

Eng.Jehad Yosef Obaid

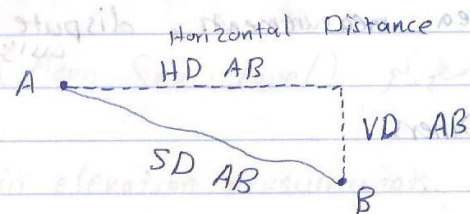
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Jehad_obaid@hotmail.com

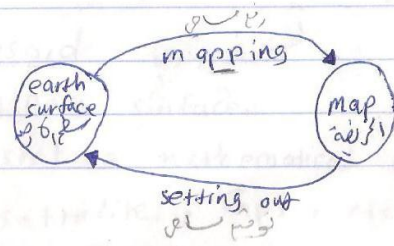
* Surveying is a science and art of taking earth measurements for mapping and setting out purposes [Geomatics]

* earth measurements include:

- ① Distances
Horizontal + Vertical + sloped
- ② elevations
Vertical distance
- ③ Angles
Horizontal or Vertical



* Surveying works either mapping or setting out



* Surveying Importance : أهمية المساحة

① important in making plans or maps associated with Engineering works (Civil, Architect, builder, town planner, etc.)

② important for other fields such as for military, geographical, geological, agricultural, etc.

③ locating and describing the property boundaries between neighbours for area measurements, dispute resolution, etc.

④ Others.

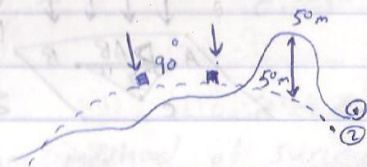
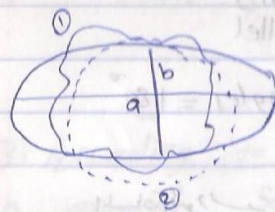
* Earth Surface : سطح الأرض

① Natural earth surface : السطح الطبيعي

- actual.

- very important (all survey measurements are taken on it)

* irregular.



② Geoid (Mean Sea level) : متوسط سطح البحر

- actual.

- used in elevation measurements.

- $\perp$ to the gravity direction.

* irregular. غير منتظمة

③ Ellipsoid : السطح البيضاوي

- imaginary surface.

- represent a mathematical model.

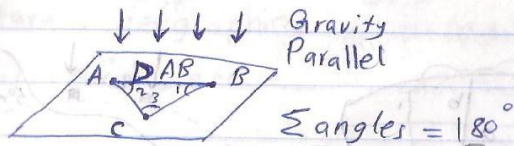
- in satellites, Gps, etc applications.

* Surveying Types : أنواع المساحة

1) According to the size of survey : حسب حجم المساحة

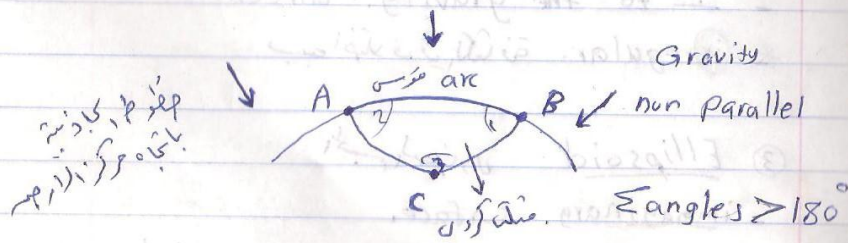
a. Plane Surveying : المساحة المستوية

- for survey size $A \leq 50 \text{ km}^2$
- consider flat surface. نعتبر سطح مستوي
- neglect curvature. نهمش انحناء الأرض



b. Geodetic Surveying : المساحة الجيوديسية

- for $A > 50 \text{ km}^2$
- Consider Curvature. نعتبر انحناء الأرض
- $50 < A \leq 500 \text{ km}^2 \rightarrow$ earth is sphere.
- $A > 500 \text{ km}^2 \rightarrow$ earth is ellipsoid.



