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اللجنة الأكاديمية لقسم الهندسة المدنية
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نوت

مساحة

إعداد : رند الشوبكي

Chapter 1
Basics of Surveying

What is Surveying?

- The art of making measurements of the relative positions of natural and man-made features on the Earth's surface, and the presentation of this information either graphically or numerically.

قياسات لاشياء موجودة بشكل طبيعي او تكون من صنع الانسان وبتحويل قياسات
الى شكل يستفاد منه

- ***The art of measuring distances, angles, and position on or near surface of earth.***

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Surveying Branches

نتعامل السطح مستوي

Plane surveying: is the process of surveying by assuming that the earth is flat. Which mean the curvature or spherical shape of the earth is not considered in plane surveying calculations.

نتعامل على انه كروي

Geodetic surveying: is a process of surveying by considering the curvature or spherical shape of the earth. The exact positions of points obtained on plane surveying are given by geodetic.

الفروق

Difference Between Plane and Geodetic Surveying

Plane Surveying

- Earth surface is assumed as plain سطح مستوي
- Line formed by any two points are considered as straight line - as the same angles are plain angles بعني إذا اجت مساحية نقطتين بنوخذ على اساس انه خط مستقيم
- Suitable for small area surveying.
- ***American survey put 250 km² for treating survey as Plane.***
- Survey accuracy is low اقل دقة
- Economic and easy survey method

Geodetic Surveying

- Earth surface is considered as spherical
- Line formed by joining any two points are considered as arch – as the same angles are spherical angles
- Suitable for large area surveying
- Survey accuracy is high
- Special instrument

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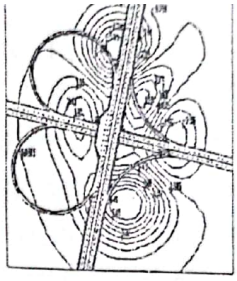
Classes of surveys



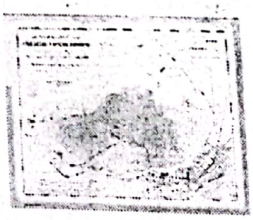
1- The preliminary survey: (data gathering)
Collection of distances, angles, and difference in elevation data to locate physical features so data can be plotted to scale on a map.

2- Layout surveys: Making on the ground the features shown on a design plan (using wood stakes, iron bars, aluminum and concrete monuments, nails, etc.).

3. Control surveys: To reference preliminary and layout surveys.

- ***Horizontal control** can be anything but usually roadways or coordinate control stations.*
- ***Vertical controls** are a series of benchmarks having X, Y & Z coordinate.*

Types of Surveys



- **Topographic surveys :** To prepare a plan/ map of a region which includes natural as well as man-made features including elevation.→ Preliminary survey
- **Hydrographic surveys:** Used to tie in underwater features to surface control points. Usually shorelines, marine features, and water depths are shown on the hydrographic map→ Preliminary surveys
- **Route surveys:** They range over a narrow but long strip of land. Like highways, railroads, ...etc. → preliminary+ layout+ control surveys
- **Property surveys (cadastral or land surveys):** Determining boundary locations or laying out new property boundaries → preliminary+ layout+ control surveys

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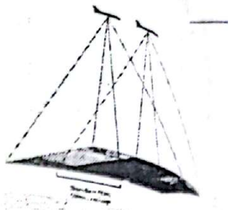
Types of Surveys

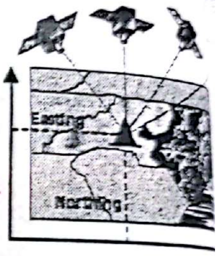
- **Final ("as built") surveys:** similar to preliminary surveys. Final surveys tie in features that have been constructed to provide a final record of the construction and to check that the construction has proceeded according to the design plans.

- **Aerial surveys:** preliminary and final surveys that use both traditional aerial photography and aerial imagery.

- **Construction surveys :** Surveys which are required for establishment of points, lines, grades, and for staking out engineering works (after the plans have been prepared and the structural design has been done)→ layout surveys

- **GPS:** N, E and elevation using NAVSTAR satellite signal.

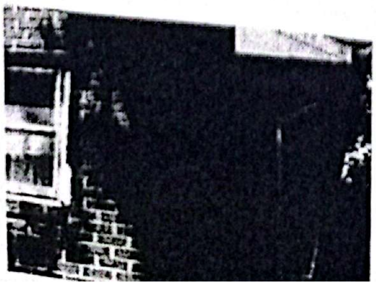


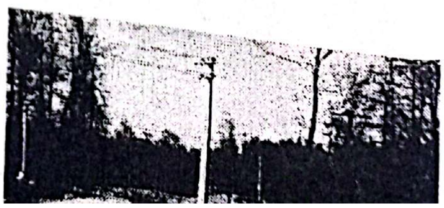


The Role of Surveying in Civil Engineering Practice

Surveyors are needed:

- to maintain the geometric order during the construction process.
- to provide fundamental data for the design and planning process
- to provide quantity control during the construction process (for example: earthwork quantities)
- to monitor the structure after the construction (subsidence, deformations, etc.)





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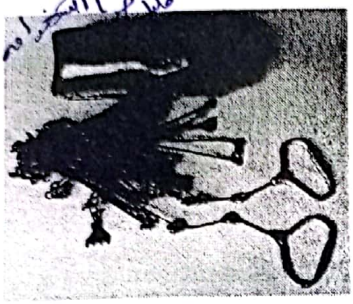
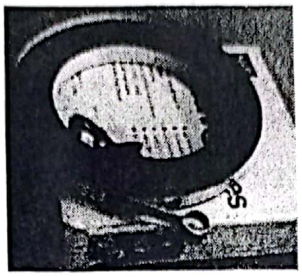
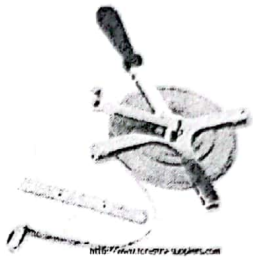
Surveying Instruments

1. Chain and Tape سلسلة و شريط القياس

Chains or tapes are used to measure distances on the field.
A **chain** is made up of connected steel segments, or links, which each measure 20 cm. Usually, a chain has a total length of 20 meters (66 ft), including one handle at each end (100 links).







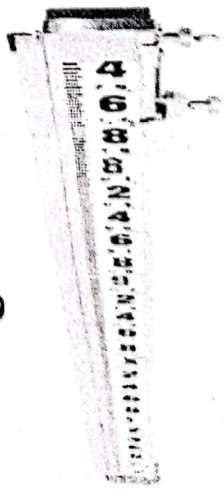
شريط القياس

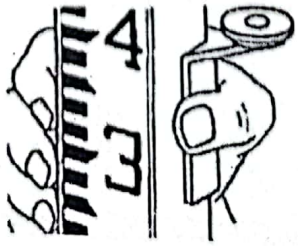
Measuring tapes: are made of steel, coated linen, or synthetic material. They are available in lengths of 20, 30 and 50 m. Centimeters, decimeters and meters are usually indicated on the tape.

Surveying Instruments

2. Measuring Rod (level staff or graduated rod) مسطرة

A measuring rod is a straight lath with a length varying from 2 m to 5 m. The rod is usually marked in the same way as a measuring tape, indicating centimeters, decimeters and meters.





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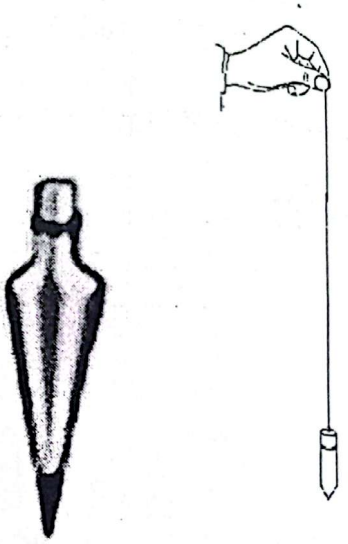
Surveying Instruments

خط الشاقول

3. Plumb Bob

تحديد او نقل الارتفاعات من الارض

A plumb bob is used to check if objects are vertical. A plumb bob consists of a piece of metal (called a bob) pointing downwards, which is attached to a cord. When the plumb bob is hanging free and not moving, the cord is vertical.



ونعرف مسافة

Surveying Instruments

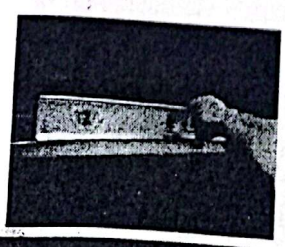
ميزان

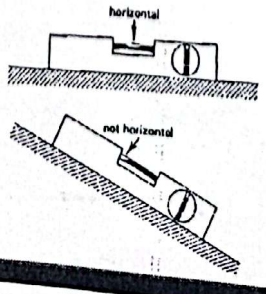
4. Hand Level

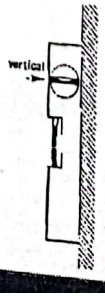
A hand level is used to check if objects are horizontal or vertical. Within a hand level there are one or more curved glass tubes, called level tubes.

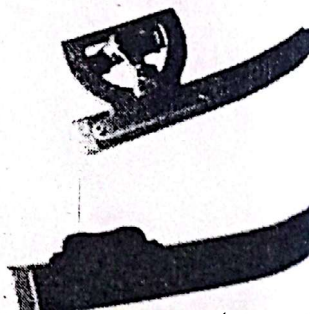
Each tube is sealed and partially filled with a liquid (water, oil or paraffin). The remaining space is air, visible as a bubble. On the glass tube there are two marks. Only when the hand level is horizontal (or vertical) is the air bubble exactly between these two marks.

tap نستخدم مع









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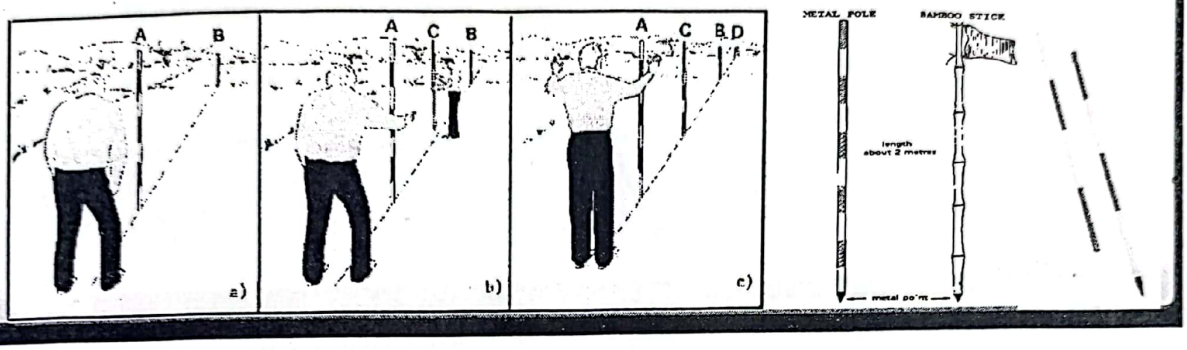
Surveying Instructions

5. Ranging Poles

Ranging poles are used to mark areas and to set out straight lines on the field. They are also used to mark points which must be seen from a distance, in which case a flag may be attached to improve the visibility.

Ranging poles are straight round stalks, 3 to 4 cm thick and about 2 m long. They are made of wood or metal.

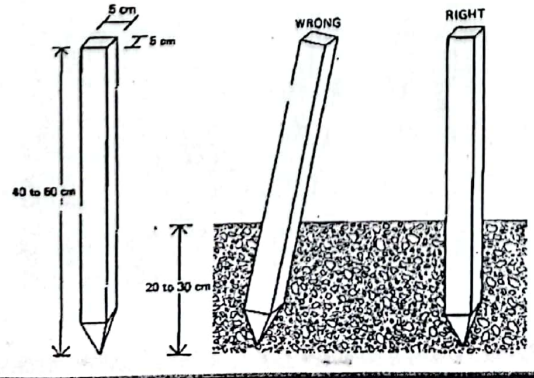
REMEMBER: Ranging poles may never be curved.
Ranging poles are usually painted with alternate red-white or black-white bands.

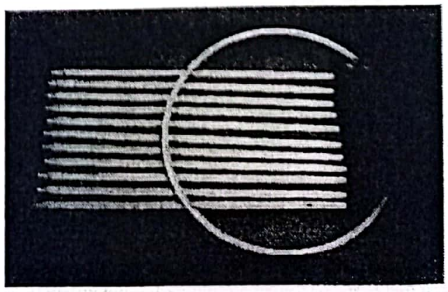


Surveying Instruments

6. Pegs and chaining pins

Pegs are used when certain points on the field require more permanent marking. Pegs are generally made of wood; sometimes pieces of tree-branches, properly sharpened, are good enough. The size of the pegs (40 to 60 cm) depends on the type of survey work they are used for and the type of soil they have to be driven in. The pegs should be driven vertically into the soil and the top should be clearly visible.





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Surveying Instruments

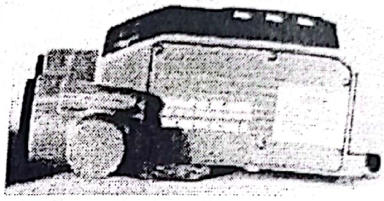
قياس مسافات افقية

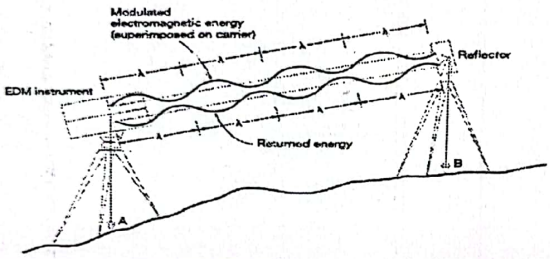
7. Electronic distance measurement (EDM):

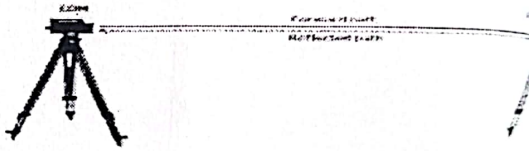
These devices measure lengths by indirectly determining the number of full and partial waves of transmitted electromagnetic energy required in traveling between the two ends of a line.

In practice, the energy is transmitted from one end of the line to the other and returned to the starting point; thus, it travels the double path distance.

يقيس ~~خط~~ بمبدأ الزمن والمسافة والسرعة







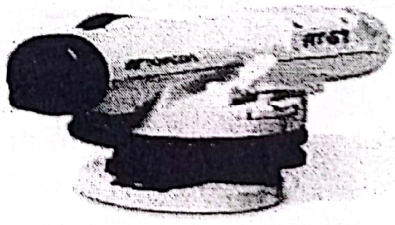
Surveying Instruments

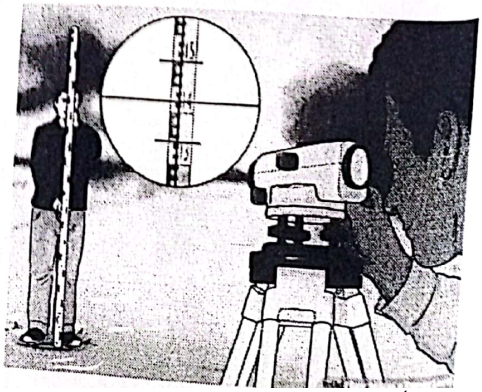
جهاز التسوية لايجاد الارتفاع

8. Levels:

Levels are used to determine elevations (ارتفاع) in a wide variety of surveying, mapping, and engineering applications

باستخدام مسطرة





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Surveying Instruments

بتحرك

9. Theodolites:

قياسه زوايا

Theodolites (sometimes called transits) are used in measuring horizontal and vertical angles and for establishing linear and curved alignments in the field.

horizontal angles ← دوران حط جهاز

نضمنا جهاز مستوي

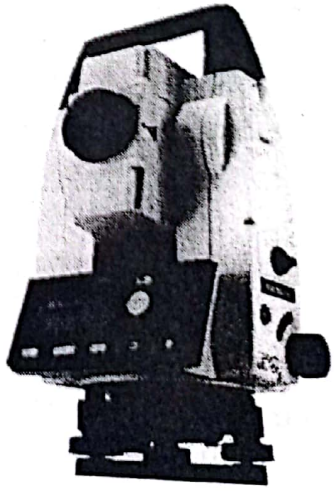
Surveying Instruments

بقيس مسافات وزوايا

10. Total stations:

وعنده كمبيوتر قدرة تخزينه

Total stations combine EDM with an electronic theodolite. In addition, it is equipped with a central processor, which enables the computation of horizontal and vertical distances. The central processor also monitors instrument status and executes software programs that enables the surveyor to perform a wide variety of surveying applications.



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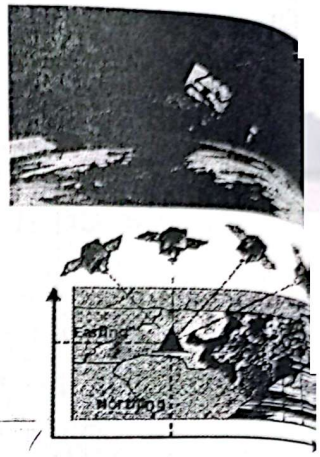
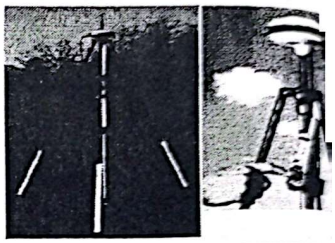
Surveying Instruments

11. Global Navigation Satellite System (GNSS):



Is a term used world-wide to describe the various satellite positioning systems now in use. Global positioning system (GPS) is the term used to describe the U.S. NAVSTAR positioning system, which was the original fully-operational global navigation satellite systems (GNSS). GLONASS→ the Russian GNSS, Galileo→ the European GNSS, Beidou→ China's GNSS

A satellite positioning receiver captures signals transmitted by four or more positioning satellites in order to determine position coordinates (e.g. northing, easting, and elevation) of a survey station.



Position Referencing

1- Geographic Reference

- Surveying includes measuring the location of physical land features relative to one another and relative to a defined reference on the surface of the earth.
- The earth's reference system is composed of the surface divisions denoted by geographic **latitudes** and **longitudes**
- **Latitude lines** run east/west and are parallel to the equator.
  - The latitude lines are formed by projecting the latitude angle out from the center of the earth to its surface.
  - The latitude angle itself is measured (90 degrees maximum) at the earth's center, north or south from the equatorial plane.

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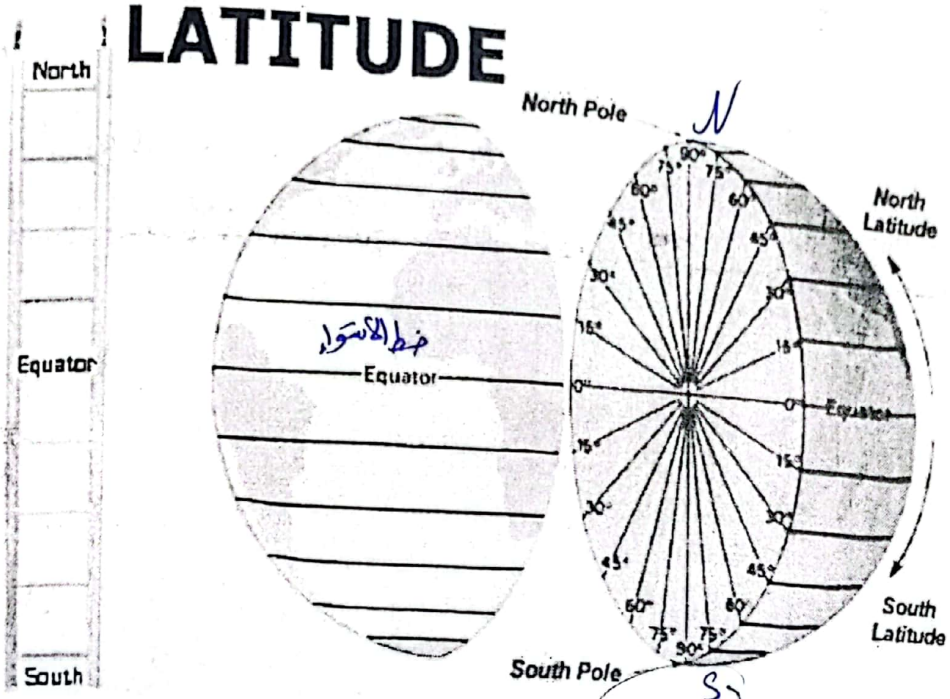
LATITUDE



http://modernsurvivalblog.com/survival-skills/basic-map-reading-latitude-longitude/

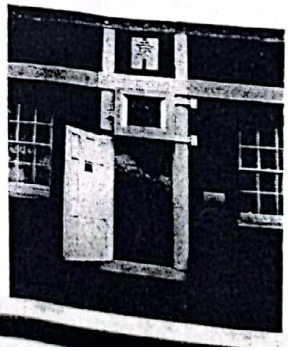
Position Referencing
1- Geographic Reference

خطوط الطول

Longitude lines run north/south, converging at the poles.

- The line of longitudes (meridians) are formed by projecting the Longitude angle at the equator out to the surface of the earth .
- The longitude angle itself is measured at the earth's center, East or west (180 degrees maximum) from 0° longitude, which has been arbitrarily placed through Greenwich, England.

360 Line



Markings of the prime meridian at the Royal Observatory, Greenwich.

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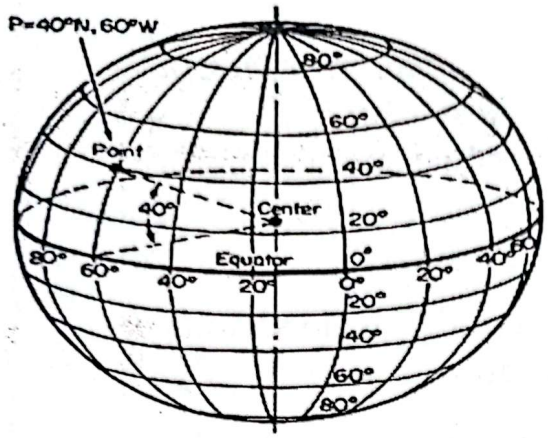

What are the Latitude and Longitude of Amman city?

http://kaffee.50webs.com/Science/activities/Astro/Activity-Latitude.Longitude.htm

Position Referencing

2- Grid Reference

- Grid references define locations on maps using **Cartesian coordinates.**
- Grid lines on maps define the coordinate system, and are numbered to provide a unique reference to features.
- Grid systems vary, but the most common is a **square grid with grid lines intersecting** each other at **right angles and numbered sequentially from the origin at the bottom left of the map.**
- The grid numbers on the **east-west (horizontal) axis are called Eastings, and the grid numbers on the north-south (vertical) axis are called Northings.**

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Position Referencing
2- Grid Reference

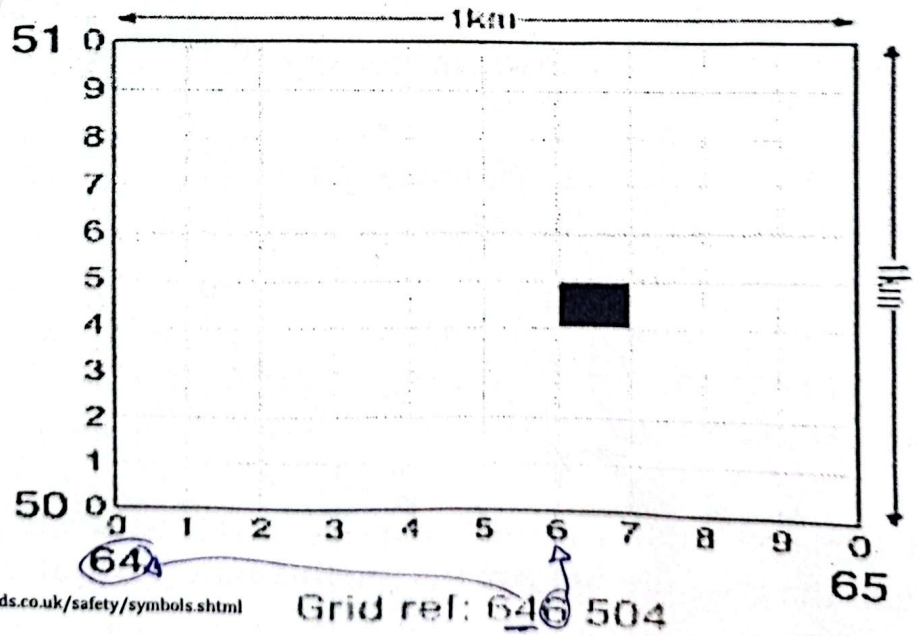
- Numerical grid references consist of an **even number** of digits. **Eastings are written before Northings**. Thus in a 6 digit grid reference 123456, the Easting component is 123 and the Northing component is 456.

- The grid is limited in area e.g. 1 squared. Km, no serious errors resulting from ignoring curvature

- Ease of calculations (plane geometry and trigonometry)

- Translation to geographic coordinates could be accomplished.

Position Referencing
2- Grid Reference



http://www.walkhighlands.co.uk/safety/symbols.shtml

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Position Referencing
3- Vertical Reference

معتمدين على مستوى سطح البحر

In addition to the X and Y dimensions of any feature, a vertical dimension can be referenced to any datum, usually Mean Sea Level (MSL).

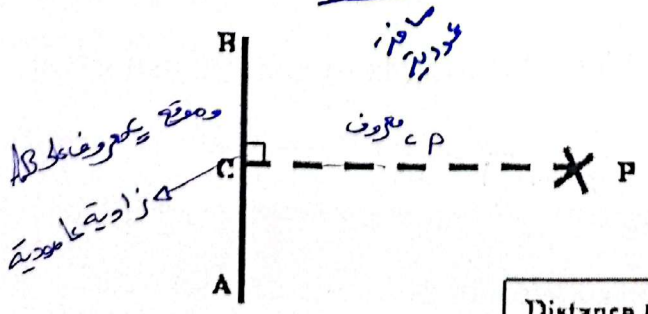
Locating Point Reference to a Line

Point "P" may be located relative to line AB by:

- Line AB is previously known
- Required to locate point P relative to line AB

مش بشرط بنضعها

1: Right-Angle offset tie (rectangular tie):



Distance CB or CA
Distance CP
Angle C (90°)

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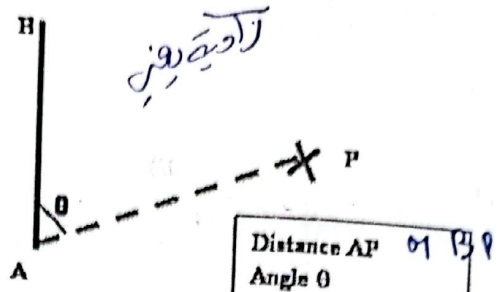
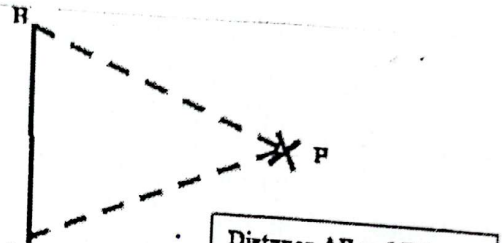
Locating Point Reference to a Line

2: Angle-Distance tie (polar tie):



3: Intersection technique:



Accuracy & Precision

- *Accuracy:* is the relationship between the value of a measurement and the "true" value of the dimension being measured
- *Precision:* describes the refinement of the measuring process and the ability to repeat the same measurement with consistently small variations in the measurements
- Ex: a wall known to be 157.22 ft long is measured using two tapes; types

	"True" Distance (ft)	Measured distance (ft)	Error (ft)
Fiberglass tape	157.22	157.3	0.08
Steel tape	157.22	157.23	0.01

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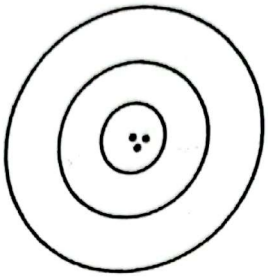
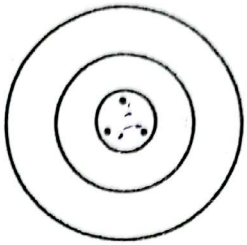
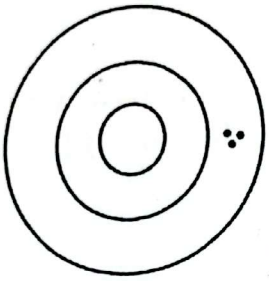
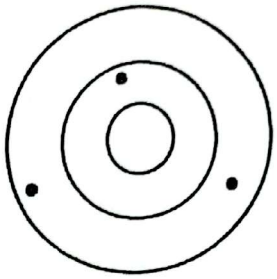
Precision الدقة

Repeatably ← نفس الشخص والأشياء
والخطأ يكون أقل بمقياس الخطأ قليلا

Reproducibly ← ينتج الخطأ الجبر

Accuracy & Precision

الدقة الضبط

High Accuracy/ High precision	High Accuracy/ Low precision
	
Low Accuracy/ High Precision	**Low Accuracy / Low precision**
	

(True) مجموع الزوايا الداخلية ← $(n-2)*180$ *

عدد الأضلاع

Accuracy & Precision

قريب من الدقة

Accuracy Ratio: is the ratio of error of closure to the distance measured

The error of closure: is the difference between the measured value and the theoretical correct value.

- Ex: a distance was measured and found to be 250.56 ft. the distance was previously known to be 250.50 ft. the error is 0.06 ft in a distance of 250.50 ft.

True ← $A = \frac{|error|}{True}$

- Accuracy ratio (AR)= 0.06/ 250.50
  = 1/ 4175 ≈ 1/4200 ← $\frac{1}{x}$ لازم يطلع
- AR is expressed as a fraction whose numerator is unity and whose denominator is rounded to closest 100 units

* اذا كانت اقل من 5 بنخفرفها تنين وماتزيادش

4175 → 4200 الجواب 50 round

- *Practice: If the measured internal angles in a triangle are: 71º 12' 13", 55º 34' 27", and 53º 56' 37", find the error of closure and the accuracy ratio in the measurements.*

دقيقة & ثانية

*error= 180° 43' 17" − 180° 0' 0"

$71^\circ\ 12'\ 13''$
$55\ 34\ 27''$
$53\ 56\ 37''$

$A = (4.008 \times 10^{-4})^{-1} =$

77

43, 17

الممسوحة ضوئيا بـ CamScanner

Errors

1. **Systematic errors:** errors whose magnitude and algebraic sign can be determined.
   - surveyor can eliminate them to improve the accuracy
   - Example: effect of temperature on steel tape

2. **Random errors (accidental error):** Occurs in every surveying measurement and is beyond the control of the surveyor. It is due to the nature of human being.

   - If surveyor is skilled and careful, random error will not b significant.

Mistakes

Mistakes are blunders made by a survey personnel.

Example:

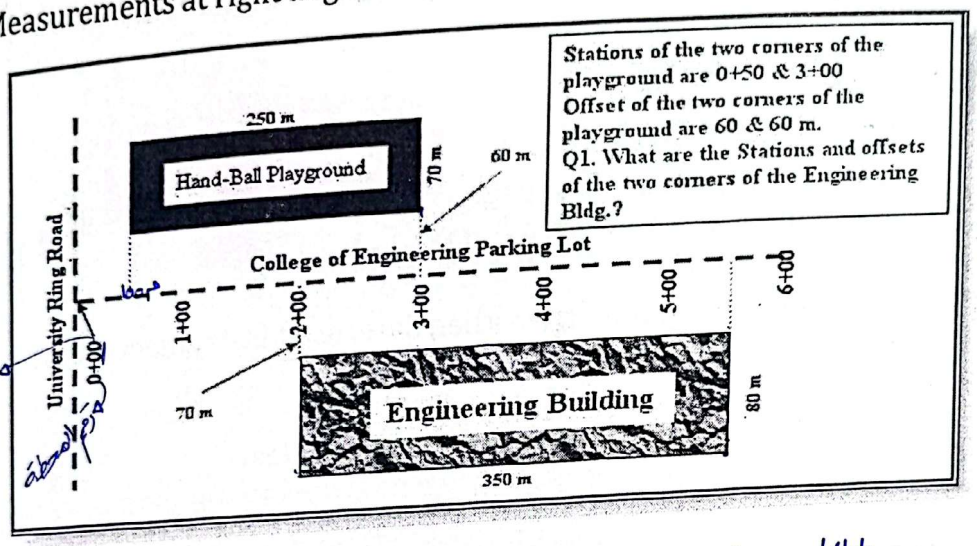
- transposing figures (recording a tape value of 68 as 86)
- Measuring from and to the wrong point

- They should be discovered and eliminated, by verification (repeating the measurement, or geometric or trigonometric analysis).

الممسوحة ضوئيا بـ CamScanner

Stationing

- Distances along baseline are called: Stations or Chainage.
- Measurements at right angles to baseline are called: Offsets.



Stationing

Many highway agencies use 1000 unit station 1+000

⇒ Full station 100 m or 100 ft
⇒ Half station -- 50'
⇒ Partial station 20 m --

- Example: If the station of a certain position is 2+ 36.72 and stations are taken each 100 m. Then the distance of that position from the base point is

= 200 + 36.72
= 236.72

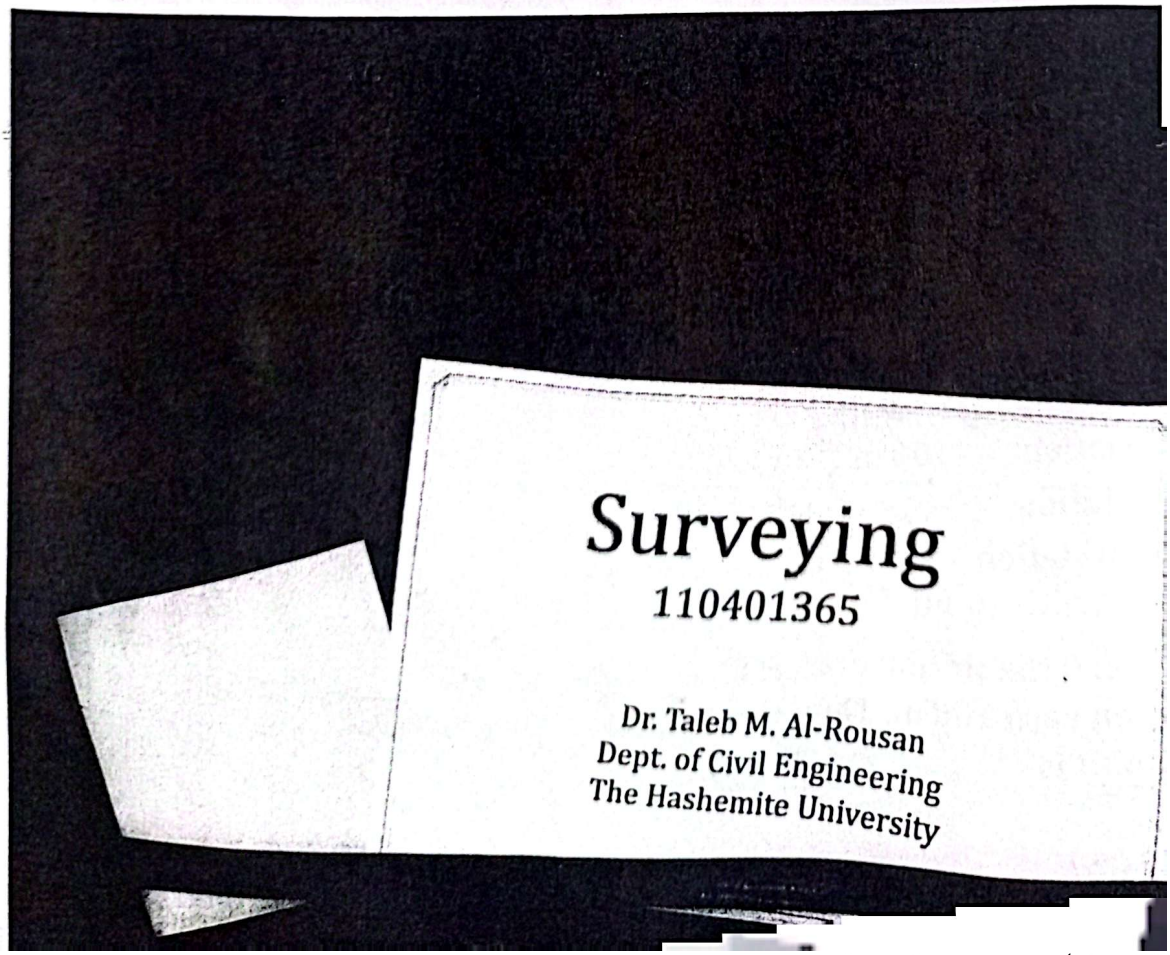
الممسوحة ضوئيا بـ CamScanner

Field Management

- **Survey Crew**
- **Chief:** responsible about the whole work.
- **Instrument operator:** operation and care of the instrument.
- **Survey assistance:** perform taping and carry the rods and prisms.

- **Field Books**
- **Bound books.**
- **Loose leaf books.**
-
- Include name and address in the first page.
- Right pages are kept for the sketches.
- Pages should be numbered.
- Should show project name, number, weather, date, used instruments a first page of the project (lab).

- **Field Notes** should be" CAN " Complete, Accurate, & Neat



الممسوحة ضوئيا بـ CamScanner

Pacing

- Imprecise غير دقيق
- Medium (neither long or short) .
- Pace length depends on legs opening.
- Very useful
- Accuracy on level ground 1/50 to 1/100
- Inaccurate in hilly areas

ماينفع الارض وتضاريسها

Note: One pace = perimeter in m/ perimeter in pace

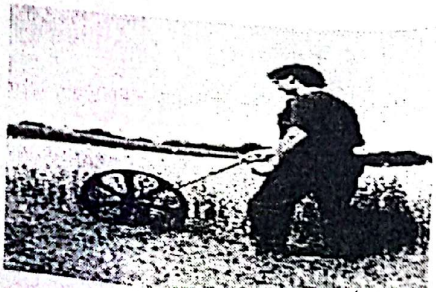
Car Odometer & Measuring Wheel

حداد المتر للسيارة — تنسب عجلة السيارة — ومحيط الدورة الواحدة معروف

- Accurate enough to collect information to begin a survey.
- Fence lines abutting a road
- Distance to a traffic accident scene (الحوادث)
- One rev =2 π r

Then, n rev = d

then d = 2π r n ← عدد مرات

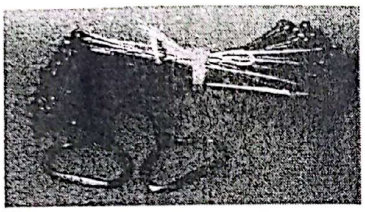


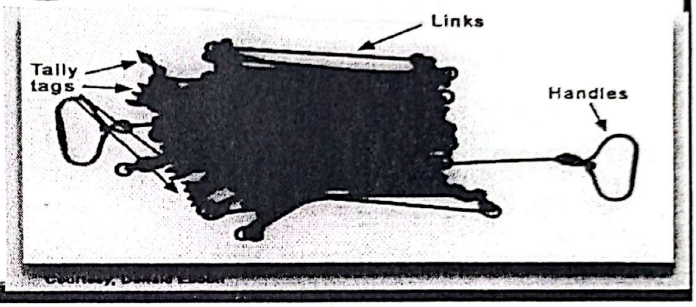
الممسوحة ضوئيا بـ CamScanner

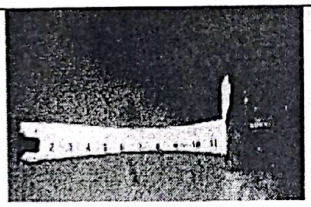
Gunter's chain

طريقة قديمة

- The Gunter's chain used to survey North America was 66 ft long and composed of 100 links (chain=100 link)
- Very old
- Not used anymore
- 80 chains = 1 mile
- 10 square chain = 1 acre

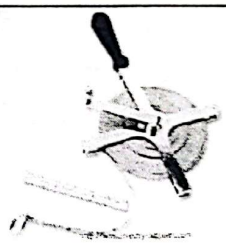






Tape

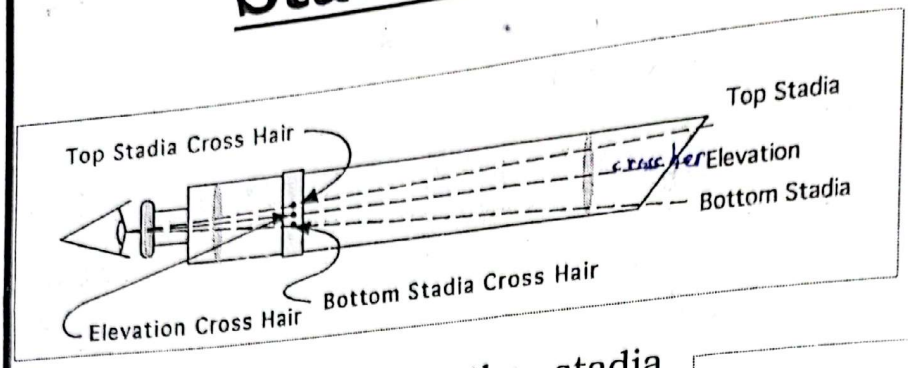
طريقة تقليدية لحساب مسافات



- Traditional method of measuring distance.
- Available in steel, cloth, and fiberglass (good when working near electric installation)
- Steel tapes are available in 20, 30, 50 m (100, 200, and 300 ft).
- Cross section: light duty (6 mm * 0.3 mm) and heavy duty (8 mm * 0.454 mm) which can be dragged.

