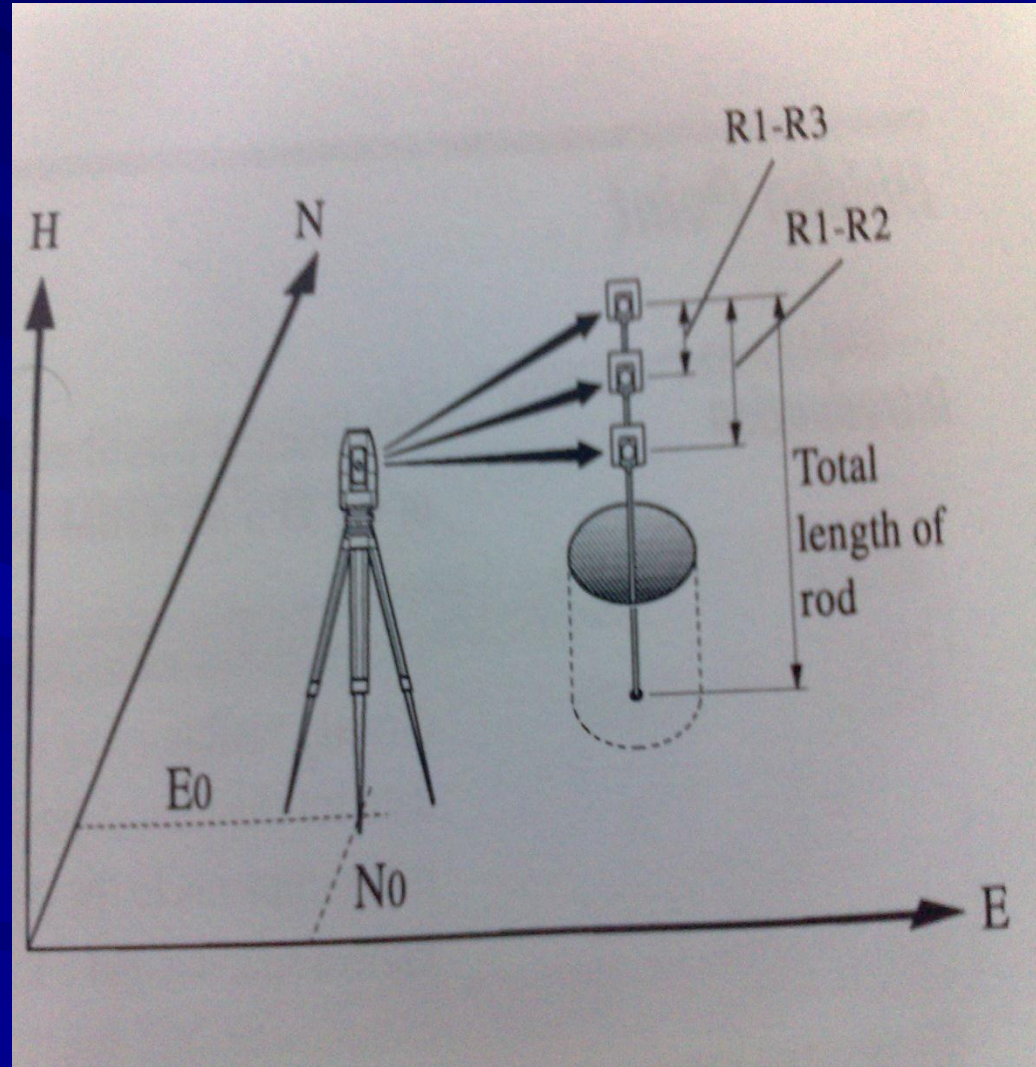
Remote Height

❑ The elevation of a remote height point is calculated from the zenith angle to the target and from the measured distance to a reflector situated vertically below or above that target.



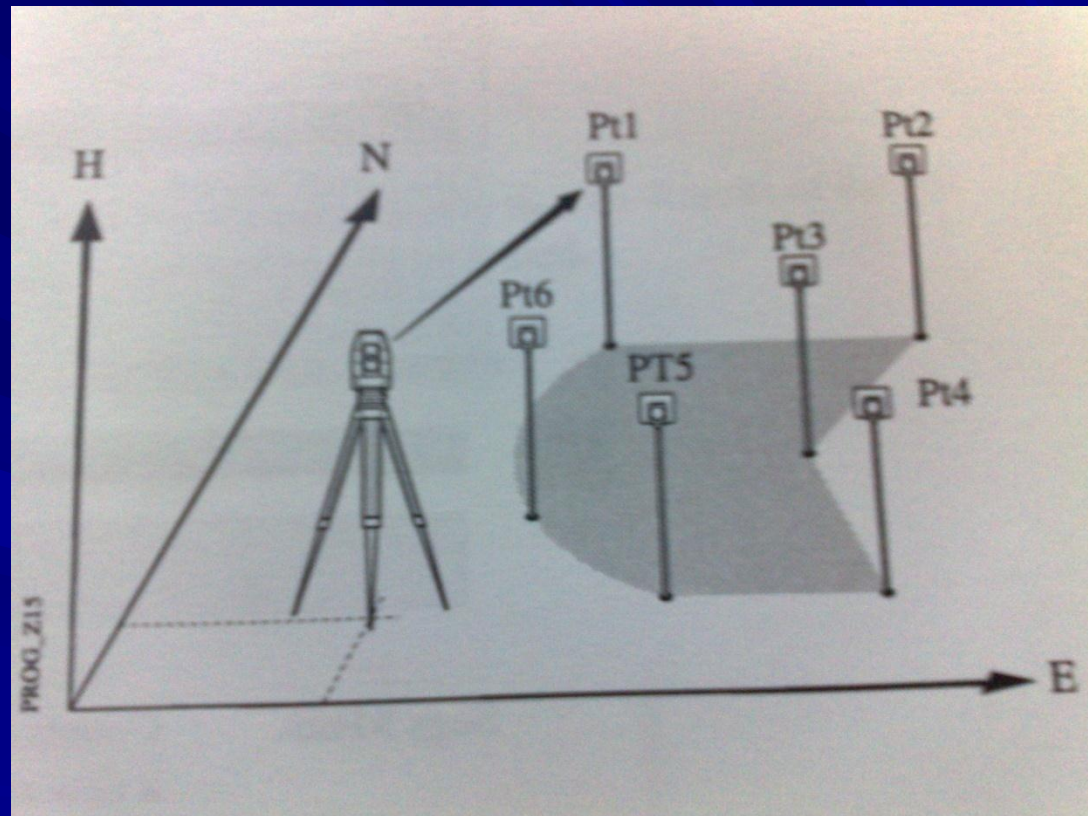
Hidden Point

- ❑ Allows measurements to a point that is not directly visible using a special hidden-point rod.
- ❑ The data for the hidden point are calculated from measurements to the prisms mounted on the pole with a known spacing and a known length of pole. The pole still may be kept slope.