المساحة حسب الغرض

2) According to the purpose of survey : حسب الغرض

- Land (cadastral) surveying. المساحة العقارية
- Topographic. الطبوغرافية
- Route. الطرق
- Hydrographic. الهيدروغرافية
- construction. البناء
- Mine. المناجم

طرق المساحة

3) According to the method of survey : حسب طريقة المساحة

- ground Surveying : المساحة الأرضية
 - measurements taken with physical contact with earth surface.
- photogrammetric Surveying : المساحة الفوتوغرافية
 - no physical contact.
 - from sensors on satellites, balloon, aircrafts, etc.

Units

① Distances: المسافات

→ Metric: m, km km = 10^3 m
km = 1000 m

→ British: in, ft, yard, Mile

✓ ft = 12 in 1 ft = 12 in

✓ yard = 3 ft

✓ Mile = 1760 yard = 5280 ft

✓ ft = 0.3048 m

✓ in = 2.54 cm

② Areas: المساحات

→ Metric: m^2 , km^2 , Donum = $1000m^2$,
hectare = 10 Donum = $10,000m^2$

→ British: ft^2 , $Mile^2$, acre 1 acre = $43560 ft^2$

4.5 acre = ?? Donum

ft = 0.3048 m
 $ft^2 = 0.09290 m^2$

$43560 ft^2 = 43560 \times 0.09290 m^2$
 $43560 ft^2 = 4046.724 m^2$
acre = $4046.724 m^2$

18.210 Donum

4.5 acre = $4.5 \times 4046.724 m^2$

4.5 acre = $18210.258 m^2$

4.5 acre = 18.210258 Donum

③ Angles الزوايا

→ Degree: 120° , $18'$, $35''$
 $1^\circ = 60' = 3600''$

→ rad: $2\pi = 360^\circ$

⇒ Scale

① Large scale: 1:10 - 1:20 - 1:50 → 1:100

② Medium scale: 1:500 - 1:1000 → 1:2500

③ Small scale: 1:25000 - 1:100,000 → 1:1,000,000

Geodesy - mapping

القياس، الخرائط

المساحة المستوية فضاء ثنائي الأبعاد
الأطوال ولم تعد موجودة

Chapter 3

Chain Surveying (Tape Surveying)

المساحة باستعمال شريط القياس (النكر)

⇒ Methods:

- pacing



- chaining



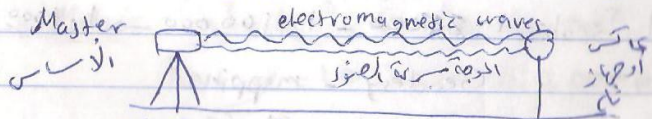
- Taping



- Tacheometry

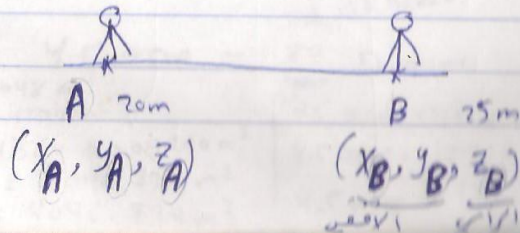
قياس الأطوال باستعمال جهاز قياس الزوايا
Theodolite

- EDM [Electronic Distance Measuring]



$$D = \frac{1}{2} \frac{c}{f} \quad \text{سرعة الضوء}$$

- GPS [Global Positioning System]



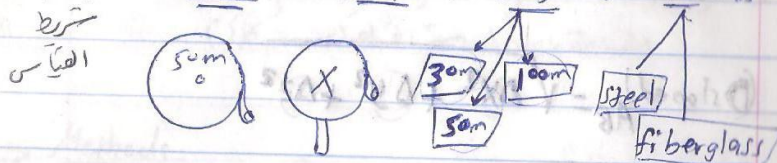
$$(D_H)_{AB} = \sqrt{\Delta x^2 + \Delta y^2}$$

$$(D_{sloped})_{AB} = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}$$

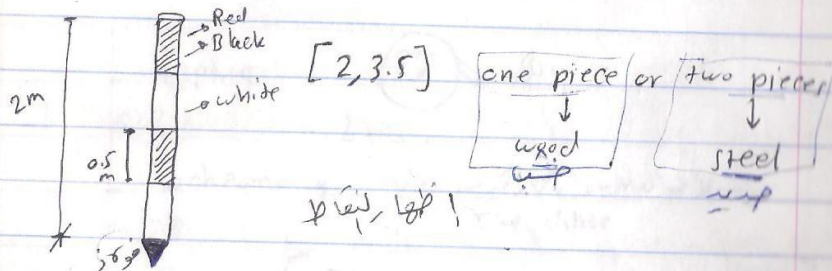
$$\Delta H = \Delta z \quad \text{الارتفاع في عمق}$$