الممسوحة ضوئيا بـ CamScanner

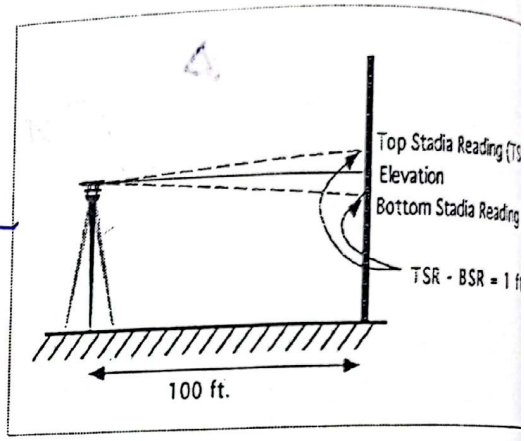
Stadia (Tacheometry)



Distance by stad
requires an
instrument with
stadia cross hair

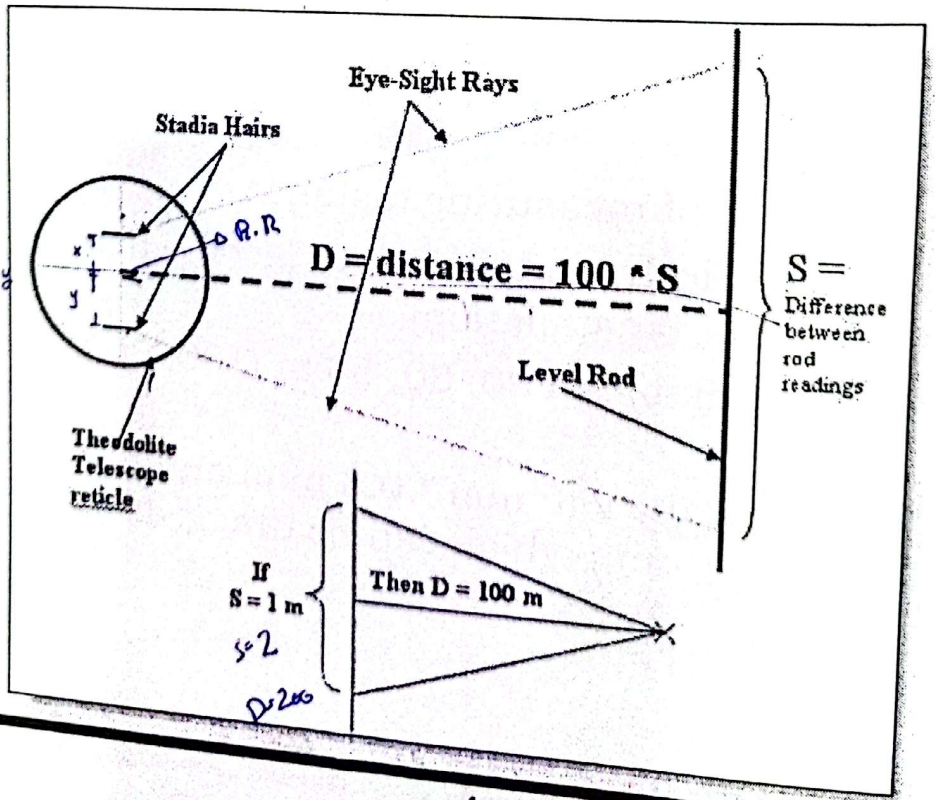
The distance between the stadia crosshairs is designed so that the divergence of the sights across the two stadia crosshairs is 1.0 feet when the instrument is 100 feet from the rod.

(Assuming an instrument stadia factor of 100.)



Stadia

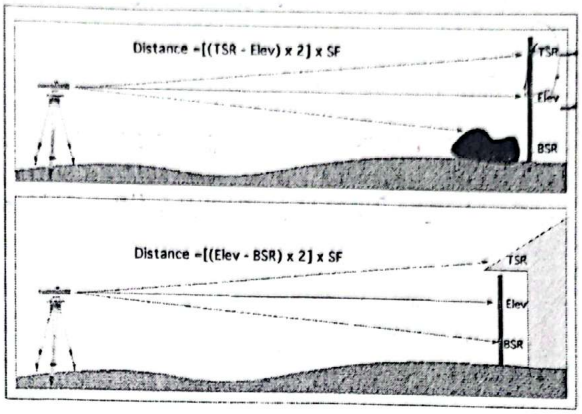
- Tachometry technique (uses trigonometry calculation)
  - Uses the horizontal marks on the theodolite cross-hair



الممسوحة ضوئيا بـ CamScanner

When the top or bottom stadia hair rod reading is obscured, a process called 1/2 stadia can be used. When 1/2 stadia is used the elevation crosshair, and which ever stadia crosshair that can be read, is used.

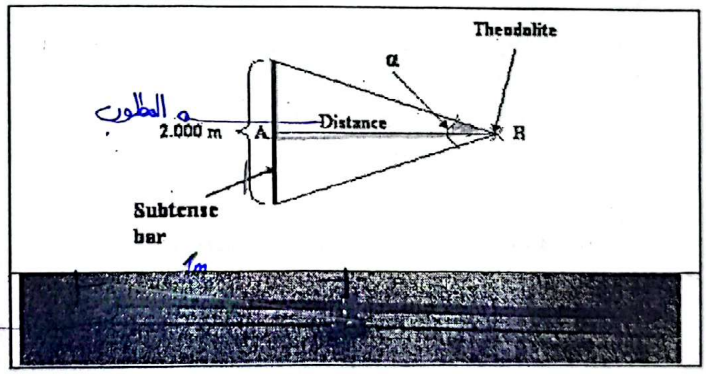
Because this stadia interval is 1/2 of the standard interval, it is multiplied by two.



$$\text{Horizontal Distance} = \left[\left(\text{TSR} - \text{Elev}\right) \times 2\right] \times 100$$
$$= \left[\left(7.34 - 6.21\right) \times 2\right] \times 100$$
$$= 226 \text{ ft}$$

Subtense Bar

- Dist $T_1 - T_2 = 2$ m regardless of Temp.
- Need a theodolite.



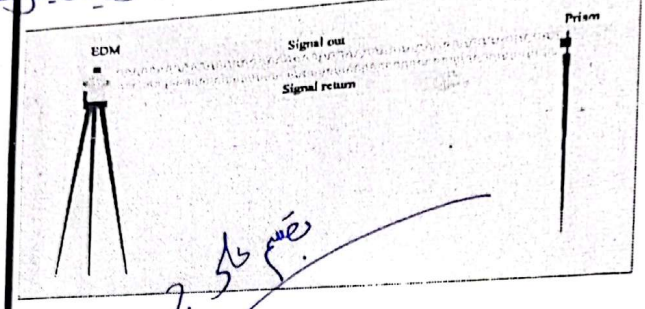
$\tan \alpha/2 = 1/AB$

$$\text{Distance AB} = \frac{1}{\tan \alpha/2} = \text{Cot}\,\frac{\alpha}{2}$$

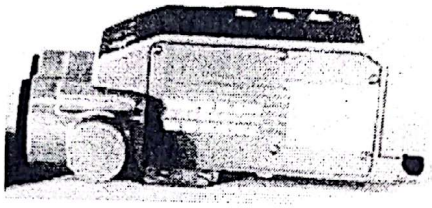
- α is independent of any vertical angle.
- Very good for hilly or mountainous country
- Not very accurate for long distances.

الممسوحة ضوئيا بـ CamScanner

Electronic Distance Measuring (EDM)



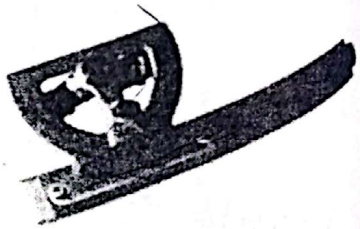
- The term EDM is used to describe a category of instruments that measure distance using an electronic signal.
- The instrument broadcasts a focused signal that is returne by a prism or reflection from the object.
- Very accurate
- Using light wave or microwav
- By measuring phase difference between transmitted and received signals



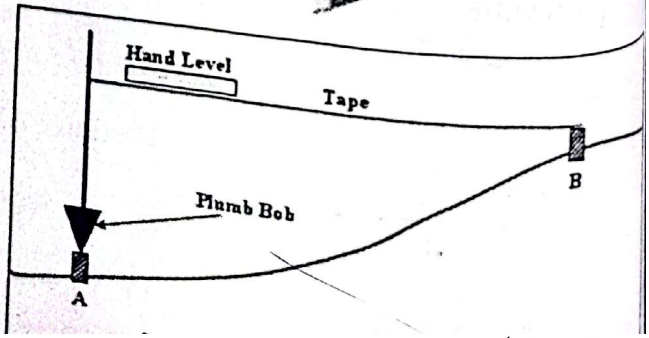
Taping Accessories

Plumb Bob:
Used to transfer from top to ground when top is held off ground to maintain the tape horizontal.

Hand level:
1-Normal hand level
- for horizontal level determination
- To keep tape horizontal

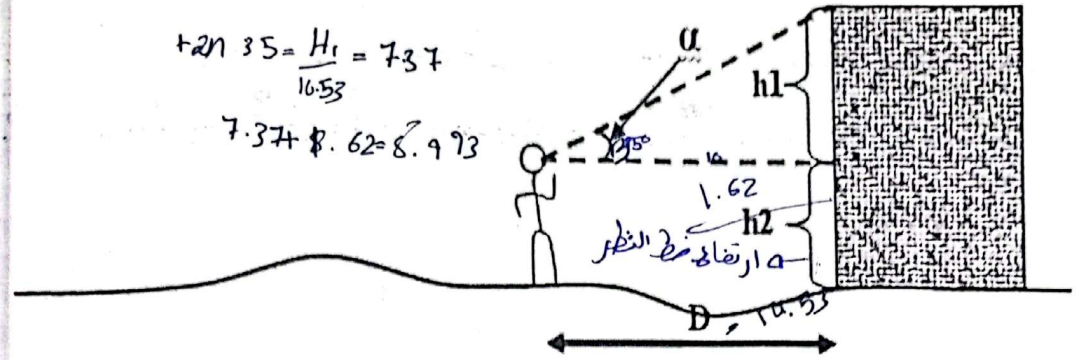


2- Abney hand level (Clinometer)
- for horizontal level determination
- for vertical angle and slope
- for height determination (not very accurate)



الممسوحة ضوئيا بـ CamScanner

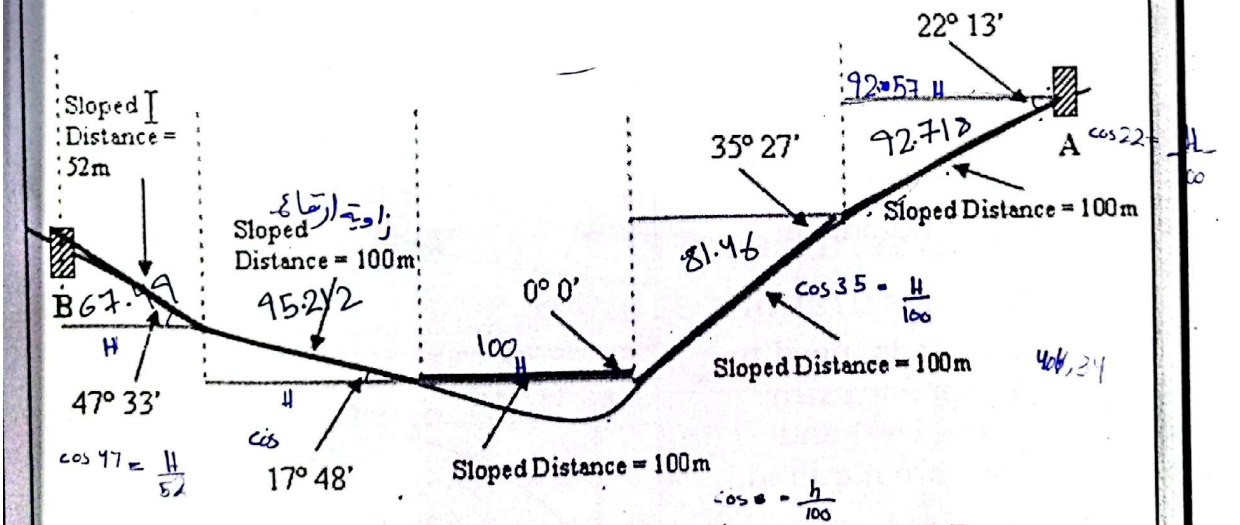
Taping Accessories/ Clinometer



If the height of the eyesight of the surveyor is 1.62, in the measured angle by the Clinometer is 35°, and the measured horizontal distance between the surveyor and building (D) = 10.53, find the total height of the building.

Measurement of height building using the Abney Hand Level

Taping Accessories / Clinometer



Find the total horizontal distance between points A & B.

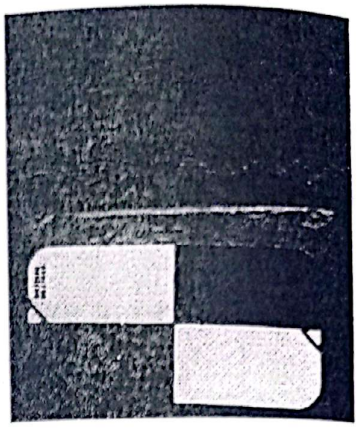
Getting the horizontal distance between two points using the tape to measure the sloped distances and the Clinometer to measure drop angles.

الممسوحة ضوئيا بـ CamScanner

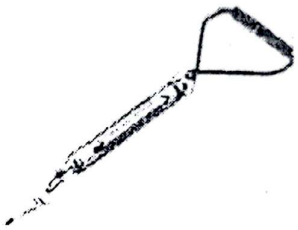
Taping Accessories

Plumb bob target

تثبيت Plumb



Tension handle



Taping Methods

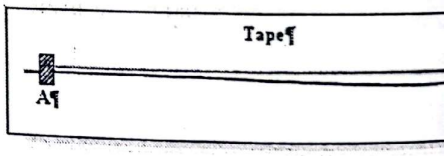
Normally the tape is held horizontally. Therefore, the way the tape is held depends on land topography.

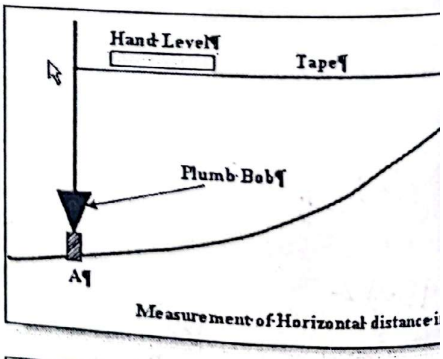
There are three methods of holding the tape.

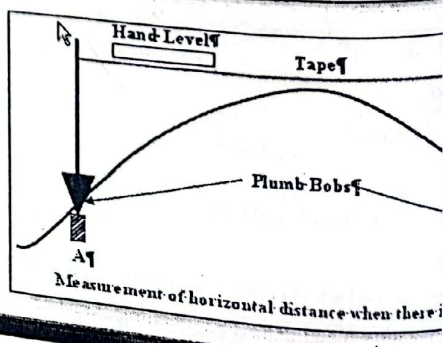
1- On smooth leveled land, the tape can be laid on the ground.

2- On sloping lands, need to use a plumb bob. For extra accuracy, a hand level and tension handles are required.

3- If there are obstacles, two plumb bobs are required







الممسوحة ضوئيا بـ CamScanner

Taping Procedures

- Head surveyor holds the zero end of the tape nd starts walking towards the target.
- Back surveyor shouts "tape" when the full ength of the tape is unwound.
- Rear surveyor aligns the front surveyor epending on a fixed range pole at the end of the istance.
- After applying the required tension, the front urveyor places a chaining pin in the ground.
- Both surveyors repeat the procedure, and the ear surveyor collects the pins after finishing om that point.

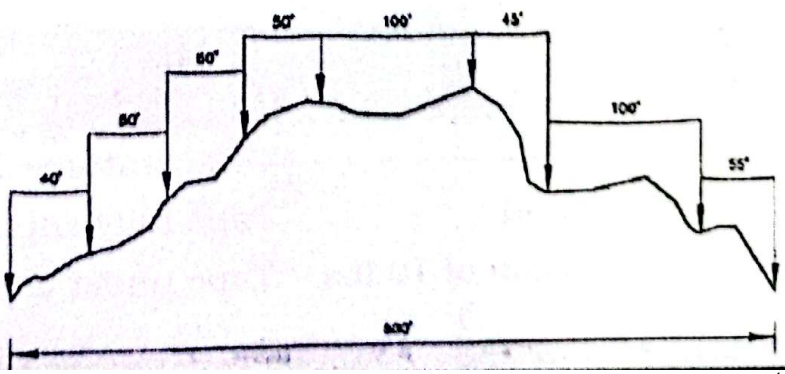
Taping in Practice

Usually horizontal distance is measured directly whenever possible.

If distance is large the Breaking-Tape technique is used.

تقسم المسافات قريبة ومتساوية

For preliminary route survey using a 100 m tape, the slope distance is measured using the tape, and the slope angle is measured using the Abney level.



الممسوحة ضوئيا بـ CamScanner

Errors

1. **Systematic errors:** errors whose magnitude and algebraic sign can be determined.
   - surveyor can eliminate them to improve the accuracy
   - Example: effect of temperature on steel tape

2. **Random errors (accidental error):** Occurs in every surveying measurement and is beyond the control of the surveyor. It is due to the nature of human being

   If surveyor is skilled and careful, random error will not be significant.

Taping Errors:

Systematic	Random
Slope	Slope
Erroneous Length	Temperature
Temperature	Tension and sag
Tension and Sag	Alignment
	Marking and plumbing

Q1. Why are some of the errors included in both systematic and random errors?

Tape standard Conditions

Foot System (100 ft) steel tape	Metric system (30 m) steel tape
temperature= 68 F	Temperature= 20 C
Tape fully supported	Tape fully supported
Tape under a tension of 10 lbs	Tape under a tension of 50N

الممسوحة ضوئيا بـ CamScanner

* إذا بدي احسب الزاوية وعطوني قيمة Gradient

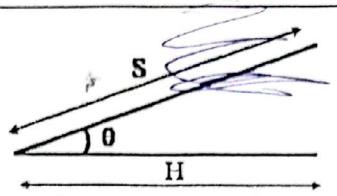
$g = \frac{V}{H}$ $\tan\theta = \frac{V}{H} = g$ $\rightarrow \theta = \tan^{-1}(g)$

Slope Corrections

- If measurements were taken on a slope, they must be converted to their horizontal equivalent distance.
- Using either the slope angle or the vertical distance.
- Slope might be expressed as a gradient or rate of grade
- To convert you should have one of the following:

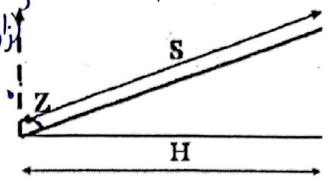
- Slope angle (0)

$H = S \cos\theta$

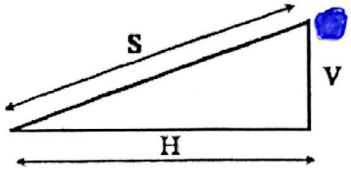


- Zenith angle (Z)

$= 90 - \theta$

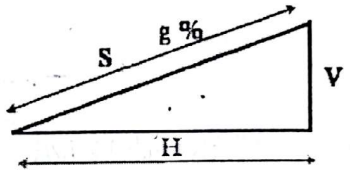


- Vertical distance (V)



- Gradient (rate of grade) (g%)

$= (V / H) * 100$



$g = S = \frac{\Delta y}{\Delta x} = \frac{V}{H}$

Example 1. Given Station of point A = 2 + 25
Elevation of point A = 228.32 m
Station of point B = 7 + 32
AB gradient = - 2.5 %
Required Elevation of point B.

Solution :

H = 732 – 225 = 507 m

g = (V / H) * 100

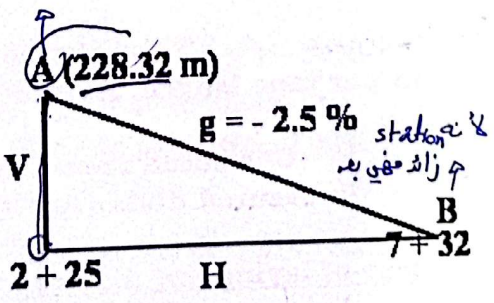
-2.5 = (V / 507) * 100

V = -0.025 * 507

= -12.68 m

B elevation = 228.32 – 12.68

= 215.64 m



الممسوحة ضوئيا بـ CamScanner

Example 2. Given Station of point A = 5 + 275
Elevation of point A = 375.85 m
Station of point B = 23 + 045
Elevation of point B = 123.67 m

Required Gradient of line AB.

Solution :

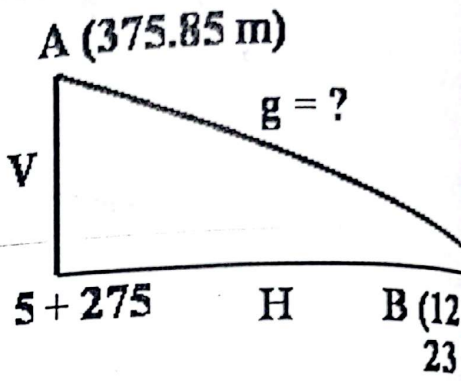
H = 23045 – 5275 = 17770 m

V = 375.85 – 123.67 = 252.18 m

g = (V / H) * 100

g = (252.18 / 17770) * 100

Gradient of line AB = 1.42%



Find the error in my solution.

-1.42%

because Going down Gradient لأنه

Tape Length Corrections

• Through extensive use of tapes, they become kinked, stretch repaired. The length can become something other than the spe length. In this case, correction has to be made.

①**Correction per tape length = Actual length – Seen Le**

Find the number of times the tape was used = (Distance/seen length of tape)

Total correction = (Correction per tape length * number of times the tape wa

Corrected measured distance = (measured distance + total correction)

In the case of laying out distance on the ground

Corrected distance = (required distance - total correcti

الممسوحة ضوئيا بـ CamScanner

Tape Length Corrections

Example 1. Given Measured distance = 171.278 m
Used tape 30 m (seen)
Actual length = 29.996 m (actual)
Required Corrected length.

Solution : Correction per tape length = Actual length – Seen Length
= 29.996 – 30.000 = - 0.004 m
Number of times the tape was used = 171.278 / 30 = 5.709
Total correction = - 0.004 * 5.709 = - 0.023 m
Corrected measured distance = 171.278 - 0.023 = 171.255 m

Tape Length Corrections

Example 2. Given Distance to lay out = 210.08 m
Used tape 30 m (seen)
Actual length = 30.006 m (actual)
Required Correct length to be laid out.

Solution : Correction per tape length = Actual length – Seen Length
= 30.006 – 30.000 = + 0.006 m
Number of times the tape will be used = 210.080 / 30 = 7.003
Total correction = + 0.006 * 7.003 = + 0.042 m
Corrected distance to be laid out = 210.080 - 0.042 = 210.038 m

الممسوحة ضوئيا بـ CamScanner

Temperature Corrections

⇒ Standard temp for steel tape:
68°F or 20°C

⇒ Thermal coefficient of expansion for steel tape:
(0.00000645 /ℓ.°F)
or
(0.0000116 /ℓ.°C)

⇒ Correction due to Temp.

$$C_t = a * (T - T_s) * L$$

where,

C_t ⇒ temperature correction
a ⇒ thermal coefficient
T ⇒ Temp. of tape
T_S ⇒ Standard temp
L ⇒ Total Distance measured

Temperature Corrections

Example 1. Given Distance to lay out = 210.08 m
Used tape 30 m (seen)
Tape temperature will be 27°C

Required Correct length to be laid out.

Solution : Temperature Correction = $C_t = a * (T - T_s) * L$
$= 0.0000116 * (27 - 20) * 210.08 = +0.017$ m
Corrected distance to be laid out = 210.080 - 0.017 = 210.063 m

⇒ For normal work ⇒ Air temp will be sufficient.
⇒ For accurate work of (1/10,000)accuracy ⇒ use Steel temp

الممسوحة ضوئيا بـ CamScanner

If a tension other than the Standard tension is used, then a tension correction should be used.

$$C_P = (P - P_s) * L / AE$$

where,

C_P = tension correction per tape length

P = applied tension

P_S = standard tension (4.5 – 5.0 kg (50N))

L = length of tape under consideration

A = tape cross-sectional area

E = average modulus of elasticity of steel tapes (21E5 kg/ sq cm)

* *Hint: 1 kg = 9.807 N*

If the tape is not fully supported while measurement, then a sag correction should be used.

Sag Corrections

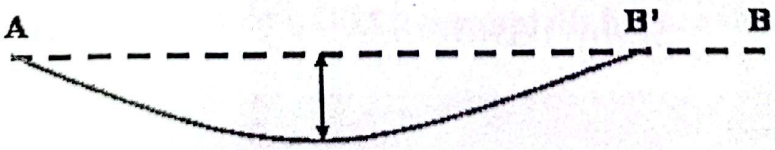
If the tape is not fully supported while measurement, then a sag correction should be used.

$$C_S = (-w^2 L^3)/ (24 P^2) = (-W^2 L)/ (24 p^2)$$

where,

w = weight of tape per unit length

W = weight of tape



الممسوحة ضوئيا بـ CamScanner

Tension Corrections

Example 1. Given Measured distance = 182.716 m
Used tape 30 m
Tape cross sectional area = 0.02 sq. cm
Standard tension force = 50 N
Used tension force = 100 N

Required Corrected measured distance.

Solution : Tension Correction = C_P

$= (100 - 50) * 30 / (0.02 * 21E5 * 9.807)$

$= + 0.0036$

Total correction = (182.716/30) * 0.0036 = + 0.022 m

Corrected measured distance = 182.716 + 0.022 = 182.738 m

Sag Corrections

Example 2. Given Measured distance = 42.071 m
Used tape 100 m
Mass of the used part of the tape = 1.63kg
Applied tension force = 100 N
Tape is not fully supported

Required Corrected measured distance.

Solution : Sag Correction = C_S

$= - (1.63 * 9.807)^2 * 42.07 / 24 * 100^2$

$= - 0.045$ m

Corrected measured distance = 42.0 - 0.045 = 42.026 m

الممسوحة ضوئيا بـ CamScanner

Angles measured in surveying are classified as either *horizontal* or *vertical*, depending on the plane in which they are observed.

تعبر عنه الاتجاهات ← Lines في المستوى الافقي ويكون باستخدام

Horizontal angles are the basic observations needed for determining bearings and azimuths.

north

Vertical angles are used in trigonometric leveling, stadia, and for reducing slope distances to horizontal

نحول مسافات مائلة إلى مسافات Horizontal

تم استخدامه

Angles are most often directly observed in the field with total station instruments, although in the past transits, theodolites, and compasses have been used.

زوايا ومسافات

الأمم القديمة

بوصلة

Three basic requirements to determine an angle are:

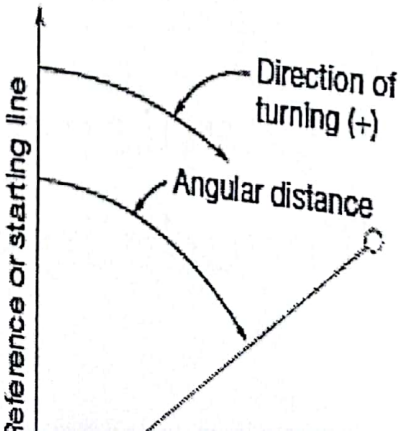
بداية الزاوية

(1) reference or starting line,

اتجاه الدوران

(2) direction of turning, and

(3) angular distance (value of the angle).



الممسوحة ضوئيا بـ CamScanner

referenced لازم نحدد

Vertical Angles are referenced to

. The horizon by plus (up) or mi

. The zenith: directly above the o

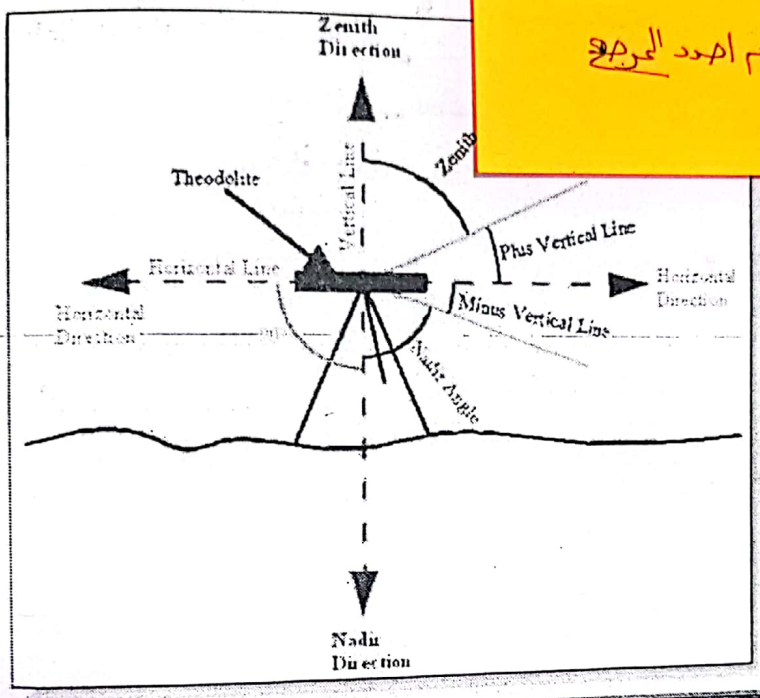
. The nadir: directly below the o

*إذا كانت القراءة قريبة إلى الصفر يكون المرجع هو Horsntal

* إذا رفعت الجهاز لفوق شوي وكانت القراءة $< 90^\circ$ ف مرجع هو zenith

* إذا رفعت الجهاز لفوق شوي وكانت القراءة $> 90^\circ$ ف مرجع هو Nadir

* أول ما اشغل الجهاز لازم احدد المرجع



اسم قديم

Theodolites/ Transits

Older versions were called Transits. Nowadays, both words (Transits and Theodolites) are used interchangeably.

Usage:

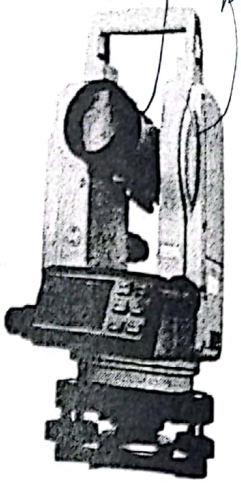
- **Measure horizontal angles (deviation from the North).** شمال كم الانحراف عن شمال
- **Measure vertical angles (deviation from horizon, Nadir, or Zenith).**
- **Establish straight lines.** انت تقطع زاوية عالية الاستوائية
- **Establish horizontal and vertical distances by using stadia.**
- **Establish difference in elevation when used as leveling machine.**

الممسوحة ضوئيا بـ CamScanner

Theodolites:

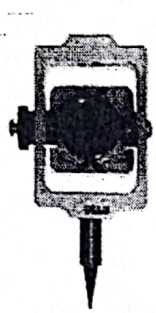
Theodolites (sometimes called transits) are used in measuring horizontal and vertical angles and for establishing linear and curved alignments in the field.

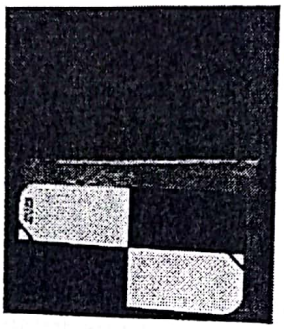
مسارات مستقيمة ومنحنية والمماسات

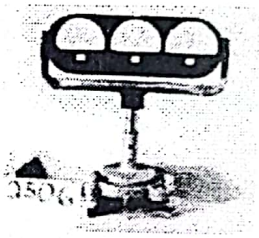


⇒ Targets: are plates having their center marked.

صفائح أو لطبقان يكون لها مركز







Types of Theodolites

أنواعهم

حسب طريقة القياس

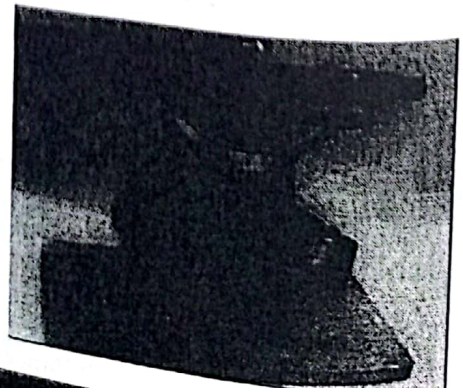
Types of Theodolites :

⇒ In terms of measuring operation:

- **Repeating instruments:**
  - Can be zeroed, measure 1α, 2α, 3α, ...
  - The circle assembly has two clamps (upper & lower)
- **Direction instruments:** يحتاج لنقطة
  - Can not be zeroed,
  - The circle assembly has just one clamp (upper)

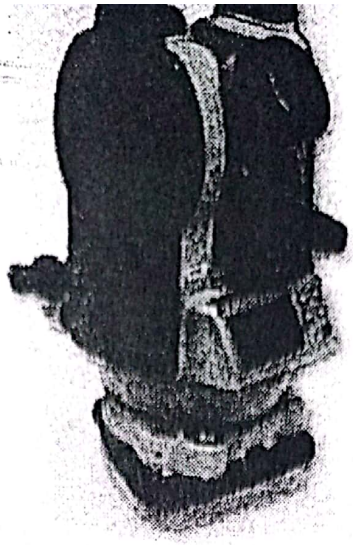
⇒ In terms of model:

- Engineer transit:
  - → Old
  - → USA
  - → Horizontal setting 0° zenith



الممسوحة ضوئيا بـ CamScanner

→ Simil... theodolites
→ Precision is high
→ Digital readouts (no interpolation)
→ Zero-set buttons
→ Horizontal angles can be turned left or right
→ Automatic repeat - angle averaging
→ Add EDM ⇒ Total Station



...ow to check if the theodolite is measuring i... Nadir, Zenith, or from Horizon?

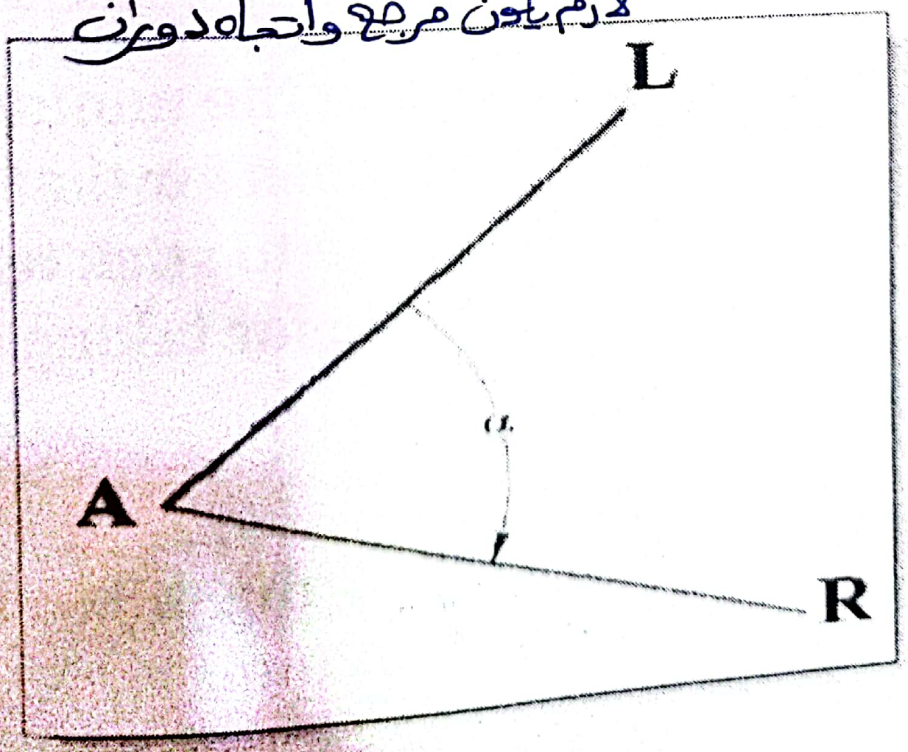
Put telescope in a horizo... position and tilt it slightl... and check reading:
· If reading close to zero... Reading from horizon
· If < 90 Þ Zenith
· If > 90 Þ Nadir

مركز دائرية تبعت الجهاز

Measuring Horizontal Angles

Turning the angle at least twice (plunging\transiting th... telescope) will eliminate mistakes, most instrument errors, and increase precision.

لازم يكون مرجع واتجاه دوران



الممسوحة ضوئيا بـ CamScanner

Directional Theodolites:

(Directional Theodolites can't be zeroed)

- 1. Theodolite at A
- 2. While instrument at Face-Left (FL), vertical circle on the left side of surveyor, target telescope at "L" point and record reading in the column FL *(a)* corresponding to point L.
- 3. Go clockwise and target at "R" point and record reading in the column FL *(b)* corresponding to point R. The difference in the readings in the "FL" Column will be nearly equal to the value of the angle.
- 4. Plunge (transit) the telescope, now the instrument is Face Right (FR), vertical circle on the right side of surveyor.
- 5. While still targeting on "R", record reading in the column FR corresponding to point R *(c)*. The difference between the FL and FR readings for the same point should be around 180°.

Directional Theodolites:

(Directional Theodolites can't be zeroed)

- Go anticlockwise and target on point "L" and record reading in the column FR corresponding to point L.
- 8. In the "Mean" column, take the mean of the minutes and seconds for each point and take the degrees for that point either from the FL or FR column. You have to stick to one of the positions, FL or FR, in the whole table for taking the degrees values.
- 9. The angle value is calculated b... between the two valu...

الممسوحة ضوئيا بـ CamScanner

Measuring Horizontal Angles

ST	PT	Position I (FL)	Position II (FR)	Mean	Angle
A	L	276° 14'23" (a)	96° 14' 34" (d)	276° 14' 28"	31° 37' 09"
	R	307° 51' 33" (b)	127° 51' 41" (c)	307° 51' 37"	

طريقة حساب mean لأخذ Position معينة ①

ناخد avg لو فاضل ثواني

127° 51' 37

② * بعد ما احسب mean نطرح الزاويتين من بعض

③ * نقيس الزاوية بالخمسة وضعية لتقليل الخطأ (مرة أدق)

Directional Theodolites:

(*Directional Theodolites* ***can't be zeroed***)

10. The angle LÂR can be obtained by calculating difference in angels from position I (FL) and position II (FR).

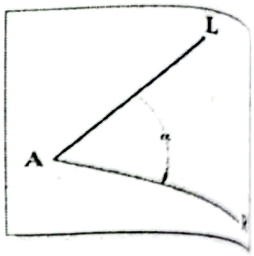
ST.	PT.	POSITION I (F.L.)	POSITION II (F.R.)
A	L	276° 14' 22"	96° 14' 34"
	R	307° 51' 33"	127° 51' 41"
	Difference	31° 37' 11"	31° 37' 07"
	Mean		31° 37' 09"

بنطرح زاوية من زاوية

الممسوحة ضوئيا بـ CamScanner

Repeating Theodolites

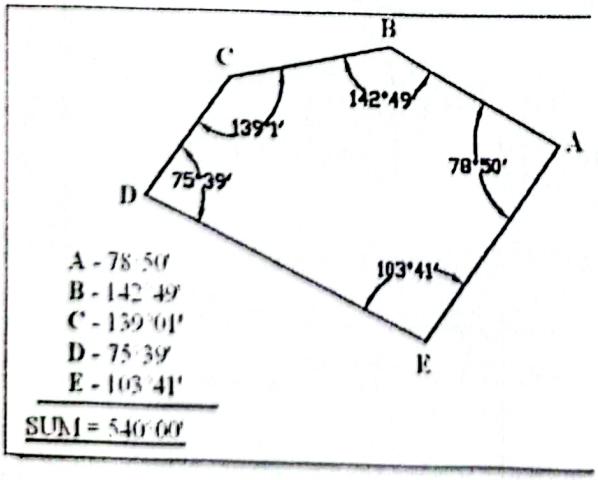
(Repeating theodolites can be zeroed)



1. Theodolite at A
2. Zero instrument and target L
3. Go clockwise and target R
4. Record in (Direct)
5. Plunge telescope disengage lower motion gear
6. Target at L, record in (Direct)
7. Go clockwise and target R and record double
8. Take mean of double

ST	Direct	Double	Mean = Angle
A	13° 20'12"	26° 40' 28"	13° 20' 14"

Example



ST	Direct	Double	Mean = Angle
A	78° 49'23"	157° 39' 08"	78° 49' 34"
B	142° 49'53"	285° 38' 28"	142° 49' 14"
C	139° 00'17"	278° 01' 56"	139° 00' 58"
D	75° 39'12"	151° 17' 56"	75° 38' 58"
E	103° 41'10"	207° 22' 28"	103° 41' 14"
		Summation	539° 59' 58"

Correct Summation of angles =
(n-2) * 180 = 3 * 180 = 540° 00'

Angular error of closure =
540° 00' 00" - 539° 59' 58" = 02"

الممسوحة ضوئيا بـ CamScanner

Measuring Vertical Angles

Vertical angles are angles measured in the vertical plane with zero or reference being a horizontal or a vertical line. That is, a vertical angle is not measured from a low point to a high point, but from the horizontal to the high point, a (+ve) vertical angle or an angle of elevation, and from the horizontal to the low point, a (-ve) vertical angle or an angle of depression.

Vertical angles are referred to the vertical line in modern instruments and called zenithal angles (or zenithal distances). If the angle lies between 0° and 90°, it is an angle of elevation (+ve), otherwise it is an angle of depression (-ve) (between 90° and 180°).

Vertical angles are subject to index error which results from:

a. Displacement of the vertical circle
b. Lack of adjustment of the vertical circle reading device.

The index error is eliminated by sighting in two positions.

Measuring Vertical Angles

Measurement Procedure

1. Sight while the theodolite is in position I (Face Left) with the horizontal hair bisecting the target.

2. Center the bubble of the index level (match both ends in case of split bubble levels). This step is not needed in theodolites with automatic vertical collimation.

3. Take the reading and record it (87° 22' 43").

4. Reverse the telescope to position II (Face Right) and repeat steps 1, 2, and 3. Record the reading (272° 39' 57").

5. Add both readings and compare the results with 360°. The difference (0° 2' 40") is twice the value of the index error.

الممسوحة ضوئيا بـ CamScanner

Measuring Vertical Angles

Measurement Procedure

6. Correct the readings such that their sum agrees with 360° exactly (87° 21' 23" + 272° 38' 37"= 360° 00' 00").

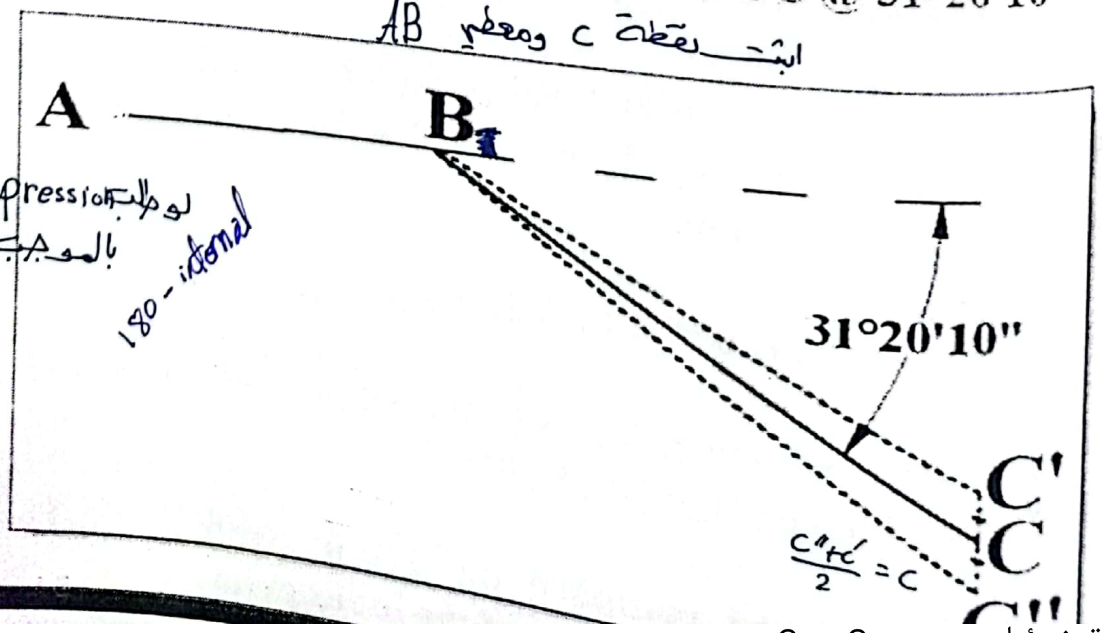
7. Subtract the corrected angle of position I from 90° to get the vertical angle (90° 00' 0" - 87° 21' 23" = + 2° 38' 37").