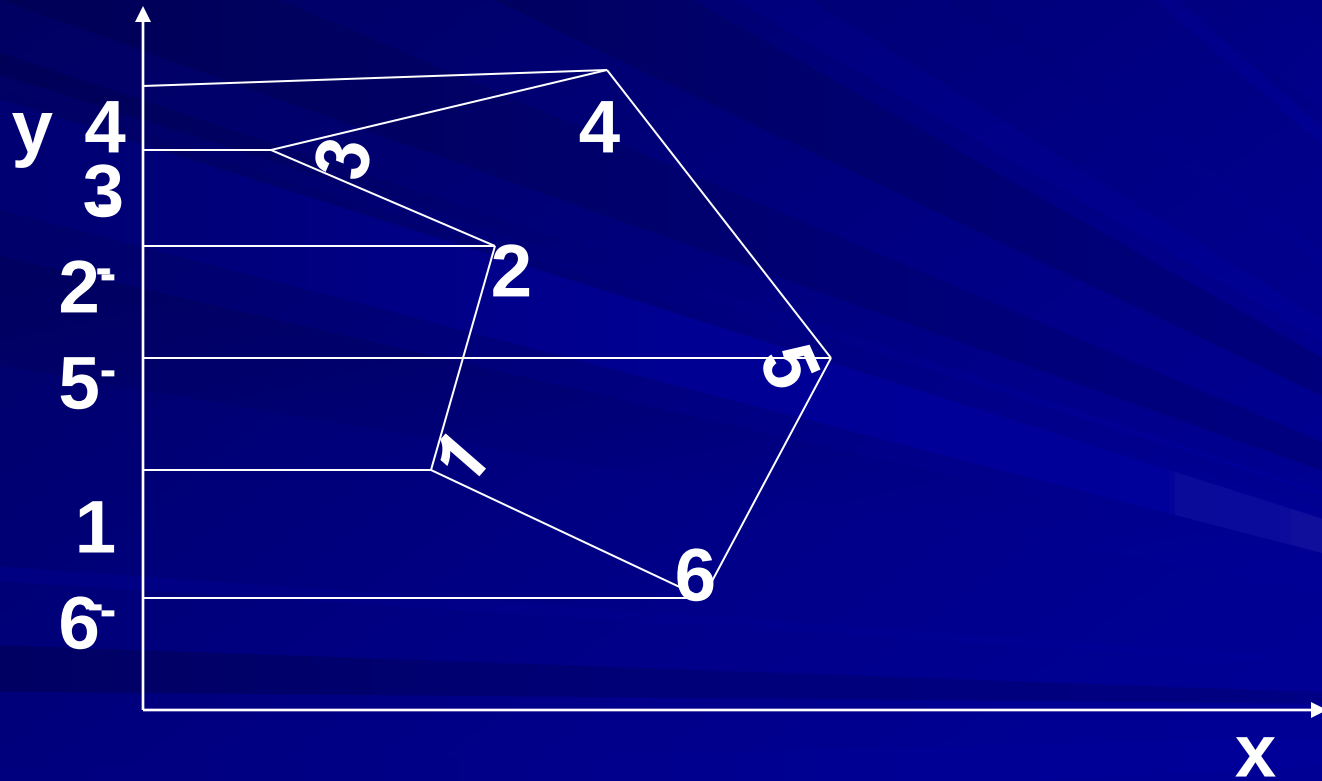


Area

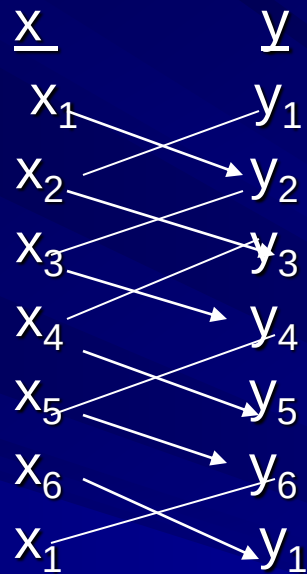
- ❑ An area can be defined by a series of straight lines and arcs.
- ❑ Arcs are defined by 3 radial points or 2 radial points and radius.



Coordinate method



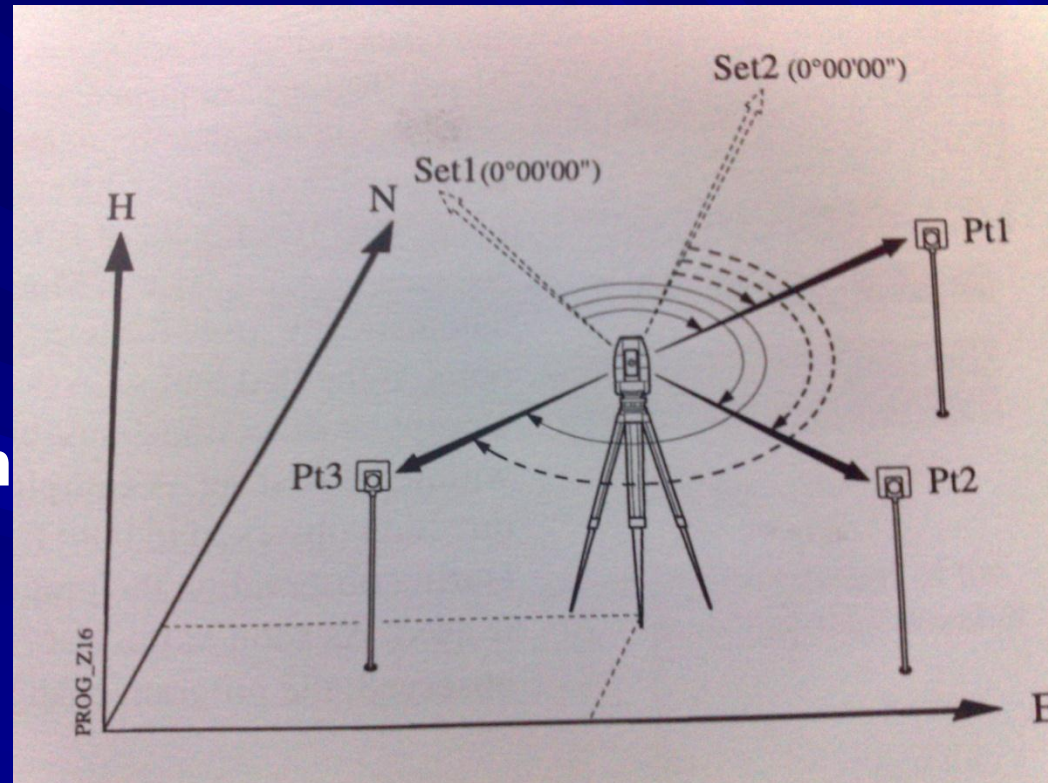
Coordinate method



$$\text{Area} = \frac{1}{2} \left[\sum_{i=1}^n +ve - \sum_{i=1}^n -ve \right]$$

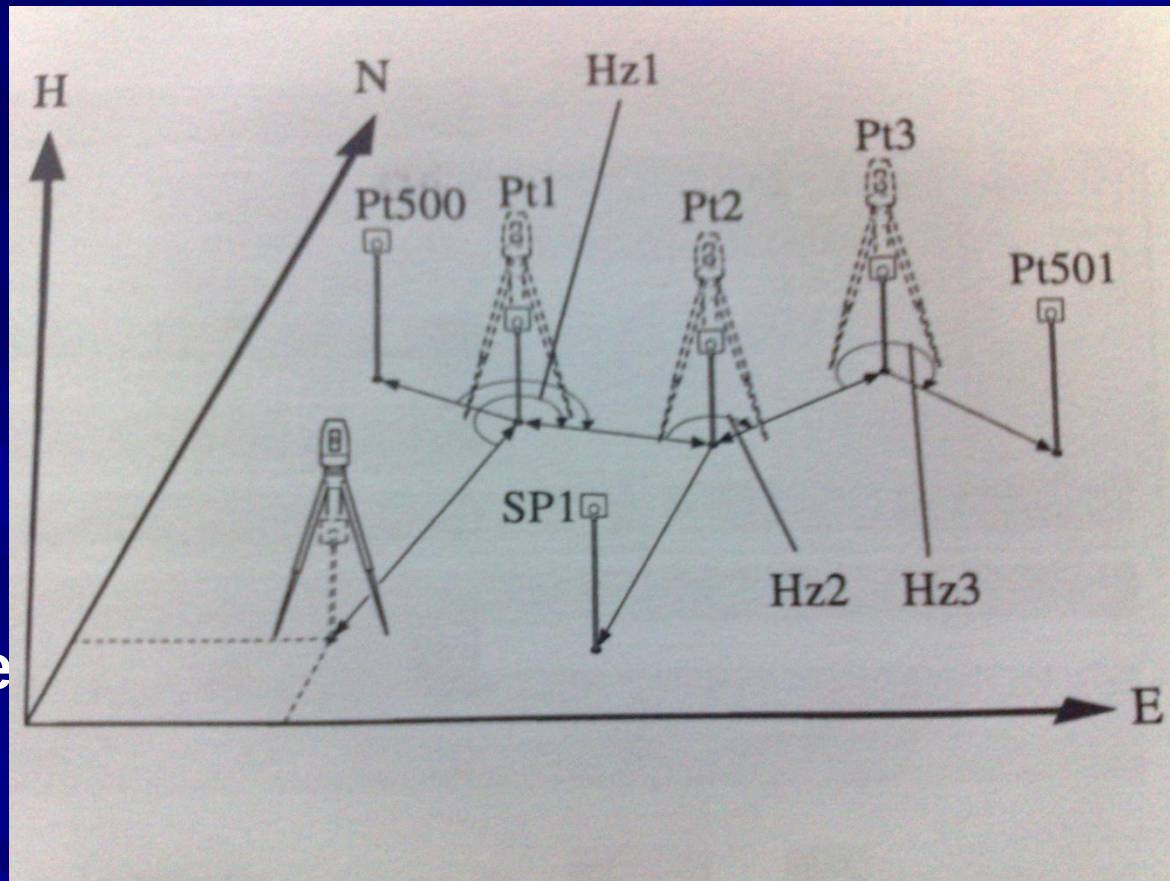
Sets of Angles

- ❑ Permits direction measurements of targets of which coordinates are not necessarily known.
- ❑ A minimum of two full sets must be observed.
- ❑ Measurements in two faces must exist for each target.
- ❑ The average direction of all sets and SD is computed.