* Linear Measuring Equipment:

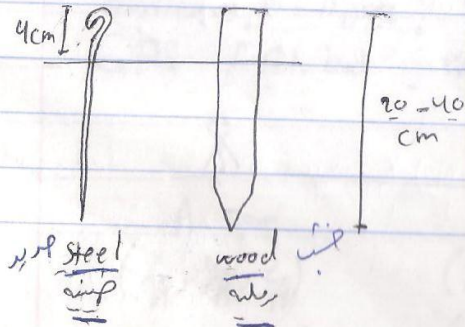
[1] Tape: Different shapes, lengths, materials



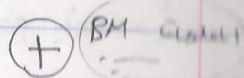
[2] Ranging Rods:
السواقي



[3] Arrows and Pegs

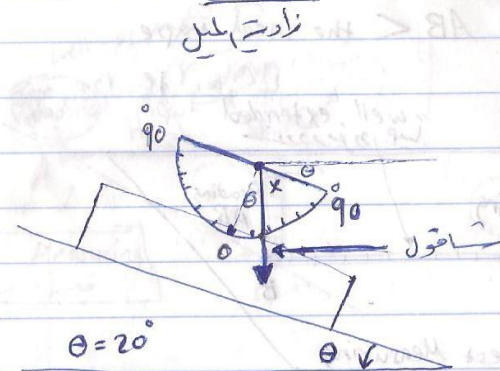


[4] Marking
الفرجة لاقت



[5] Clinometer or Aloney level

- Measuring the slope angle of inclined surfaces.

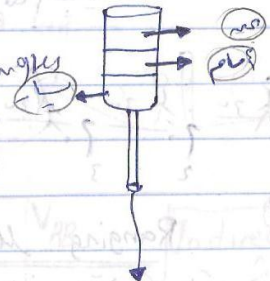


[6] prisma

- optical square

setting out

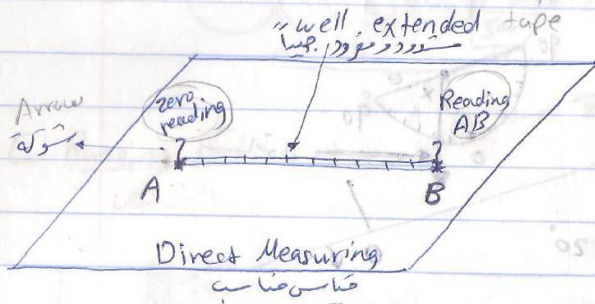
perpendicular angles



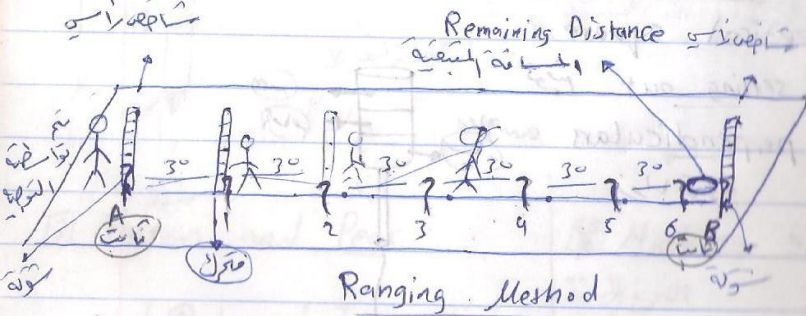
→ Measuring Process:

1] For Flat Area:

a. when $AB < \text{the used tape}$



b. when $AB > \text{the used tape (length)}$

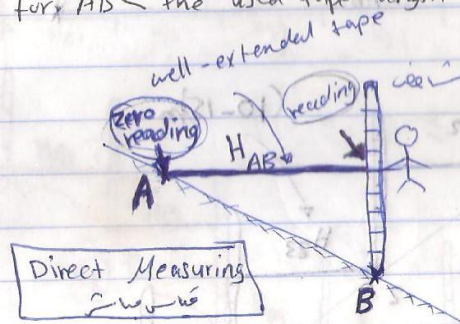


طريقة توبية (الرanging) بالأسلاك والعمود

$$\begin{aligned} \rightarrow D_{AB} &= \# \text{ of median arrows} \times \text{tape length} + \text{Remaining Distance} \\ &= 6 \times 30 \\ &= 190 \text{ m} \end{aligned}$$