PT.	POSITION I	POSITION II	SUM	INDEX ERROR	VERTICAL ANGLE
P5	87° 22' 43"	272° 39' 57"	360 2' 40"	2' 40"	+ 2° 38' 37"
	87° 21' 23"	272° 38' 37"	360° 00' 00"	- 0° 1' 20"	

Field Applications

i) **Laying out external angles:**

Given Line AB ⇒ required to layout line BC @ 31°20'10"



الممسوحة ضوئيا بـ CamScanner

Field Ap

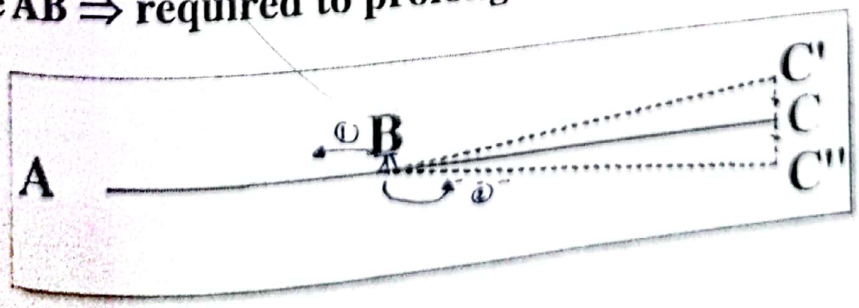
Procedure:

1- Set Theodolite at B.
2- Sight on A and zero Theo
3- Plunge (transit) telescope
(31°20'10").
4- Locate point C'.
5- Hold the angle reading and sight again on A.
6- Release the angle reading, plunge the telescope and turn it the required angle again. The reading will be double the angle value (62°40'20").
7- Locate point C".
8- Locate point C which is midway between C' and C".

Field Applications

Prolonging straight lines

Given Line AB ⇒ required to prolong the line



Procedure:

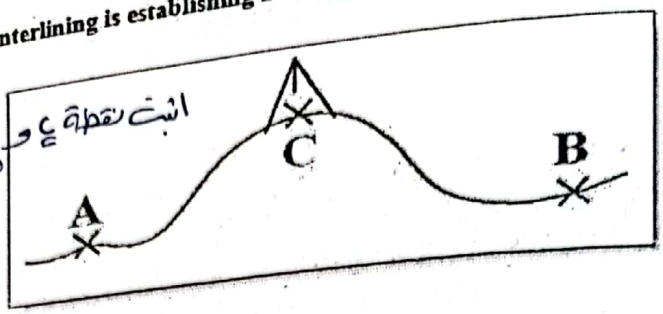
1. Set Theodolite at B and sight on A.
2. Plunge telescope and locate point C'.
3. Rotate telescope and sight again on A.
4. Plunge telescope and locate point C".
5. Locate point C which is midway between C' and C".

الممسوحة ضوئيا بـ CamScanner

Field Applications

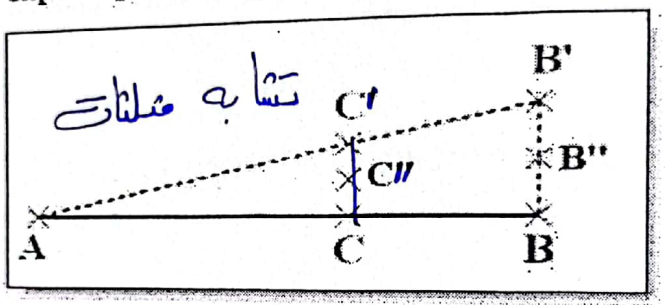
III. Interlining (Balancing in)

Interlining is establishing a straight line between two not inter-visible points.



Procedure:

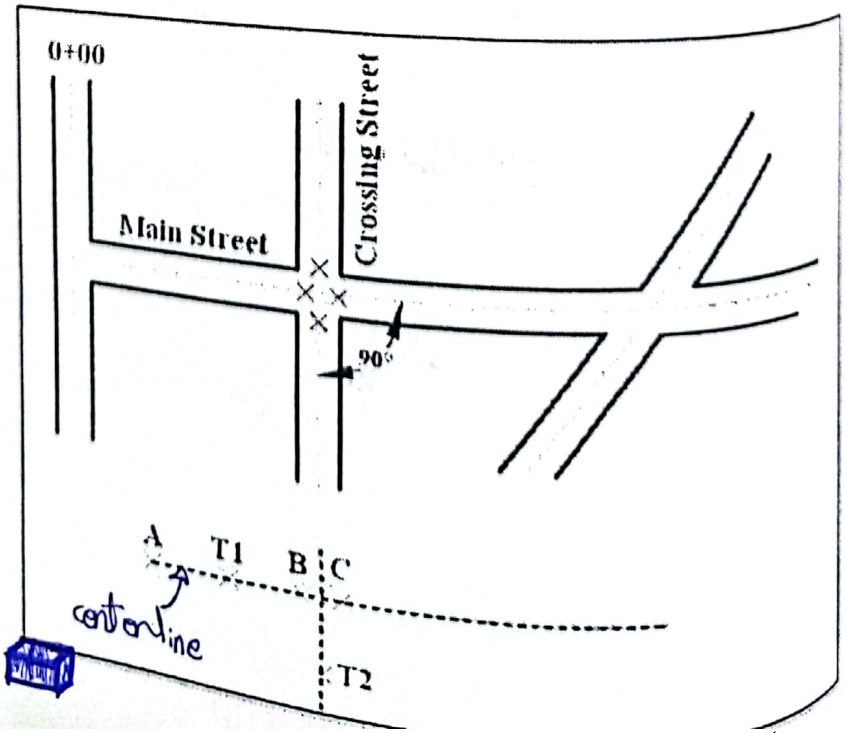
1- Select a point "C" between the two points that you can see both points from it.
2- Roughly align C' between A & B.
3- Sight at A.
4- Plunge telescope and locate point B'.
5- Measure BB' & calculate CC'.
6- Shift Theodolite to C".
7- Repeat steps 3 – 6 until A, B & C are aligned.



Field Applications

- **Intersection of two straight lines**

- This is a common situation when the surveyor is required to locate the intersection point when laying out intersecting streets with the main street.



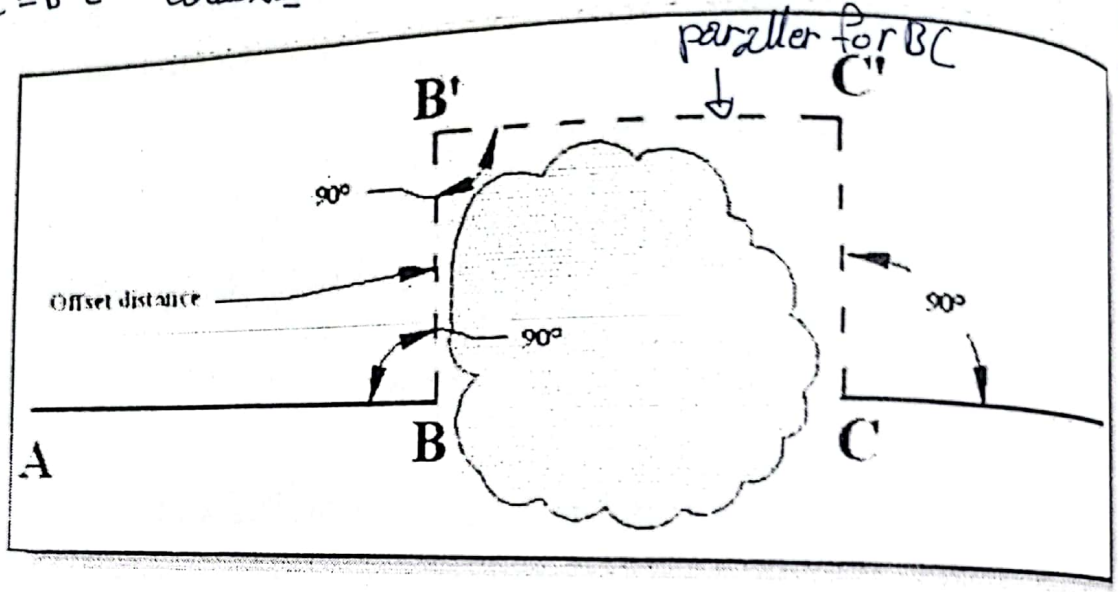
الممسوحة ضوئيا بـ CamScanner

Field Applications

Prolonging a line past an obstacle

Right angle offset

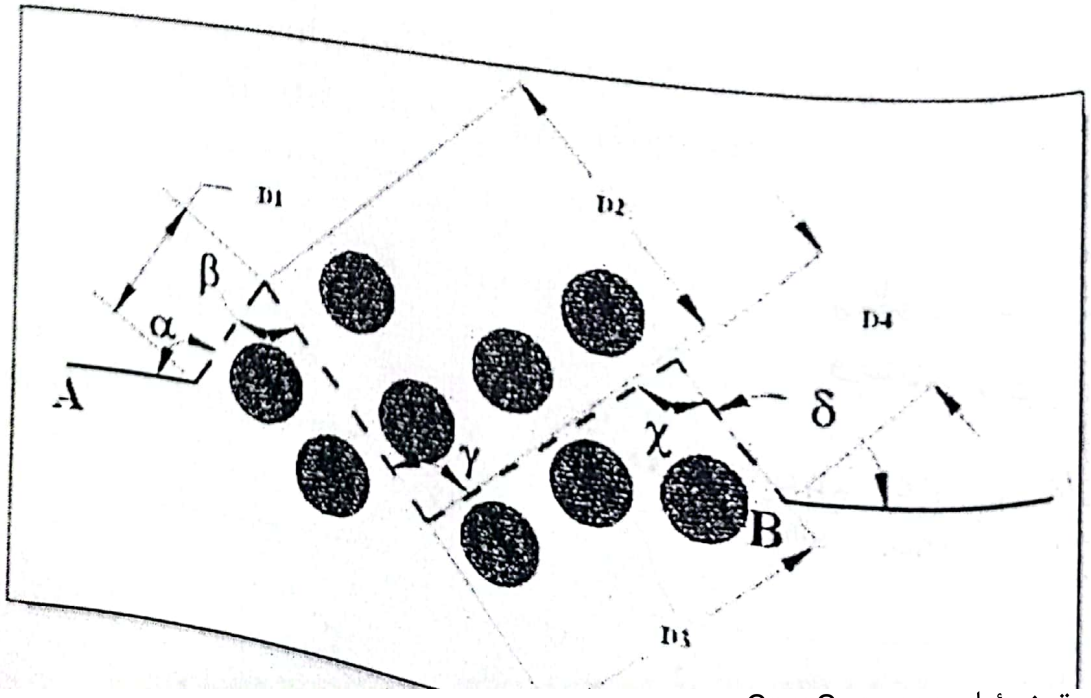
BC = B′C′ اقيسه مسافة



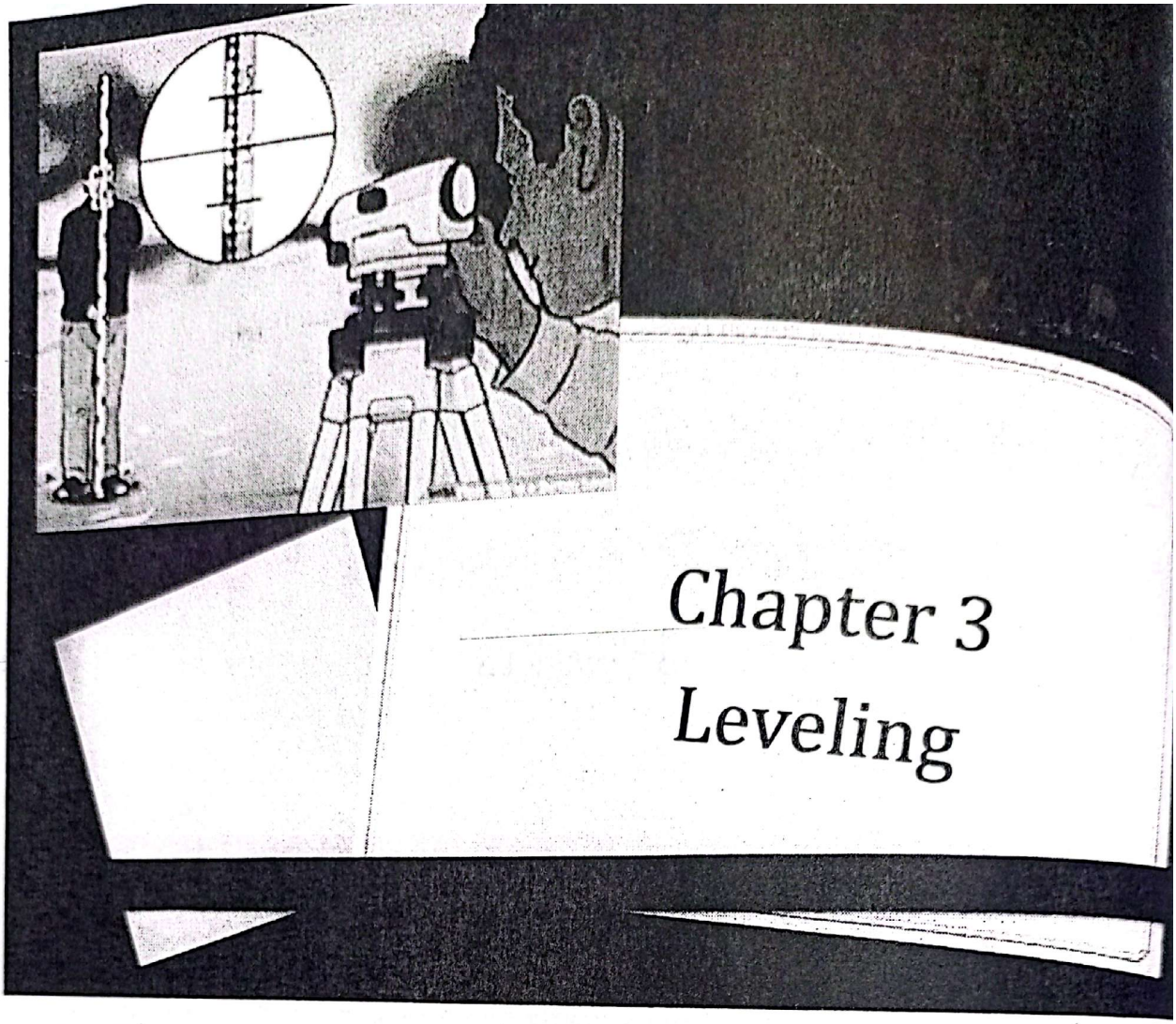
Field Applications

ممكن انحرف عن مسار الأول

صانة **Random-line method**



الممسوحة ضوئيا بـ CamScanner

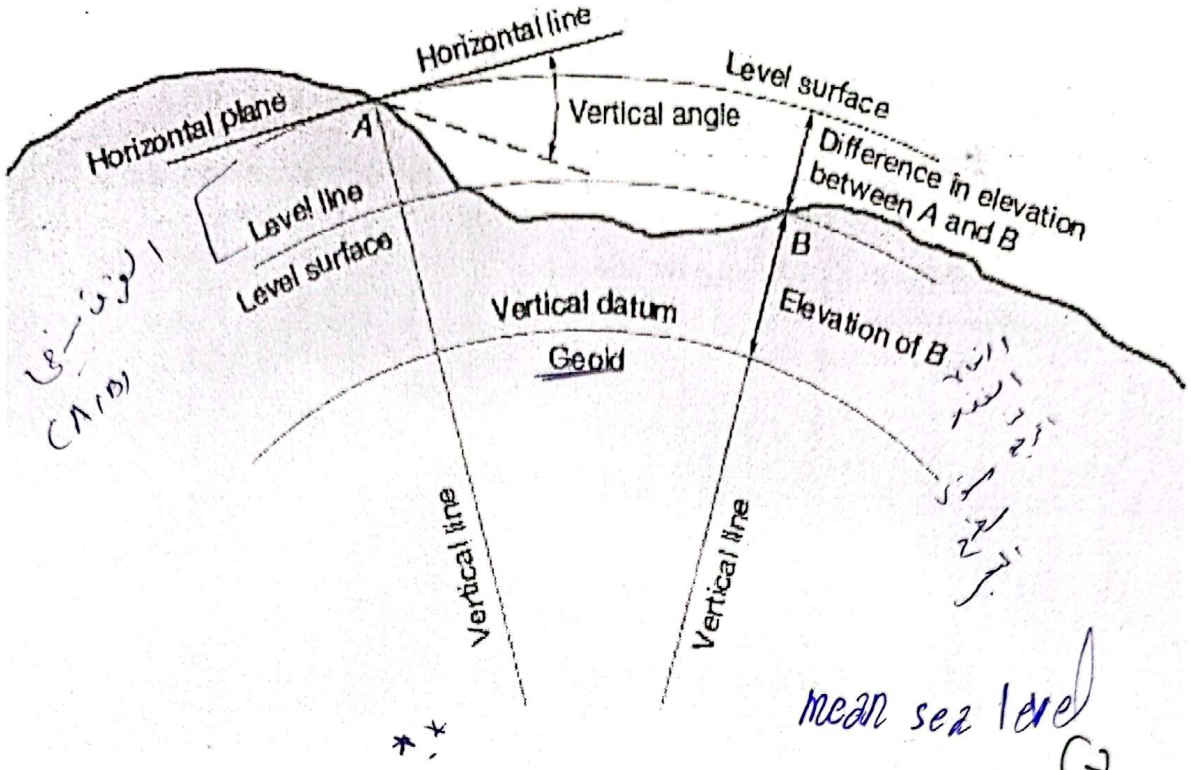


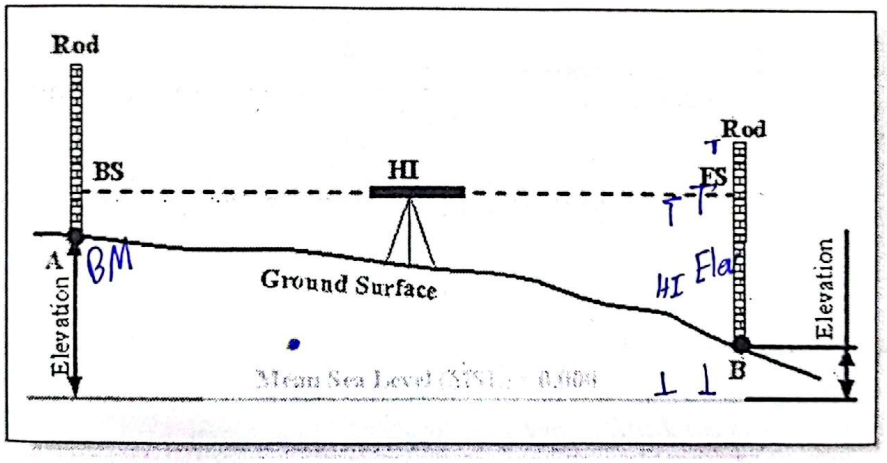
Chapter 3
Leveling

Leveling

- Leveling: Determining differences in elevation between two point
- Elevation: Vertical distance above or below a reference datum (MSL (Mean Sea Level), NAVD88 (North America Vertical Datum 1988)).
- Level surface: curved surface parallel to the mean surface of the earth (i.e. parallel to surface of large body of water) and at every point is perpendicular to the local plumb line (the direction in which gravity acts). Level surfaces are approximately spheroid in shape.
- Level line: a line in a level surface (curved line)
- Horizontal line: a line perpendicular to the vertical line

الممسوحة ضوئيا بـ CamScanner





Leveling Crew

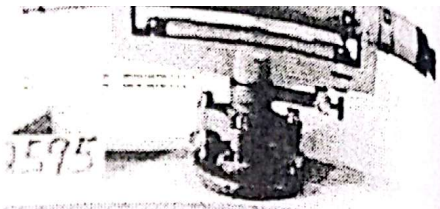
- **The instrument–man: levels the instrument, takes the readings and calls them loud.**
- **Two rod-men: choose the turning points, so that the distances to and from the instrument are equal and hold the rods vertically on the chosen points using rod levels.**
- **The recorder: takes care of the field book, hears the instrument man, and calls the readings loud to confirm that what he has heard is correct. He records the readings and makes the necessary calculations.**

الممسوحة ضوئيا بـ CamScanner

Types of Level Instruments

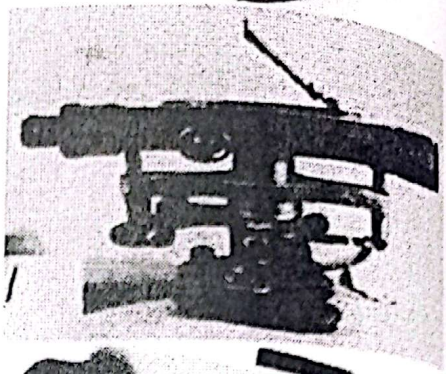
details)

- Basic level machine
- Has four leveling screws



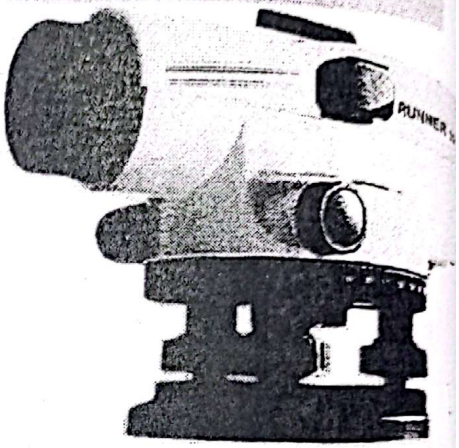
2. Tilting level

- Advanced leveling technique and usually more accurate
- Has tilting screws



3. Automatic level *(Press on Link to see details)*

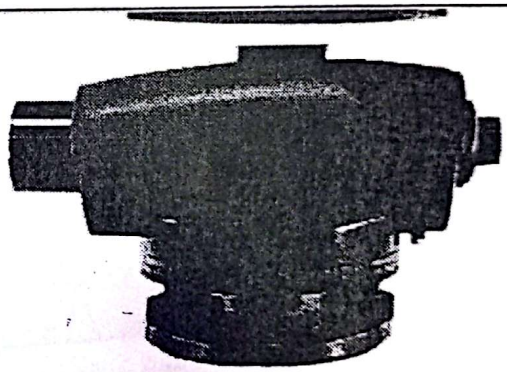
- Very popular, quick and easy to setup and easy to use and can be obtained for use at any required accuracy.
- Equipped with gravity referenced prism or mirror



Types of Level Instruments

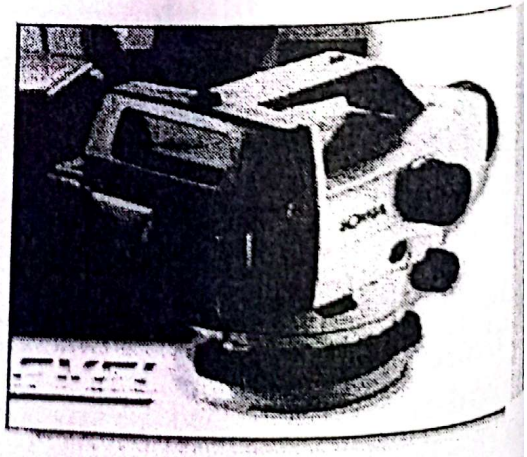
4. Precise level

- Very precise tilting or automatic levels usually used to establish vertical control



5. Digital level (Electronic level)

- Automatic level
- Uses coded bars *(Press on Link to see details)*
- Electronic image processing
- Automatic recording of data
- Format of data is similar to total station
- Data can be transferred to computer
- Determine height and distance



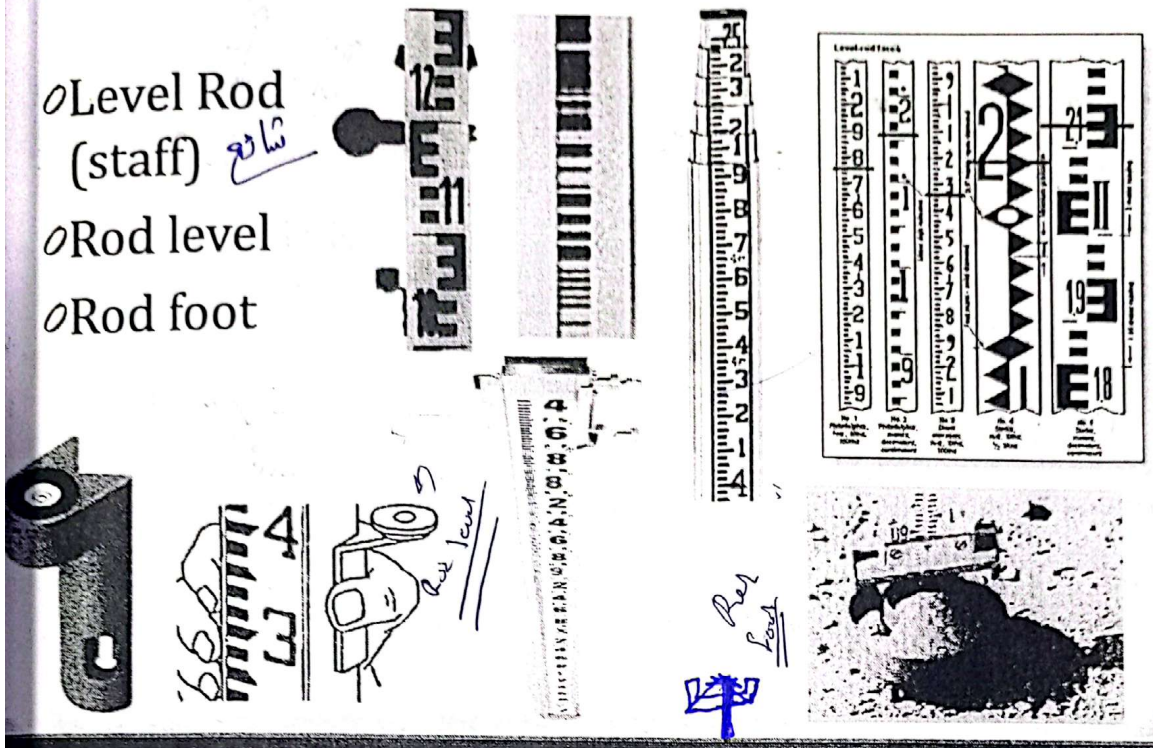
6. Automatic Self-Leveling Rotary Lasers

- Transmits laser beams to specify a circular horizontal circle

الممسوحة ضوئيا بـ CamScanner

Leveling Accessories

- Level Rod (staff)
- Rod level
- Rod foot



Types of Leveling Errors:

1. Curvature error, due to earth curvature.

$$(R + C)^2 = R^2 + KA^2$$

$$R^2 + 2RC + C2 = R^2 + (KA)^2$$

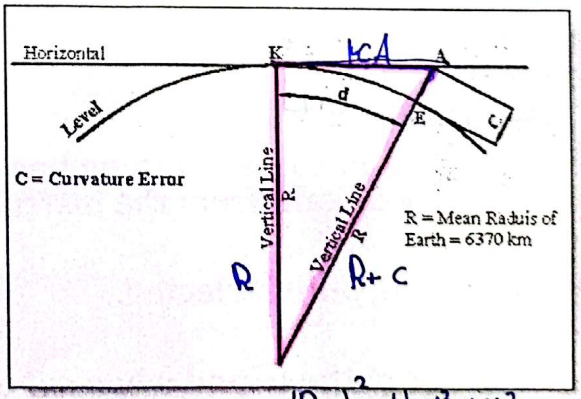
$$C(2R + C) = (KA)^2$$

$$C = \frac{(KA)^2}{2R + C} \approx \frac{(KA)^2}{2R}$$

taking $R = 6370$ km

$$C = \frac{(KA)^2 \times 10^3}{2 \times 6370} \approx 0.0785 KA^2 \quad (m)$$

KA : substituted in formulae in (km)



الممسوحة ضوئيا بـ CamScanner

2. Refraction error:

- Sight lines are refracted down by earth atmosphere
- One seventh of curvature error
- In the opposite direction of curvature error

Taking refractor error = 1/7 of curvature error

and $C = 0.0785\ KA^2$

Then $C + r = 6/7\ C$

Shots < 300' (91m): C is negligible

C = .000206' at 100' (30.5 m)

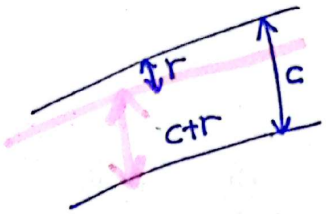
C = .00185' at 200' (61 m)

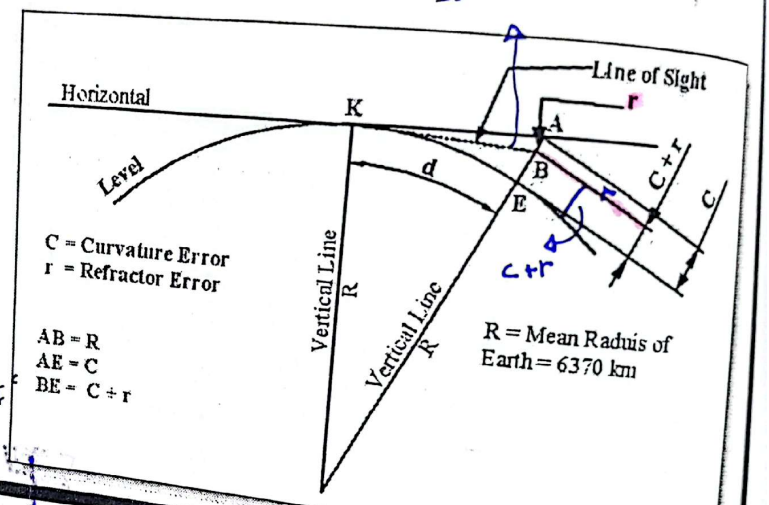
C = .0206' at 1000' (305 m)

$r = \frac{1}{7} C$

$C + r = C + \frac{1}{7} C$

$C + r = \frac{6}{7} C$ *

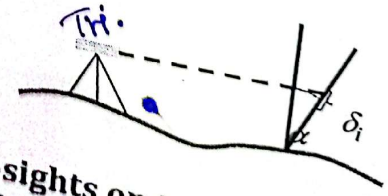




3. Parallax Error:

- Occurs if telescope focus and/or eyepiece lens focus are/is not correct.
- Will lead to cross hair not showing correctly on the rod resulting in errors in the readings.

4. Rod not held vertically straight.



5. Foresights and corresponding back-sights on turning points not equally distant from the instrument.

6. Poor turning point selected.

7. Settlement of the tripod when set over soft ground.

8. Bubble not in middle of tube at instant of sighting.

9. Clump of dirt stuck on the bott...

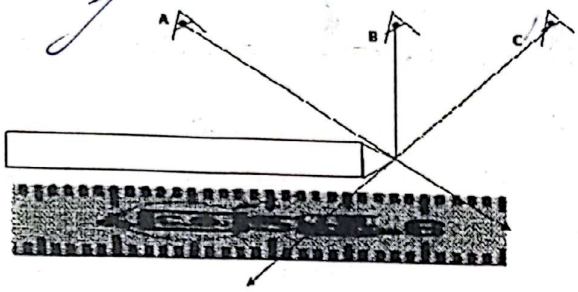
الممسوحة ضوئيا بـ CamScanner

- Parallax is the change in the apparent position of an object when the position of the observer changes.

- If you have placed a pencil on a meter rule and you are reading its length then you can place you eye everywhere you want.

- Clearly at these three position we can have the following reading

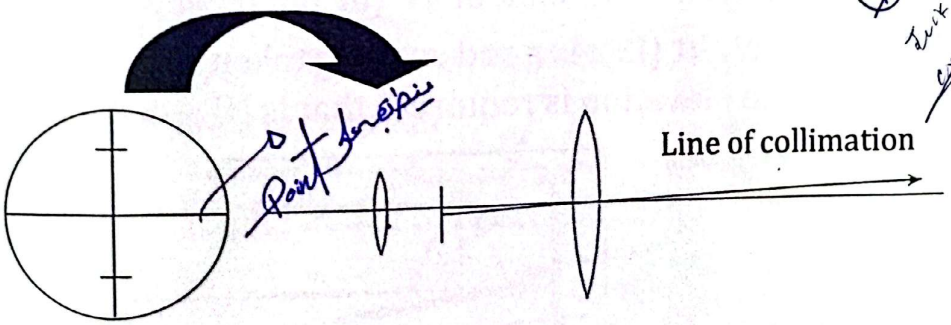
- Reading at A = 6.2 cm
- Reading at B = 5.8 cm
- Reading at C = 5.5 cm
- What do you think would be the correct reading?
- The correct reading is would be obtained when the eye is placed at B.



The diaphragm (cross-hairs)

To provide visible horizontal and vertical reference lines in the telescope.

With adjustment screws the diaphragm can be moved in the telescope to adjust the line of collimation.



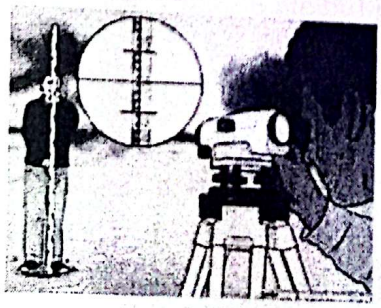
الممسوحة ضوئيا بـ CamScanner

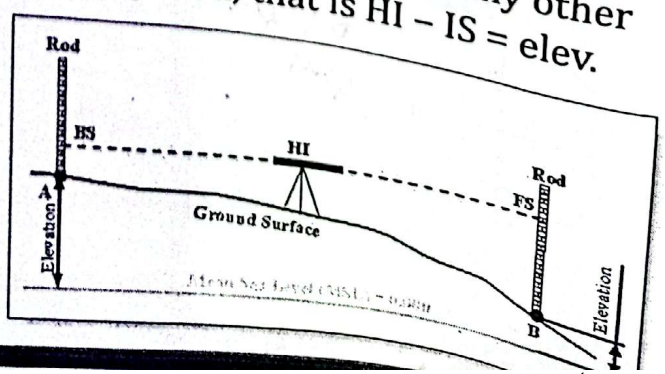
Leveling Operation/ Definitions

- **Benchmark (BM):** A relatively permanent object, natural or artificial, having a marked point whose elevation above or below a reference datum is known or assumed.
- **Temporary Benchmark (TBM):** is a semi-permanent point of known elevation.
- **Turning point (TP):** is a point temporarily used to transfer an elevation.
- **Backsight (BS):** is a rod reading taken on a point of known elevation to establish the elevation of the instrument line of sight.

Leveling Operation/ Definitions

- **Height of instrument (HI):** is the elevation of the line of sight through the level (i.e. elev. Of BM + BS = HI)
- **Foresight (FS):** is a rod reading taken on a turning point, benchmark, or temporary benchmark to determine its elevation; that is, HI –FS = elev. of TP (or BM or TBM)
- **Intermediate sight (IS):** is a rod reading taken at any other point where the elevation is required; that is HI – IS = elev.



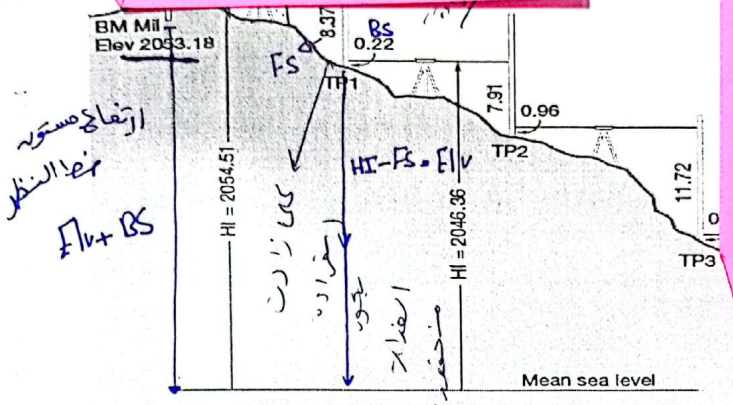


الممسوحة ضوئيا بـ CamScanner

(H.I) Elevation ارتفاع النقطة المعلومة
* خط القراءة على Rod ونقطة معلومة ارتفاع
هاي النقطة المعلومة (B.M)
* القراءة (الرقم) B.S
* لما نوخذ قراءة على Rod لنقطة مجهولة
الارتفاع (F.S)
* HI ارتفاع خط نظر الجهاز عن مستوى سطح
B.M + B.S = HI

veling

1. conventional method
s in height between



ارتفاع مستوى خط النظر
Elv + BS

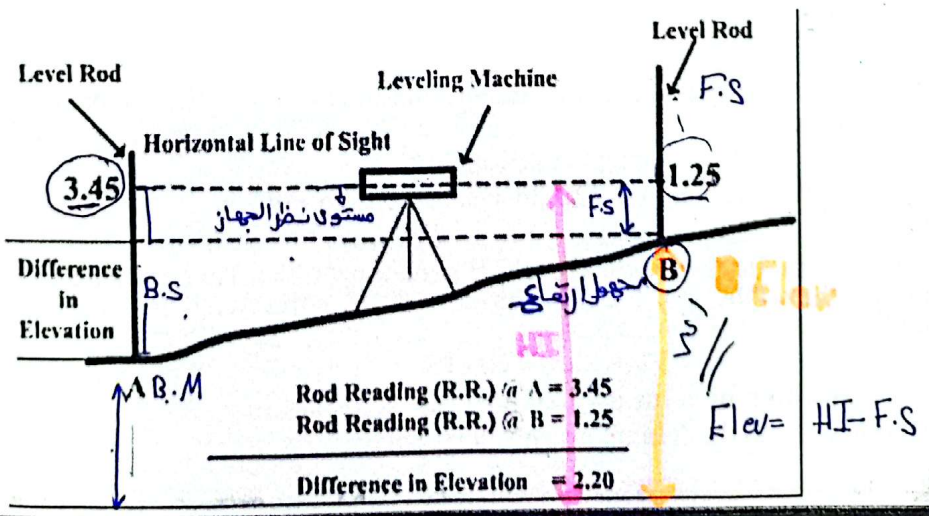
HI = Elev + B.S
النقطة المعلومة الارتفاع
Elv = HI − F.S
النقطة المجهولة الارتفاع

بمحور ارتفاع الجهاز لانه خط نظر افقي فبكل مرة مختلف

Rand-Std

Procedure & Numerical Example

- **From the following figure, you are required to get the difference in elevation between points A & B, and to get elevation of point B if point A is considered a BM and has an elevation of 323.24m.**



الممسوحة ضوئيا بـ CamScanner

3. Change in elevation- summation of t
the foresight then subtract

Point	BS	HI	FS	
BM_1	12.64	112.64		
TP_1	10.88	120.41	3.1	
TP_2	9.72	127.57	2.56	117.85
BM_2			3.10	124.47

+33.24 -8.77

Change in elevation = **33.24 -8.77 =24.47**

$\Sigma BS - \Sigma F.S$

4. The initial ***backsight (BS)*** is taken to a point of known elevation

5. The backsight reading is added to the elevation of the known point to compute the ***height of the instrument (HI)***

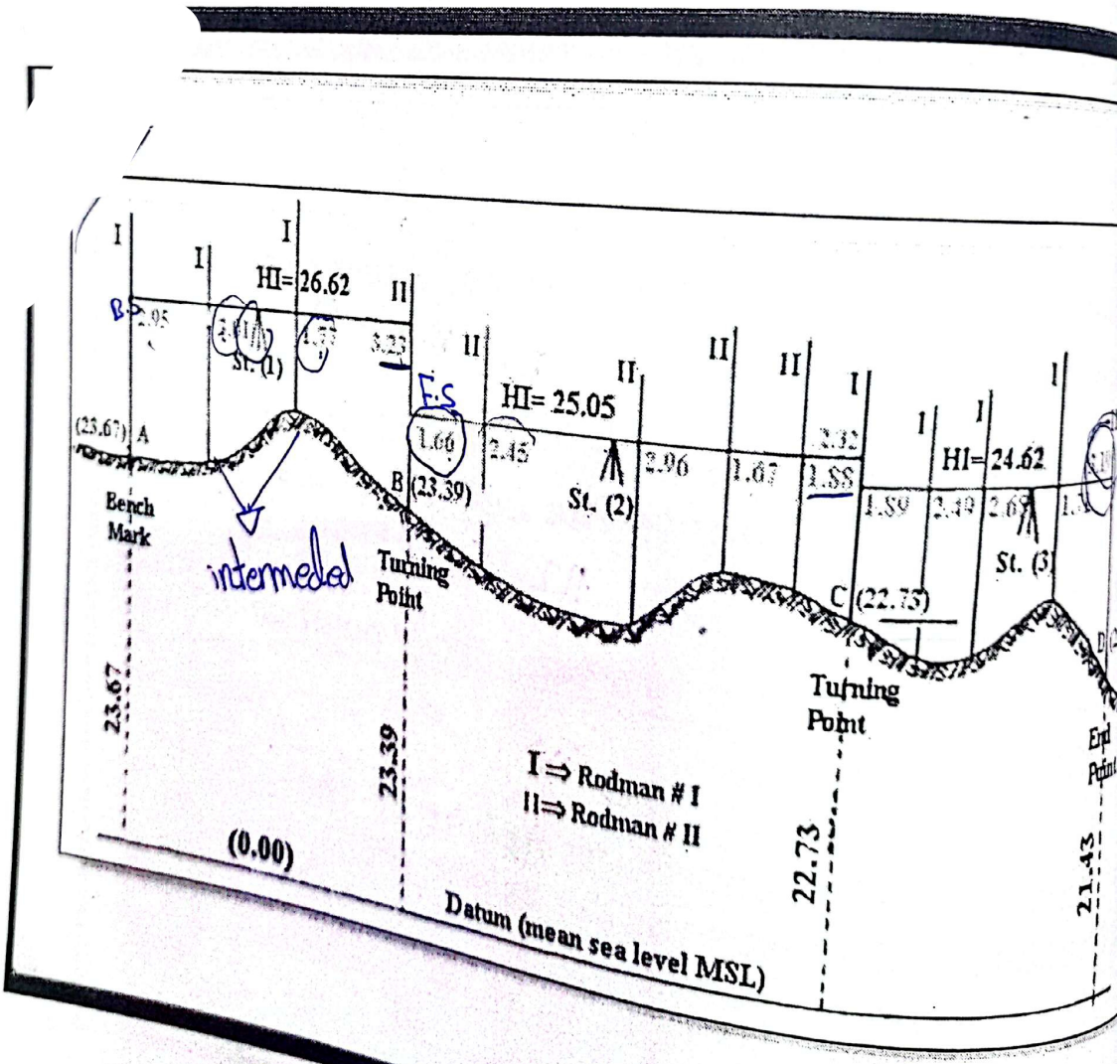
6. The level may be moved to a temporary point called a ***turning point (TP)***

7. The elevation of a point is the ***height of the instrument (HI)*** minus the ***foresight (FS)***

الممسوحة ضوئيا بـ CamScanner

Numerical

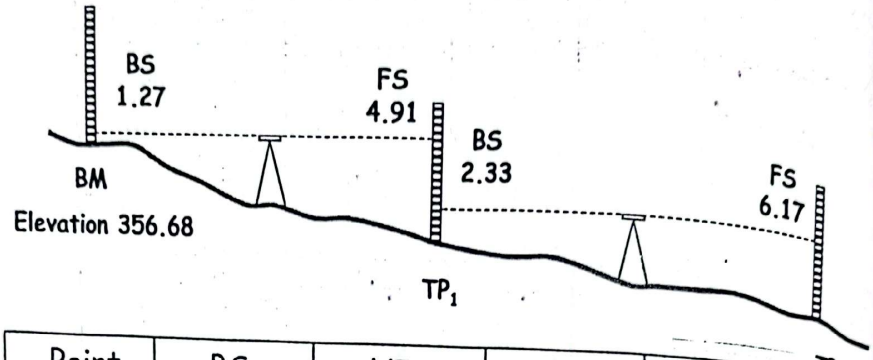
From the following figure, you are required to get the difference in elevation between points A & D, and to g elevation of point D if point A is considered a BM and i an elevation of 23.67m. Points A&D are far apart, therefore two turning points are required. In addition you are required to find elevations of the intermediate points.