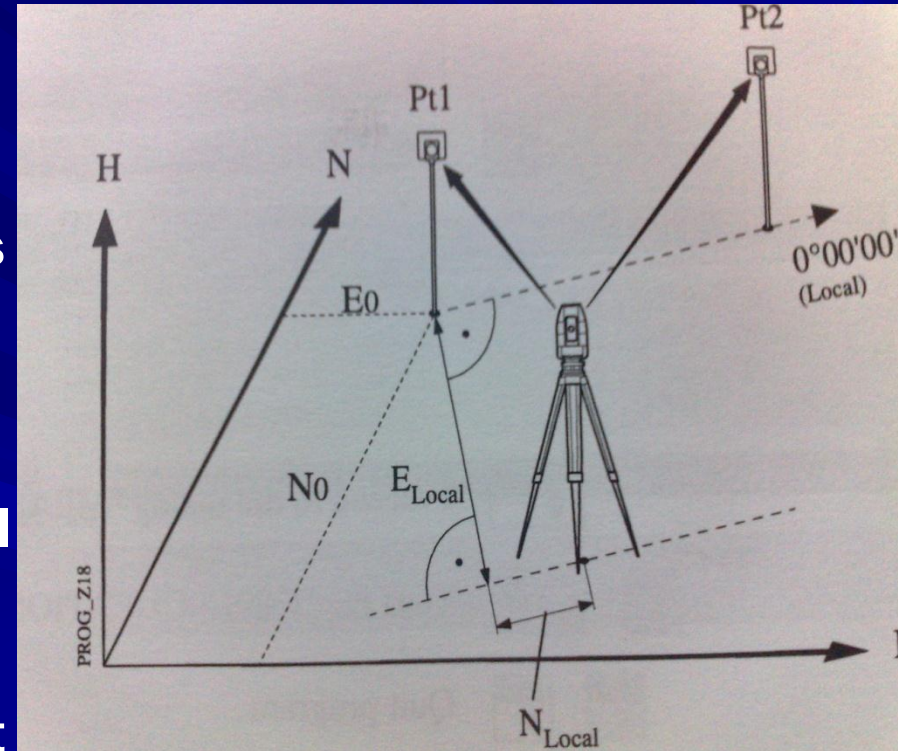
Traverse

- ❑ The instrument moves from one station to the next, previously measured point.
- ❑ The program continuously computes the coordinates of the station and aligns the horizontal circle.
- ❑ Plot traverse and compute azimuths.

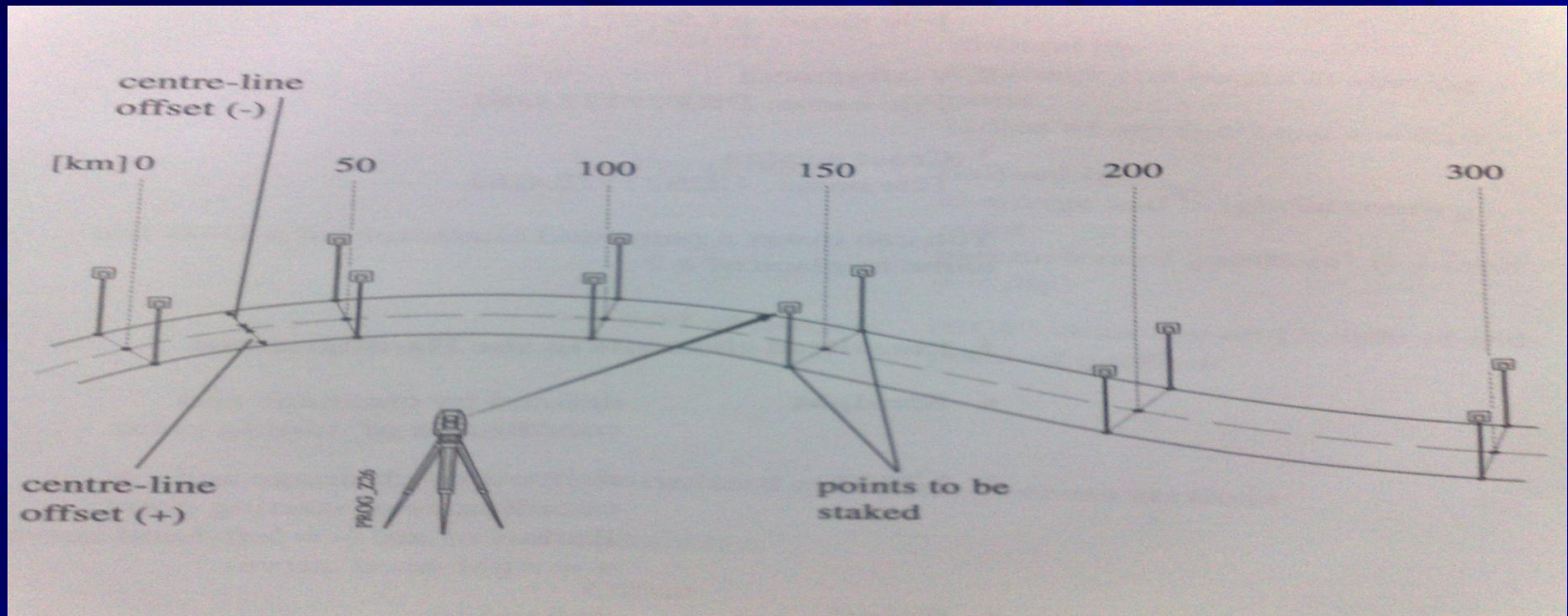


Local Resection

- ❑ Two points are measured from any instrument station.
- ❑ First point measured forms the center of a local coordinates ($N, E, H=0$)
- ❑ Second point measured determines the direction of the positive N-axis
- ❑ Distance between the two points ≥ 50 mm
- ❑ Program could deduce the 3-D local coordinates for instrument station and H-orientation to 2 target points.
- ❑ To compute position coord. At least 4 elements are necessary (2 distances and 2 directions)



Road Line



- ❑ Suitable for setting out points which are determined by chainage and C.L. along calculated alignment.
- ❑ If V-alignment and X-section are defined for the alignment, the points can be calculated and setout spatially (road stakeout)

❑ Conversely, if a point in the vicinity of the alignment has been determined by measurement, the chainage and C.L. offset can be determined (X-section check).

❑ Permitted elements in H-alignment:

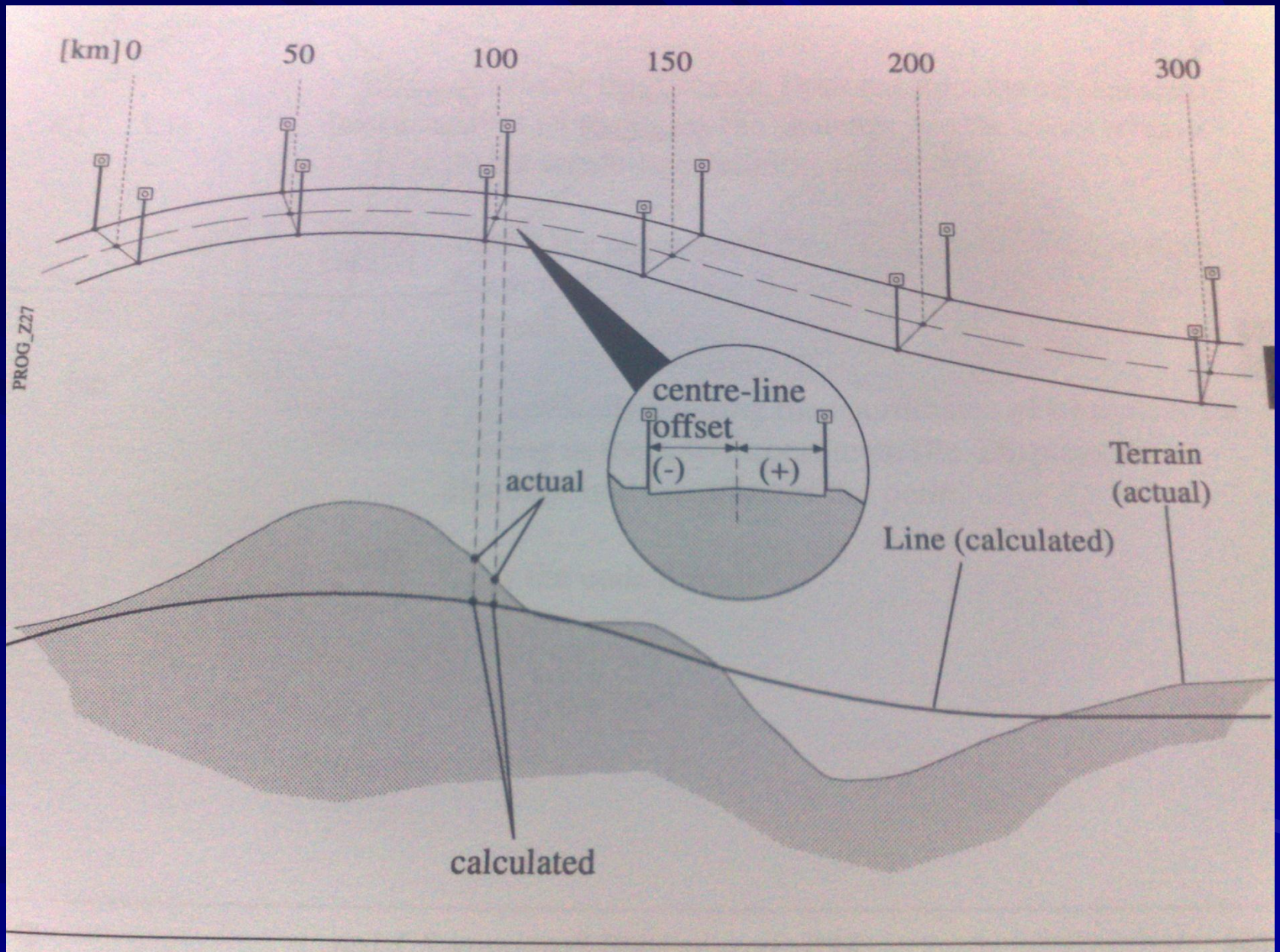
✓ Straight, Curve , Spiral, and End of project.