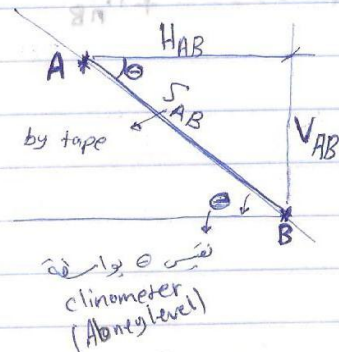
2] For Uniformly Sloped Area:

a. for $AB < \text{the used tape length}$



OR

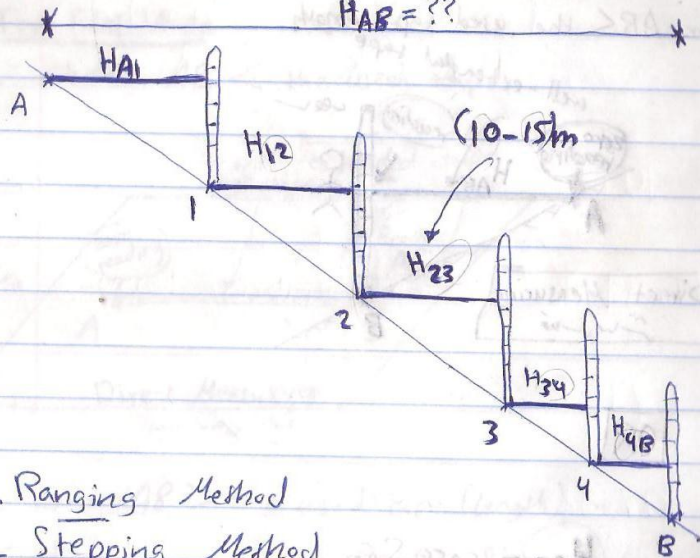
$$\begin{aligned} H_{AB} &= \cos \theta S_{AB} \\ V_{AB} &= \sin \theta S_{AB} \end{aligned}$$



Indirect Measuring
طريقة غير مباشرة

b. for $AB >$ the used tape length.

$H_{AB} = ??$

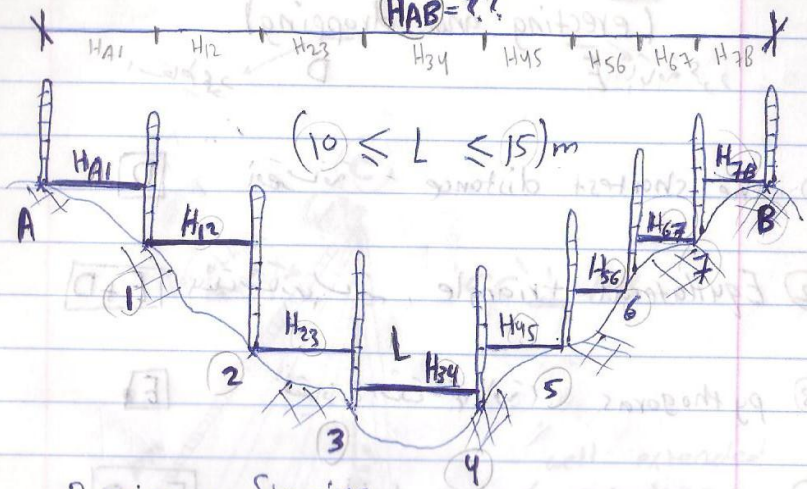


- Ranging Method
- Stepping Method

$$H_{AB} = H_{A1} + H_{12} + H_{23} + \dots + H_{nB}$$

③ For Uneven Ground.