الممسوحة ضوئيا بـ CamScanner

Differential Leveling

Computation of Elevations



Point	BS	HI	FS	Elevation
BM_1	1.27	357.95		356.68
TP_1	2.33	355.37	4.91	353.04
TP_2			6.17	349.20
	+3.60		-11.08	-7.48

Differential Leveling

Common Mistakes

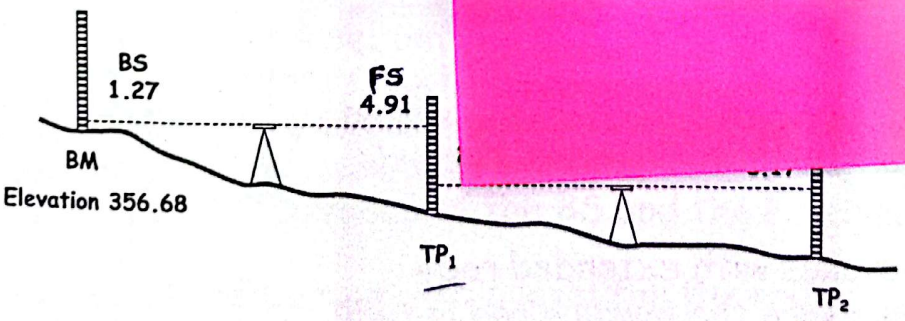
1. Misreading the rod - *reading 3.54 instead of 3.45*
2. Moving the turning point - *use a well-defined TP*
3. Field note mistakes - *work within your group to check you records*
4. Mistakes with extended rod - *make sure the leveling rod is fully extended*

الممسوحة ضوئيا بـ CamScanner

BS (m)	IS (m)	FS (m)	HI (m)	Elevation (m)	Remarks
2.95			26.62	23.67	Point A (BM)
	3.01			23.61	
	1.77			24.85	
1.66		3.23	25.05	23.39	Point B
	2.45			22.60	
	2.96			22.09	
	1.67			23.38	
	1.88			23.17	
1.89		2.32	24.62	22.73	Point C
	2.49			22.13	
	2.68			21.94	
	1.71			22.91	
		3.19		21.43	Point D
6.50		8.74			Sum
	-2.24			-2.24	Difference

Example:

Prepare a set of level notes for the
the elevations of points TP_1 and TP_2



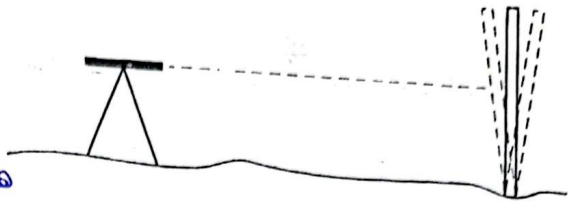
* rod الذي يحتوي على قراءة واحدة نسميه intermediate rod (الاخر) باستثناء rod 1 و rod
(IS)

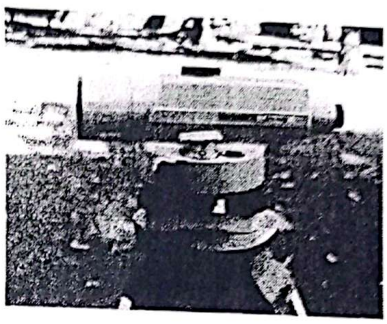
I.S
F.S الذي يحتوي على قراءتين اسمه rod *
H.I لازم يكون الماقمة باول سطر وعند بداية كل جهاز (يعني بس اغير مكانه)

الممسوحة ضوئيا بـ CamScanner

Common Mistakes

5. Level rod not vertical
6. Settling of leveling rod
7. Leveling rod not fully extended or incorrect length
8. Level instrument not level
9. Instrument out of adjustment
10. Environment - wind and heat





Suggestions for Good Leveling

1. Anchor tripod legs firmly
2. Check the bubble level before and after each reading
3. Take as little time as possible between BS and FS
4. Try to keep the distance to the BS and the FS equal
5. Provide the rod person with a level for the rod

الممسوحة ضوئيا بـ CamScanner

DIFFERENTIAL LEVELS

Sta.	B.S.	H.I.	F.S.	Elev.	Adj. Elev.
				2053.18	2053.18
BM Mil.	1.33			(-0.004)	
		2054.51	8.37	2046.14	2046.14
TP1	0.22		7.91	(-0.008)	
		2046.36	8.91	2038.45	2038.44
TP2	0.96			(-0.012)	
		2039.41	11.72	2027.69	2027.68
TP3	0.46			(-0.016)	
		2028.15	8.71	2019.44	2019.42
BM Oak	11.95			(-0.02 1	
		2031.39	2.61	2028.78	2028.76
TP4	12.55			(-0.026)	
		2041.33	0.68	2040.65	2040.62
TP5	12.77			(-0.030)	
		2053.42	0.21	2053.21	2053.18
BM Mil.					
	Σ = +40.24		Σ = -40.21		

Page Check:

2053.18
+ 40.24
2093.42
- 40.21
2053.21 Check

BM Mil. to BM Oak
29 Sept. 2000
Clear, Warm
T.E. Henderson
J.F. King
D.R. Moore
Level #6

BM Mil. on GLU Campus SW of Engineering Bldg. 9.4 ft. north of sidewalk to instrument room and 1.6 ft. from Bldg. Bronze disk in concrete flush with ground, stamped "Mil"

BM Oak is a temporary project bench mark located at corner of Cherry and Pine Sts., 14 ft. West of computer laboratory. Twenty penny spike in 18" Oak tree, 4 ft. above ground

Loop Misclosure = 2053.21 - 2053.18 = 0.03

Permissible Misclosure = $0.02\sqrt{n}$ = $0.02\sqrt{7}$ = 0.05 ft.

Adjustment = $\frac{0.03}{7}$ = 0.004 per H.I.

J.E. Henderson

الحد المسموح به الفرق بين الارتفاع الحقيقي والارتفاع الذي حصلت عليه

Closed Leveling

In normal practice, to check accuracy of measurements, the leveling is checked by closing it to either a point of known elevation (might be a BM) or to the point of beginning by back leveling.

ارجع لنقطة المعروفة الارتفاع (اللي بتعرفها)

The final elevation **should agree with the starting elevation** if returning to the initial benchmark. The amount by which they differ is the **loop misclosure**.

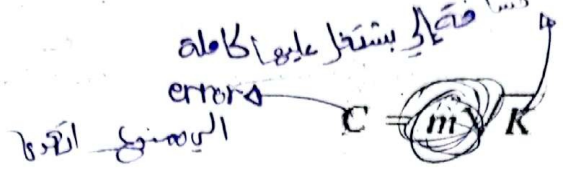
اذا خذت نقطة قريبة ما تكون الطلعة

If closure is made to another benchmark, **the section misclosure is the difference between the closing benchmark's given elevation and its elevation obtained after leveling through the section.**

الممسوحة ضوئيا بـ CamScanner

Leveling error/ misclosure

The Federal Geodetic Control Subcommittee (FGCS) recommends the following formula to compute allowable misclosures:



Where:
C is the allowable loop or section misclosure, in millimeters;
m: is a constant; and
K: the total length leveled, in kilometers.

For "loops" (circuits that begin and end on the same benchmark), K is the total perimeter distance, and the FGCS specifies constants of 4, 5, 6, 8, and 12 mm for the five classes of leveling, designated, respectively, as (1) first-order class I, (2) first-order class II, (3) second-order class I, (4) second-order class II, and (5) third-order.

Leveling error/ misclosure

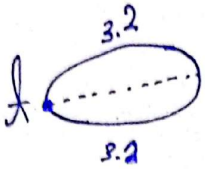
- If the allowable misclosure is exceeded, one or more additional runs must be made (survey operation has to be repeated).
- When acceptable misclosure is achieved, final elevations are obtained by making an adjustment.
- The error is distributed according to traveled distance between the traverse points. Therefore, correction to the observed elevation of any point included in the survey is:

$$\text{Elevation Correction} = \frac{\text{Distance from previous point}}{\text{Total traveled distance}} \times \text{Error}$$

الممسوحة ضوئيا بـ CamScanner

Example:

A differential leveling loo
a point 3.2 km away and back, with a misclosure of 17 mm.
What order leveling does this represent?



$$m = \frac{C}{\sqrt{K}} = \frac{17}{\sqrt{3.2 * 2}} = 6.7$$

This leveling meets the **allowable 8-mm tolerance level for second-order class II** work, but does not quite meet the 6-mm level for second-order class I ***Since distance leveled is proportional to number of instrument setups, the misclosure criteria can be specified using that variable.***

ADJUSTMENTS OF SIMPLE LEVEL CIRCUITS

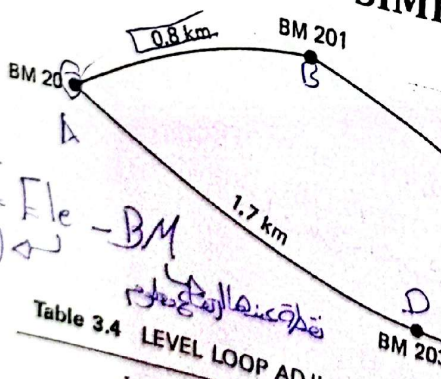


Table 3.4 LEVEL LOOP ADJUSTMENTS

BM	Loop Distance: Cumulative (km)	Field Elevation	Correction: $\frac{\text{cumulative distance}}{\text{total distance}} \times E^*$	Adjusted Elevation
A 20		186.273 (fixed)		186.273
B 201	0.8	184.242	$+0.8/4.7 \times 0.015 = +0.003$	184.245
C 202	2.4	182.297	$+2.4/4.7 \times 0.015 = +0.008$	182.305
D 203	3.0	184.227	$+3.0/4.7 \times 0.015 = +0.010$	184.237
A 20	4.7	186.258	$+4.7/4.7 \times 0.015 = +0.015$	186.273

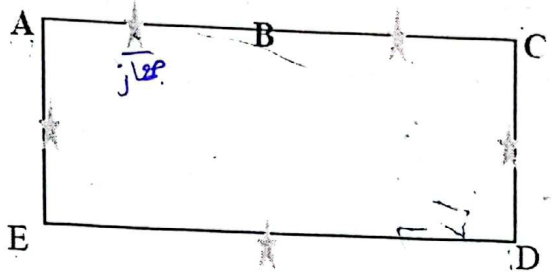
*$E = 186.273 - 186.258 = 0.015$ m.

الممسوحة ضوئيا بـ CamScanner

If the distances are not known then the correction can be distributed according to the number of instrument positions

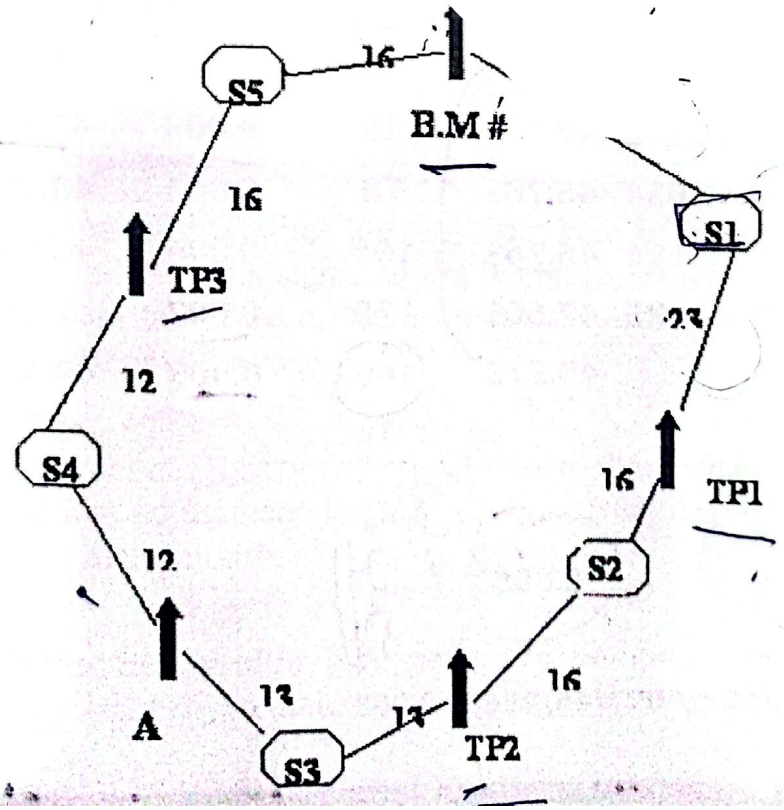
Example:

point	measured elevation	number of set up to the point	correction	corrected elevation
A	100.000	0	-0.02*(0/5)= 0.000	100.000
B	102.458	1	-0.02*(1/5)= -0.004	102.454
C	103.539	2	-0.02*(2/5)= -0.008	103.531
D	102.553	3	-0.02*(3/5)= -0.012	102.541
E	101.389	4	-0.02*(4/5)= -0.016	101.373
A	100.02	5	-0.02*(5/5)= -0.020	100.000



Example:

For the following closed leveling Complete th ble



الممسوحة ضوئيا بـ CamScanner

2. Profile Leveling:

- Profile leveling consists simply of differential leveling with the **addition of intermediate minus sights (foresights) taken at required points along the reference line.**
- Whether the stationing is in feet or meters, intermediate sights are usually taken at all full stations.
- If stationing is in feet and the survey area is in rugged terrain or in an urban area, the specifications may require that readings also be taken at half- or even quarter-stations.
- If stationing is in meters, depending on conditions, intermediate sights may be taken at 40-, 30-, 20-, or 10-m increments.
- In any case, sights are also taken at high and low points along the alignment, as well as at changes in slope.
- Intermediate sights should always be taken on "critical" points such as railroad tracks, highway centerlines, gutters, and drainage ditches.

2. Profile Leveling:

As in differential leveling, the page check should be made for each left-hand sheet. However in profile leveling, intermediate minus sights play no part in this computation.

The page check is made by adding the algebraic sum of the column of plus sights and the column of minus sights to the beginning elevation. This should equal the last elevation tabulated on the page for either a turning point or the ending benchmark if that is the case

In the adjustment process, **HIs** are adjusted, because they will affect computed profile elevations. The adjustment is made progressively in proportion to the total number of **HIs** in the circuit.

After adjusting the HIs, profile elevations are computed by subtracting intermediate minus sights from their corresponding *adjusted HIs.*

الممسوحة ضوئيا بـ CamScanner

error* عكس إشارة error

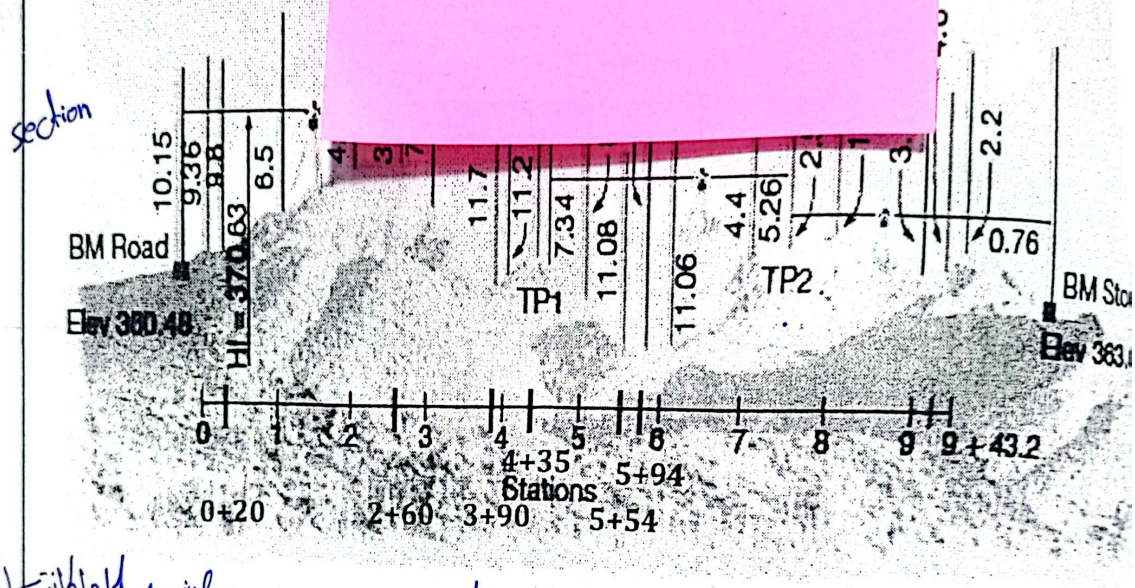
correction= error* $\frac{1}{3}$ وبكون correction موقع الخطوة

* بضيف الناتج لـ HI فهيك بطلع قيمة HI المعدلة

وبعدين بنطرحها من IS وبطلع الـ dest المعدل

*Error= 363.04 - 363.01

* correction = $\frac{1}{3}$ *



كل ما كانت الحركة inter ← أدق

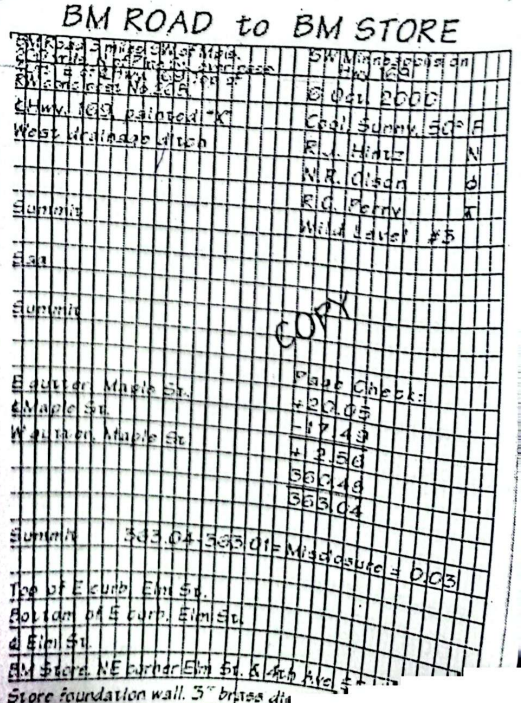
فائدته بطلع تفاصيل المنطقة

PROFILE LEVELS

Station	Sight +	HI	Sight −	int. Sight	Unadj. e	Adj. elev.
BM Road	10.15	370.63			360.48	
0+00		$\frac{1}{3}$*0.03		9.36	361.27	361.26
0+20				9.8	360.83	360.82
1+00				8.5	364.13	364.12
2+00				4.3	366.33	366.32
2+60				3.7	366.93	366.92
3+00				7.1	363.53	363.52
3+90				11.7	358.93	358.92
4+00				11.2	359.43	359.42
4+35	($\frac{2}{3}$*0.03)+	366.48		9.5	361.13	361.12
TP1	7.34	366.50	11.47		359.16	359.15
5+00				8.4	358.1	358.08
5+54				11.08	355.4	355.40
5+74				10.66	355.8	355.82
5+94				11.06	355.4	355.42
6+00	($\frac{2}{3}$*0.03)	(363.77)		10.5	355.9	356.0
7+00				4.4	362.1	362.08
TP2	2.56	363.8	5.26		361.24	361.22
8+00				1.2	362.6	362.57
9+00				3.9	359.9	359.87
9+25.2				3.4	360.4	360.37
9+25.3				4.6	359.2	359.17
9+43.2				2.2	361.6	361.57
BM Store			0.76		363.04	363.01
Σ	20.05		17.49		(363.01)	

360.83

363.04 - 363.01



الممسوحة ضوئيا بـ CamScanner

3. GRID, CROSS-SECTION, OR BORROW-PIT LEVELING

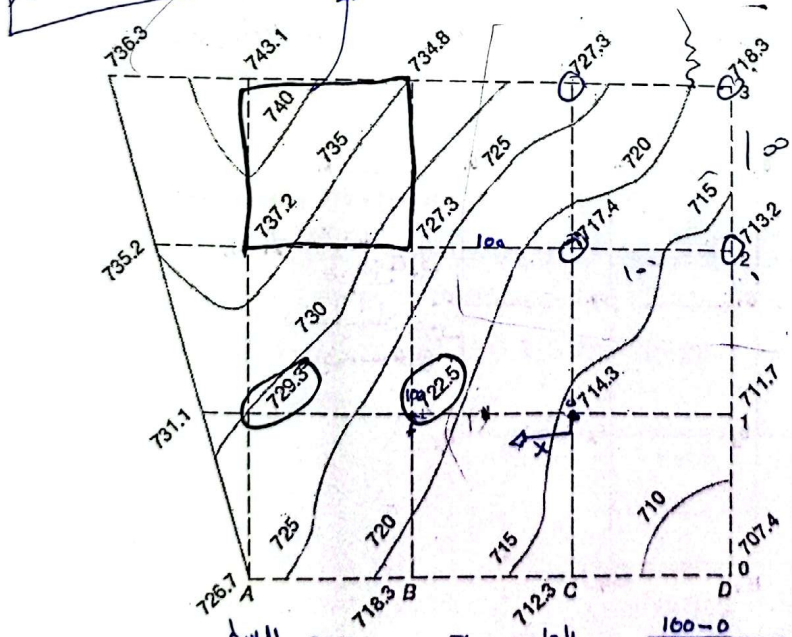
Grid leveling is a method for locating contours.

It is accomplished by staking an area in squares of 10, 20, 50, 100, or more feet (5, 10, 20, or 40 m) and determining the corner elevations by differential leveling.

The grid size chosen depends on the project extent, ground roughness, and accuracy required.

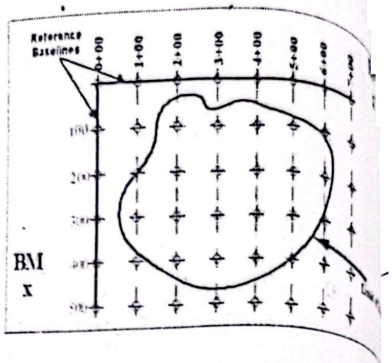
In plotting contours by the grid method, a widely spaced grid can be used for gently sloping areas, but it must be made denser for areas where the relief is rolling or rugged.

Contours are interpolated between the corner elevations (along the sides of the blocks) by estimation or by calculated proportional distances.



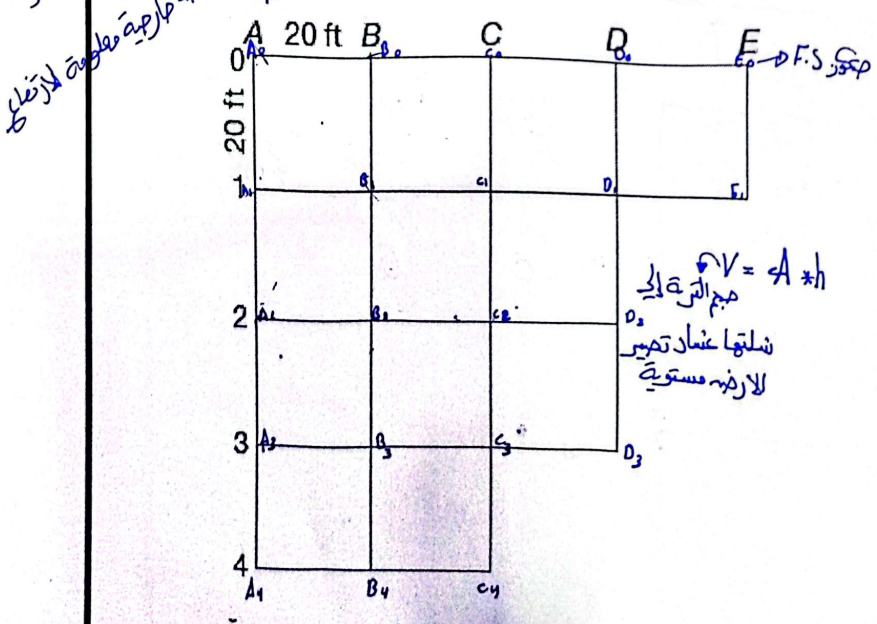
Grid Leveling

borrow-pit leveling Earth Volume Calculation



The level machine can be used to calculate volume of granular material (rock, gravel, sand), and volume of cuts and fills.

1- Establish one or two external reference baselines
2. Locate two external Bench Marks at convenient locations
3. Cross sections are established over and beyond the area
4. Establish datum X, Y, and Z coordinate points and get original volume of material.
5. Measure changes in Z coordinate and convert them to volume changes.



Borrow-pit leveling.

الممسوحة ضوئيا بـ CamScanner

بنوخذ Avg للارتفاعات * A/2 بعطي الحجم
المهم نكل مربع بعدين نجمع كل المربعات

الطريقة الثانية :-

H ← يعني كم مرة النقطة ظهرت بمربعات
+
كم مرة دخل النقطة بمربعات
بعدين نجمع كل hn ونقسم على 4 ليه بسطح
h والله لجمع الشكل في عشان اطلع

Example:

I.S

B.S

BORROW-PIT LEVELING

Point	Sight	HI	Sight	Elev.	Cut
BM Road	4.22	364.70		360.48	
A.0			6.2	358.5	1.5
B.0			5.4	359.3	1.8
C.0			5.7	359.0	1.0
D.0			5.9	358.8	0.8
E.0			6.2	358.5	0.5
A.1			4.7	360.0	2.0
B.1			4.8	359.9	1.9
C.1			5.2	359.5	1.5
D.1			5.5	359.2	1.2
E.1			5.8	358.9	0.9
A.2			4.2	360.5	2.5
B.2			4.7	360.0	2.0
C.2			4.8	359.9	1.9
D.2			5.0	359.7	1.7
A.3			3.8	360.9	2.9
B.3			4.0	360.7	2.7
C.3			4.6	360.1	2.1
D.3			4.6	360.1	2.1
A.4			3.4	361.3	3.3
B.4			3.7	361.0	3.0
C.4			4.2	360.5	2.5
BM Road			4.22	360.48	

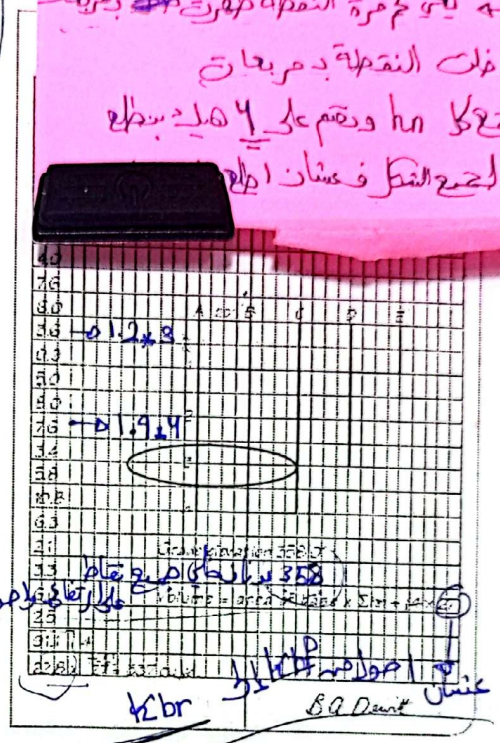
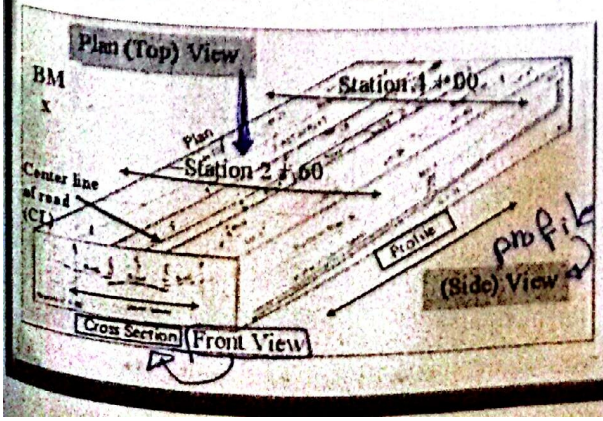


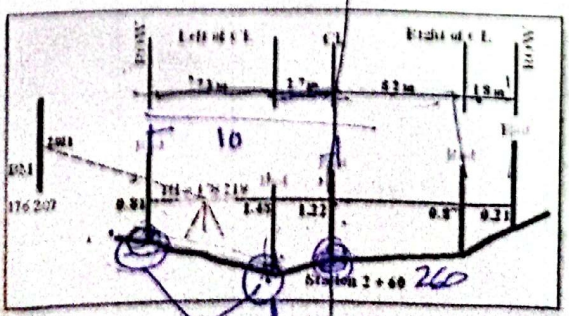
Plate B.2

Cross-Section Leveling

Profile: is a side view or elevation of a certain area (surface of road or top of pipeline) in which the longitudinal surfaces are obtained. Profile levels are taken along a path (center line of a road) that is of interest to the engineer.

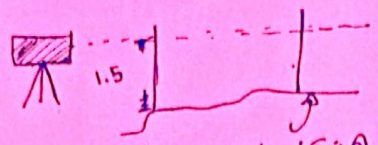
Cross section: shows the end view of a section at a certain station, and is at right angles to the center line.





الممسوحة ضوئيا بـ CamScanner

*كلما قلت قراءة الـ rod reading بتجوز الأرض طلعوا (Rise) سنفس مقدار الفرق
*كلما زادت قراءة الـ rod reading نزلوا (Fall)



هو قراءة اقل من 1.5 لأنها جايبة على نقطة ارتفاع

& Fall Method

A relative B
Fall

tween A & B = 3.222 – 1.414 = 1.808

B relative A
rise

he height of land at B relative to A.

- If the reading at B is greater than A, or of the direction of survey is from B to A, then the difference in elevation would represent a fall in the height of land at A relative to B.
- If the actual level of one of the two points is known, the level of the other may be found by either adding the rise or subtracting the fall.

Rise & Fall Example

Point #	B.S	I.S	F.S	Rise	Fall	Elevation	Remarks
BM 1	3.25					1050.17	BM 1050.17 m
A		3		0.25		1050.42	
B		2.85		0.15		1050.57	
C	1.82		2.75	0.1		1050.67	T.P.
D		2.13			0.31		
E	3.16		0.78	1.35		1050.36	
F		2.18		0.98		1051.71	T.P
G		1.01		1.17		1052.69	
BM 2			0.68	0.33		1053.86	
Sum	8.23		4.21	4.33	0.31	1054.19	BM 1054.19 m

الممسوحة ضوئيا بـ CamScanner

Checking Computation in Rise & Fall

- The following conditions should be met:

The number of B.S. = The number of F.S.

Sum (B.S) – Sum (F.S) = Sum (Rises) – Sum (Falls)
= Last R.L – First R.L

Check

Checking Computation in Rise & Fall Example

- No. of B.S readings = 3
- No. of F.S readings = 3
- 1st condition is O.K

- Sum (B.S) – Sum (F.S) =8.23 – 4.21 = 4.02 m
- Sum (Rises) – Sum (Falls) = 4.33 – 0.31 = 4.02 m
- Last R.L – First R.L = 1054.19 – 1050.17 = 4.02 m
- 2nd Condition is O.K ✓

الممسوحة ضوئيا بـ CamScanner

In this particular example, the effect is to read too high on the staff.

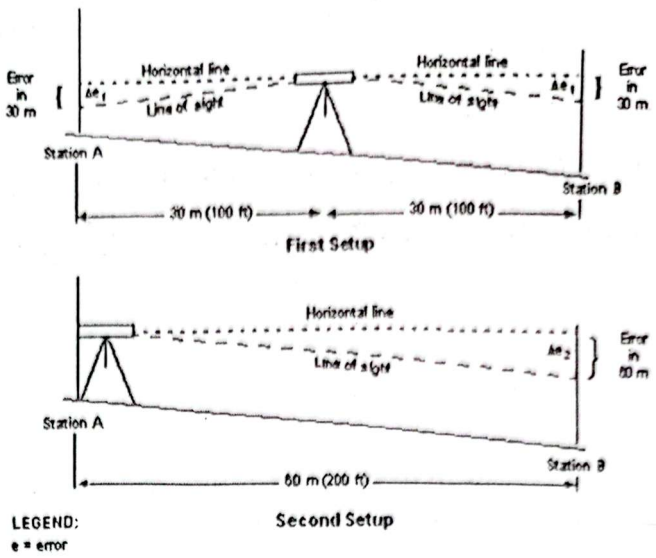
For a typical collimation error of 20", over a sight length of 50m the effect is 5mm.

If the sight lengths for backsight and foresight are *equal*, the linear effect is the same for both readings.

When the height difference is calculated, this effect cancels:

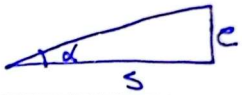
$$\Delta h = (b + s.\alpha) - (f + s.\alpha)$$
$$= b - f$$

That is, the effect of the collimation error is eliminated if sight lengths are kept equal.



$\tan\alpha = \frac{e}{s}$ α is very small $\rightarrow \tan\alpha = \alpha$

$\alpha = \frac{e}{s} \rightarrow e = s\alpha$



DETERMINATION OF COLLIMATION ERROR

Collimation error is much more significant than the other errors. It should be kept as small as possible so that one need not be too precise in ensuring that fore- and back sights are of equal length (these are usually paced out). It is possible to determine the collimation error and reduce its size using the so-called **Two-peg test.**

1. Place the level midway between two rods which are 60 m apart.
2. Take Rod Readings for both rods. If line of sight is not horizontal, the error in rod readings (Δe_1) will be identical.
3. Calculate difference in elevation between A & B, this is the correct difference since both stations have equal Δe_1.
4. Move level close to Station A. Get difference in elevation between A & B.
5. Calculate the difference in the readings (Δe_2) from point 3 (true difference in elevation) and point 4 (difference in elevation containing error).
6. Divide De_2 by the total distance (60m). Obtained value in (m/m) is called collimation factor (C factor).

- *To eliminate the effect of the collimation error, the leveling machine is placed midway between the BS and FS.*

الممسوحة ضوئيا بـ CamScanner

* كيف اعرف مين النقطة اللي فوق مين التانية؟
كل ما قراءة rod قلت يعني عالي وكل ما زادت بتكون واطي فإذا المتحركة a1 أكبر من b1 فـ B ارتفاعها أكبر من A

2) Move the level to point D (Figure 4.15b) so that the distance AC = BD. Take the two readings a_2 at A and b_2 at B. Calculate the second elevation difference:

$$\Delta H_2 = a_2 - b_2$$

السؤال بيطلب اوجد elev النقطة A او النقطة B وبالتالي elev المجهول ← بحسب ΔH ويكون معي اوجد elev في

Calculate the correct elevation di

$$\Delta H = \frac{\Delta H_1 + \Delta H_2}{2} = \frac{(a_1 - b_1) \oplus (a_2 - b_2)}{2} \quad .....$$

$E_B = E_A + H_i \pm V - RR$

8. Trigonometric leveling

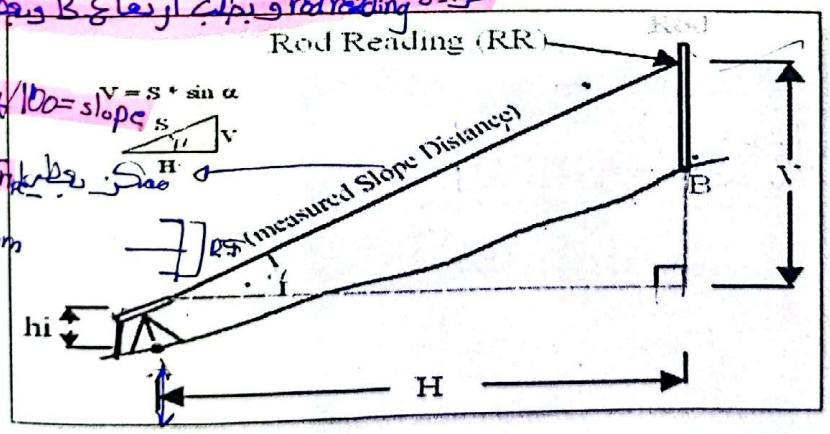
حساب الارتفاع عن طريق جهاز Theodolite

The Theodolite (angles measuring equipment) can also be used to calculate differences in elevations. There are three cases for the target point position:

بطلب بالامتحان ارتفاع A و HI و

1. Target point is higher than the Theodolite

قراءة rod reading وبطلب ارتفاع B وبطلب زاوية slope



R*/100 = slope

= Rod/Tr بطرح

Top – bottom

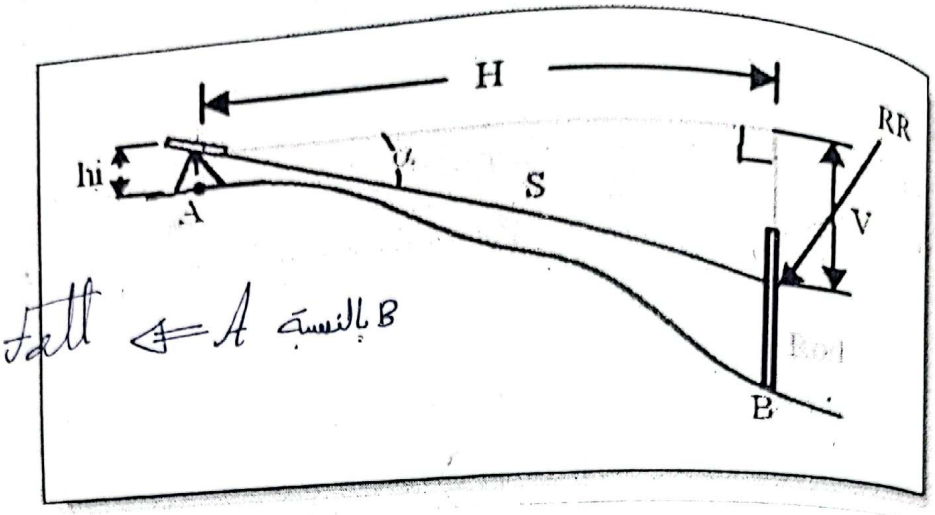
$V = S \sin \alpha$

Elevation of B (Rod position) = Elevation of A (Theodolite position) + hi + V - RR

الممسوحة ضوئيا بـ CamScanner

بـ شابتر 7

2. Target point is lower than the Theodolite:



Fall ⇐ A بالنسبة B

V = S sin a

Elevation of B (Rod position)= Elevation of A (Theodolite position
+ hi - V - RR

ماتكون عندنا أرضيات

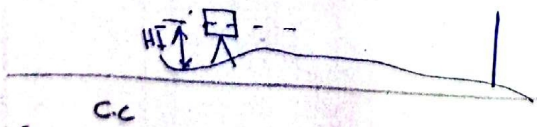
3. Target point is at the same level of the Theodolite (α = 0.000)

In this case the Theodolite is handled similar to the level because now it
horizontal.

صفر

V = S sin α = 0

Elevation of B (Rod position) = Elevation of A (Theodolite positi
+ hi - RR



C.C

① 221° 35' 0"

② 35° 46' 0"

الممسوحة ضوئيا بـ CamScanner

Chapter 5
Angles & Directions

For Reminder:

نفرق كم الزاوية وإذا Horz او Vert

- Determining the locations of points and orientations of lines frequently depends on the observation of angles and directions.

- Angles measured in surveying are classified as either *horizontal or vertical*, depending on the plane in which they are observed.

- Horizontal angles are the basic observations needed for determining bearings and azimuths.

- Vertical angles are used in trigonometric leveling, stadia, and for reducing slope distances to horizontal

علاقات مثلثية

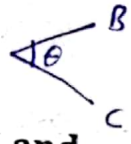
الممسوحة ضوئيا بـ CamScanner

KINDS OF HORIZONTAL ANGLES

The kinds of horizontal angles most commonly observed in surveying are:

زوايا داخلية

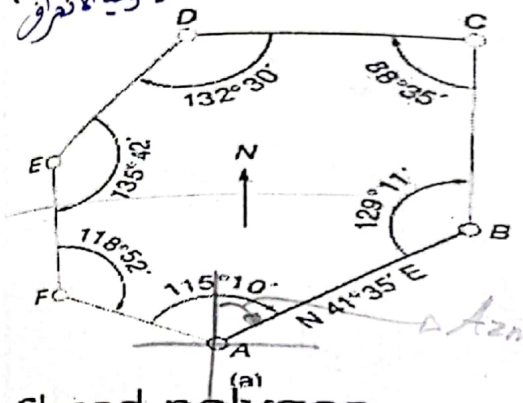
(1)Interior angles,
(2)Angles to the right, and
(3)Deflection angles.