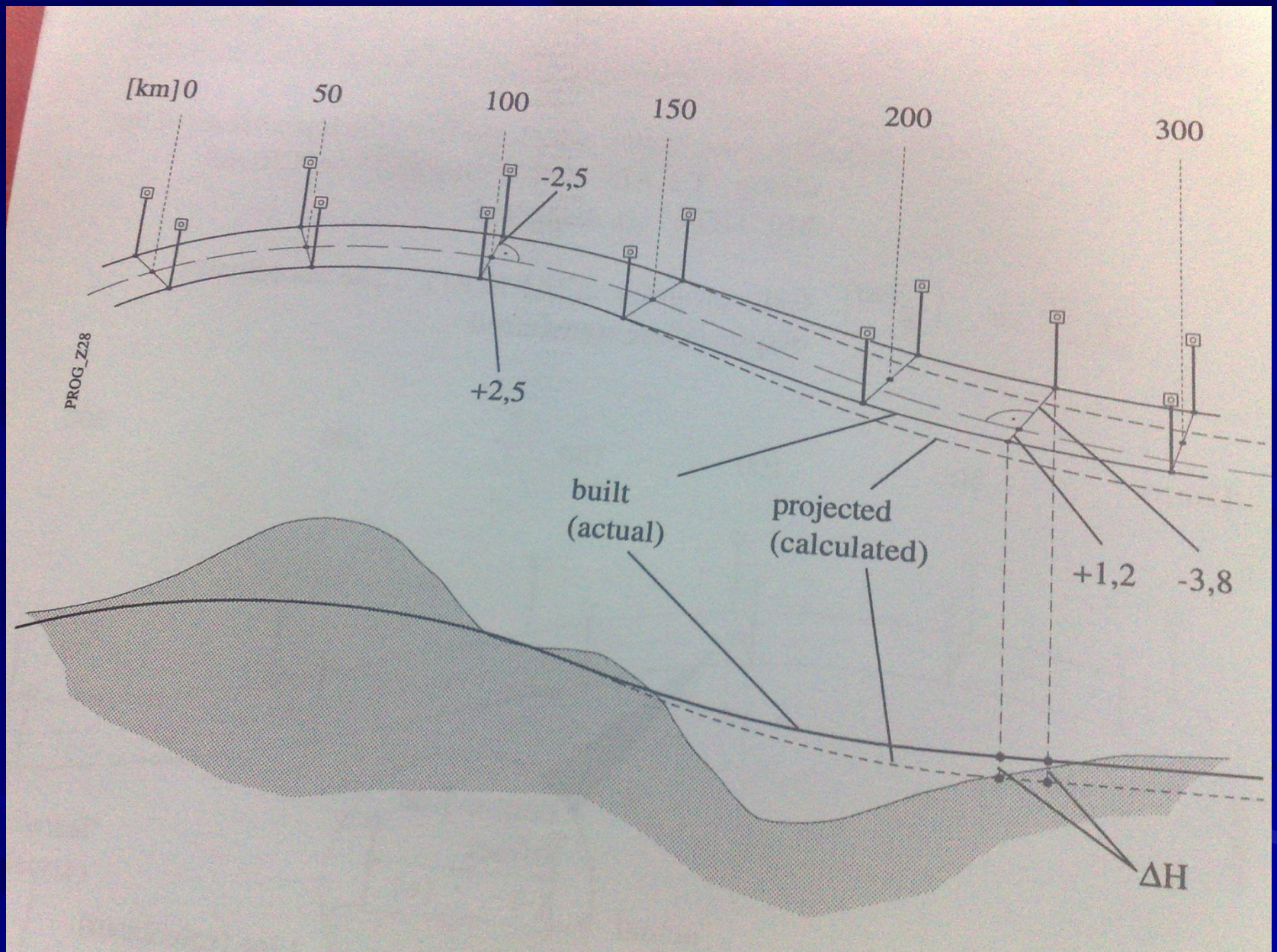
❑ Permitted elements in V-alignment:

✓ Straight, Curve , Parabola, and End of project.

❑ Permitted elements in X-Section:

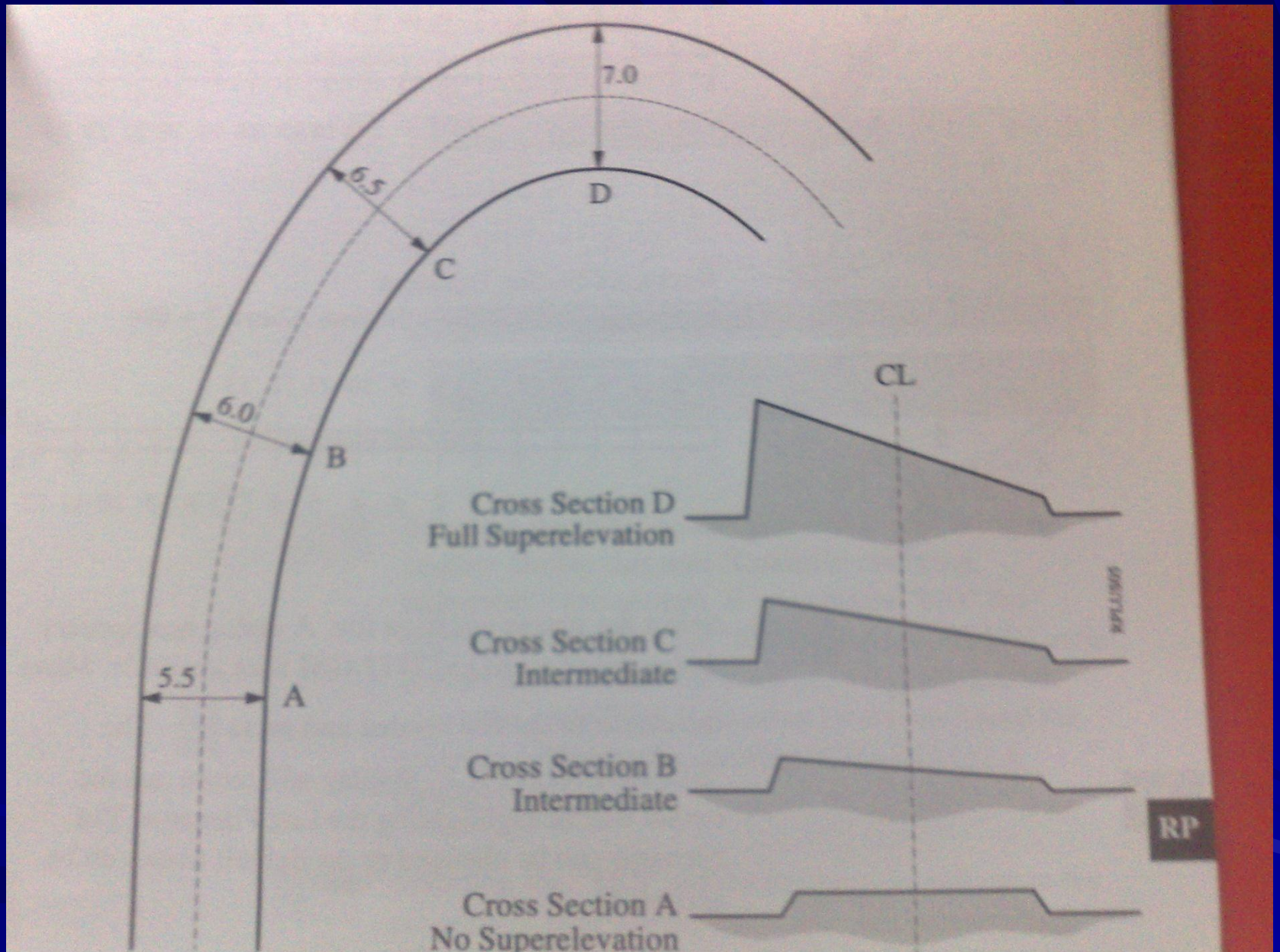
✓ Chainage, Offset, Height Difference relative to axis.