زاوية الانعراف

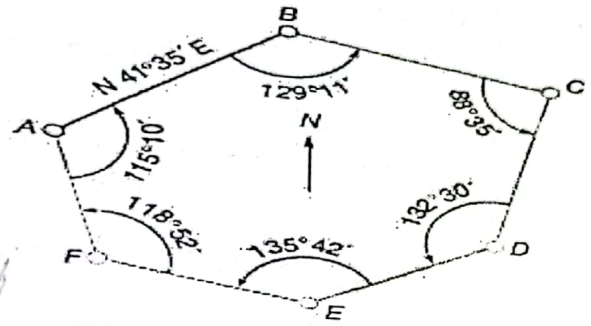
sum of all interior angles in any polygon must equal: $(n-2)*180°$, n: no. of angle

check (1)



Closed polygon.
(a) Clockwise interior angles (angles to the right).

مع عقارب ساعة



عكس عقارب ساعة

(b) Counterclockwise interior angles (angles to the left).

زاوية خارجية

exterior

- Exterior angles, located outside a closed polygon, explement interior angles. (explement: the quantity by which an angle or an arc falls short of 360° or a circle).

- The advantage to be gained by observing them is their use as another check, since the sum of the interior and exterior angles at any station must total 360°.

check (2)

- Angles to the right are measured clockwise from the rear to the forward station.

مستخدم بكثرة

- Most data collectors require that angles to the right be observed in the field.

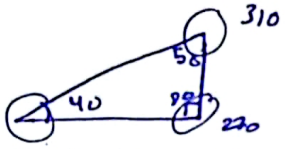
- Angles to the left, turned counterclockwise from the rear station

الممسوحة ضوئيا بـ CamScanner

$\Sigma_{int} = 40+50+90 = 180$

$\Sigma_{ext} = 320+270+310 = 900$

$(n+2)*180 = (3+2)*180 = 900$



Angles to the right can be either interior or exterior angles of a closed polygon traverse.

Whether the angle is an interior or exterior angle depends on the direction the instrument proceeds around the traverse.

If the direction around the traverse is counterclockwise, then the angles to the right will be interior angles.

معاكسة عقارب الساعة

However, if the instrument proceeds clockwise around the traverse, then exterior angles will be observed.

أي بحدود مضلع صحيح بالشكل

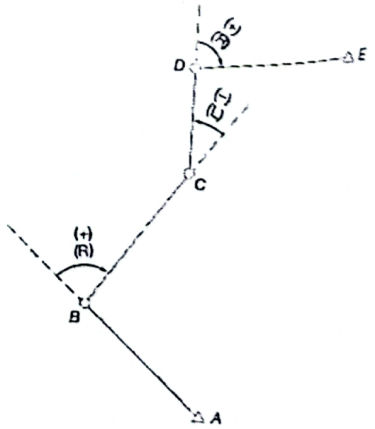
If this is the case, the sum of the exterior angles for a closed-polygon traverse will be (n+2)* 180° Analysis of a simple sketch should make these observations clear.

للزوايا الخارجية

تغيير الاتجاهات عن المسار (الانحراف عن مسار الأصلي)

Deflection angles

Deflection angles are observed from an extension of the back line to the forward station. They are used principally on the long linear alignments of route surveys.



- **Deflection angles may be observed to the right (clockwise) or to the left (counterclockwise) depending on the direction of the route.**
- **Clockwise angles are considered plus, and counterclockwise ones minus, as shown in the figure.**

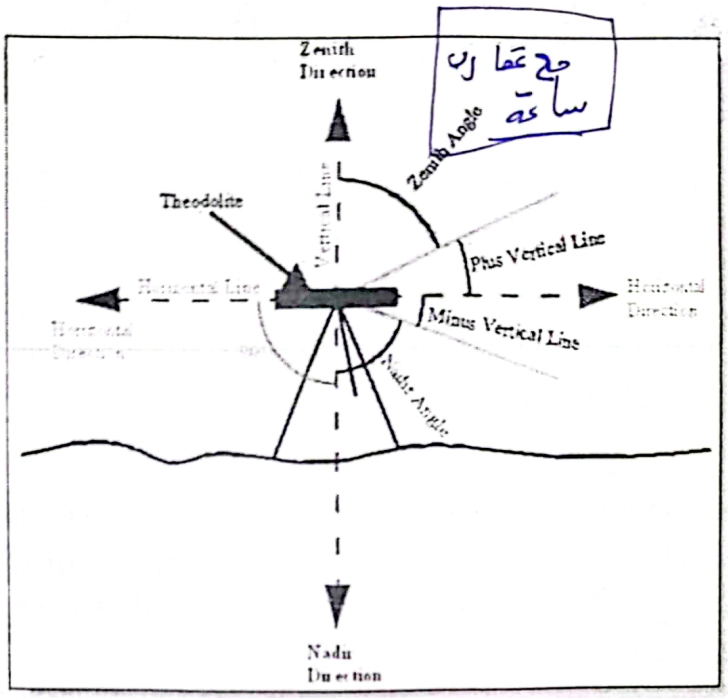
دائماً زاوية الانحراف أصغر من 180

- **Deflection angles are always smaller than 180° and appending an R or L to the numerical value identifies the direction of turning.**

الممسوحة ضوئيا بـ CamScanner

Vertical Angles are referenced to:

- The horizon by plus (up) or minus (down) angles.
- The zenith: directly above the observer.
- The nadir: directly below the observer.



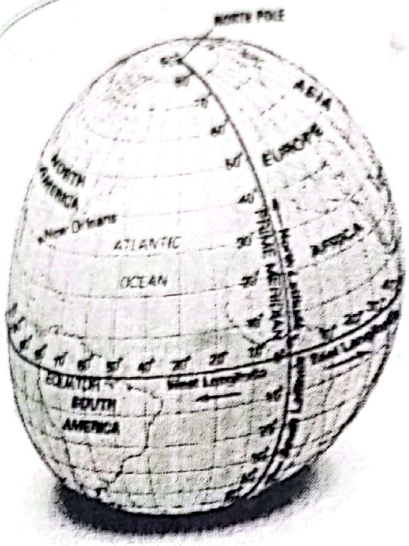
DIRECTION OF A LINE

The direction of a line is defined by the horizontal angle between the line and an arbitrarily chosen reference line called a *meridian*.

Different meridians are used for specifying directions including:

(a) geodetic (also often called true),
(b) astronomic,
(c) magnetic,
(d) grid,
(e) record, and
(f) assumed.

الممسوحة ضوئيا بـ CamScanner

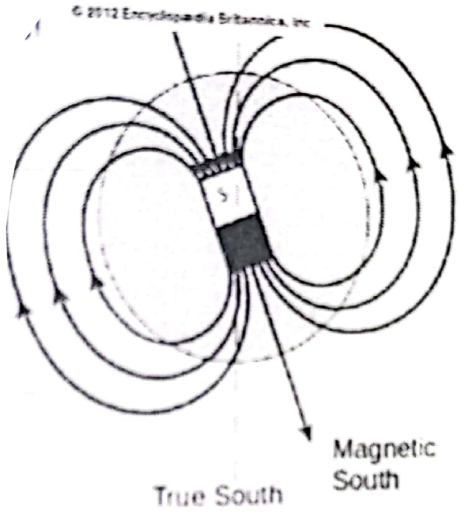


THE EARTH'S GRID SYSTEM

- Only the city of New Orleans, La., is located at the crossing of the 30th east-west line north of the Equator and the 90th north-south line west of the prime meridian.
- Lines of latitude cross lines of longitude at right angles.
- Although only a few lines of latitude and longitude are shown on globes and maps, their number is infinite.

Grid

نقطة تقاطع خطوط الطول وخط العرض عند زاوية 90°



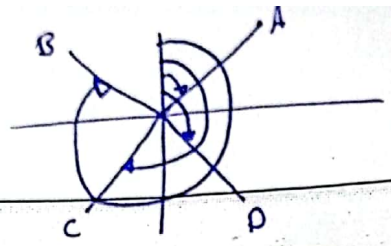
Magnetic

تقسيم الأراضي

- In boundary surveys, the term record meridian refers to directional references quoted in the recorded documents from a previous survey of a particular parcel of land.

- An assumed meridian can be established by merely assigning any arbitrary direction—for example, taking a certain street line to be north. The directions of all other lines are then found in relation to it.

الممسوحة ضوئيا بـ CamScanner



دائمًا ابدأ من North و يكون المرجع وضع اتجاه عقارب الساعة

④	①
③	②

AZIMU

ك مع عقارب ساعة

- Azimuths are horizontal a
  clockwise from any refere
  surveying, azimuths are g
  north. Range: 0 - 360°

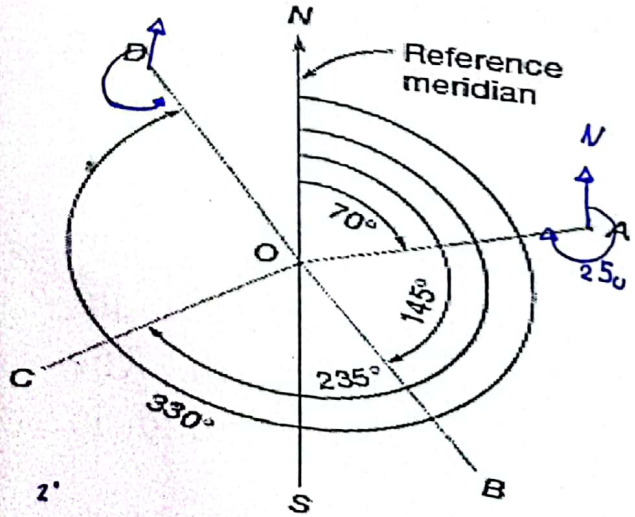
الرينج

- A line's forward direction can be given by its forward azimuth, and its reverse direction by its back azimuth. In plane surveying, forward azimuths are converted to back azimuths, and vice versa, by adding or subtracting 180°.

عكس عقارب الساعة

للتحويل

AZIMUTHS



For example,

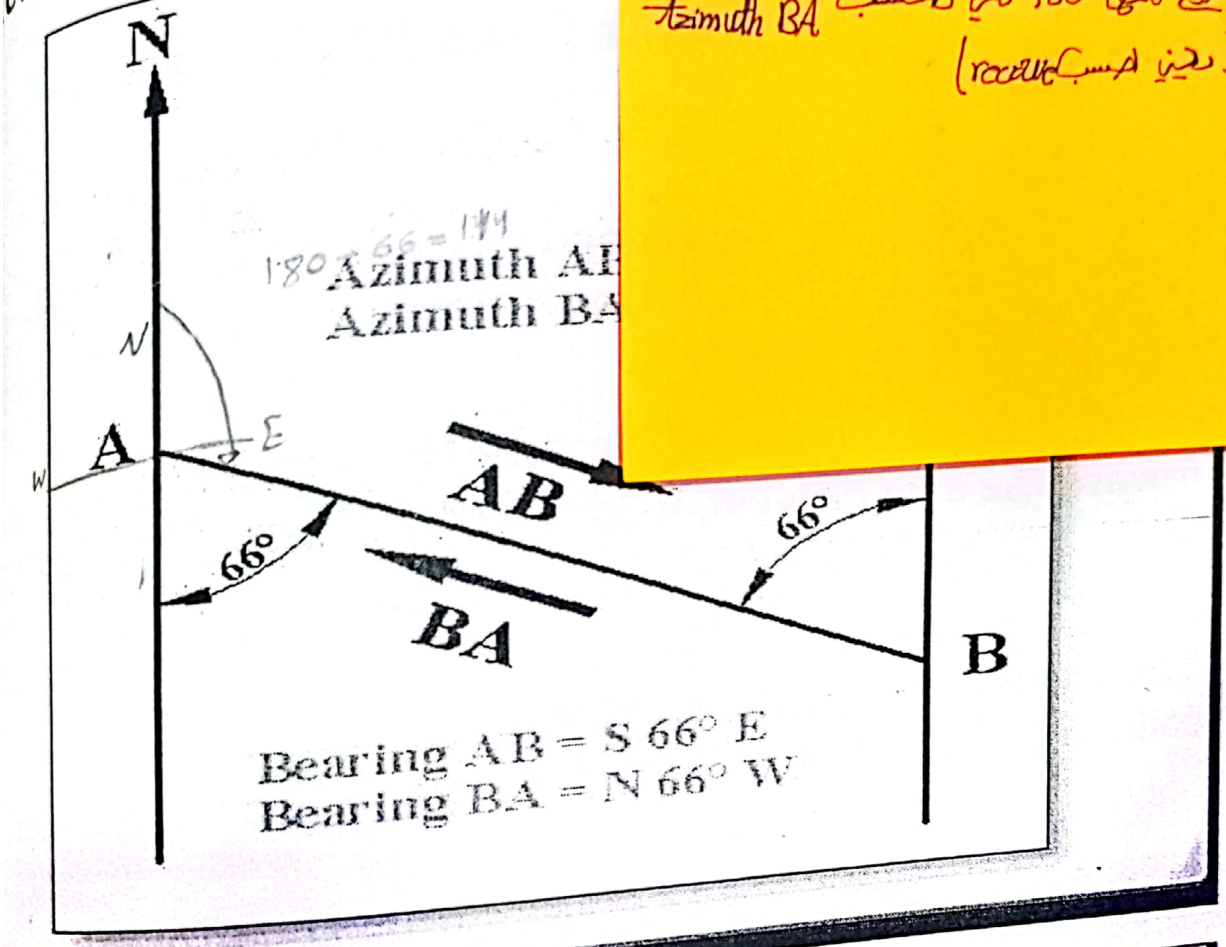
if the azimuth of OA is 70°, the azimuth of AO is 70°+ 180°=250°

If the azimuth of OD is 330°, the azimuth of DO is 330° - 180° = 150°.

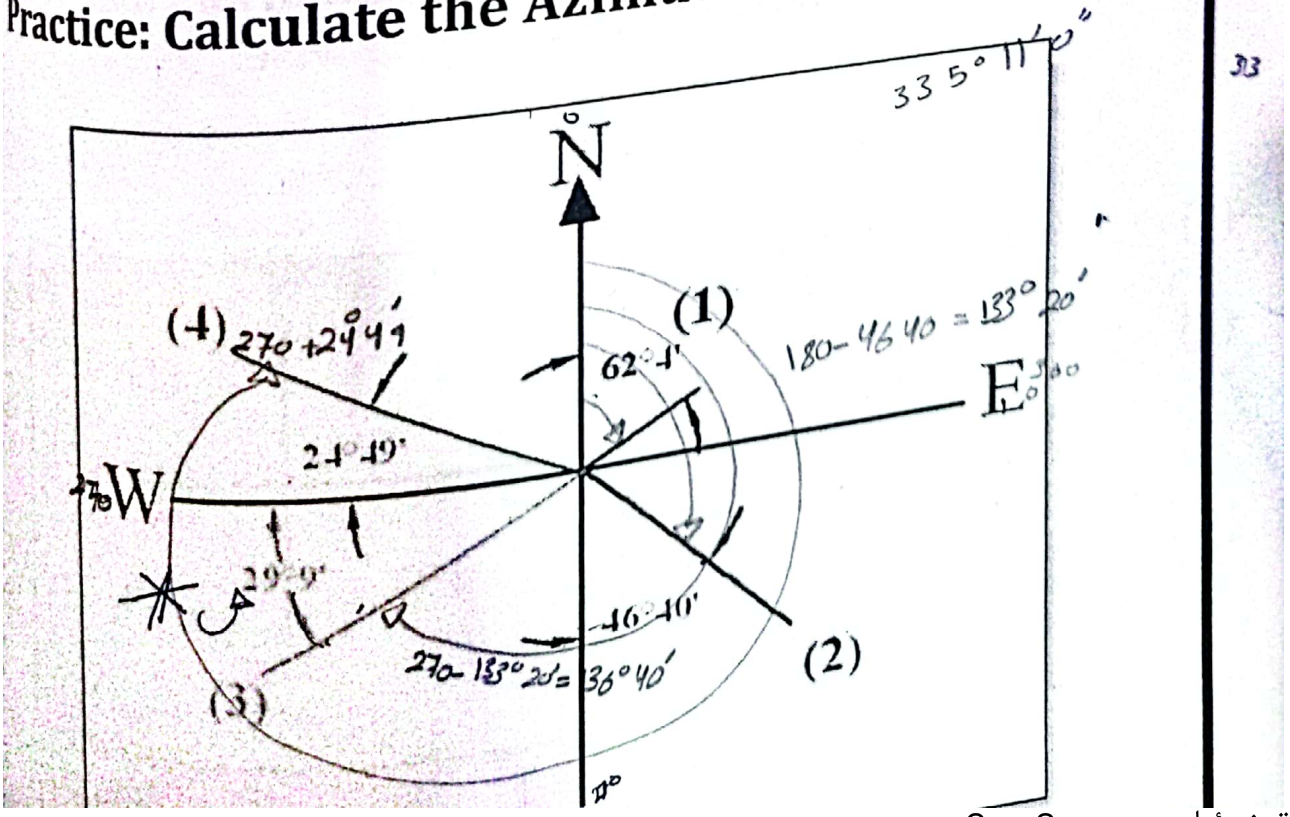
الممسوحة ضوئيا بـ CamScanner

إذا طلعت زاوية AB وكانت أقل من 180 نجمعلها 180 وإذا كانت الجزء من 180 نطرح منها 180 لأن نحسب Azimuth BA (reverse)

everse Azimuth



Practice: Calculate the Azimuths of lines 1-4.



الممسوحة ضوئيا بـ CamScanner

BEARINGS

Bearings are another system for designating directions of lines.

The bearing of a line is defined as the acute horizontal angle between a reference meridian and the line.

The angle is observed from either the north or south toward the east or west, to give a reading smaller than 90°.

The letter N or S preceding the angle, and E or W following it shows the proper quadrant.

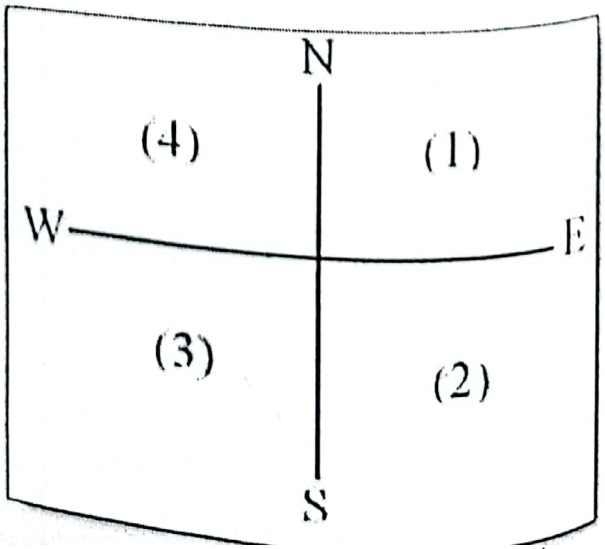
Bearing: Acute angle between N-S meridian and the line measured clockwise or counterclockwise.

(1) N # # # E

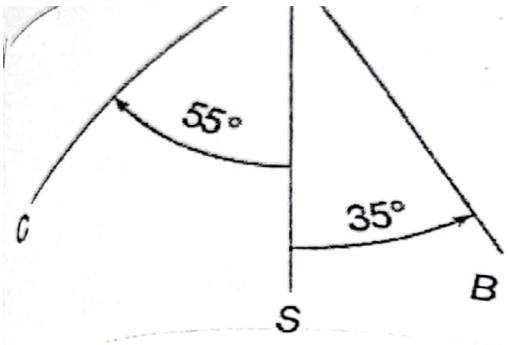
(2) S # # # E

(3) S # # # W

(4) N # # # W



الممسوحة ضوئيا بـ CamScanner



...he bearing of line *OA* is N70°E.

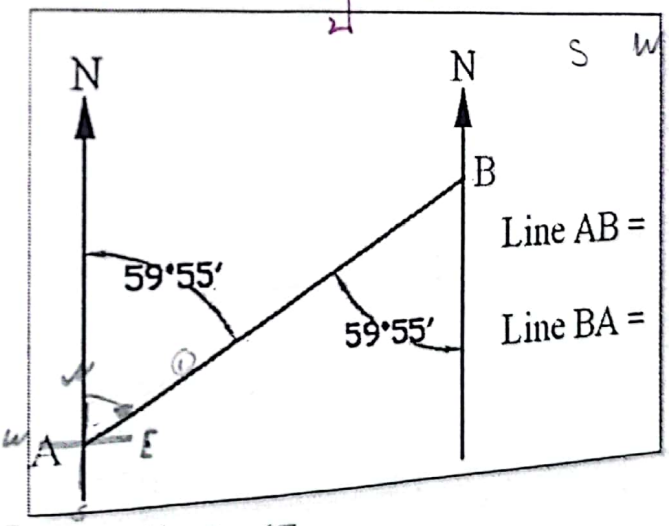
All bearings in quadrant *SOE* are counterclockwise from the meridian, so *OB* is S35°E. Similarly, the bearing of *OC* is S55°W and that of *OD*, N30°W

...en lines are in the cardinal directions, the bearings ...uld be listed as "Due North," "Due East," "Due South," or "Due West."

...k bearings should have the same numerical values as forward ...rings but opposite letters. Thus if bearing *AB* is N44°E, bearing *BA* is ...W.

To reverse Bearing:
Reverse direction letters

AB	BA
N →	S
S →	N
E →	W
W →	E



Bear → N 59° 55′ E

and angles stay as is.

W ⇄ E و S ⇄ N تعكس فقط BA اتجاه عشان

* فرضًا كان AB S59°55′W ← BA N 59°55′E

الممسوحة ضوئيا بـ CamScanner

* لما تطلع الزاوية الحرمه 360 يجب طرحها من 360 (يعني بدهها ضمن الربع)

* لما تكون الزاوية بالربع الاول متكون Bearing

* اذا كانت القراءة اقل من الصفر نجمع 360

zimuths to bearings for directions of
sier to work with, especially when
n computers.

azimuth angles provide correct
ures and latitudes

Azimuth calculations are best made with the aid of a sketch

- Traverse angles must be adjusted to the proper geometric total before azimuths are computed.
  - in a closed-polygon traverse, the sum of interior angles equals 180(n-2)
  - If the traverse angles fail to close, it should be adjusted prior to computing azimuths

طريقة لحساب Azimuth

Azimuth Computation

1: Check interior angles sum = (n - 2) 180°

2: Counterclockwise (recommended)

- **a- reverse Azimuth**
- **b- add next interior angle**
- **c- go to start and check**

لازم نتأكد انه مجموع زواياه الداخلية = قيمة True

True ← 540° 0' 0"

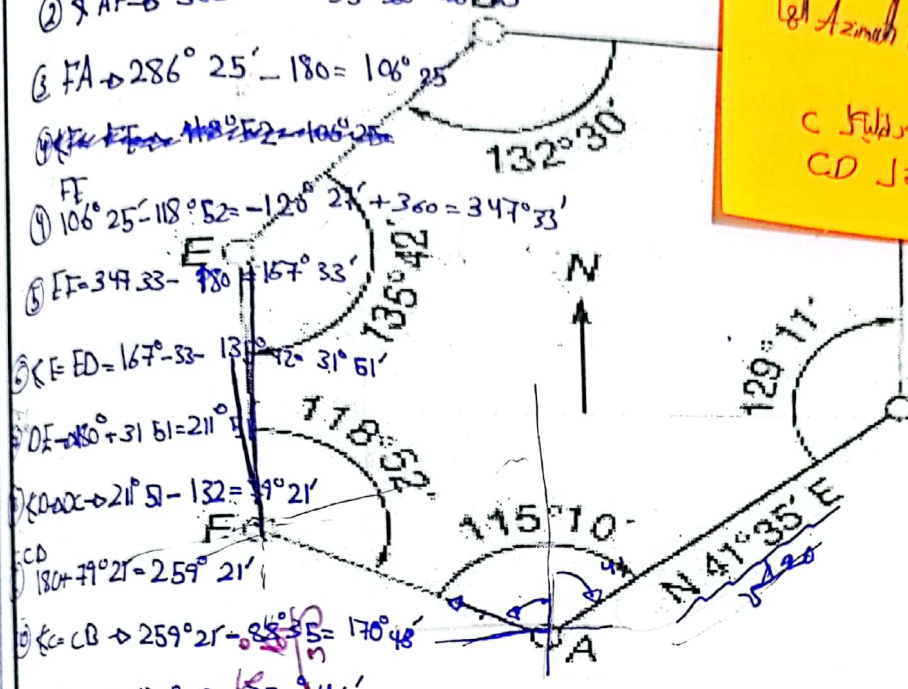
اذا ما طلعوا لازم نعمل Correction

- **3: Clockwise**
  - **a- find the Azimuth of the starting line (going clockwise)**
  - **b- reverse Azimuth**
  - **c- subtract interior angle**
  - **d- go to start to check**

- **Note: you may need to add 360° to subtraction.**

الممسوحة ضوئيا بـ CamScanner

CCW SOLUTION OF CL



طريقة C.C :-

Bearing أو Azimuth لازم أبدأ من نقطة معلومة (لجاهزة معطى) AB

بنطلع BA (المجهولة) نطرح منها 180 والعكس صحيح

بنطلع زاوية B ← BC = B ثم أخذ قراءة داخلية

لحد ما نجيب الزاوية BA هيك بنطلع الـ Azimuth اللي

بنطلع CB

بنطلع زاوية C ← CD = C ثم أخذ زاوية داخلية

نجيب الـ Azimuth هيك بنطلع لـ CD

طريقة C.W :-

لازم نبدأ من نقطة معروف لها Azimuth أو Bearing

نطرح الزاوية الداخلية من الزاوية اللي قبلها هيك بنطلع

360 - Ang ← Azm لازم نطلع Azimuth أو Bearing

نحسب FA ← المجهولة نطرح والعكس صحيح

نطرح أخر Azimuth من الزاوية الداخلية

اللي بنوصل لها أخر Azm - الزاوية الداخلية

OF CLOSED TRAVERSE

(FROM NORTH) FOR LINES OF FIGURE 7.2(a)

the Right [Figure 7.2(a)]

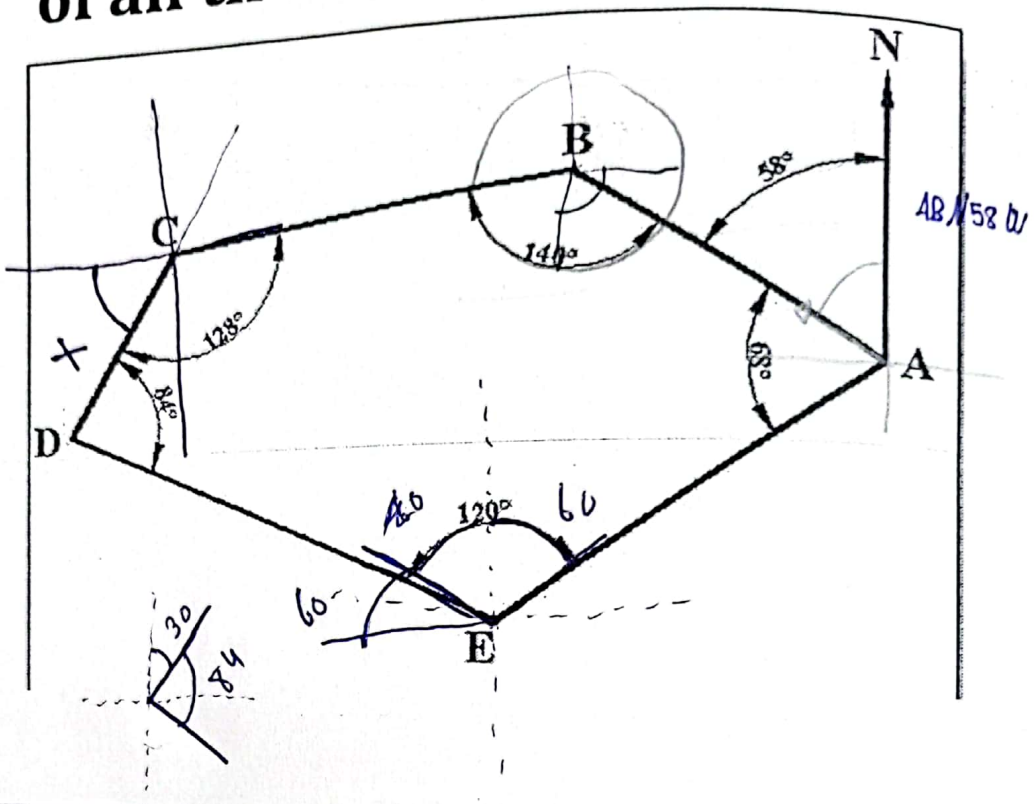
211°51′ = DE
−180°00′
31°51′ = ED
+135°42′
167°33′ = EF
+180°00′
347°33′ = FE
+118°52′
466°25′ − *360° = 106°25′ = FA
−180°00′
286°25′ = AF
+115°10′
401°35′ − *360° = 41°35′ = AB ✓

+68°35′
259°21′ = CD
−180°00′
79°21′ = DC
+132°30′
211°51′ = DE

*When a computed azimuth exceeds 360°, the correct azimuth is obtained by merely subtracting 360°.

الممسوحة ضوئيا بـ CamScanner

Example: Find the Bearing /azimuth of all the lines of the traverse



-∴ Bearing

* بنوخد كل زاوية لحال

* بنوخد Back العطس Bearing لل

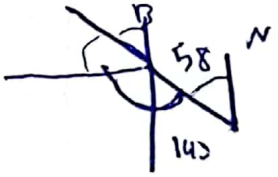
N 58 W ← AB

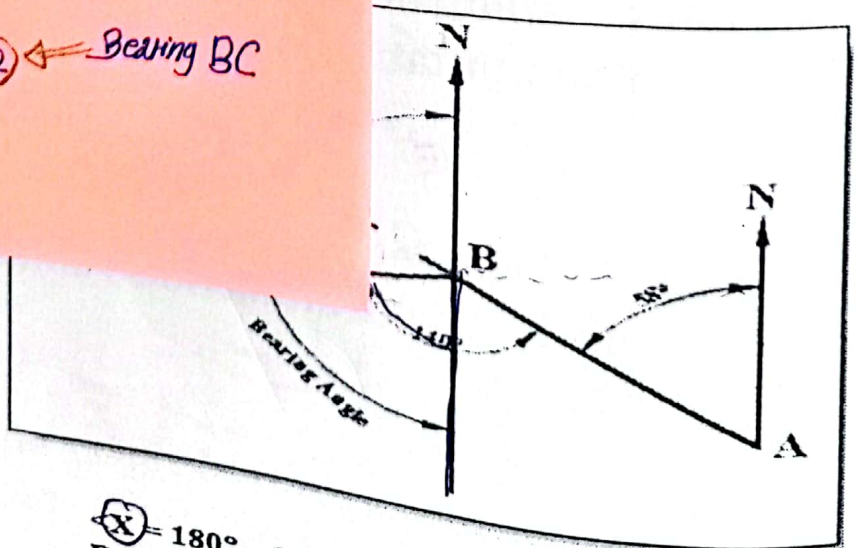
S 58 E ← BA

S ↓ W

140 - 58 = 82 ← Bearing BC

ine Ab &BC





(X) = 180° − 140° = (40°)

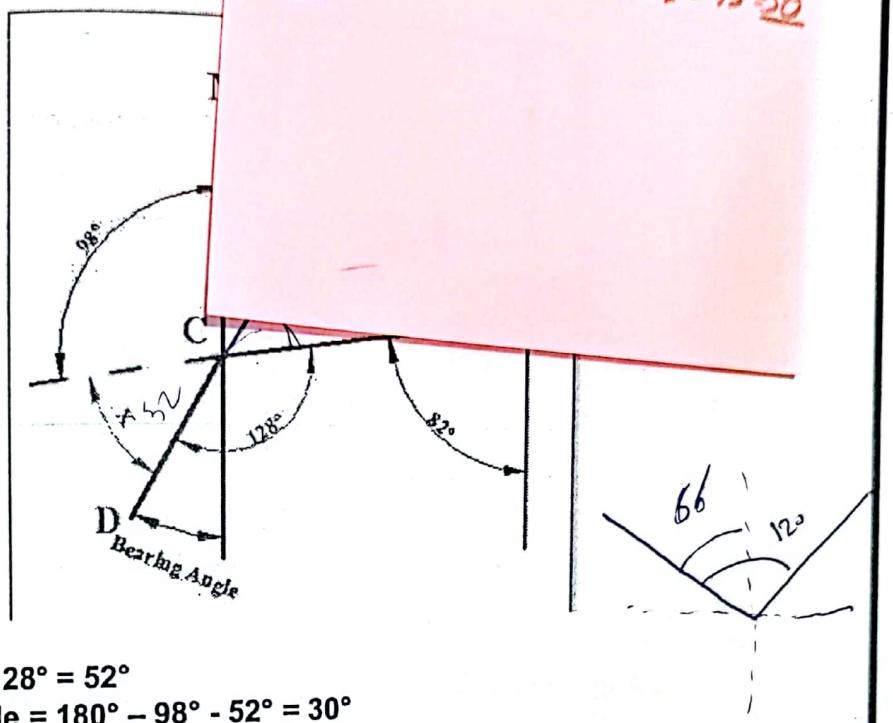
Bearing Angle = 180° − 58° − 40°

BC = S 82° W

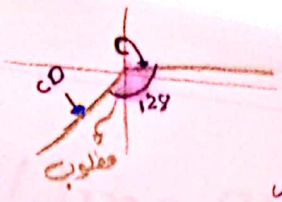
الممسوحة ضوئيا بـ CamScanner

Solution

3- Line CD



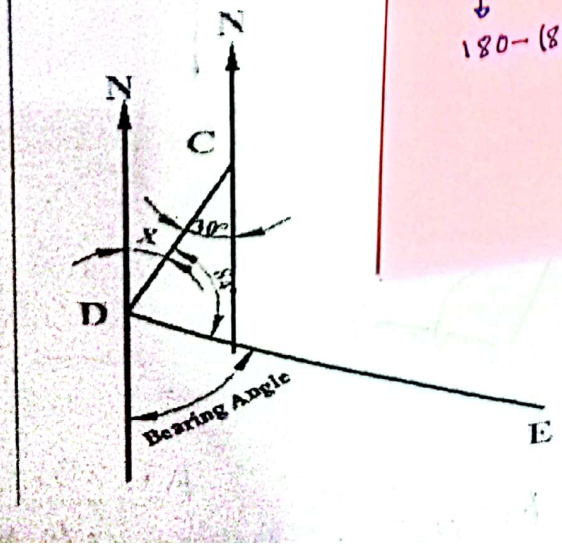
<X = 180° – 128° = 52°
Bearing Angle = 180° – 98° - 52° = 30°
CD = S 30° W



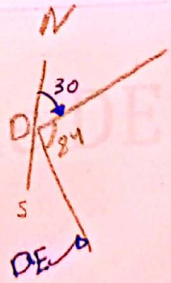
S 82W ← BC
N 82 E ← CB
180 – 82 = ~~98~~ 80
129 – 99 = 30
CD ↑
S 30 W

Solution/

4- Line DE



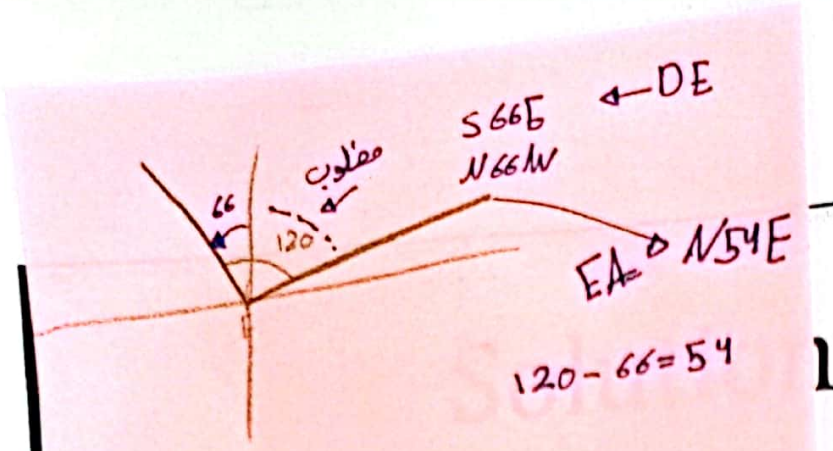
X = 30°



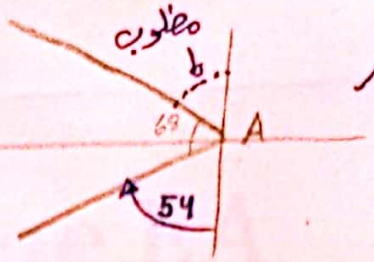
S 30W ← CD
N30E ← DC

S E
↓
180 – (84+30) = 66 ← DE

الممسوحة ضوئيا بـ CamScanner

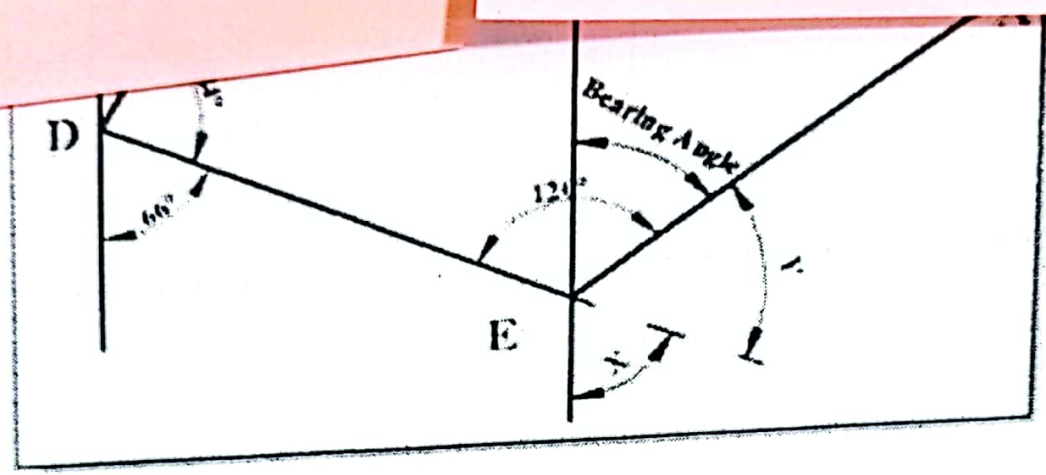


عنان تاكد انه الشغل صح :-



180 - (68 + 54) = 58

AB N 58 W



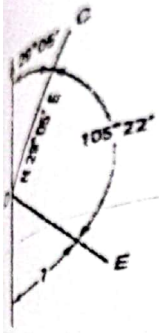
<X = 66° Why?

<Y = 180 - 120° = 60°

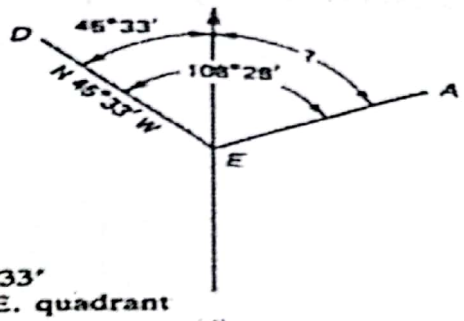
Bearing Angle = 180° – 60° - 66° = 54°

EA = N 54° E

الممسوحة ضوئيا بـ CamScanner

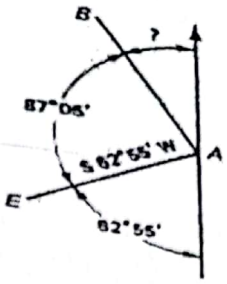


LINE DE
(?) = 180° − (105°22′ + 29°05′)
(?) = 45°33′ in S.E. quadrant
i.e., S 45°33′ E



LINE EA
(?) = 108°28′ − 45°33′
(?) = 62°55′ in N.E. quadrant
i.e., N 62°55′ E

(c)



LINE AB
(?) = 180° − (62°55′ + 87°05′)
(?) = 30°00′ in N.W. quadrant
i.e., N 30°00′ W
CHECK (LINE BA was S 30°00′ E)

(a)

Finish

مجال مغناطيسي
بالنسبة للـ North

Magnetic Direction

نتيجة دوران الارض بتغير

The **North Magnetic Pole** is the point on the surface of Earth's Northern Hemisphere at which the planet's magnetic field points vertically downwards (in other words, if a magnetic compass needle is allowed to rotate about a horizontal axis, it will point straight down).

يتغير

The North Magnetic Pole moves over time due to magnetic changes in the Earth's core.

لذا عدنا خطأ بالنسبة لنصف الارض

Its southern hemisphere counterpart is the South Magnetic Pole. Since the Earth's magnetic field is not exactly symmetrical, the North and South Magnetic Poles are not antipodal: i.e., a line drawn from one to the other does not pass through the geometric Center of the Earth.

اتجاه خطوط S-N

The direction of magnetic field lines are defined to emerge from the magnet's south pole and enter the magnet's north pole.

الممسوحة ضوئيا بـ CamScanner

- **True North** (geodetic north) is the direction along the earth's surface towards the geographic North Pole.

- True geodetic north differs from magnetic north.

* نتيجة دوران الارض مع تغير الزمن يتغير محور الـ

Magnetic North and Magnetic Declination

- The compass aligns itself to the local geomagnetic field, which varies in a complex manner over the Earth's surface, as well as over time.

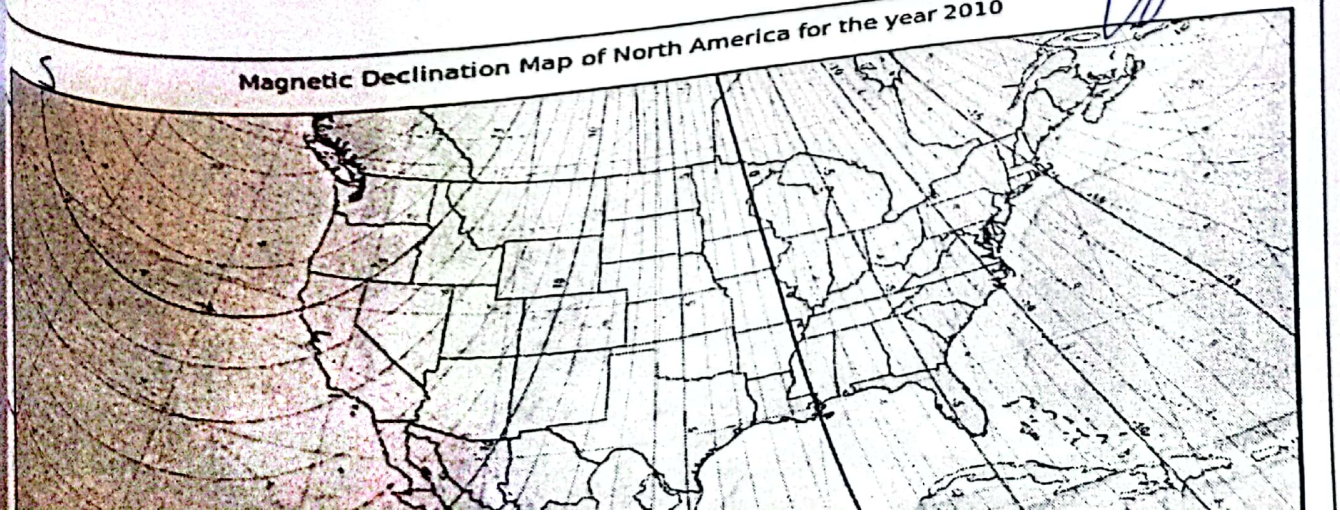
- The local angular difference between magnetic north and true north is called the magnetic declination.

- Most map coordinate systems are based on true north, and magnetic declination is often shown on map legends so that the direction of true north can be determined from north as indicated by a compass.

- Many countries issue *isogonic charts*, usually every 5-10 years, on which lines are drawn (isogonic lines) that join points on the earth's surface that are experiencing equal annual changes in magnetic declination.

- *Due to uncertainties of determining magnetic declination, magnetic directions are not employed for any but the lowest order of surveys.*

Magnetic Declination for USA – 2010 epoch



الممسوحة ضوئيا بـ CamScanner

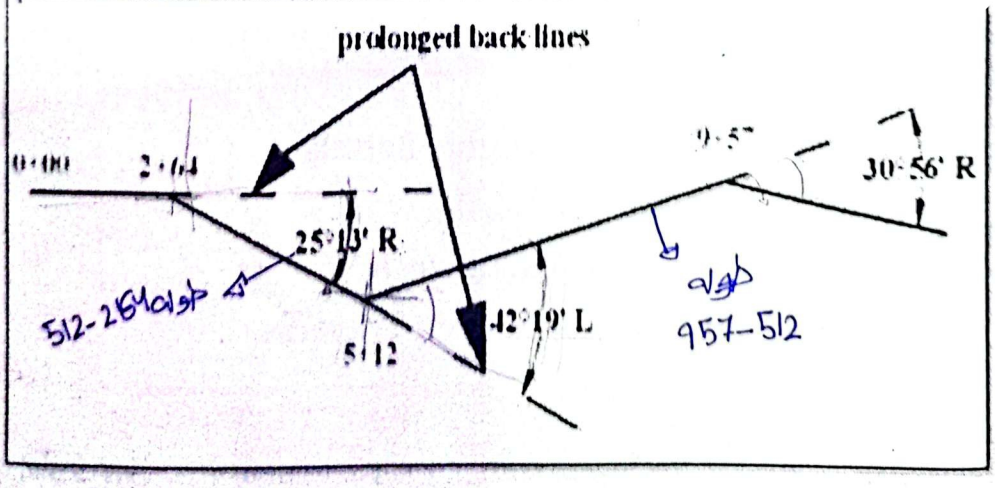
Open Traverses

- A series of measured straight lines and angles that do not geometrically close.
- No geometric verification of stations. So for field verifications:
  - Distances measured twice
  - Angles doubled
- When traverse stations can be tied to control monuments (BM's) or by using accurate GPS then verification is possible (it becomes Closed Travers).
  - In route survey, open traverse stations can be verified by tying in the initial and terminal stations of a route survey to coordinate grid monuments whose positions are known.
  - In this case, the route survey becomes a closed traverse and is subject to geometric verification and analysis

تحركت باتجاه east بـ distance معينة وبس سيقها تحركت بزاوية معينة to the right

Open Traverses

to the right دائما مع عقارب الساعة
to the left -- -- عكس --



الممسوحة ضوئيا بـ CamScanner

Double / 2 = mean بنوحد

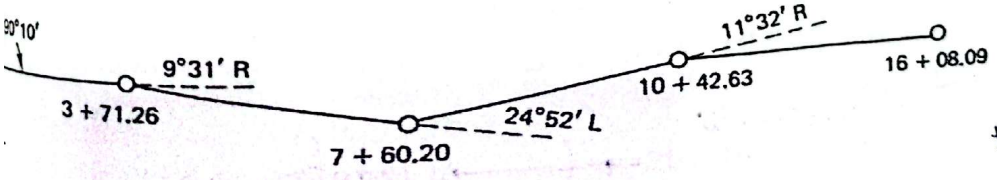
Field notes of the above drawing

Station	Direct	Double	Mean	L/R
0+00	90° 00'	180° 00'	90° 00'	N 90° 00' E
2+64	25° 12'	50° 26'	25° 13'	R
5+12	42° 20'	84° 38'	42° 19'	L
9+57	30° 56'	61° 52'	30° 56'	R

Chainages بالمتر

	Direct	Reverse	Mean	Corrected Chainage
				0+00
	264.3	264.5	264.4	2+64.4
	248.1	248.0	248.1	5+12.5
	445.4	445.8	445.6	9+58.1
	235.7	235.9	235.8	11+93.9

Direct + reverse / 2



Δ = Control Station

O = Traverse Station

PRELIMINARY SURVEY FOR CLEAR LAKE ACCESS ROAD—TONLIN TOWNSHIP

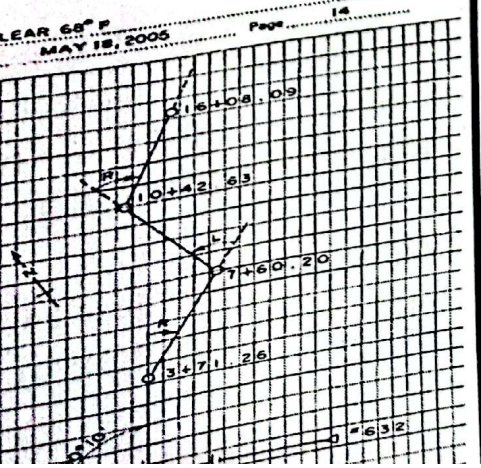
Job CLEAR 66° F Page 14

Date MAY 18, 2005

DIRECT	DOUBLE	MEAN	L/R
90° 11'	180° 20'	90° 10'	SEE SKETCH
DEFLECTION ANGLES			
9° 31'	19° 02'	9° 31'	R
24° 51'	49° 44'	24° 52'	L
11° 32'	23° 04'	11° 32'	R

CHAINAGES

DIRECT	REVERSE	MEAN	CHAINAGES
371.24	371.28	371.26	0+00.00
388.93	388.80		3+71.26
389.63	389.95	388.94	7+60.20
282.43	282.43	282.43	10+42.63
568.44	568.42		



Number of Pages

الممسوحة ضوئيا بـ CamScanner

Closed Traverse

- Begins and ends at the same points (Loop traverse)
- Begins and ends at points of known position
- <u>Balancing Angles:</u>
- This is the first step in Traverse calculation
- Interior angle sum = (n - 2) 180
- Distribute error equally (recommended) , arbitrary or according to weights.
- Acceptable angular closure error is usually quite small (i.e., < 03')

Traverse Computations

Traverse computations include the following:

1. Balancing field angles
2. Compute latitudes and departures
3. Compute traverse error
4. Balance latitudes and departures
5. Adjust original distances and directions
6. Compute coordinates of the traverse stations
7. Compute area enclosed by a closed traverse

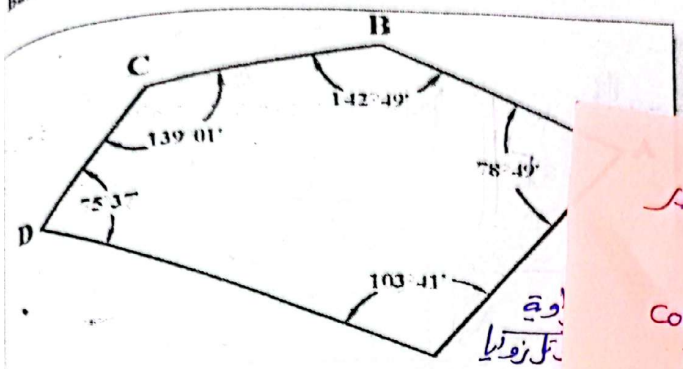
In modern practice these computations are routinely performed on computers and on total stations

الممسوحة ضوئيا بـ CamScanner

Closed Traverse/ Example

Adjusting sum of angles according to weights

Balance the following traverse.



Point	Angle Value		
A	78° 49'	(78°49 + 00° 00	
B	142° 49'	(142°49' / 540°) * 03' = + 00° 00' 48"	142° 49' 48
C	139° 01'	+ 00° 00' 46"	139° 01' 46"
D	75° 37'	+ 00° 00' 25"	75° 37' 25"
E	103° 41'	+ 00° 00' 35"	103° 41' 35"
Total	539° 57'	+ 00° 03'	540° 00' 00"

Closed Traverse/ Example

Table 6.1 TWO METHODS OF ADJUSTING FIELD ANGLES

Station	Field Angle	Arbitrarily Balanced	Equally Balanced
A	101° 24'00"	101° 24'00"	101° 24' 12"
B	149° 13'00"	149° 13'00"	149° 13' 12"
C	80° 58'30"	80° 59'00"	80° 58' 42"
D	116° 19'00"	116° 19'00"	116° 19' 12"
E	92° 04'30"	92° 05'00"	92° 04' 42"
	538° 119'00"	538° 120'00"	538° 118'120"
	= 539° 59'00"	= 540° 00'00"	= 540° 00' 00"
	Error = 01'	Balanced	Balanced
			Correction/angle = 60/5 = 12"

الممسوحة ضوئيا بـ CamScanner

Latitudes & Departures

⇒ **Latitude:** North/South rectangular component of a line

N = +ve +y
S = −ve −y

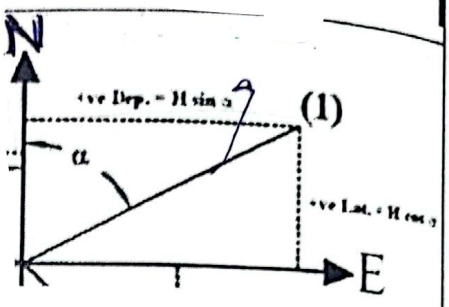
⇒ **Departure:** East/West rectangular component

E = +ve
W = −ve

α Azimuth (أو الزاوية)

⇒ Latitude (Δy) = dist (H) co

⇒ Departure (Δx) = dist (H) sin



where, H ≡ horizontal dist of Traverse course

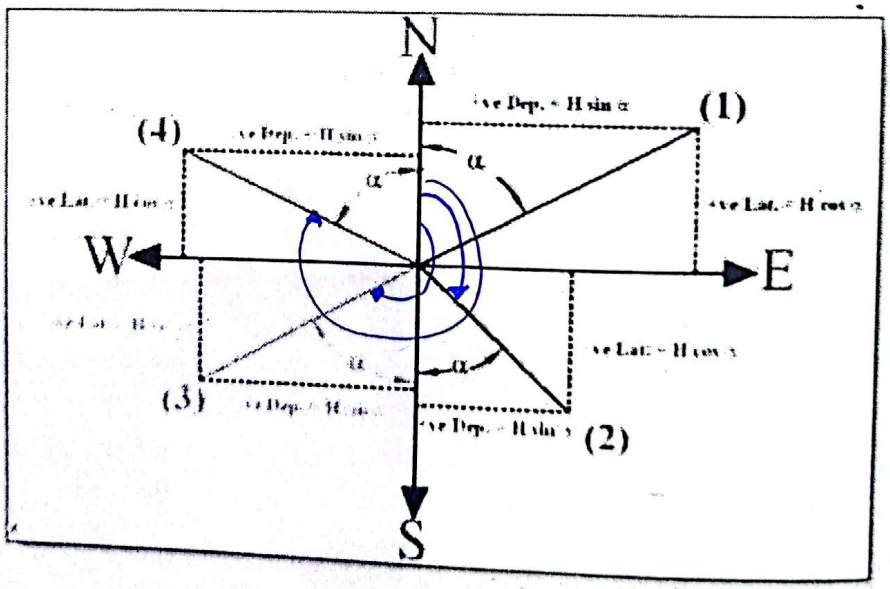
α ≡ is Azimuth (sign is automatically corrected)

or

Bearing (sign must be entered)

Azimuth بزاوية

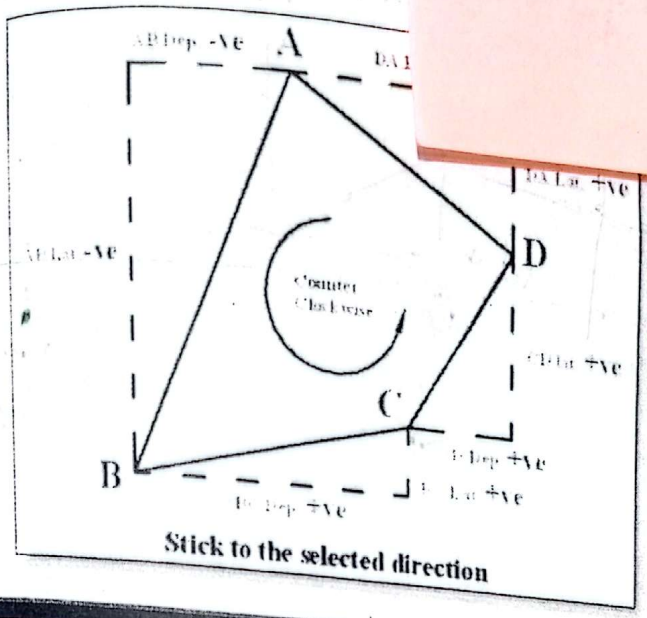
Latitudes & Departures



الممسوحة ضوئيا بـ CamScanner

Latitudes & D

⇒ In a perfect (or corrected) surve
Σ +ve Latitudes = Σ -ve Latit
Σ +ve Departures = Σ -ve Dep



dep L.d عند line لأي مضلع *
و يفترض أن ΣL.t=0 و أيضا مجموع
Σdepar =0
لو كان مجموع ≠ هنا يكون عندنا
error

rror of closure (linear error of closure): is the net accumulation of ndom errors associated with the measurement of traverse angles and se distances.

rror of closure is compared to the perimeter of the traverse to mine the **precision ratio** = Error / المحيط ← مجموع الأطوال

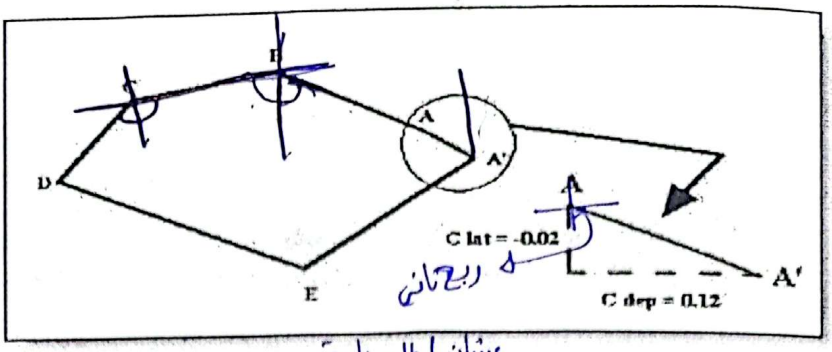
raction **E/P** is always expressed so that the numerator is 1, and the minator is rounded to the closest 100 units.

lly E/P: **1/3000-1/10000** for engineering surveys

P is not within the permissible limits:
Double-check all computations
Double-check all field entries
Compute the bearing of the linear error of closure and check to see if it is similar to a course bearing (±5°)
Re-measure the sides of the traverse, beginning with a course having a bearing similar to the linear error of closure bearing (if there is one)
When a correction is found for a measured side, try that value in the latitude-departure computation to determine the new level of precision.

الممسوحة ضوئيا بـ CamScanner

Error of Closure



ربعتاني

عشان اطلع زاوية

$$AA' = \sqrt{C_{lat}^{\ 2} + C_{dep}^{\ 2}}$$

$$= \sqrt{(0.02)^2 + (-0.12)^2} = 0.12$$

$$bearing\ of\ AA' = \tan^{-1}\frac{C_{dep}}{C_{lat}}$$

عشان اطلع bearing لازم ايجد $\tan^{-1}\left(\frac{dep}{Lat}\right)$

$= \tan^{-1}(0.12 / -0.02)$

$= S\ 80^{o}\ 32'\ 16''E$

Lat و dep والاتجاه يعتمد على اشارة

Accuracy

- Accuracy ratio not enough for ensuring accuracy!
- Errors might cancel each other
- So in addition to accuracy ratio:
  - Check max allowable error in angle E_a
  - Check overall max allowable angular error

$$= E_a \sqrt{n}$$

الخطأ المسموح لزاوية واحدة

مطلوب اطلع

حسب traverse

الممسوحة ضوئيا بـ CamScanner

Traverse Adjustments

- **Compass rule adjustment for lat & dep:-**

$$\Rightarrow \text{Correction in Lat} = -(\text{error in Lat}) * \frac{H}{P}$$

$$\Rightarrow \text{Correction in Dep} = -(\text{error in Dep}) * \frac{H}{P}$$

where,

H ⇒ side length (Horizontal distance)

P ⇒ perimeter length ($\Sigma \ell$)

- **Once the latitudes and departures have been adjusted, the original polar coordinates (distance and direction) will no longer be valid**

- **The distances and directions should be corrected**

$$\textbf{distance corrected} = \sqrt{lat^2 + dep^2}$$

$$\tan(\textbf{bearingangle}) = \frac{dep}{lat}$$

الممسوحة ضوئيا بـ CamScanner

* لذا ما لطرحنا احداثيات نفرضن رقم كبير مثل 1000

* عشان اطلع احداثيات B لازم اطلع dep و lat لـ line AB

كيف طلعنا احداثيات B ؟!

احداثيات A (1000^{x} , 1000^{y})

بجمع لـ x قيمة dep لـ A هيا طلعت x لـ B

مسكت احداثيات نقطة A وضفت عليها قيمة lat لـ (y) AB line

* عشان نتأكد من صح لازم آخر نقطة احداثيات ترجع نفسها

rrection of the previous example

imuth	Bearing	Lat.	Dep.	Correcte Latitud
1° 10'	N 78° 50' W	2.21	-11.17	2.21
	S 63° 59'	-4.32	-8.86	-4.32

الممسوحة ضوئيا بـ CamScanner

ssing (Omitted) Measurement

e to presence of obstacles like trees, water tunnel, or ghway, sometimes it is difficult to directly measure e side of the traverse.

The technique of latitudes and departures can be used find that side, and complete the traverse.

The idea is to arrange the sides in a form of closed verse with one side missing.

Mainly you have to stick to a certain direction ockwise or counterclockwise) in naming and solving e traverse.

(1302.96 N
1692.14 E)

C

+368.19

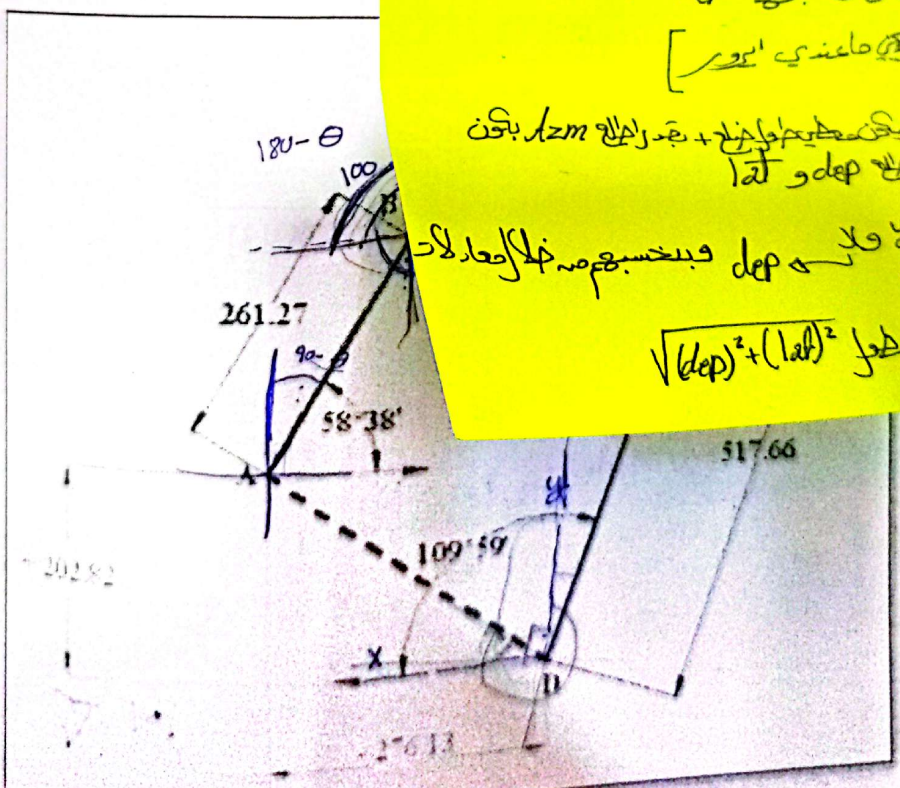
D

+47.60

+246.08

(934.77 N
1684.54 E)

Example 1 Find the missin



نفرض في هذه الامثلة أن مجهول = lat مفرد

مجهول = dep مفرد

[يعني ماعندي اتعب]

عايكون معطيني اتجاه + بعد الخط azm بكون بعد الخط dep و lat

نفرض y هو dep وبنحسبهم من خلال معادلات lat

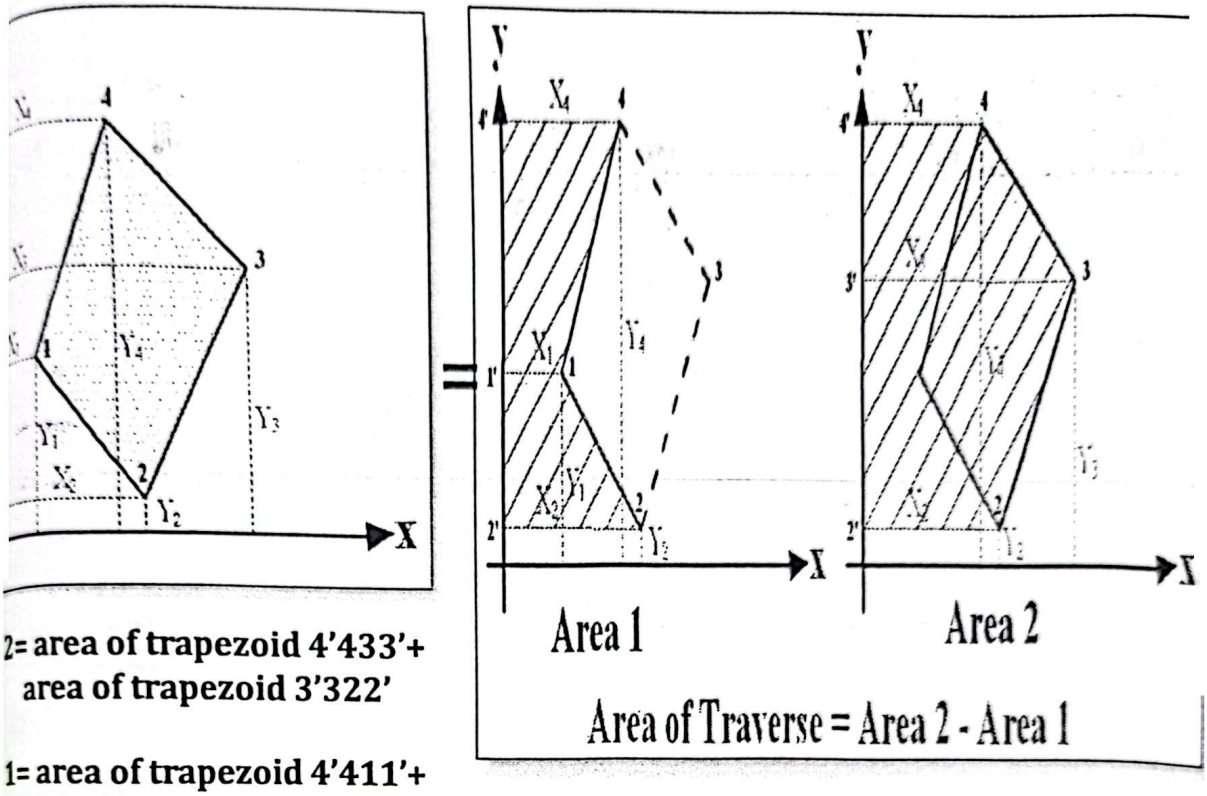
عشان اطلع الوتر $\sqrt{(dep)^2+(lat)^2}$

departures

	East
0.00	(assumed)
0.27	
0.27	
4.27	
4.54	
7.60	
2.14	
6.53	
3.61	
3.61	
0.00	Check

الممسوحة ضوئيا بـ CamScanner

Area of a closed traverse by the coordinate method



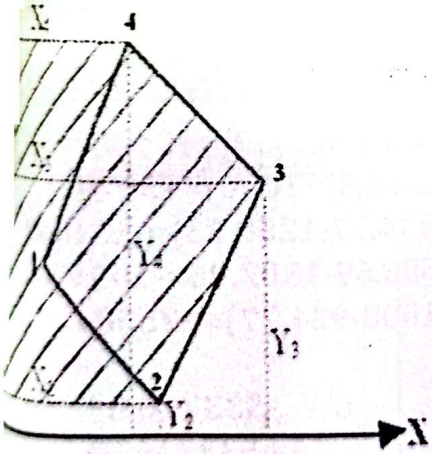
2= area of trapezoid 4'433'+
area of trapezoid 3'322'

1= area of trapezoid 4'411'+
area of trapezoid 1'122'

(1) لو جمع عقارب ساعة من نقطة

$2Area = x_1(y_4-y_2) + x_4(y_3-y_1) + x_3(y_2-y_4) + x_2(y_1-y_3)$

وما ننسى انه نقسم على 2 بس نعوض الارقام



2= area of trapezoid 4'433'+
area of trapezoid 3'322'

= ½ (X4+X3)(Y4-Y3) +
½ (X3+X2)(Y3-Y2)

area of trapezoid 1'122'

= ½ (X4+X1)(Y4-Y1) +
½ (X1+X2)(Y1-Y2)

= [½ (X4+X3)(Y4-Y3) + ½ (X3+X2)(Y3-Y2)] - [½ (X4+X1)(Y4-Y1) + ½ (X1+X2)(Y1-Y2)]

Multiplying both sides by 2:

Area = [(X4+X3)(Y4-Y3) + (X3+X2)(Y3-Y2)] - [(X4+X1)(Y4-Y1) + (X1+X2)(Y1-Y2)]

الممسوحة ضوئيا بـ CamScanner

* بنحسب $= 2Area$

* عادي نبلش بأي نقطة إما نكمل مع عقارب ساعة
او عكس عقارب ساعة

عكس عقارب ساعة

فرضنا بلشنا من 1 بنكتب $x_1(y_2 - y_4)$

قبل نقطة — وبعد نقطة

بعدين $x_2(y_3 - y_1) +$

$x_3(y_4 - y_2) +$

$x_4(y_1 - y_3) +$

دائمًا نوخذ قيمة مطلقة

الممسوحة ضوئيا بـ CamScanner

2 Area= X4Y4-X4Y3+X3Y4-X3Y3+X3Y3-X3Y2+X2Y3-X2Y2

[X4Y4-X4Y1+X1Y4-X1Y1+X1Y1-X1Y2+X2Y1-X2Y2]

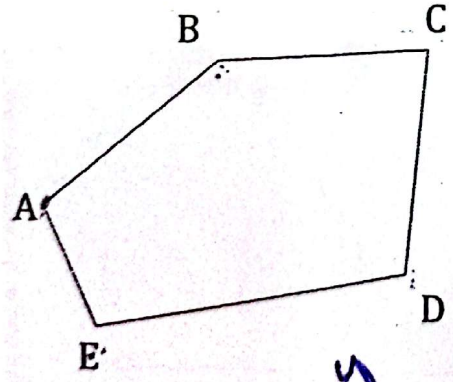
→2 Area = X1(Y2-Y4)+X2(Y3-Y1)+X3(Y4-Y2)+X4(Y1-Y3)

Simply, the double area of a closed traverse is the algebraic sum of each x coordinate multiplied by the difference between the y coordinates of the adjacer stations.

The final area can result in a positive or a negative number, reflecting only the direction of computation (CW or CCW). The physical area is, of course, positive.

Example:

Calculate the area of the closed traverse ABCI Using the area by coordinates method?



Station	North	East
A	1000.00 ft	1000.00 ft
B	1250.73	1313.61
C	1302.96	1692.14
D	934.77	1684.54
E	688.69	1160.27

XA(YB-YE)= 1000(1250.73-688.69)=+562040
XB(YC-YA)= 1313.61(1302.96-1000)=+39797
XC(YD-YB)= 1692.14(934.77-1250.73)=-5346
XD(YE-YC)= 1684.54(688.69-1302.96=-10347
XE(YA-YD)= 1160.27(1000-934.77)=+75684

CW -533716 ft²
2A= 533716 ft²

Area= 266858 ft²

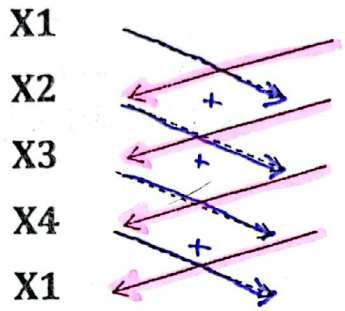
C.C = -2668 576

الممسوحة ضوئيا بـ CamScanner

rea of a closed traverse by the coordinate method

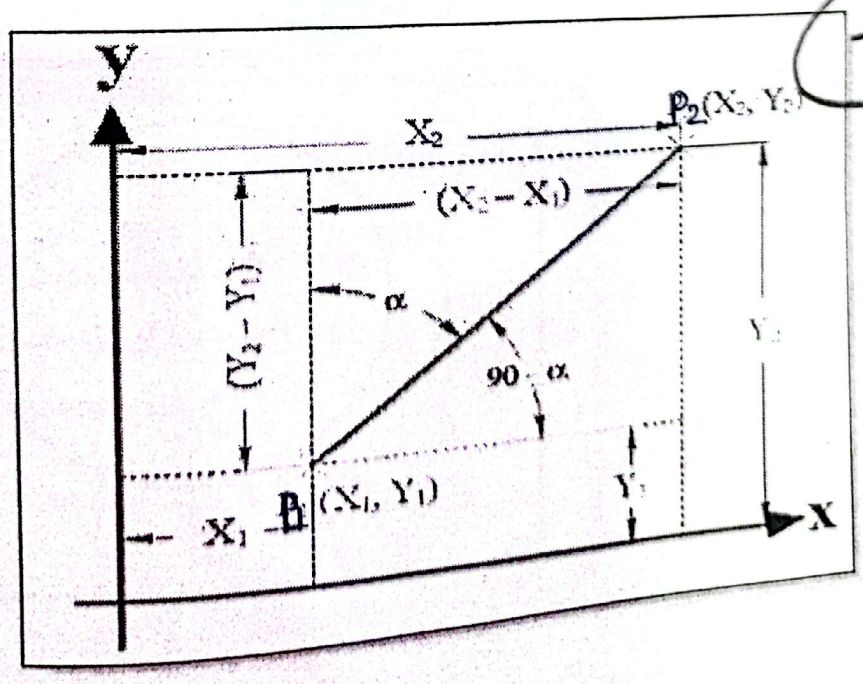
n can be reduced to an easily remembered form by listing the X and Y ates of each point in succession in two columns, with coordinates of ing point repeated at the end.

ducts noted by diagonal arrows are ascertained with dashed arrows red plus and solid ones minus. The algebraic summation of all s is computed and its absolute value divided by 2 to get the area.



$$= \left(X1Y2 + X2Y3 + X3Y4 + X4Y1\right) - \left(X2Y1 + X3Y2 + X4Y3 + X1Y4\right)$$

metry of angular rdinates



⇒ **Equation of line P_1P_2:**

$$y - y_1 = \frac{y_2 - y_1}{x} \quad (1) \qquad (2)$$

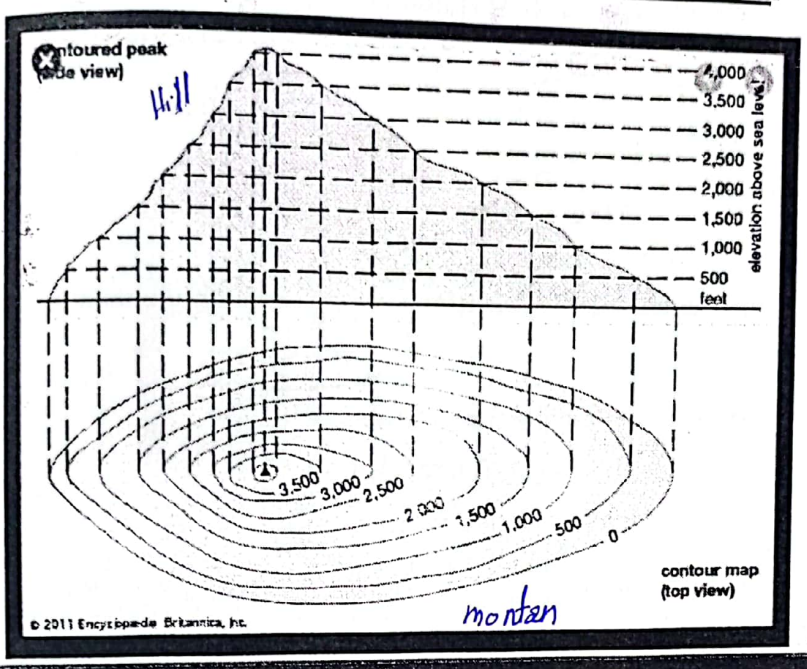
الممسوحة ضوئيا بـ CamScanner

خطوط كنتورية

same elev

خطوط وهمية توصل بين نقاط لها

Contour line: a line on a map representing an imaginary line on the land surface, all points of which are at the same elevation above a datum plane, usually mean sea level.



اعلى قيمة بالوسط

* اي نقطة على خط تكون نفس الارتفاع

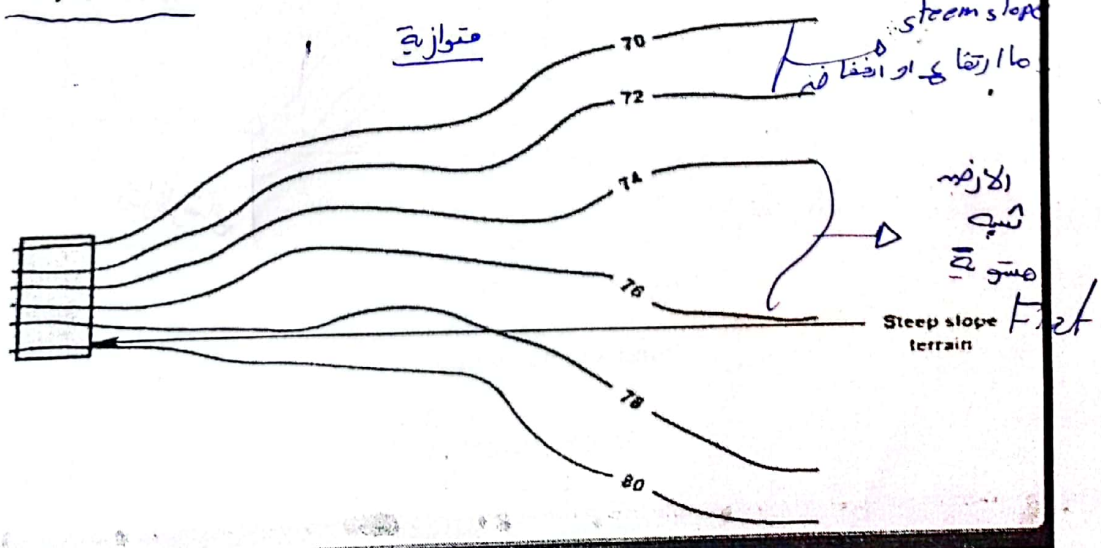
CHARACTERISTICS OF CONTOURS

The principal characteristics of contour lines which help in plotting or reading a contour map are as follows:

خطوط مغلقة

1. Contour lines must close, not necessarily in the limits of the plan.
2. The horizontal distance between any two contour lines indicates the amount of slope and varies inversely on the amount of slope.
3. Widely spaced contour indicates flat surface. مسطح
4. Closely spaced contour indicates steep slope ground.

متوازية



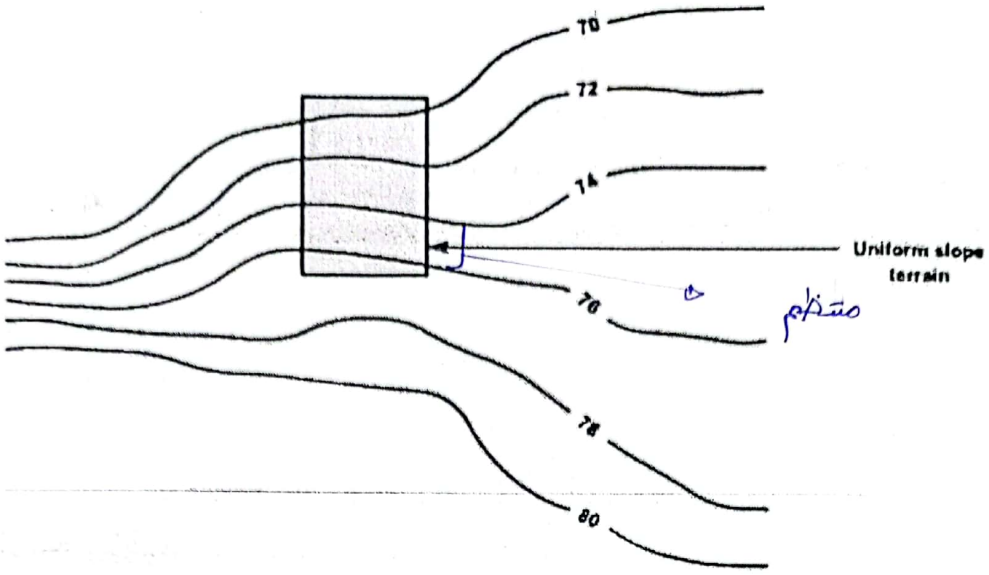
steam slope
ما ارتفاع او انخفاض

الارض شبه مستوية

Flat

الممسوحة ضوئيا بـ CamScanner

5. Equally spaced contour indicates uniform slope.



Contours of Terrain having different types of slope

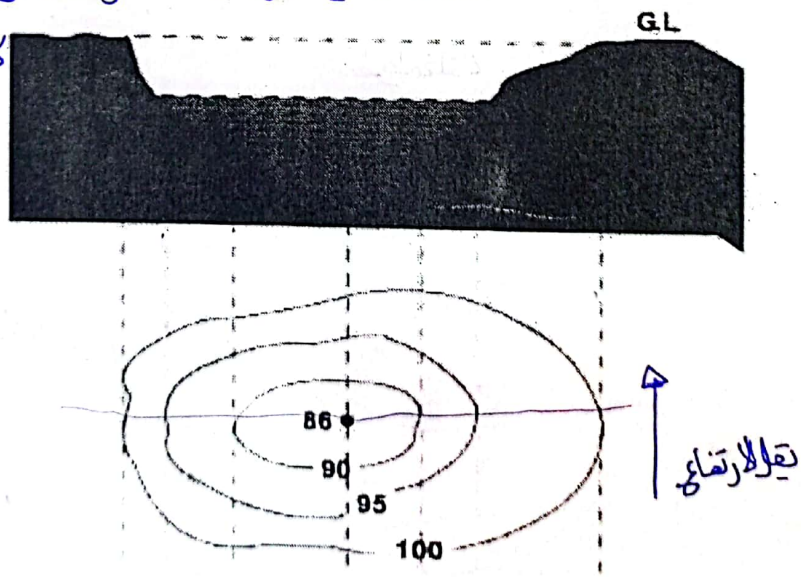
منتظم

contour showing uniform slope terrain

6. Irregular contours indicate uneven surface.

7. Approximately concentric closed contours with decreasing values towards centre indicate a pond.

خطوط تقطع مركزية (تلف حول مركز) الحلقات تنخفض (بالارتفاع)
كلما اقتربنا من مركز في تقطع
انطباع مدرج او منطقة منخفضة
بالوسط



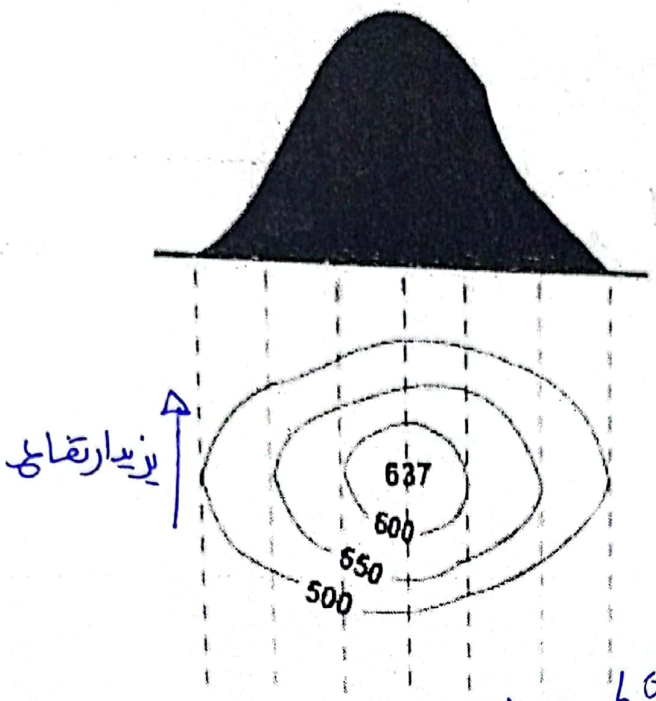
يقل الارتفاع

Pond and its contour

Pond and its contour

الممسوحة ضوئيا بـ CamScanner

8. Approximately concentric closed contours with increasing values towards centre indicate hills.

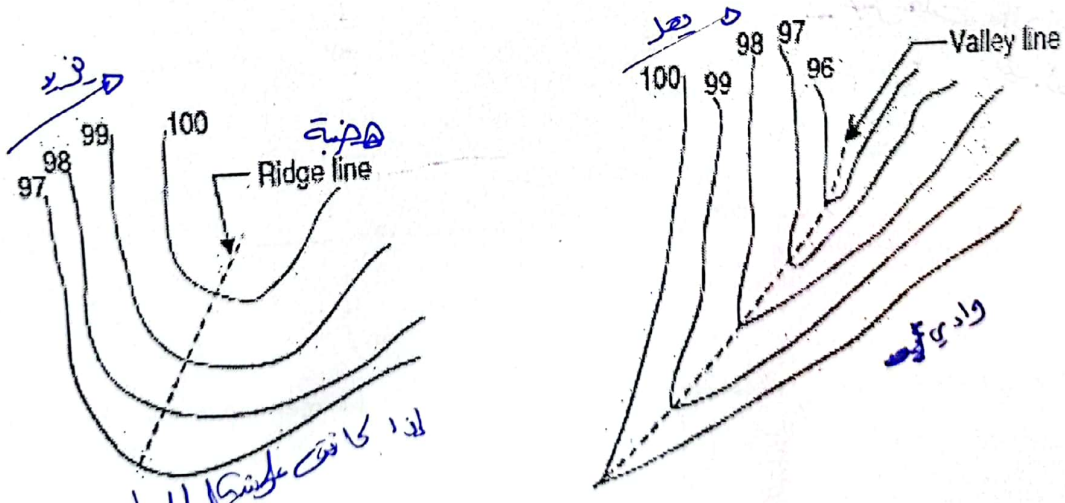


Hill and its contour

Hill and its contour

9. Contour lines with U-shape with convexity towards lower ground indicate ridge.

10. Contour lines with V-shaped with convexity towards higher ground indicate valley.

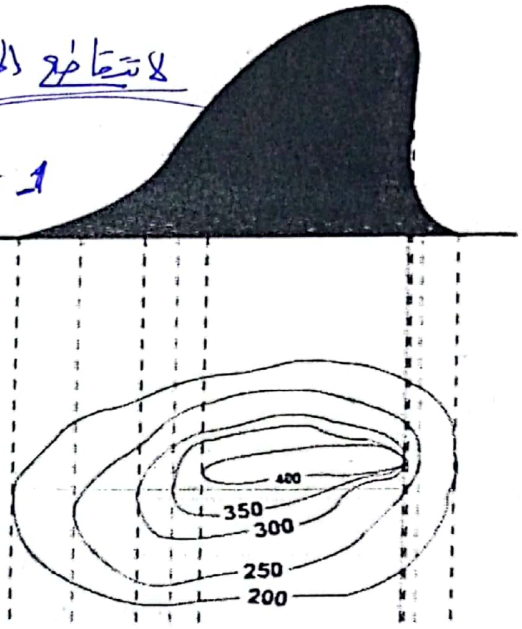


contour showing ridge line and valley line

الممسوحة ضوئيا بـ CamScanner

11. Contour lines generally do not meet or intersect each other. If contour lines are meeting in some portion, it shows existence of a vertical cliff.