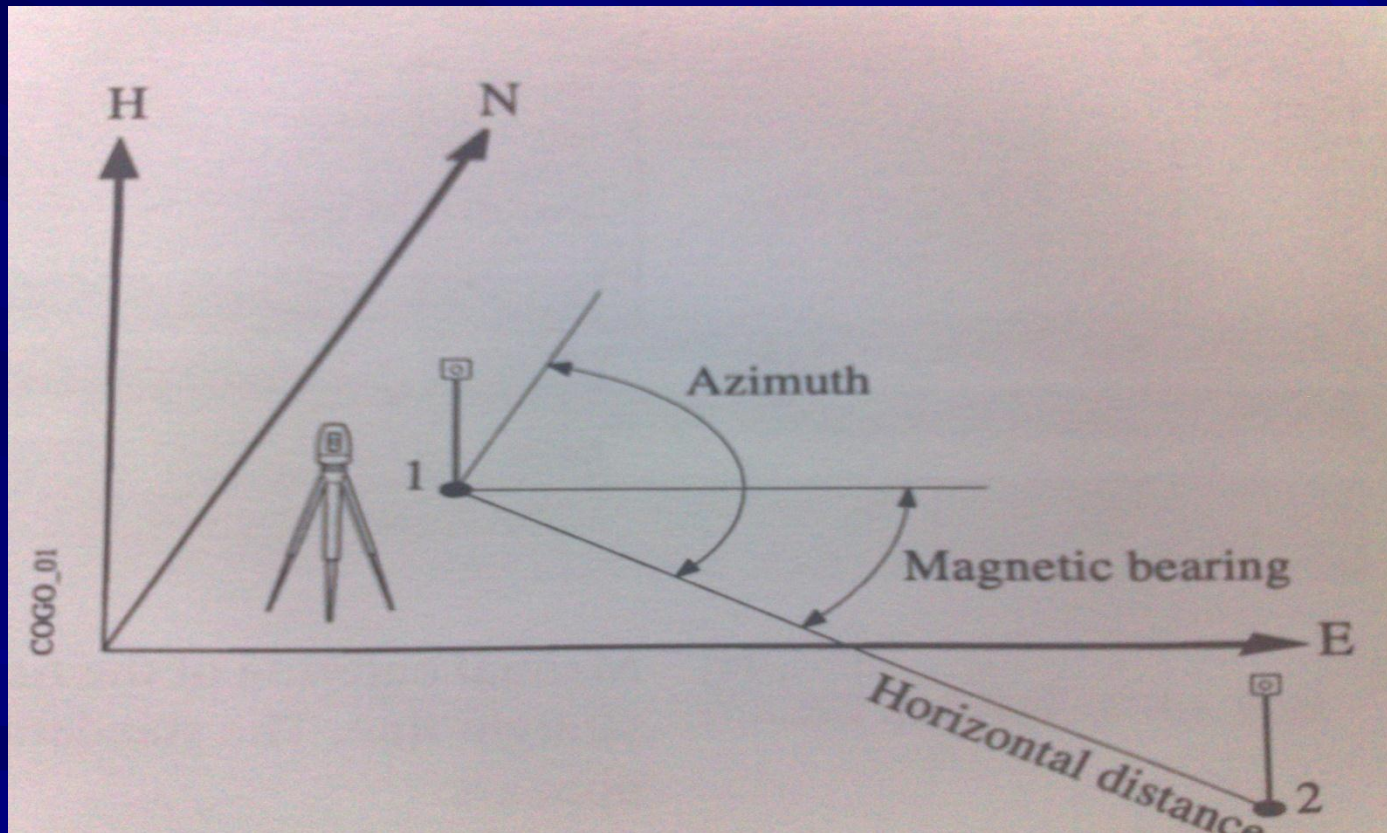
Road Plus

- ❑ Allows for the stakeout of roads using the typical offset method of construction staking.
- ❑ In addition, the program supports station equations, X-Section assignment by station, X-Section definition, X-Section interpolation, superelevation, widening, and slope stake/catch points.

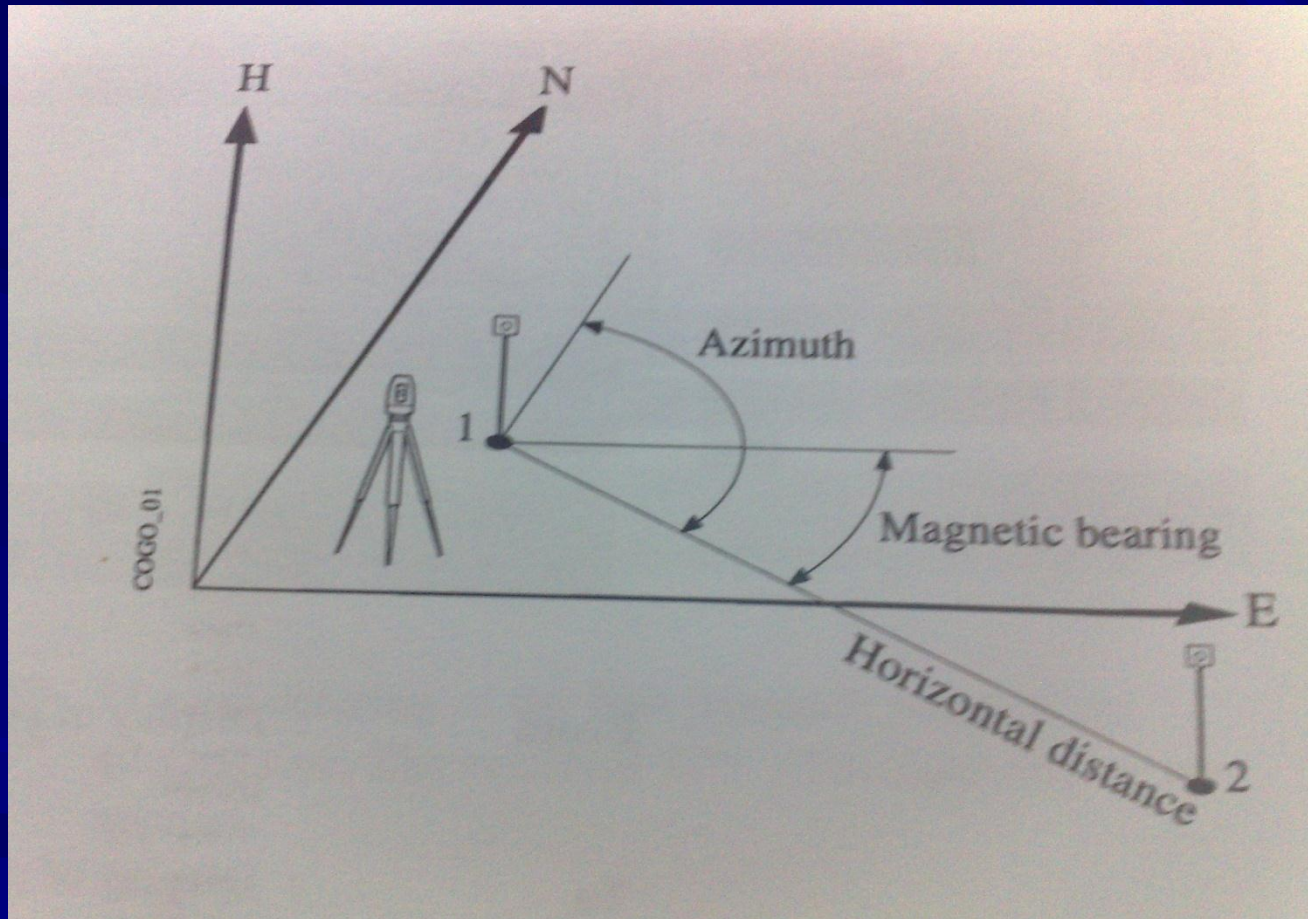


COGO

- Inverse (Polar Calculation):
- Computes the directional distance between two points.