لا تتقاطع الأبحاث معينة :-
1- قطع رأسي

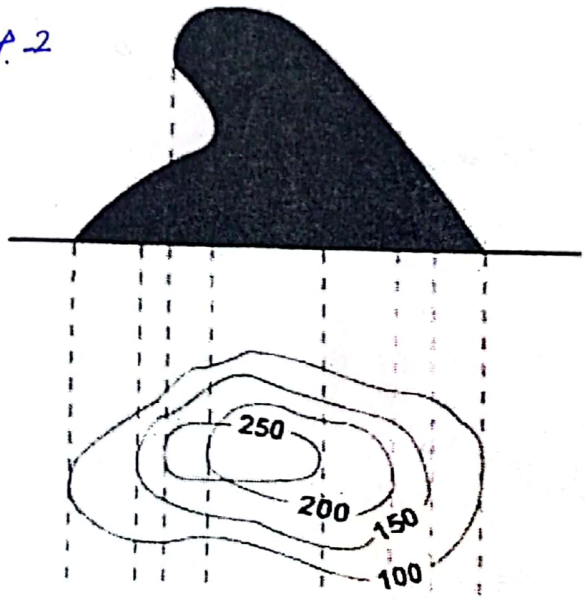


Vertical cliff and its contours

Vertical cliff and its contour

12. Contours of different elevations cannot cross each other. If contour lines cross each other, it shows existence of overhanging cliffs or a cave.

2- جرف معلق أو الحالة التي يتقاطع بها الخطوط



Overhanging cliff and its contour

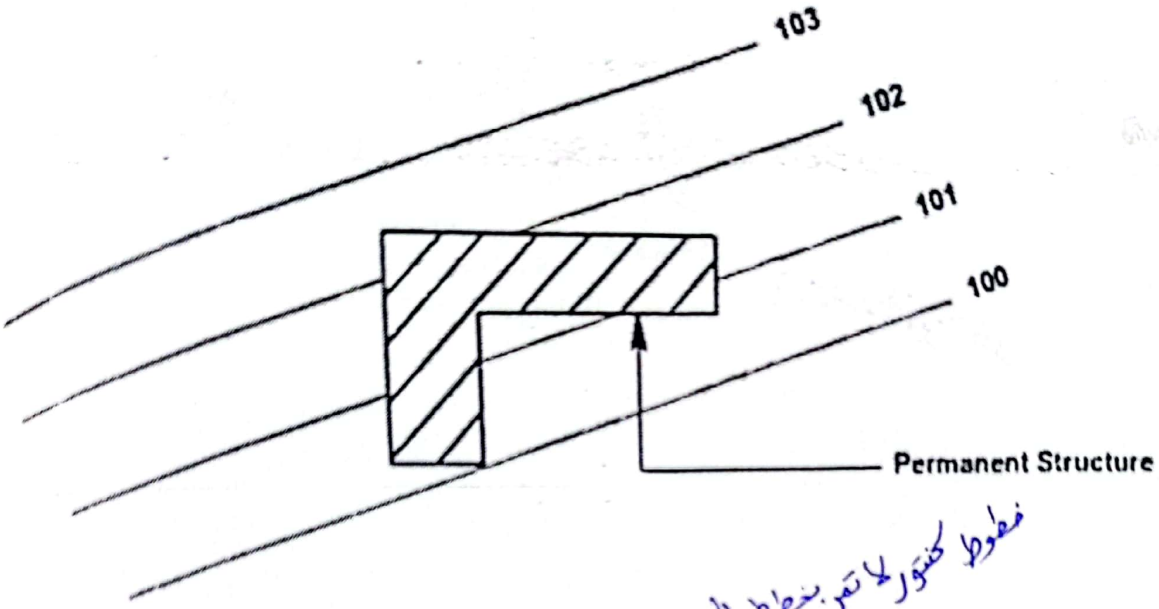
overhanging cliff and its contour

الممسوحة ضوئيا بـ CamScanner

إذا كان عندي منشأة ثابتة خطوط لا تقاطع الشكل

the steepest slope of terrain at any point on a contour is represented along the normal of the contour at that point.

Contours do not pass through permanent structures such as buildings.



خطوط كنتور لا تمر بخطوط المبنى

Contours across permanent structure

contour across a permanent structure

⇒ **Scale and precision**

1 : 100 ⇒ 1cm on map = 1 m on land
or
1" on map = 100" on land

on map (على الخارطة)

Large scale	Intermediate	Small scale
1 : 100		
1 : 200	1 : 2,000	1 : 20,000
1 : 500	1 : 5,000	1 : 50,000
1 : 1000	1 : 10,000	1 : 100,000
		1 : 200,000
		1 : 500,000
		1 : 1,000,000
		1 cm = 10 Km

على الواقع

⇒ **Field precision should be compatible with possible on map plotting precision at the designated map scale.**

Example 1.

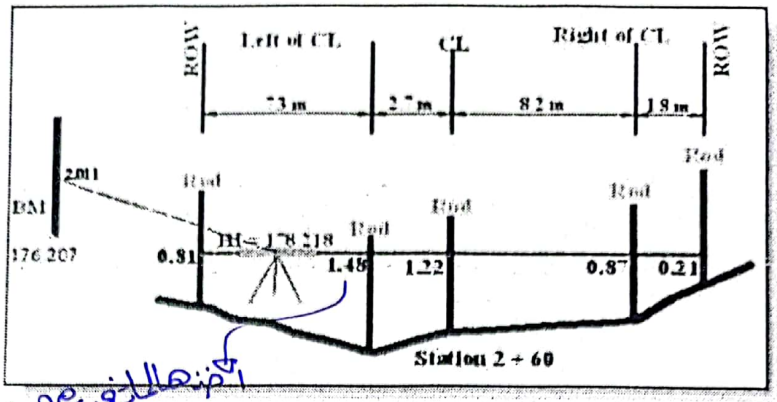
If points can be plotted to the closest 0.5 mm at scale 1:500

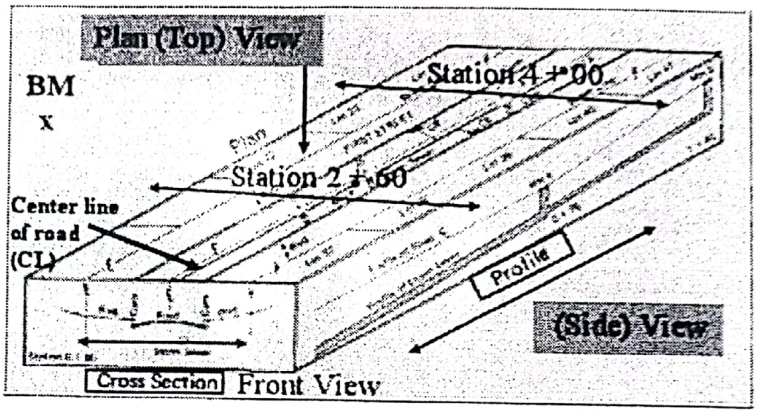
Required field precision = 0.5 * 500 mm

الممسوحة ضوئيا بـ CamScanner

Cross Sections & Profiles

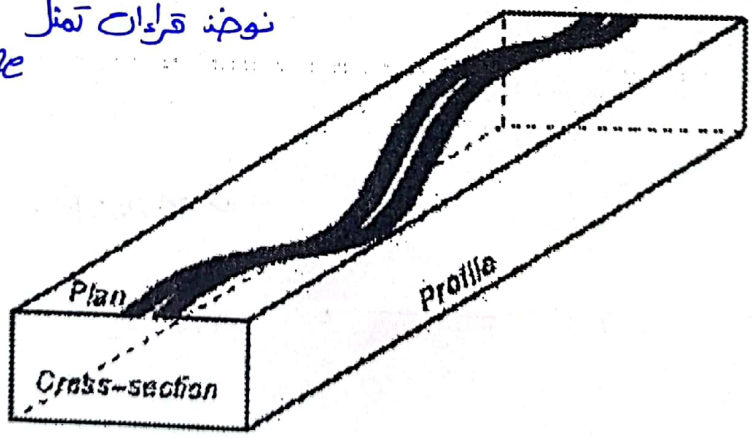
⇒ Cross section: a series of elevations taken at right angles to a baseline at specific stations.

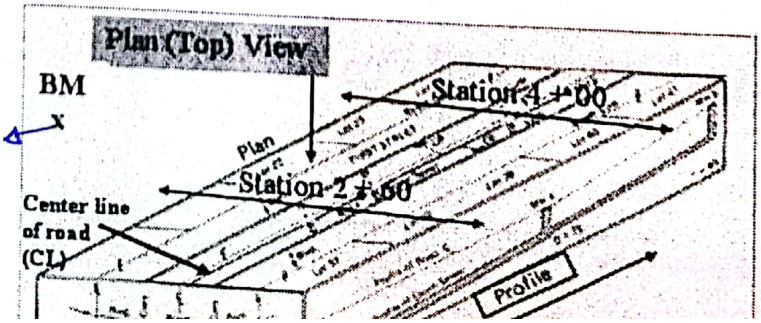




Cross Sections & Profiles

Profiles: a series of elevations taken along a baseline at some specified repetitive station interval.





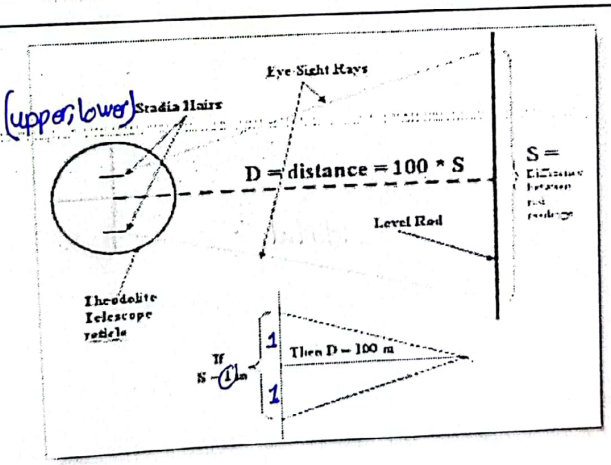
الممسوحة ضوئيا بـ CamScanner

Stadia Principles

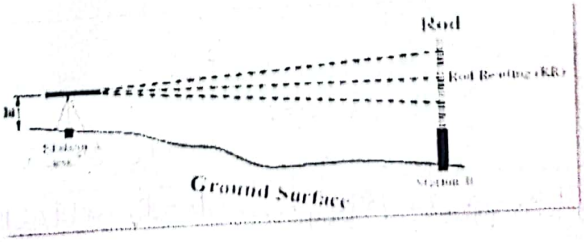
نستخدم المثلثات

- Tachometry technique (uses trigonometry calculation) to measure distances.
- Used in topographic surveys where accuracy is around 1/400.
- Uses the horizontal marks on the theodolite or level cross-hair.
- Stadia hairs are positioned in the reticle so that, if a rod is held 100m away from instrument, the difference between upper and lower stadia hairs readings on a level rod is 1m.

Stadia Principles



⇒ **Horizontal distance (D) = Rod interval (S) * 100**



- **If level or theodolite with leveled telescope in addition to the rod are used**
  - **Horizontal distance (D) = Rod interval(S) * 100**
  - **Elevation of B = Elevation of A + hi – RR**

الممسوحة ضوئيا بـ CamScanner

ال المسافة إلي بنظلعها مش شرط تكون Horizontal هي
دائماً بتكون متوازية لخط النظر (جهاز Level)

الـ 11 طرح top من bottom بعطيني مسافة متوازية لخط النظر جهاز ولضرب بـ 100

⇑ theodolite

a Measurements

s applied when the rod is
scope will be inclined
read interval.
sloped sighting must be
terval would have been if
en perpendicular to the
rod.

- **The read interval is S', while the corrected interval is S.**

$$S = S' \cos \alpha$$

فرق قراءات بين

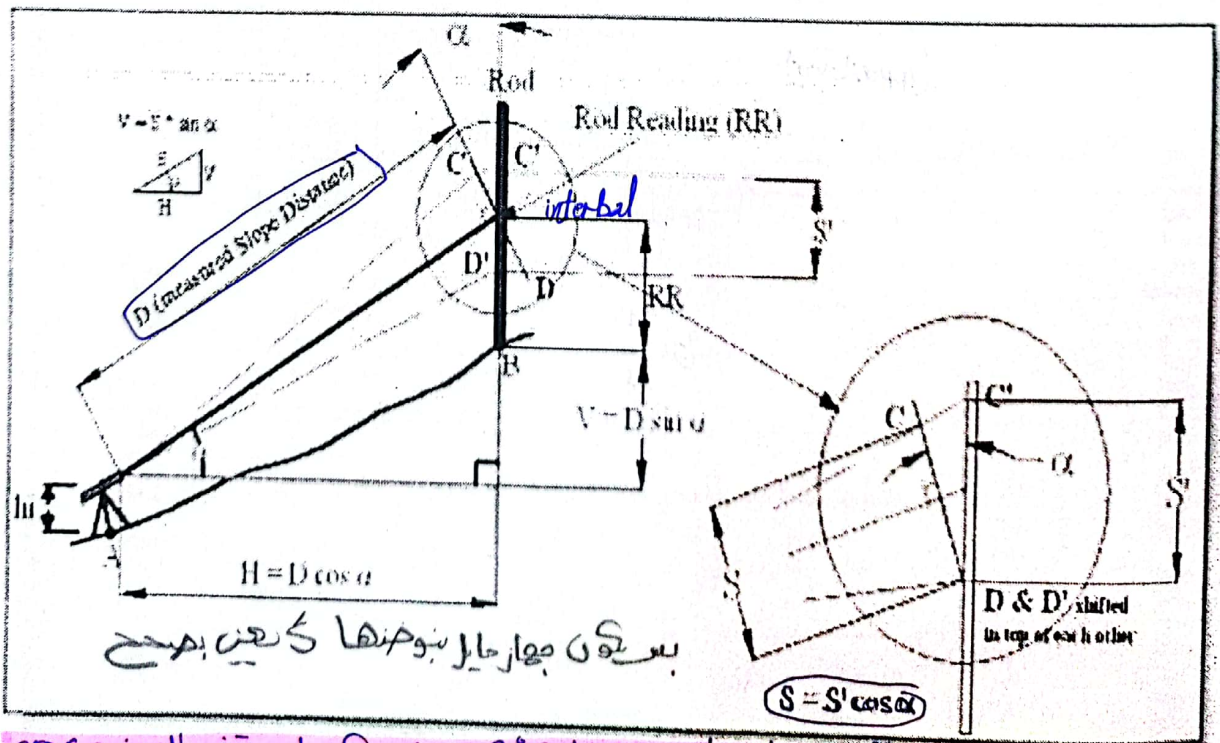
فرق قراءات في الحالة المائلة

معطى بالسؤال

upper Lower المعطاة

3
5
12

vertical angle نجيبها



بس يكون جهاز حابل بنوعها كعين بمعنى

لازم انتباه لحظة انه قراءة حابل تصنع زاوية 90° وهي لازم تكون عامودية فبطلع عندي error

الممسوحة ضوئيا بـ CamScanner

$D = 100\,S$

$S = S' \cos\alpha$

$D = 100\,S' \cos\alpha$

$H = D \cos\alpha$

$\therefore H = 100\,S' \cos^2\alpha$

$V = D \sin\alpha$

$D = 100\,S' \cos\alpha$

$\therefore V = 100\,S' \cos\alpha \sin\alpha$

$\therefore$ Elevation of B = Elevation of A + hi + V − RR

The vertical distance (V) should be taken with its sign.
i.e., if A is lower than B ⇒ the angle α is an angle of inclination (−ve) leading to (−ve) V.
i.e., if A is higher than B ⇒ the angle α is an angle of depression (−ve) leading to (−ve) V.

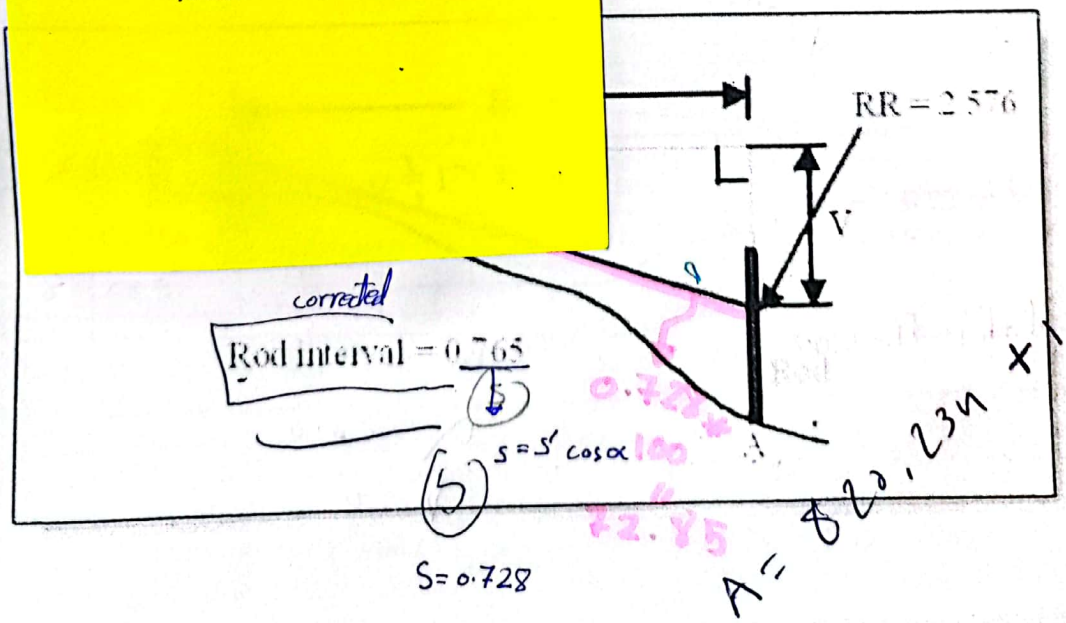
طريقة ٢

$0.728 = \cos 17°45' * 0.765$ *

$72.85 = 0.728 * 100$ = Slope

B.M + HI − V − RR ← dep ← sin α = V / 72.85 → V = 22.23 dep

Q ... in the following figure:



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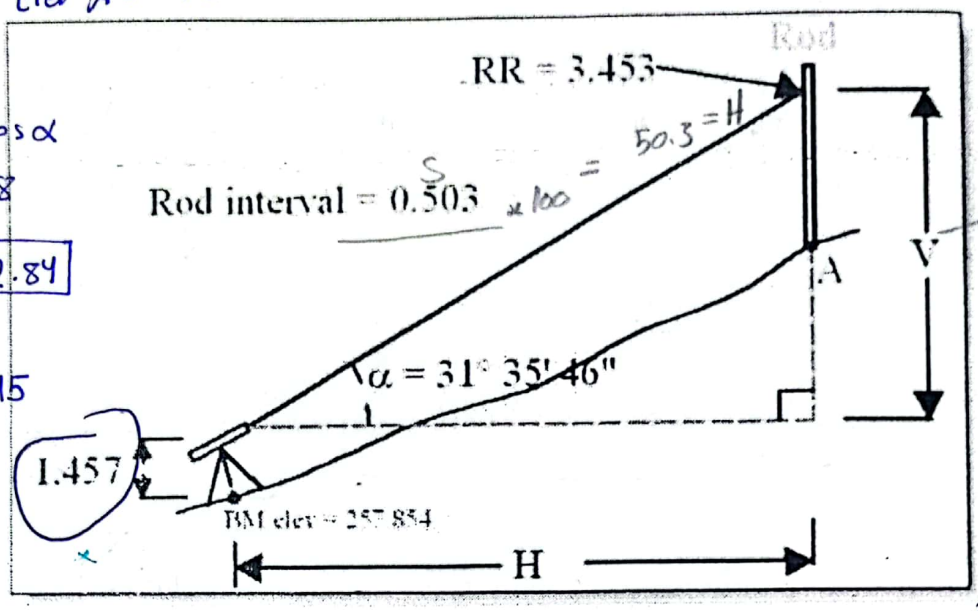
Q 2. Calculate elevation of point A in the following figure:

Elev A = HI + B.M + V - RR



S = S' cos α

S = 0.428

Slope = 42.84

V = 22.45

50.3 = H

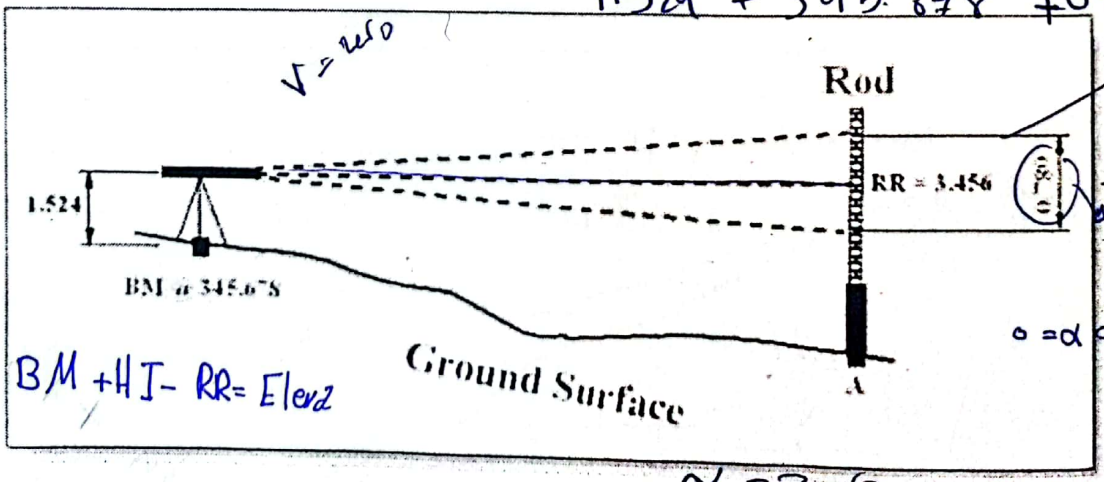
V = Δ cos α

S' sin α x cos α x cos α

Q 3. Calculate elevation of point A in the following figure:

1.524 + 345.678 + 0 +

V = zero



BM + HI - RR = Elev2

α = zero

V = 0

RR = HI

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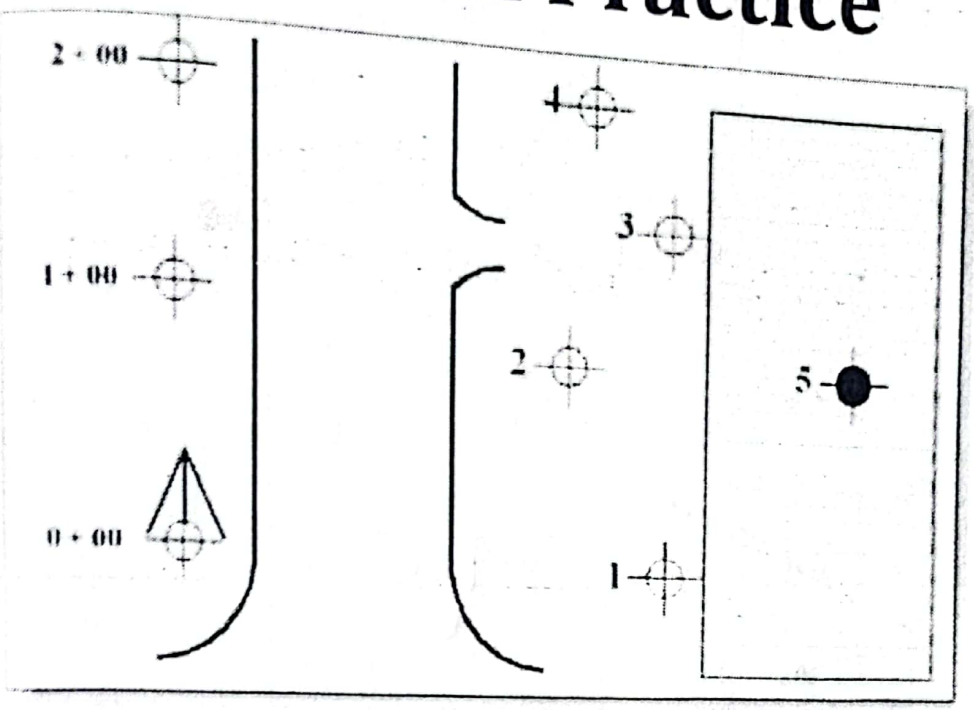
Field Practice



Q1. If the coordinates of Station 0+00 are (245.47, 348.57) find the (x, y, z) coordinates of all the stations and points shown in the above figure.

Station	Hor. Angle	Rod Interval	Ver. Angle	Hor. distance	RR	Elev. Difference	Elevation
0 + 00	Theodolite at this Station & hi = 1.55						222.32
1 + 00	0° 30'	1.002	+ 5° 36'	99.2*	1.55	9.73**	232.05♦
2 + 00	5° 20'	0.401	- 1° 24'	40.1	1.55	- 0.98	221.34
①	93° 25'	0.723	+ 5° 38'	71.6	1.55	7.06	229.38
②	73° 47'	1.245	- 7° 54'	122.1	2.03	- 16.95	204.89
③	68° 32'	2.075	- 12° 24'	197.9	1.32	- 43.52	179.03
④	35° 20'	0.224	0° 00'	22.4	2.22	0.00	221.65
⑤	80° 30'	3.123	+ 42° 24'	170.3	1.87	155.51	377.51

* $H = 100\ S' \cos^2 \alpha = 100 * 1.002 * (\cos (+ 5° 36'))^2 = 99.2$

** $V = 100\ S' \cos \alpha \quad \sin \alpha = 100 * 1.002 * \cos (+ 5° 36') * \sin (+ 5° 36') = 9.73$

♦ Elevation of B = Elevation of A + hi − V − RR = 222.32 + 1.55 − 9.73 − 1.55 = 232.05

In some table formats the RR column is omitted and if RR is equal to hi the RR value is not mentioned. If RR is not equal to hi the RR value is placed in the same cell of the Ver. angle value. (See textbook for an example).

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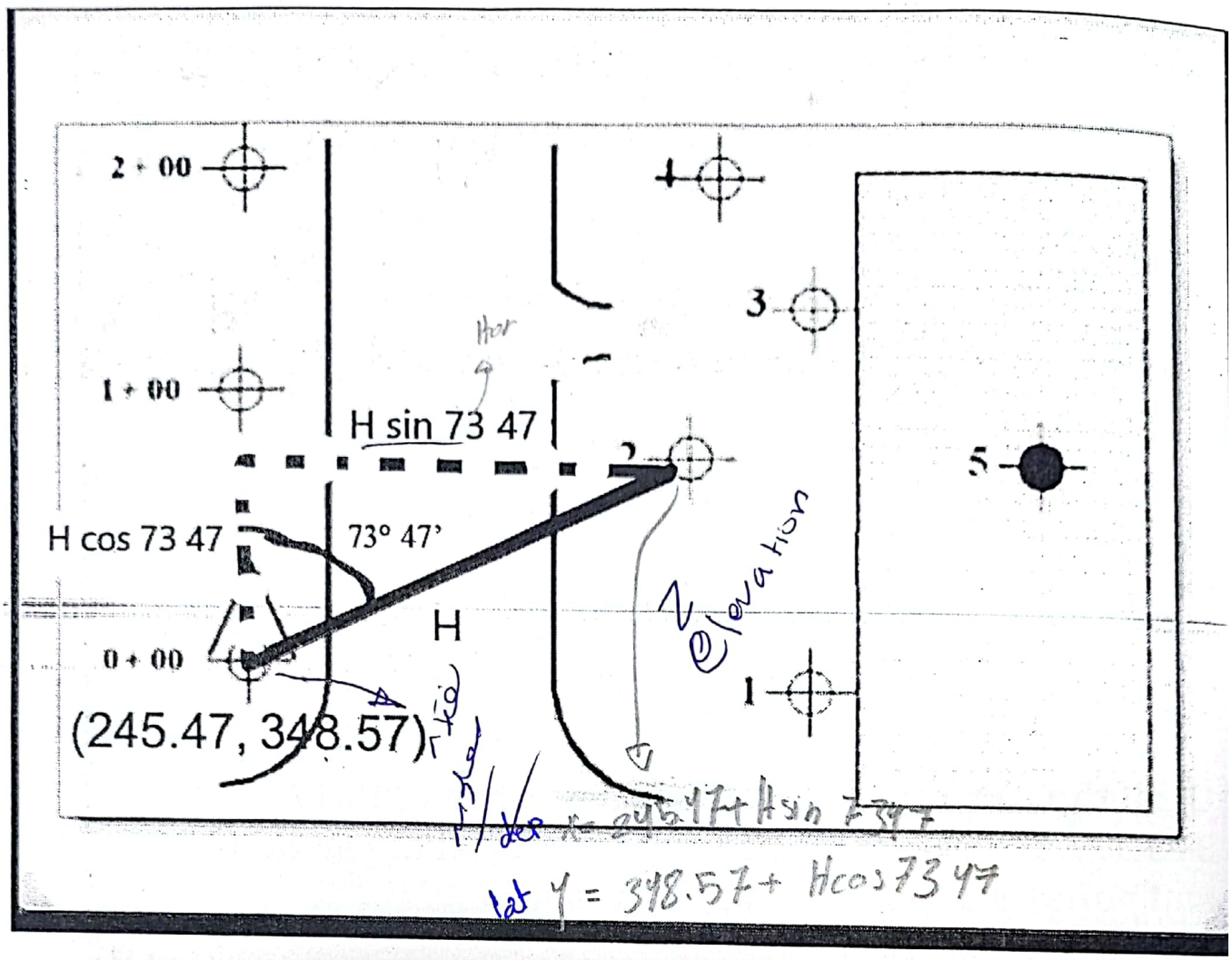

Surveying

110401365

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Dept. of Civil Engineering
The Hashemite University

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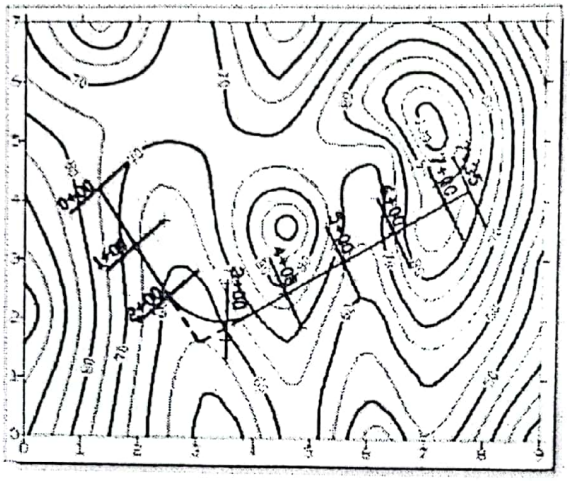
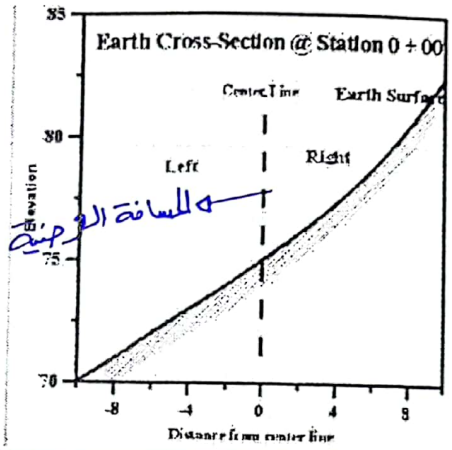
Drafting Cross Sections

Cross section: ground elevation at right angles to a proposed route.

- Used for determining quantities of cut and fill.
- Can be developed from a contour plan.



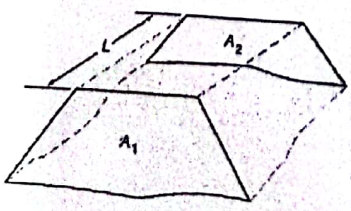
The cross-section at station 0+00 will appear like this:

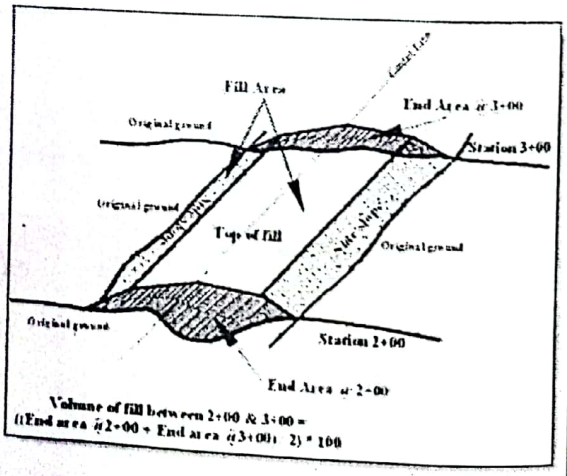


Volume Calculations

End Area Method

- Not Precise
- Cross section area = A_1
- Cross section area = A_2
- Average area = $(A_1 + A_2)/2$
- Volume = L * average area.

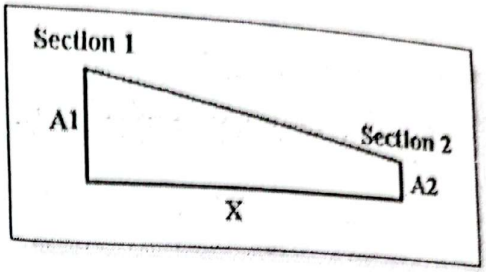




الممسوحة ضوئيا بـ CamScanner

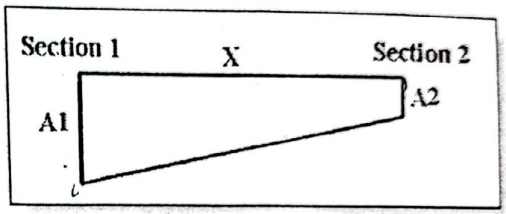
lume Calculation/ End Area Method

f successive cross sections are both cut sections ⇒



$$Volume\ of\ cut\ between\ Sec.1\ \&\ Sec.2 = \frac{A1+A2}{2} * X \quad (1)$$

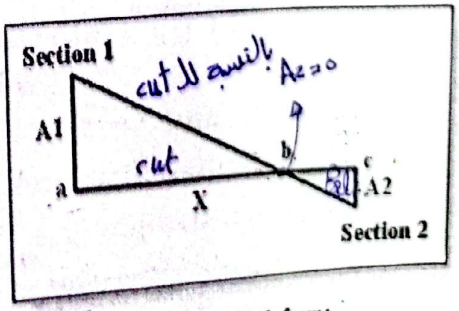
If successive cross sections are both fill sections ⇒



$$Volume\ of\ fill\ between\ Sec.1\ \&\ Sec.2 = \frac{A1+A2}{2} * X \quad (2)$$

olume Calculation/ End Area Method

If one of the successive cross sections is fill and the other one is cut ⇒



Get length of ab from:

$$\frac{A1}{ab} = \frac{A2}{X-ab} \quad (3)$$

Volume of cut = 1/2 * A1 * ab (4)

Volume of fill = 1/2 * A2 * bc (5)

الممسوحة ضوئيا بـ CamScanner

$V = L \times \frac{(A_1 + 4A_m + A_2)}{6}$

Volume Calculation/Prismoidal Formula

- Prismoid: many-sided body with two bases that are polygons in parallel planes.
- More precise than end area volume
- Good when sections are changing from cut to fill
- Usually used for expensive cut and fill operations

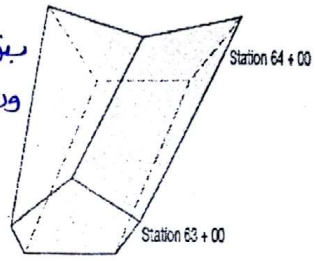
$$V = L \times \frac{(A_1 + 4A_m + A_2)}{6}$$

A_1: Face area

A_m: Middle area (at ½ L)

A_2: Back area

L: Distance between A_1 & A_2



The prismoidal formula generally gives a volume SMALLER than that found by the average-end-area formula.

METHODS OF MEASURING AREA

Both field and map measurements are used to determine area.

Field measurement methods are the more accurate and include:

1. division of the tract into simple figures (triangles, rectangles, and trapezoids),
2. coordinates, and
3. double-meridian distances.
4. Offset from a straight line.

Methods of determining area from map measurements include:

1. Counting coordinate squares,
2. dividing the area into triangles, rectangles, or other regular geometric shapes,
3. digitizing coordinates, and
4. running a planimeter over the enclosing lines.

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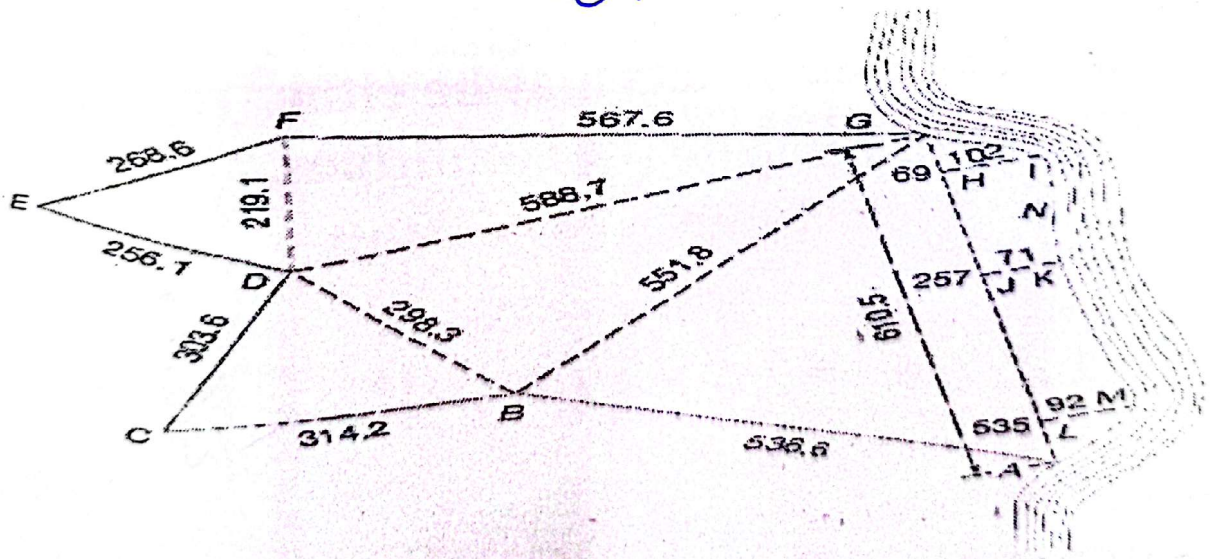
m^2	hectares	$(39.37/36)^2 \approx 1.19596$
acres	acres	$[39.37/(4.356 \times 12)]^2 \approx 2.47099$
hectares		$(4.356 \times 12/39.37)^2 \approx 0.40470$

1. AREA BY DIVISION INTO SIMPLE FIGURES

tract can usually be divided into simple geometric figures such as riangles, rectangles, or trapezoids. The sides and angles of these igures can be observed in the field and their individual areas alculated and totaled.

An example of a parcel subdivided into triangles is shown in the Figure below:

معرفة اطوال الاضلاع



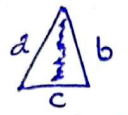
الممسوحة ضوئيا بـ CamScanner

Formulas for computing areas of rectangles and trapezoids are well known.

The area of a triangle whose lengths of sides are known can be computed by the Formula: Heron's Formula

$$area = \sqrt{s(s-a)(s-b)(s-c)}$$

where a, b, and c are the lengths of sides of the triangle and



$$s = \frac{1}{2}(a+b+c)$$

Another formula for the area of a triangle is:

$$area = \frac{1}{2}ab\sin C$$

where C is the angle included between sides a and b.

The choice of whether to use the appropriate Equation will depend on the triangle parts that are most conveniently determined; a decision ordinarily dictated by the nature of the area and the type of equipment available.