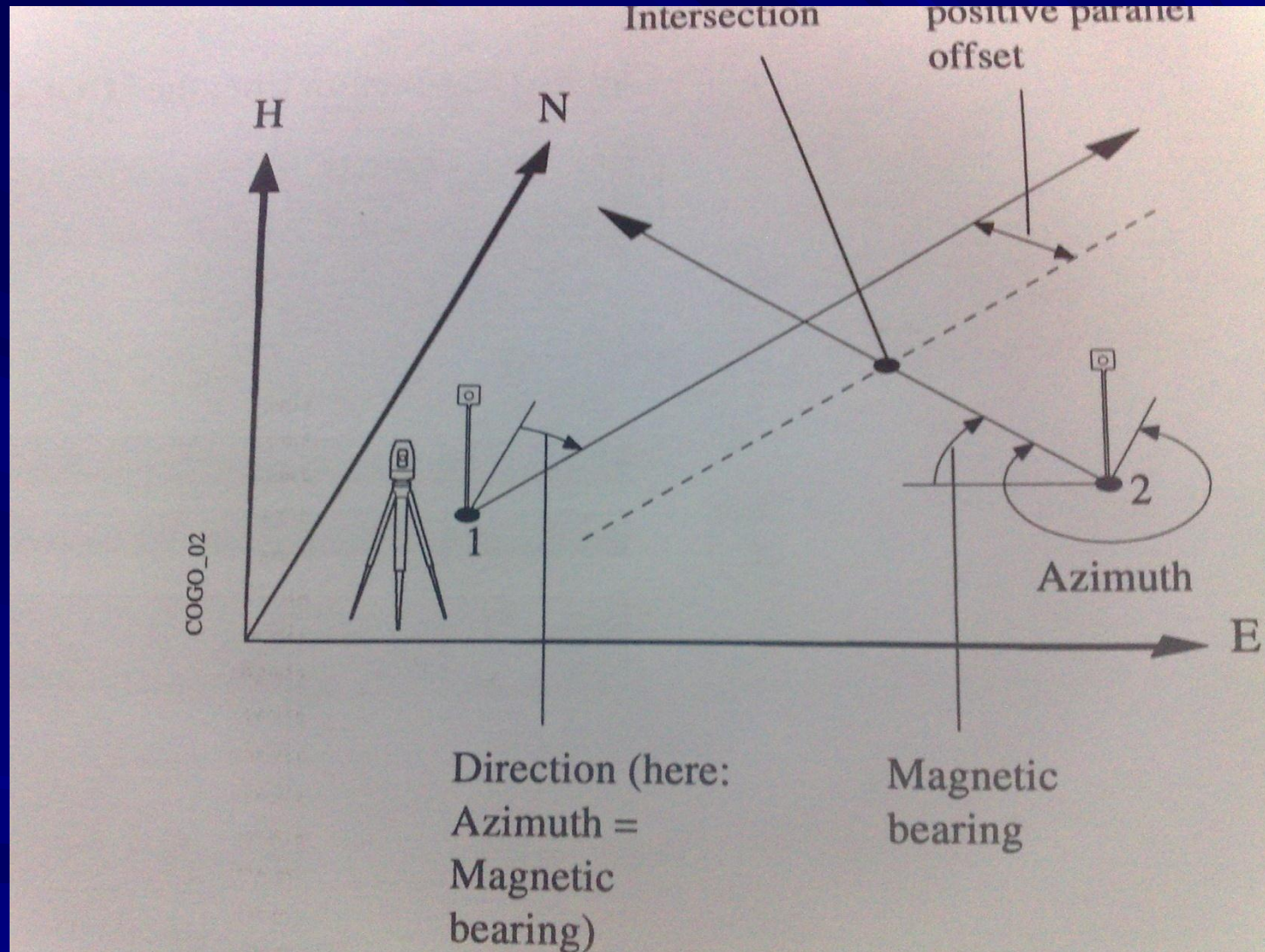
➤ Traverse routine: Computes a new coordinates point given a direction and a distance from a known point (Polar plotting)



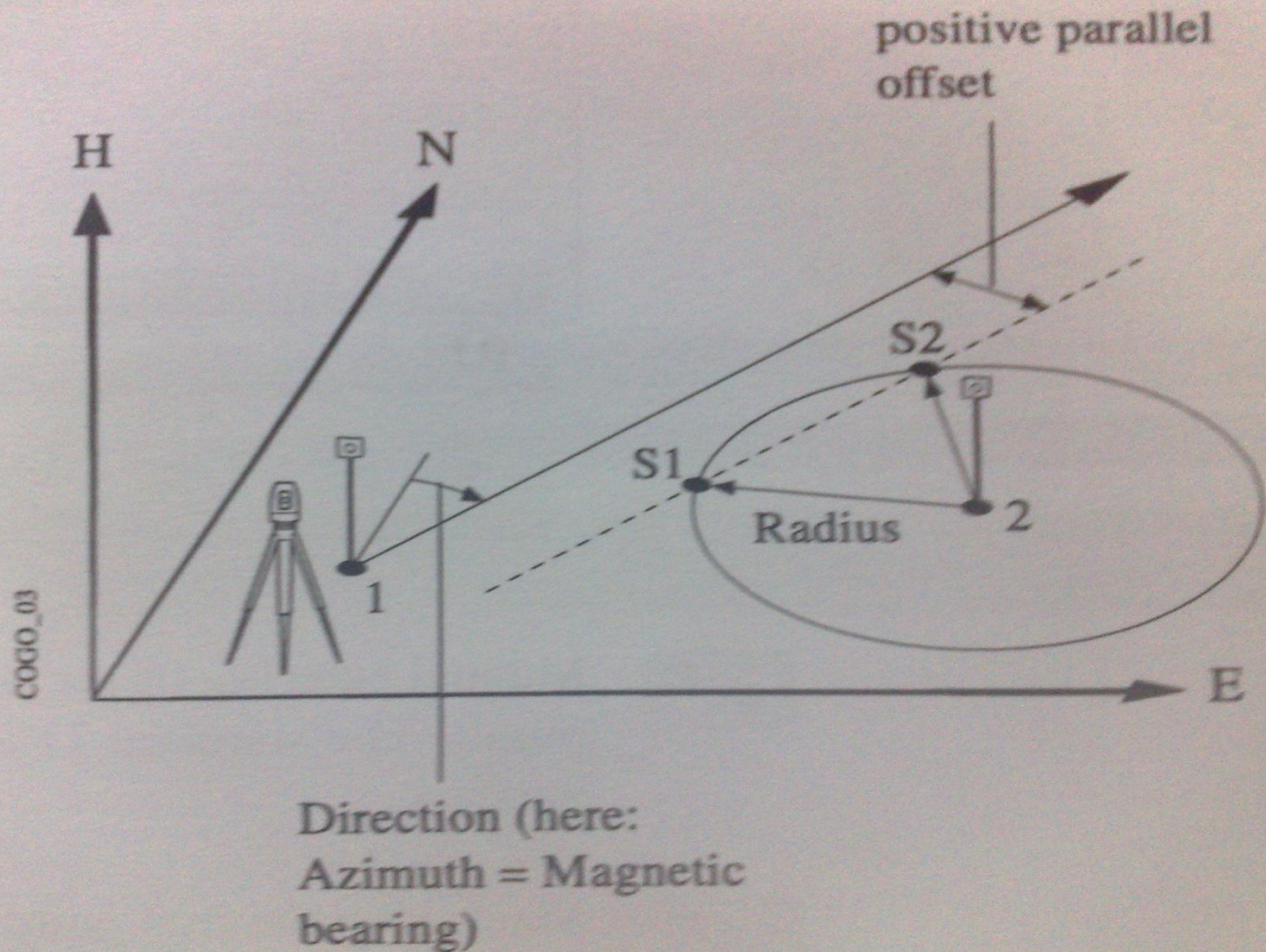
➤ Intersections routine: Computes

- Bearing-Bearing intersection.
- Bearing-Distance intersection.
- Distance-Distance intersection.

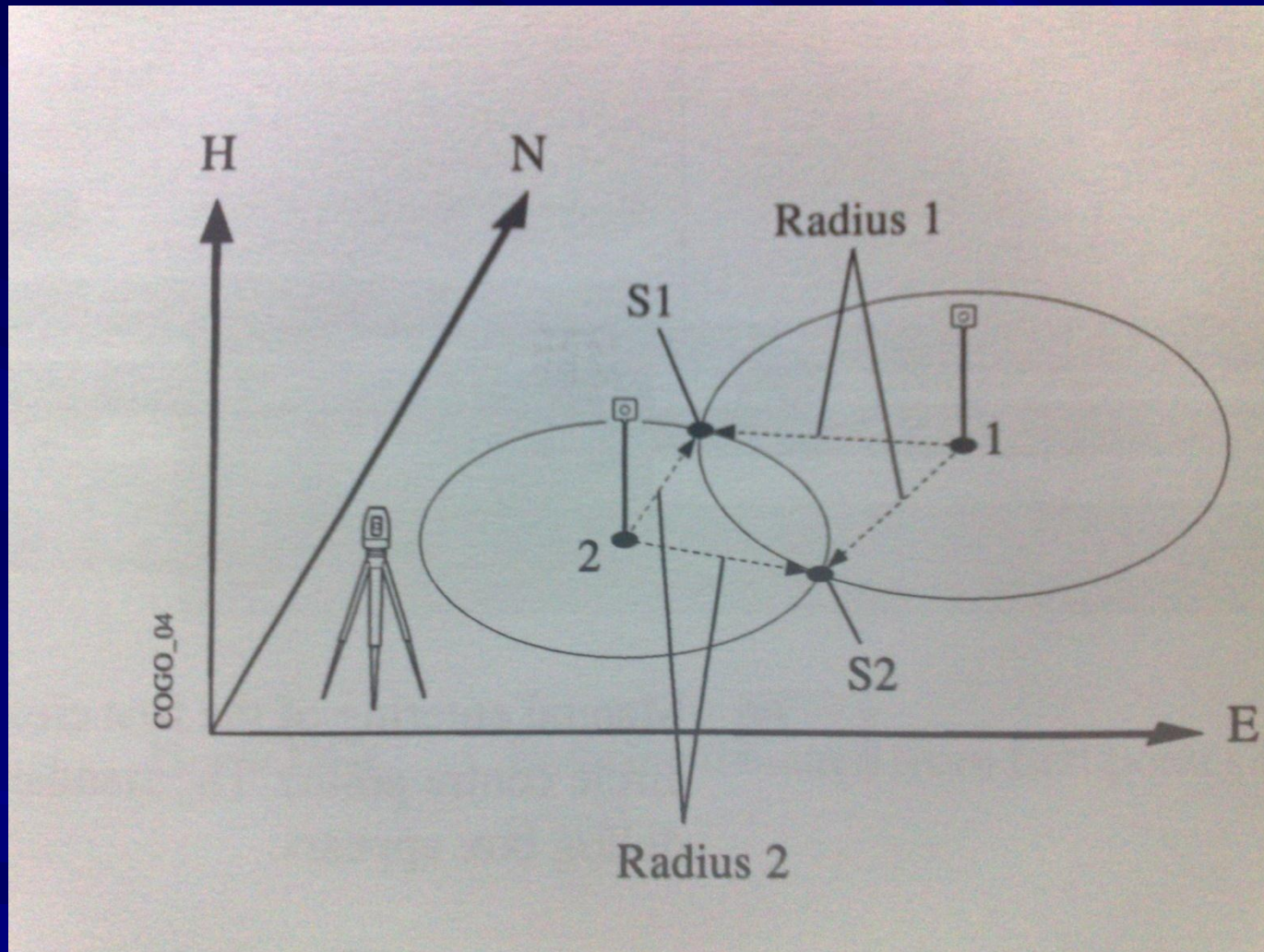
□ Bearing-Bearing Intersection



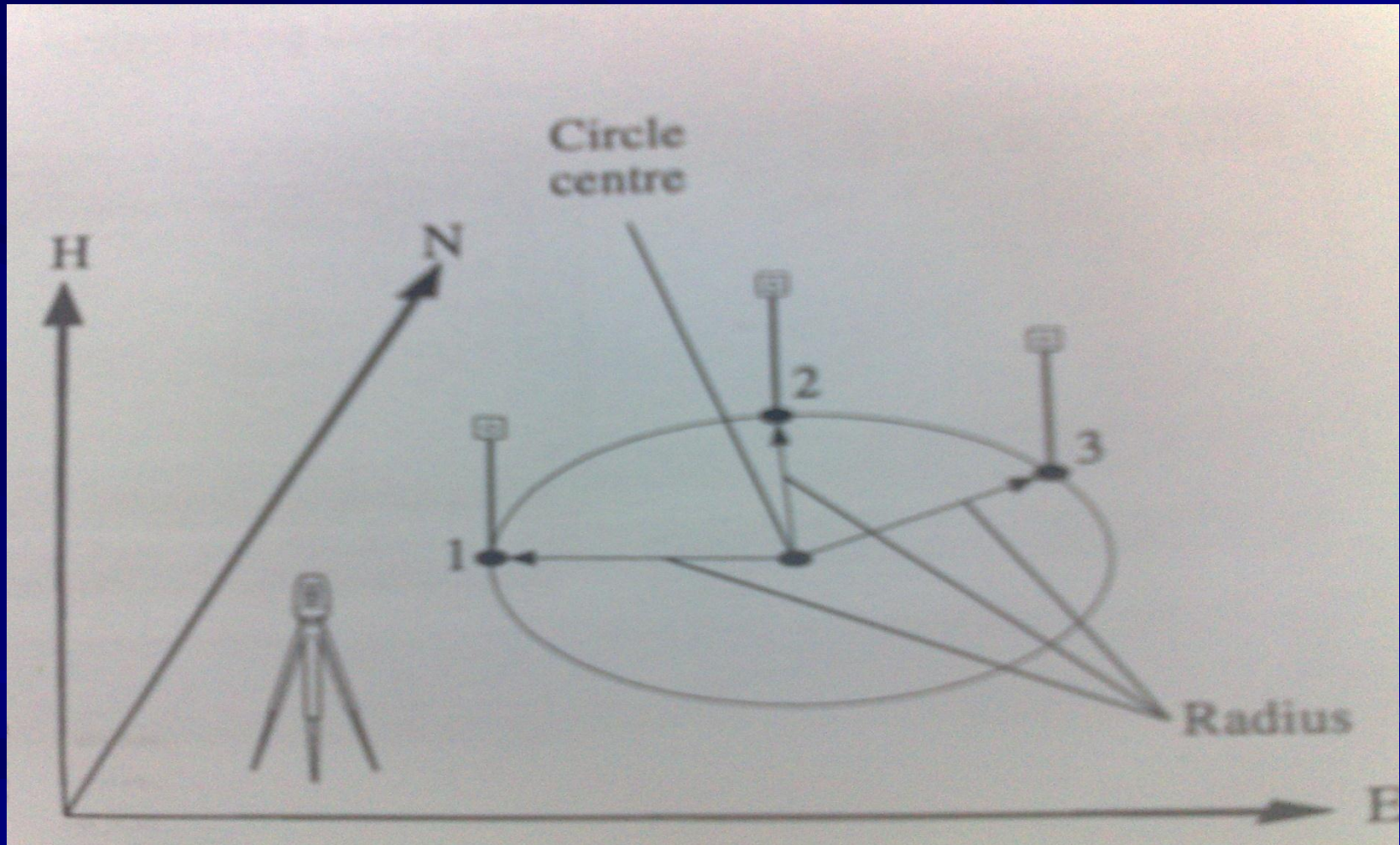
□ Bearing-Distance Intersection



□ Distance-Distance Intersection

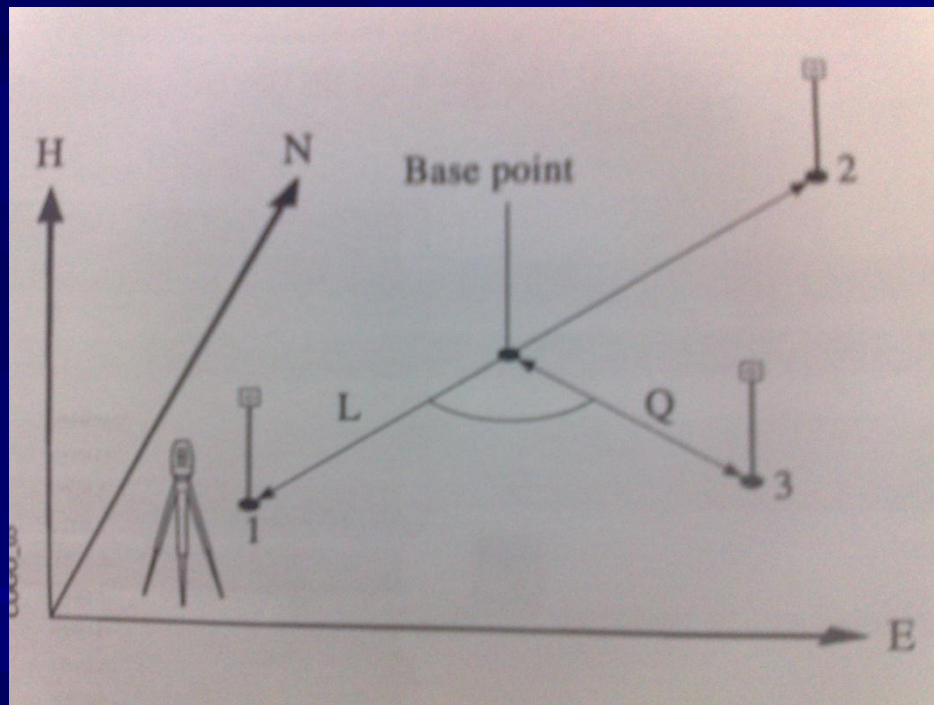


❑ Point Arc Routine: Computes a radius point given any three points

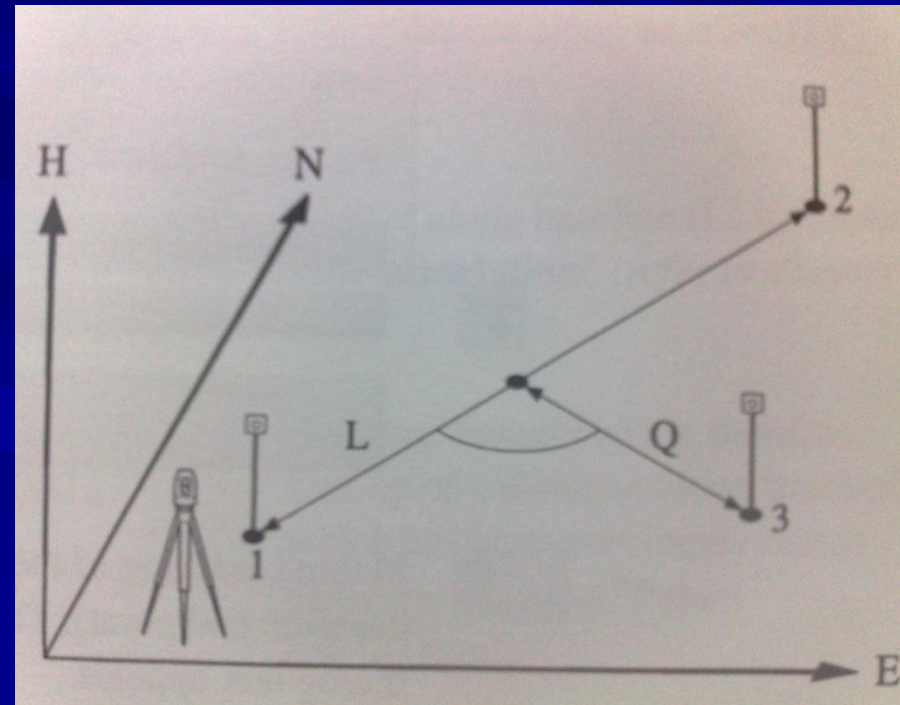


❑ Offsets Subroutine:

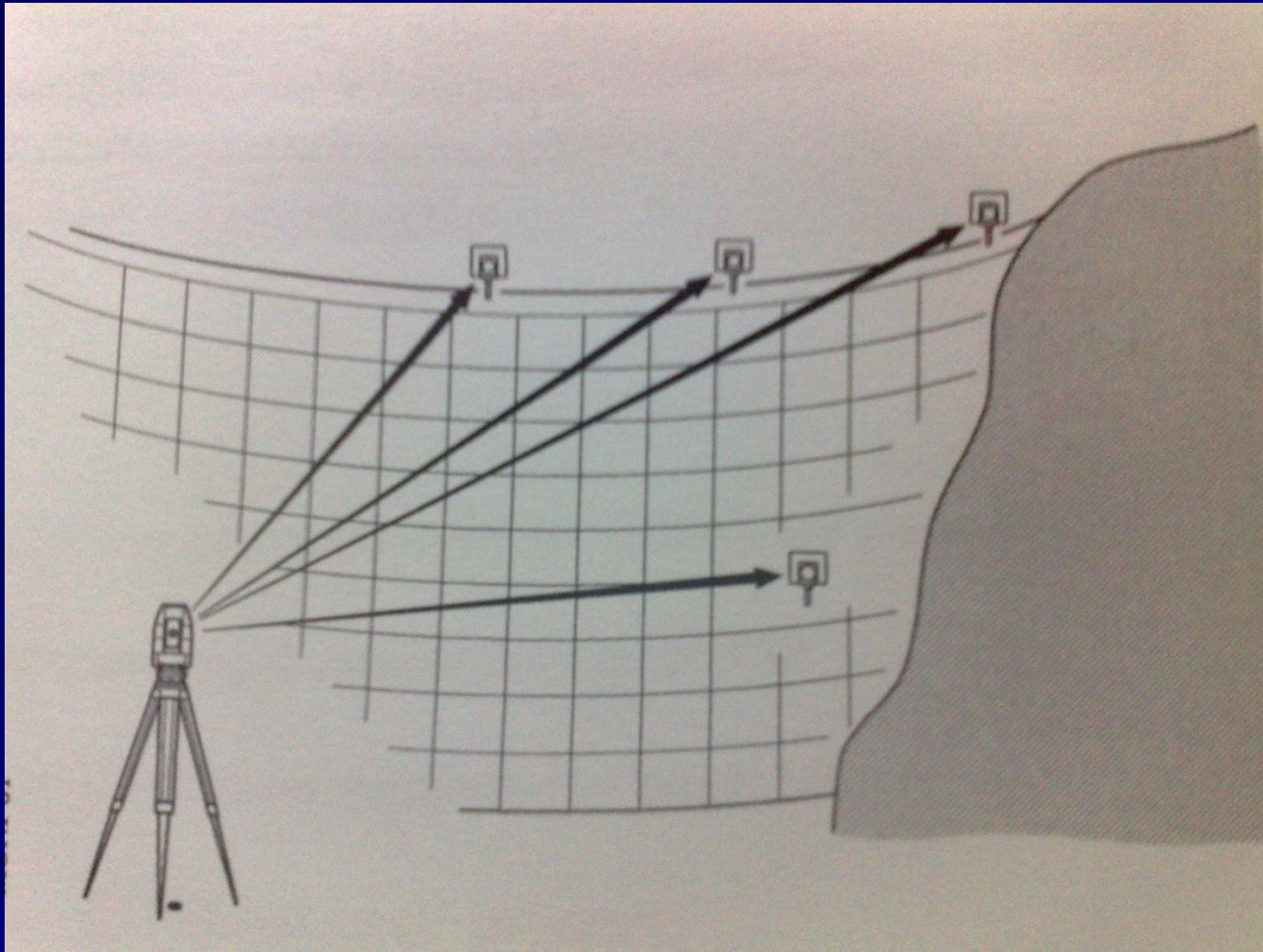
✓ Distance-Point
straight line



✓ Orthogonal-Point
calculation



□ Monitoring



Exercises

- ❑ Total Station Setup.
- ❑ Practicing components of the instrument.
- ❑ Practicing the software of the instrument.
- ❑ Practicing: Stakeout, Layout, etc.
- ❑ Practicing all the routines of the instrument.
- ❑ Practicing SURFER software.

Projects

- ❑ **Project 1: Stakeout of a given coordinates boundaries at JUST campus.**
- ❑ **Project 2: Layout of a building and a road at JUST campus.**
- ❑ **Project 3: Use total station's output coordinates in SURFER SOFTWARE to plot contours and make earth work computations.**
- ❑ **Project 4: Integrate total station's output with CAD and Land Development Software.**



Thanks

Prof. Mohammed Taleb Obaidat

Civil Engineering Department

Jordan University of Science and Technology (J.U.S.T.)

Irbid, JORDAN

E-Mail: mobaidat@just.edu.jo

Website: www.just.edu.jo/mobaidat