AREA BY OFFSETS FROM STRAIGHT LINES

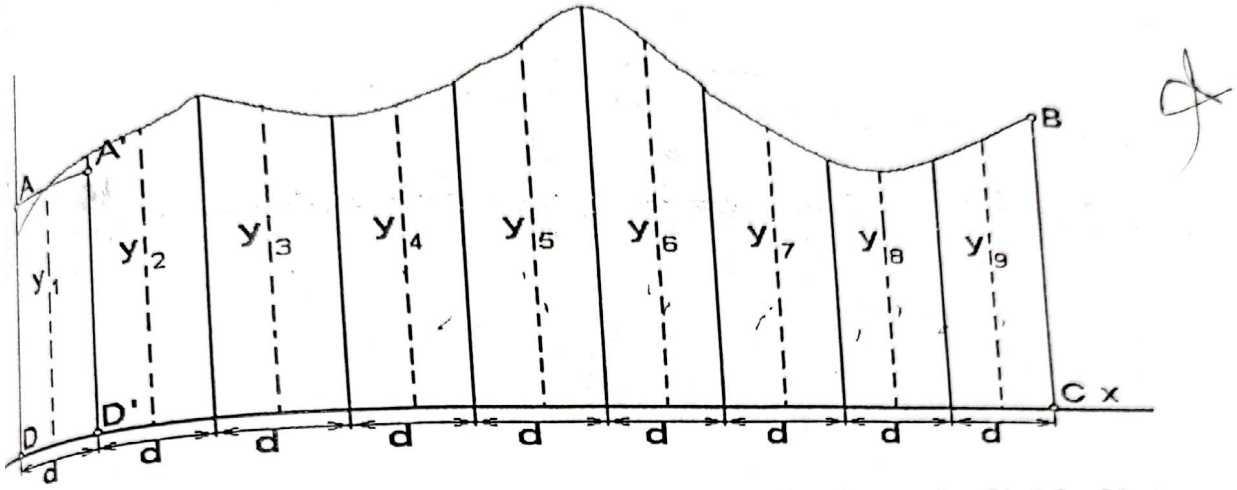
- Irregular tracts can be reduced to a series of trapezoids by observing right-angle offsets from points along a reference line.

- The spacing between offsets may be either regular or irregular, depending on the conditions.

الممسوحة ضوئيا بـ CamScanner

a. Regularly spaced offsets

1. Mid ordinates rule



d the area of ABCD of the Figure above, the base is divided into
er of equal strips width d.

th the trapezoidal rule, the greater the number of intervals used the
accurate the result.

h strip assumed to be a rectangular (see AA'D'D in figure above) and
of it is equal to base multiplied by mid-ordinate y_i.

Hence, the approximate area of ABCD is equal to:

$$\text{Area} = y_1 d + y_2 d + y_3 d + \ldots + y_n d$$

where

الممسوحة ضوئيا بـ CamScanner

A formula for calculating area for this case is:

$$\text{area} = \frac{1}{2}[a(h_0 + h_1) + b(h_1 + h_2) + c(h_2 + h_3) + \dots]$$

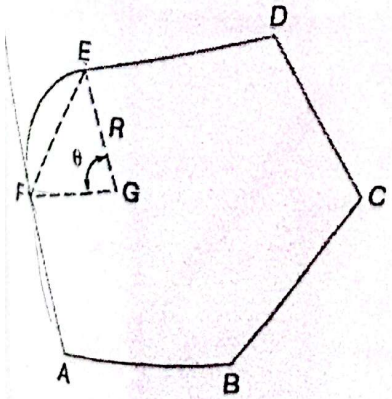
$a, b, c, \dots$ are the varying offset spaces, and $h_0, h_1, h_2, \dots$ are the observed

أزاحات

مسافات موجودة

REA OF PARCELS WITH CIRCULAR BOUNDARIES

The area of a tract that has a circular curve for one boundary can be found by dividing it into two parts:



مضلع ①

polygon ABCDEGFA and sector EGF.

②

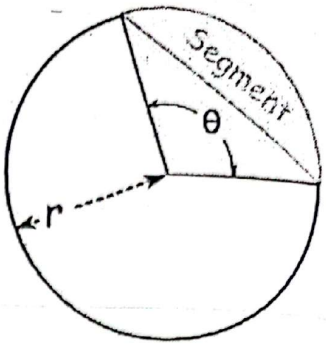
To obtain the tract's total area, the sector area is added to area ABCDEGFA found by either the coordinate or DMD method.

الممسوحة ضوئيا بـ CamScanner

$A = \pi \times r^2$

$A = (\theta/2\pi) \times \pi \times r^2$
$= (\theta/2) \times r^2$

re are using radians for the angles.



$A = \frac{1}{2} \times (\theta - \sin\theta) \times r^2$

ea of Sector = ½ × θ × r² *(when θ is in radians)*
ea of Sector = ½ × (θ × π/180) × r² *(when θ is in degrees)*

ıe Area of a Segment is the area of a sector minus the angular piece (shown in light blue here).

Area of Segment = ½ × (θ - sin θ) × r² (when θ is in radians)

Area of Segment = ½ × ((θ × π/180) - sin θ) × r² (when θ is in degrees)

$\frac{1}{2} r^2\theta$

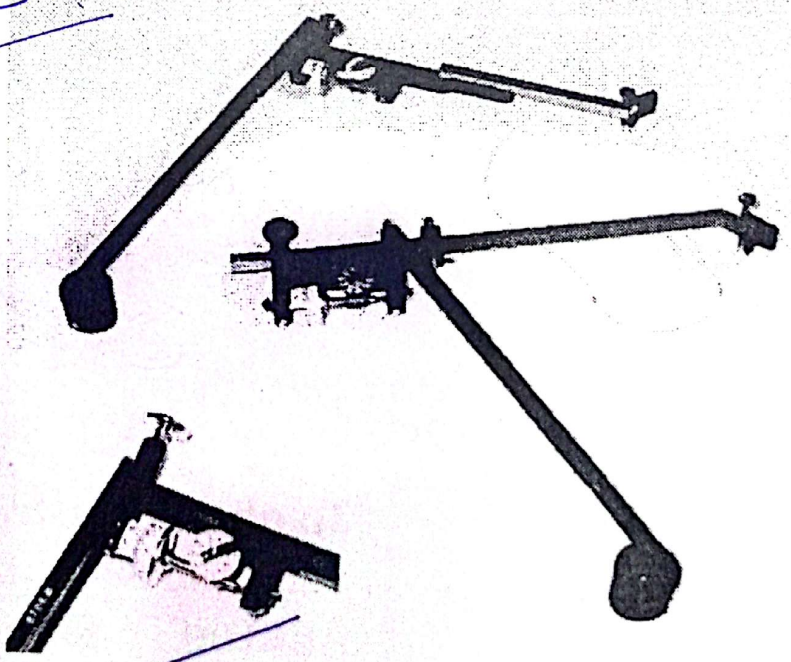
Area Calculation

1- Double meridian distance DMD

2- Coordinated method

3- Planimeter

$\frac{1}{2}(\theta - \sin\theta) \times r^2$

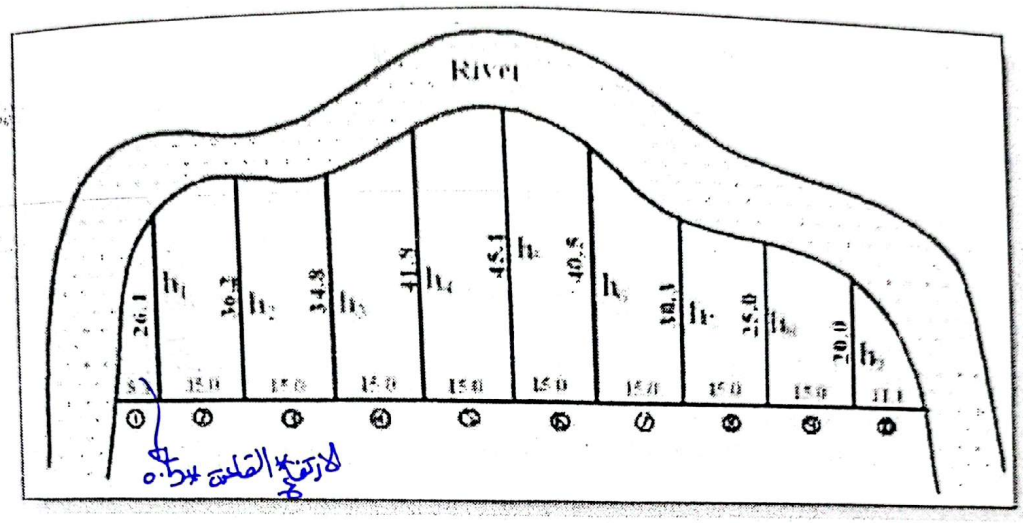


- for irregular shapes
- graphical

الممسوحة ضوئيا بـ CamScanner

Area Calculation/ Trapizoidal

- Semi irregular shapes
- Not very accurate
- Both end areas are taken as triangles
- Interior areas are considered trapezoids



مساحة مثلث

$A① = (8.1 * 26.1) / 2 = 106\ m^2$ $8.1*26.1*0.5=106$

$A Š = (11.1 * 20.0) / 2 = 111\ m^2$. $20*0.5*11.1=111$

Other areas are taken as trapezoids

مجموع الارتفاع / ارتفاع / ارتفاع قبل الاخير

$$Area = X\left(\frac{h_1 + h_n}{2} + h_2 + h_3 + \ldots\ldots + h_{n-1}\right)$$

مسافات افقية

where,

X = common interval between the lines
h = Offset measurement
n = number of offset measurements

$$Area = 15\left(\frac{26.1+20.0}{2} + 36.2 + 34.8 + 41.8 + 45.1 + 40.5 + 30.3 + 25.0\right) = 4151.25$$

$= 4136\ m^2$ 36.2

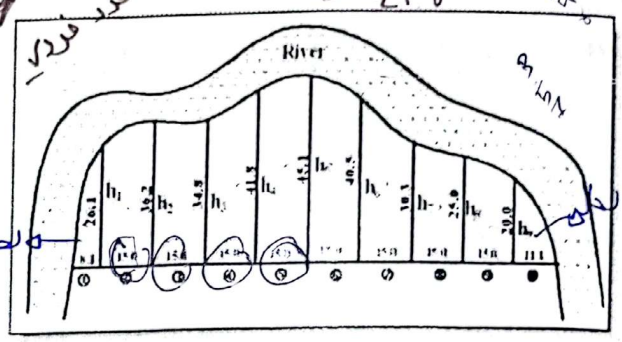
Total Area = 4136 + 106 + 111 = ~~4353 m²~~ 4368.25

الممسوحة ضوئيا بـ CamScanner

Area Calculation/ Simpson's

$$A = \frac{interval}{3}(h_1 + h_n + 2\sum hodd + 4\sum heven)$$

- For semi irregular shapes
- Assumes that an odd number of offsets is involved and that lines joining the ends of three successive offset lines are parabolic in configuration
- More accurate than Trapizoidal.
- If offsets are even then last area is calculated using trapezoidal technique



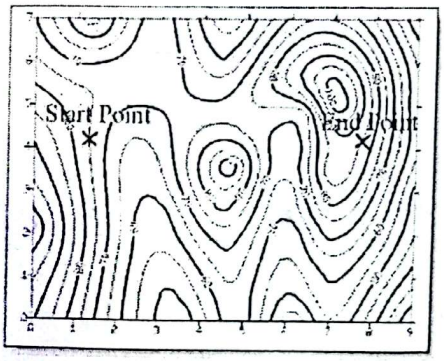
$$A = \frac{15}{3}[26.1 + 20.0 + 2(34.8 + 45.1 + 30.3) + 4(38.2 + 41.8 + 40.5 + 25.0)]$$

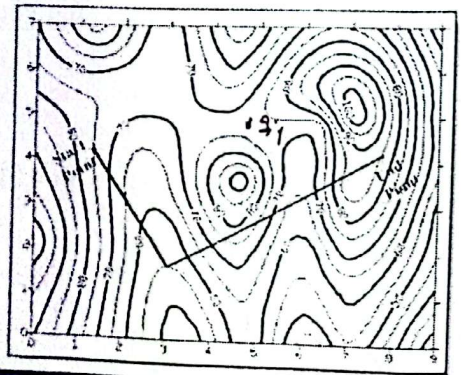
$$= 4183 \text{ m}^2$$

Total Area = 4183 ÷ 106 ÷ 111 = 4353 m^2

Complete Road Lay-Out Example

You are required to connect a road between the two marked points





1. Connect the two points with straight sections. The best section is the direct connection. Due to large differences in elevations or presence of obstacles, the connecting road might include some turns.

Shown lines are the plan of the center- line of the road.

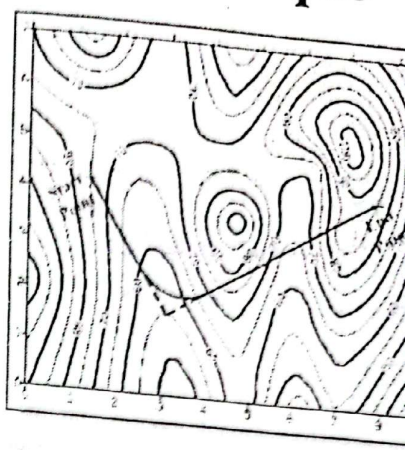
الممسوحة ضوئيا بـ CamScanner

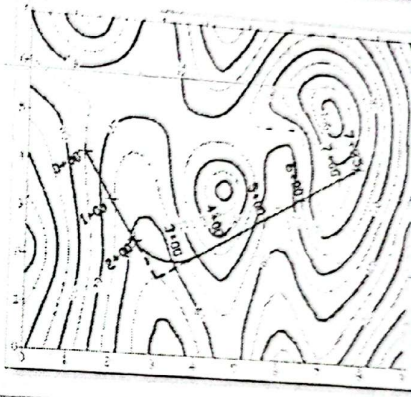
Complete Road Lay-Out Example

مخطط طريق كامل

2. Design the turns. These turns are circular horizontal curves. The minimum radius of these curves is controlled by allowable super-elevation and design speed.

لا دائرية دائرية





3. Locate the Stations.

تحديد محطة

Complete Road Lay-Out Example

4. Find the elevations of all the stations by reading them directly from the control map.

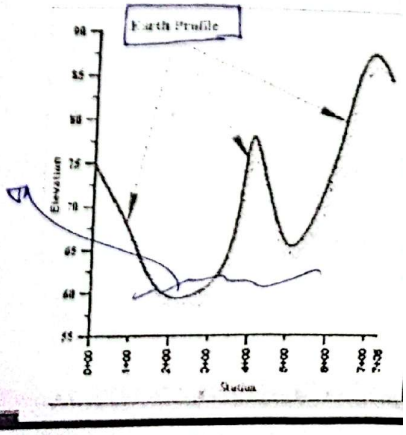
نوجد جميع الارتفاعات للمحطات التي تم تحديدها

Station	Elevation
0 + 00	75
1 + 00	66.5
2 + 00	59.5
3 + 00	61
4 + 00	78
5 + 00	65.5
6 + 00	75
7 + 00	87.5
7 + 35	84.7

Profile

5. From the obtained table, draw the earth profile of the center line of the road.

نرسم رسم تخطيطي عند شكل الطريق

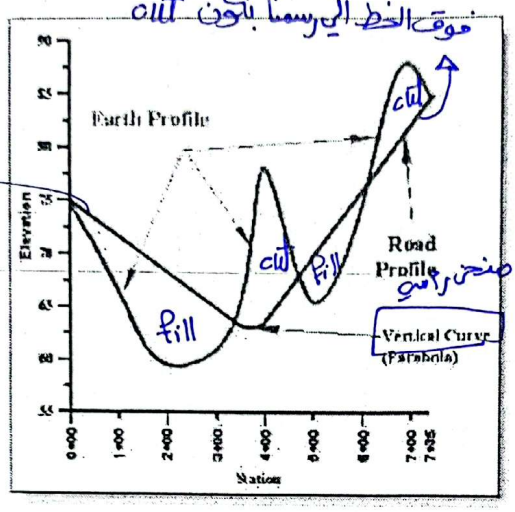


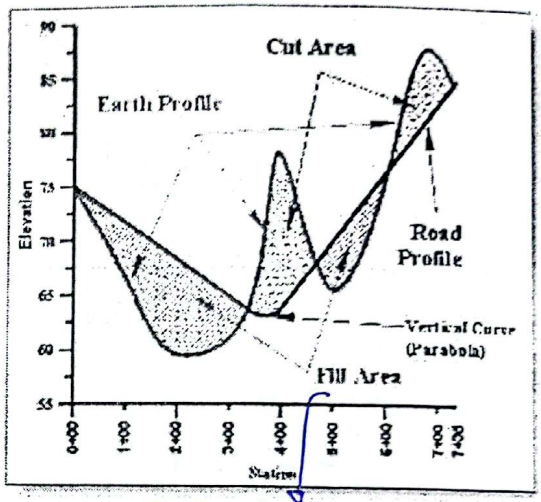
الممسوحة ضوئيا بـ CamScanner

* % of cut = % of fill

Complete Road Lay-Out Example

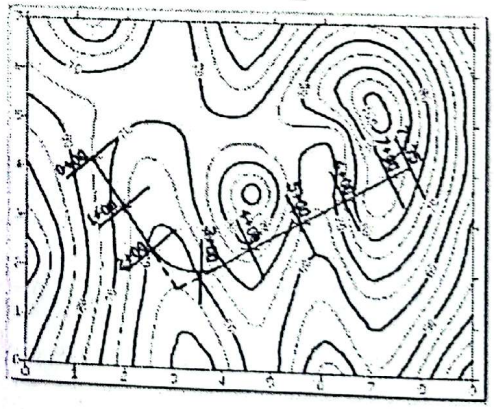
6. On the profile, connect the start and end points with straight lines. When connecting, select the connecting lines in a way to have the amount of cut to be equal to the fill amount. The slope of the lines is controlled by the maximum allowable vertical slope.



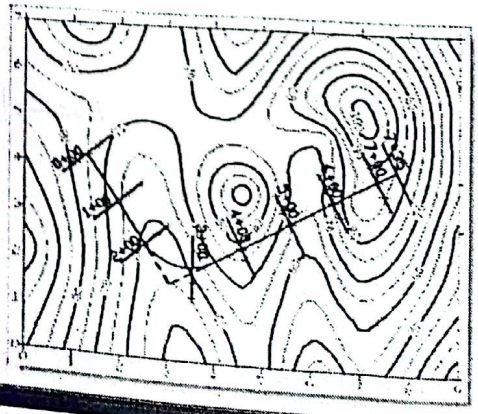


Complete Road Lay-Out Example

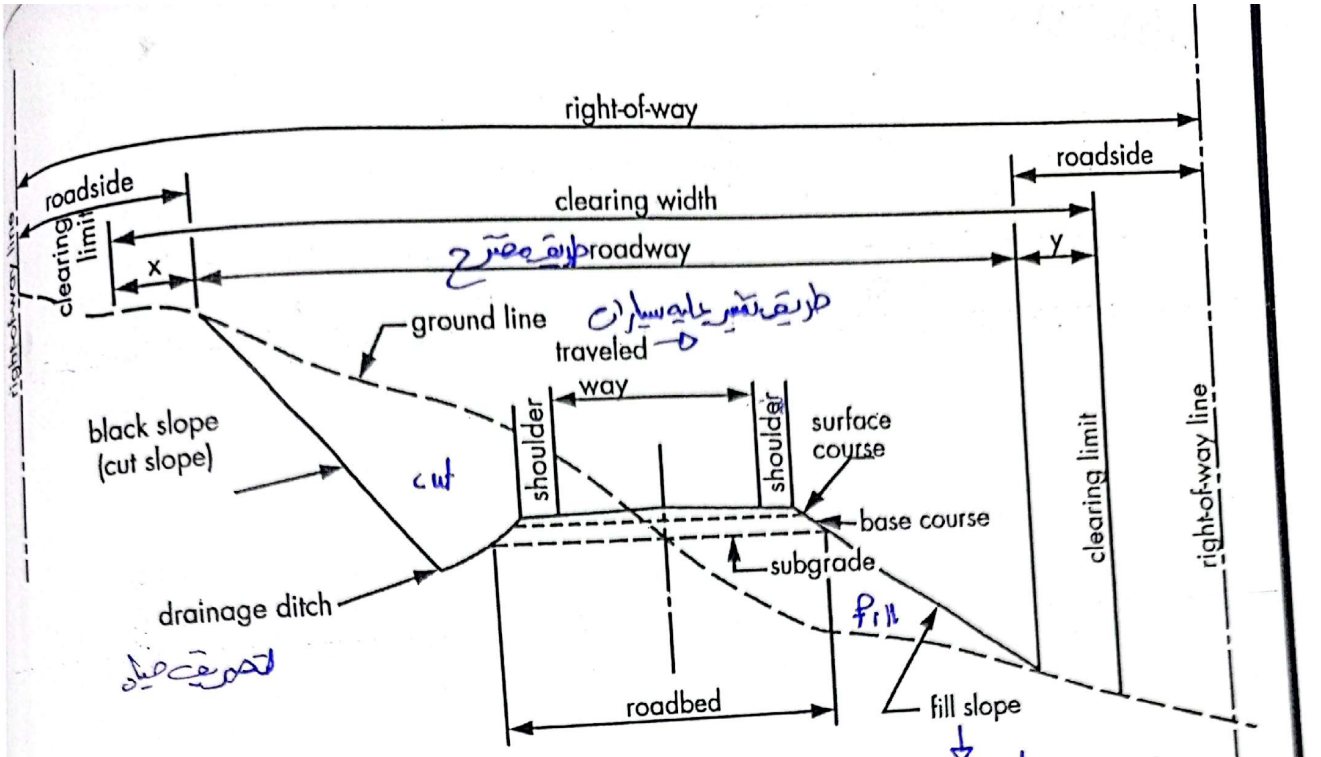
7. To get the cross section (ground elevations) at the different stations, perpendicular lines are drawn in the contour map on all the stations. The length of these lines is equal to the width of the right of way (ROW) of the road.



8. The constructed lines are divided into equal distances. Ground elevations are taken at these divisions.



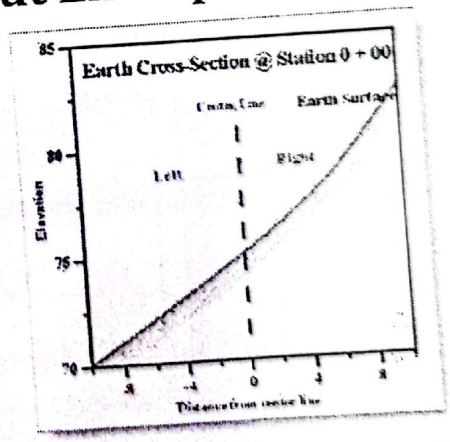
الممسوحة ضوئيا بـ CamScanner



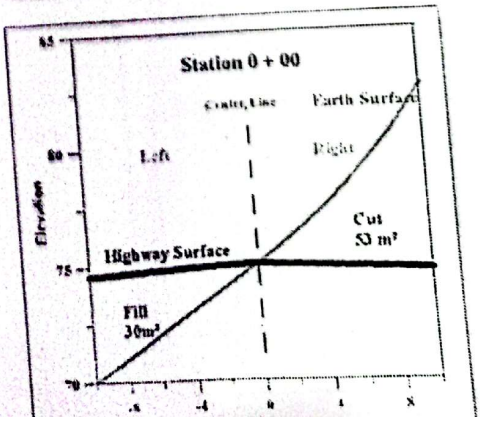
Note: Shapes and dimensions will vary to fit local conditions
See drawings for typical sections
x and y denote clearing outside of roadway

Complete Road Lay-Out Example

9. Obtained elevations at each station will be used to draw the cross sections.



10. Get the elevation of the road center-line from the road profile. Then layout the pavement cross-section on the earth cross-section for each



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ممكن إعادة استخدام

- In highway and railroad construction, excavation or cut material is used to build embankments or fill sections.

يفضل يكون كمية fill = كمية cut

- Unless there are other controlling factors, a well-designed grade line should nearly balance total cut volume against total fill volume.

- To accomplish a balance, either fill volumes must be expanded or cut volumes shrunk (Expansion of fill volumes is generally preferred).

زيادة بالأحجام التي يتم دكها

- This is necessary because, except for rock cuts, embankments are compacted to a density greater than that of material excavated from its natural state, and to balance earthwork this must be considered.

ممكن مجتمعا قبل ما تعمل compaction

- The rate of expansion depends on the type of material and can never be estimated exactly.

تقلص او زيادة يعتمد على نوع المادة

قدر نستفيد من مشاريع المجاورة

- However, samples and records of past projects in the immediate area are helpful in assigning reasonable factors.

- To investigate whether or not an earthwork balance is achieved, *cumulative volumes* are computed.

- This involves adding cut and expanded fill volumes algebraically from project beginning to end, with cuts considered positive and fills negative.

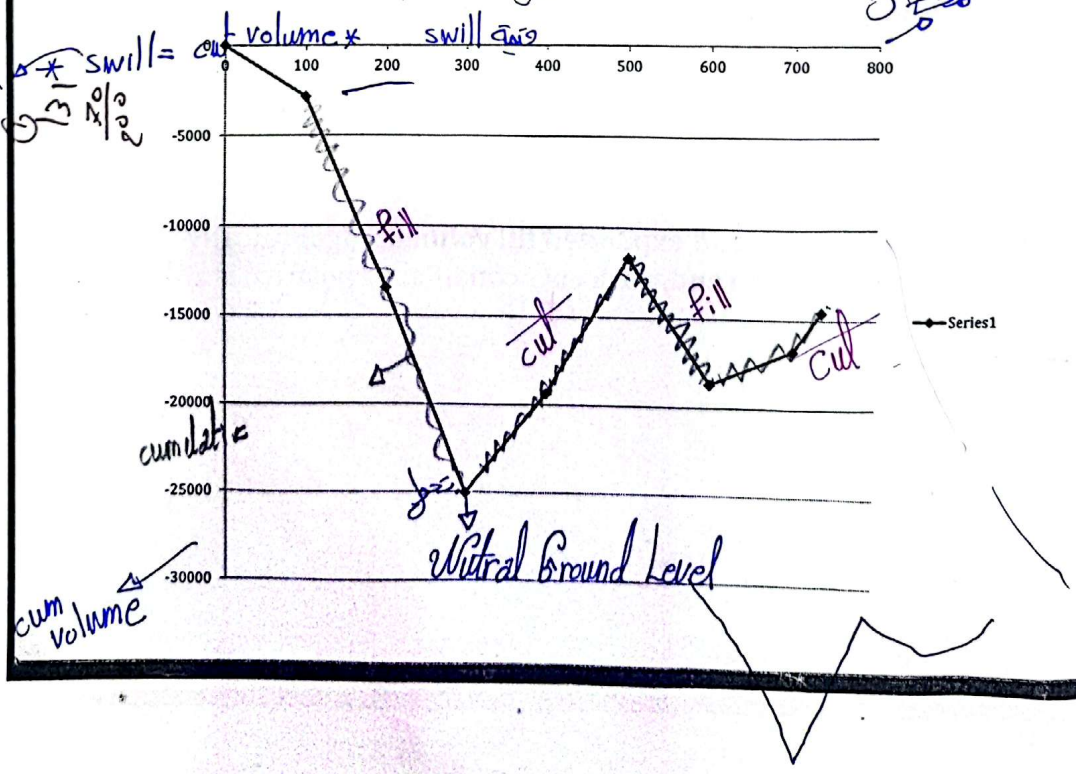
الممسوحة ضوئيا بـ CamScanner

Complete Road Lay-Out Example

11. Calculate the cut and fill areas for each cross section. Then, fill the mass diagram table.

Station	Distance	Cut Area (m2)	Fill Area (m2)	Cut Volume (m3)	Fill Volume (m3)	Shrinkage (10%) (m3)	Total Fill (m3)	Net Volume (m3)	Cumulative (m3)
0+00									0
	100	53	30	3100	-5400	-540	-5940	-2840	-2840
1+00		9	78	450	-10050	-1005	-11055	-10605	-13445
	100	0	123	350	-10850	-1085	-11935	-11585	-25030
2+00									
	100		94	10850	-4700	-470	-5170	5680	-19350
3+00									
	100	210	0	11400	-3400	-340	-3740	7660	-11690
4+00									
	100	18	68	1050	-7300	-730	-8030	-6980	-18670
5+00									
	100	3	78	6200	-3900	-390	-4290	1910	-16760
6+00									
	100	121	0	3062.5	-787.5	-78.75	-866.25	2196.25	-14563.75
7+00									
	35	54	45						
7+35									

Mass Haul Diagram



ارتفاع خط يعني fill < cut

نزول خط يعني fill > cut

Mass Haul Diagram

يعطي رسمة لا حجم الترابية بالمشروع و بوريني مسافات النقل

- Basic Definition of Mass Diagram: A graphical representation of the cumulative amount of earthwork moved along the centerline and distances over which the earth and materials are to be transported.

- Characteristics of Mass Curve: ارتفاع خط

1- Rising sections of the mass curve indicates areas where excavating exceeds fill, whereas falling sections indicate where fill exceeds excavation.

2- Steep slopes reflect heavy cuts & Fills, while flat slopes indicate areas fro small amount of earthwork.

3- The difference in ordinates between any two points indicate net excess of excavation over embankment or vise versa. فرقد بين منسوبين يعطي لكم فرق الحجم

4- Any horizontal line drawn to intersect two points within the same curve indicates a balance of excavation (cut) and embankment (fill) quantities between the two points.

5- Points of zero slope represent points where roadway goes from cut to fill or from fill to cut.

6- The highest or the lowest points of the mass haul diagram represents the crossing points between the grade line (roadway level) and natural ground level. تمثل نقاط تماس

What does a Mass Diagram tell us?

1.Mass diagrams determine the average haul, free haul, and overhaul on a given segment of roadway. امست كميات نقل لونقل كاملة

2.Mass diagrams tell the contractors and inspectors the quantity of material moved and how far it can be economically moved.

يعطي فكرة هندسية

Definitions

- Haul : the transportation of excavated material from its original position to is final location in the work or other disposal area. This is also know as authorized haul. نقل كميات من مكان طبيعي إلى مكان النقل

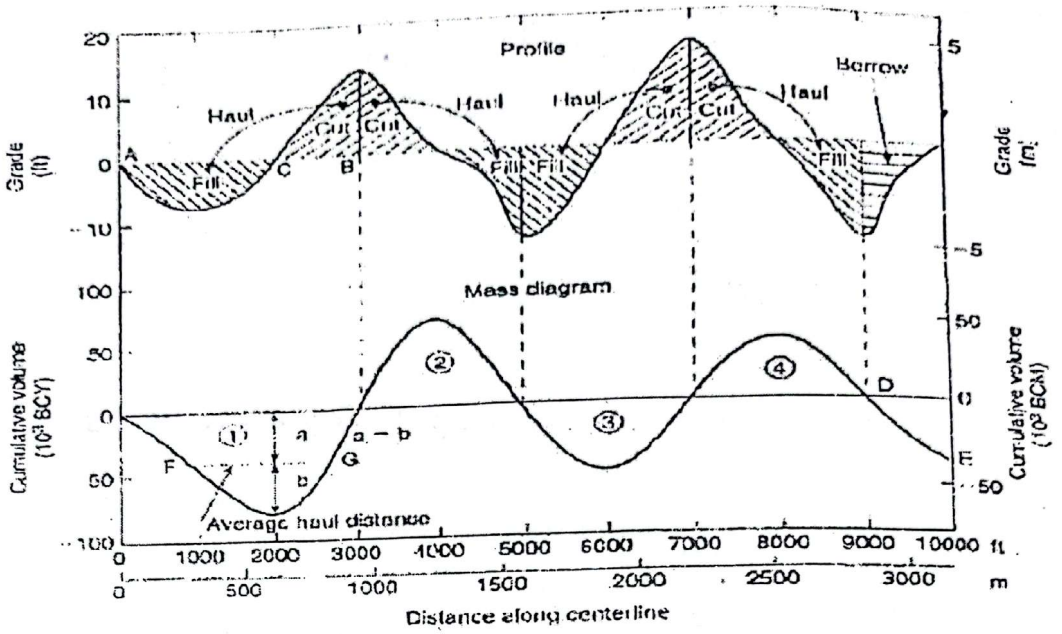
- Average haul : determined from mass diagram. Average haul is the area of the mass diagram representing the number of cubic yard stations of haul between balance points divided by the ordinate of the mass which the yardage is hauled. تمثل الحجم → التي يتم نقلها * مسافة النقل

- Overhaul : the authorized hauling of excavation beyond the specified free-haul distance. → free haul الحجم الزيادة عن

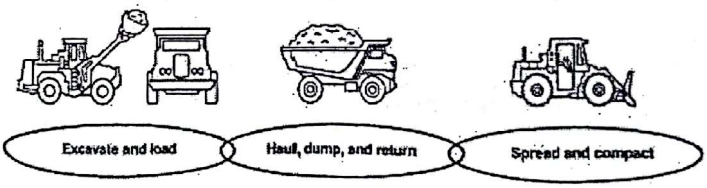
- Free haul : Average haul for project that is free. → تعويض مجانية

الممسوحة ضوئيا بـ CamScanner

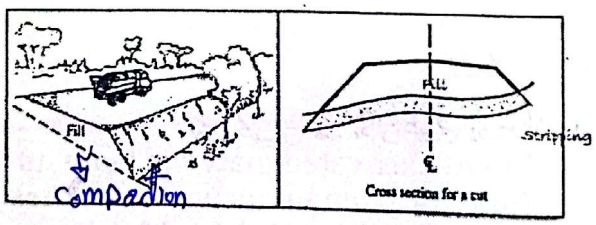
Sample Mass Diagrams



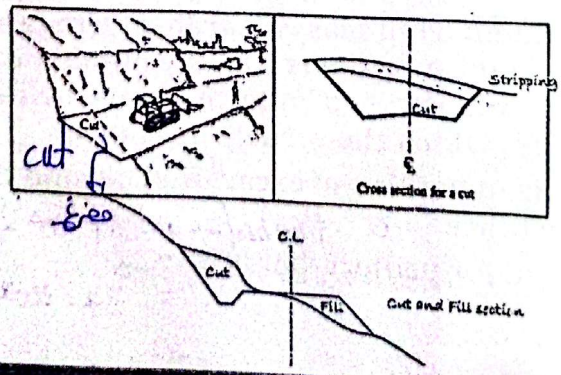
4. DISTRIBUTION OF THE ERATHWORK QUANTITIES.



Excavate and load | Haul, dump, and return | Spread and compact



The (+ve) sign indicates an excavation.



الممسوحة ضوئيا بـ CamScanner

station	Area cut	Area fill	volume cut	volume fill	corr fill	cum +
0	10 (100 المسافة)		$\frac{10+12}{2}*100$ = 1100			1100
1	12		$\frac{12+14}{2}*100$ = 1300			1400 + 1300 = 2400
2	14		$\frac{14+16}{2}*100$ = 1500		نسبة shr ثابتة = 10%	2400 + 1500 = 3900
3	16		$\frac{16+14}{2}*100$ = 1500			3900 + 1500 = 5400
4	14 (50 المسافة)		$\frac{14+0}{2}*50$ = 350	$\frac{0+10}{2}*50$ = 250	250*10% + 250 = 275	5400 + 350 − 275 = 5475
5		10		$\frac{10+16}{2}*100$ = 1300	1300*10% + 1300 = 1430	5475 − 1430 = 4045
6		16		$\frac{16+14}{2}*100$ = 1500	1500*10% + 1500 = 1650	4045 − 1650 = 2395
7		14		$\frac{14+12}{2}*100$ = 1300	1300*10% + 1300 = 1430	2395 − 1430 = 965
8		12		$\frac{12+8}{2}*100$ = 1000	1000*10% + 1000 = 1100	965 − 1100 = −135
9	50 المسافة	... 8	$\frac{0+12}{2}*50$ = 300	$\frac{0+8}{2}*50$ = 200	200*10% + 200 = 220	−135 + 300 − 220 = −55
10	12					
11	16		$\frac{16+12}{2}*100$ = 1400			−55 + 1400 = 1345

المسافة بتكون معطى ⟸

نسبة shrinkage ثابتة ⟸ 10% ⟸ soil is sand, silt or clay

نسبة swell ثابتة ⟸ 30% ⟸ stone or lime stone

الممسوحة ضوئيا بـ CamScanner

GPS نظام ملاحة تابع على الأقمار الصناعية

اسم آخر لـ GPS

- The Global Positioning System (GPS), originally Navstar is a satellite-based radionavigation system owned by the United States government and operated by the United States Space Force.

توفر معلومات عن الوقت والموقع

- It is one of the global navigation satellite systems (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

وجود الجبال والمباني يؤثر على اشارات GPS

- Obstacles such as mountains and buildings block the relatively weak GPS signals.

- Used to find the position of a point on earth (x, y, z) called Northing, Easting, and elevation.

GPS

لذلك اقل اثني نحتاج لاربع اقمار صناعية — سيتخدم لتحديد محاور (x,y,z) و time

- A minimum of four satellites must be tracked at any position to calculate the three unknowns(x, y, z) and to calculate the time difference between the satellite and receiver.

- Satellites weigh 860 Kg and span 5m, and include solar panels. They orbit the earth at 20,000 km in a period of 11 hrs and 58 min.

على 6 مدارات موزعين بحيث كل مدار 4

- The GPS consists of 24 satellites orbiting the earth in six orbits with additionally three spare satellites. Therefore, there are always at least four satellites visible at any point on earth.

عندي 24 قمر صناعي و 3 احتياط (غير 24)

- GPS satellites are Block II meaning a life span of seven years.

- Tracking stations are located at different positions on earth to

الممسوحة ضوئيا بـ CamScanner

بشكل اسرع والدقه

GPS

* كلما زاد عدد اقمار يكون تحديد موقع

- Russia has another 24 satellites (GLONASS) at an elevation of 19,100 km with an orbit time of 11 hrs15 min. GLONASS can be added to GPS devices, making more satellites available and enabling positions to be fixed more quickly and accurately, to within two meters .

- China's BeiDou Navigation Satellite System began global services in 2018, and finished its full deployment in 2020. There are also the European Union Galileo positioning system, and India's NavIC. Japan's Quasi-Zenith Satellite System (QZSS) is a GPS satellite-based augmentation system to enhance GPS's accuracy in Asia-Oceania, with satellite navigation independent of GPS scheduled for 2023

نظام معزز لزيادة الدقة

GNSS يطلق عليهم

- The combination of GPS, GLONASS, and Galileo is called GNSS (Global Navigation Satellite System).

* امريكي (الجيش) يعطي لاقرب نقطة 1cm والباقي 2cm

GPS Accuracy

- When selective availability was lifted in 2000, GPS had about a five-meter (16 ft) accuracy. The latest stage of accuracy enhancement uses the L5 band and is now fully deployed. GPS receivers released in 2018 that use the L5 band can have much higher accuracy, pinpointing to within 30 centimeters or 11.8 inches.
- The US military's GPS is still more accurate than what most of us can access. It's good to the centimetre level, because it uses two frequencies to ping between satellites and receivers, one of which is encrypted.
- GPS-enabled smartphones are typically accurate to within a 4.9 m (16 ft.) radius under open sky . However, their accuracy worsens near buildings, bridges, and trees. High-end users boost GPS accuracy with dual-frequency receivers and/or augmentation systems

ممكن عشان نزيد دقة تحديد موقع نستخدم

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GPS Receivers اجهزة الاستقبال

- A GPS Receiver is a L-band radio processor capable of solving the navigation equations in order to determine the user position, velocity and precise time (PVT), by processing the signal broadcasted by GPS satellites. جهاز استقبال يعمل على نطاق L قادر على حل معادلات مستخدم السرعة والوقت (السرعة = المسافة / الزمن)
- Any navigation solution provided by a GNSS Receiver is based on the computation of its distance to a set of satellites, by means of extracting the propagation time of the incoming signals traveling through space at the speed of light, according to the satellite and receiver local clocks. مسافة اقل يعني وقت اقل

الممسوحة ضوئيا بـ CamScanner

GPS Receivers

Receivers can be categorized by their type in different ways, and under different criteria.

- Receivers can be stand-alone, or may benefit from corrections or measurements provided by augmentation system or by receivers in the vicinities (DGPS).
- Receivers might be generic all purpose receivers or can l built specifically having the application in mind: navigation, accurate positioning or timing, surveying, et
- In addition to position and velocity, GPS receivers also provide time. An important amount of economic activit such wireless telephone, electrical power grids or financial networks rely on precision timing for synchronization and operational efficiency. GPS enable the users to determine the time with a high precision without needing to use expensive atomic clocks.

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GPS Receivers

الغرض الاولي لنظام كان عسكري

- The initial purpose of the GPS system was military but with the free availability of GPS signals and the availability of cheap GNSS receivers, the GPS technology is having a pervasive use in civil, industrial, scientific areas.
- Currently the use of GPS in Civil Applications is generalized, and it is well known that GPS Receivers have been spread very fast as well as the manufacturers dedicated to this (e.g. CSR, BroadCom, Garmin,...).

GPS Receivers

- Range in ability and cost from high precision used in surveying operations, to mapping and Geographic Information System (GIS), to marine navigation receivers, and finally to positioning and low-precision mapping and GIS receivers.

- They differ in 1) Number of satellites that can be tracked at one time. 2) Whether receiver is double frequency or single frequency receiver (L1 and / or L2), in addition can it receive code phase or carrier phase.

- Higher cost receivers are dual frequency, require shorter observation times, and can be used for real-time positioning.

- General purpose receivers track one satellite at a time. Sequencing from satellite to satellite as tracking progresses.

الممسوحة ضوئيا بـ CamScanner

∴ بشكل عام مستقبل GPS يحدد المكان والسرعة والوقت

GPS Receivers

- Most GPS receivers consist of three basic components: (1) an antenna, which receives the signal and, in some cases, has anti-jamming capabilities; (2) a receiver-processor unit, which converts the radio signal to a useable navigation solution; and (3) a control/display unit, which displays the positioning information ...

- GPS receivers can be divided into three general classes: survey-grade, mapping-grade and consumer-grade (or recreational-grade).

1- جهاز مسح 2- رسم خرائط 3- اجهزة استهلاك

الممسوحة ضوئيا بـ CamScanner

أنواع الرسيفر:-

تركيز ⇩ مقارنة

Satellite Signals

- Satellites generate two codes:
  - - Coarse Acquisition (C/A) available to the public. متاح للعام
  - - Code designed mainly for the military use exclusively. عسكرياً
- Two types of carrier waves (L1 and L2) at two different wave lengths carry these codes.
- Receivers can use carrier phase measurement and / or code measurement. Carrier phase measurement is more accurate than code measurement.

قياس طور الموجة أدق

- Accuracy of the receivers increases by the increase in number of measurements and frequencies.

تزداد دقة مستقبلات بزيادة عدد قياسات والتردد

الممسوحة ضوئيا بـ CamScanner

Position Measurements

تحديد موقع نقطة واحدة

- **Single Point Positioning: uses one GPS receiver to track satellite code signals.**

تحديد موقع نسبي

- **Relative Positioning: employs two GPS receivers to track satellite signals to determine baseline vector (DX, DY, and DZ) between both stations. Data should be collected from both receivers by the same set of satellites simultaneously.**

نجمع D_x و D_y و D_z

وقت واحد

- **Differential Global Positioning System (DGPS): uses two or more GPS receivers to track the same satellites simultaneously. At least one receiver must be set up at a station of known coordinates. Therefore, it consists of one base receiver with radio and a set of rover receivers in a radius < 15 km.**

يعطي دقة أعلى ← Double ← ×

يكون Double أو أكثر ← frequency

الممسوحة ضوئيا بـ CamScanner