$H_{AB} = ??$



Ranging + Stepping

$$H_{AB} = H_{A1} + H_{12} + H_{23} + \dots + H_{nB}$$

نومنا زوايا قائمة

⇒ Setting Out Perpendiculars : من مسترنا فقر (erecting and dropping)

E كامة عمود D اسقاط عمود

① the shortest distance اقصا مسافة D

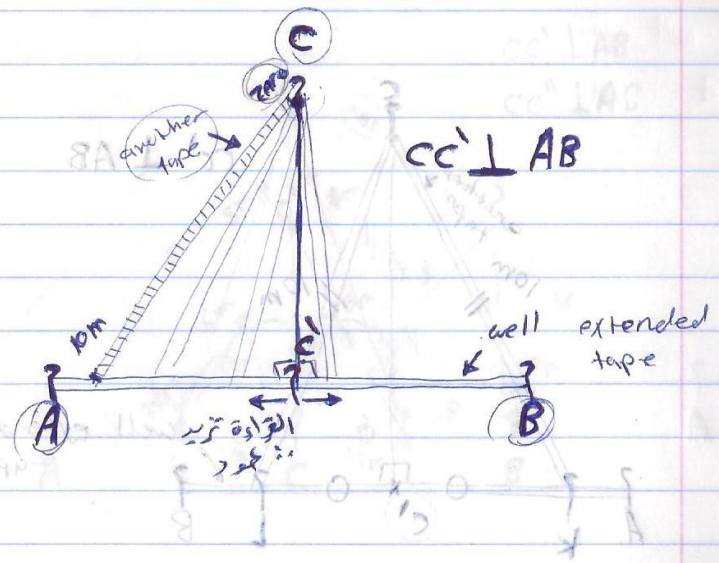
② Equilateral triangle مثلث متساوي الساقين E+D

③ pythagoras ختصاصية (مثلث قائم الزاوية) E

④ the prisma البرزخ E+D

اقصا مسافة : اسقاط عمود

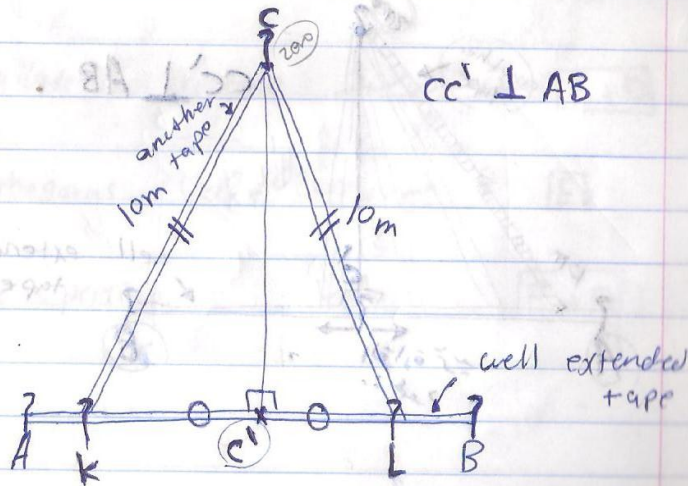
① The shortest Distance (Just Dropping)



امانة اسقاط المثلث متساوي الساقين

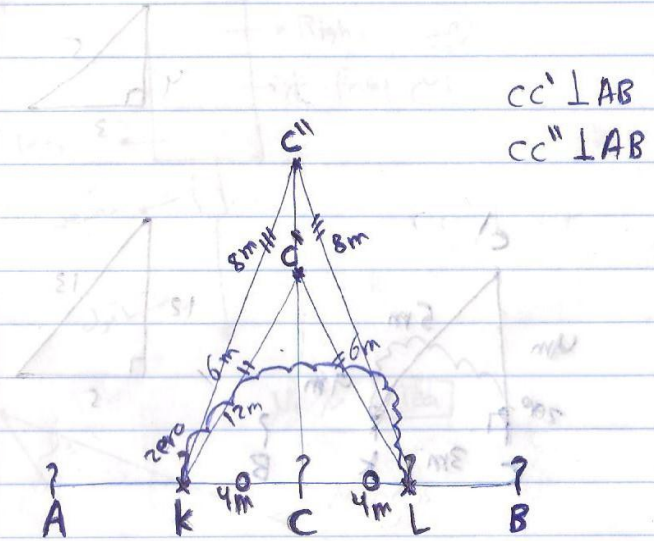
[2] The Equilateral Triangle. (Dropping + Erecting)

a. Dropping. الإسقاط



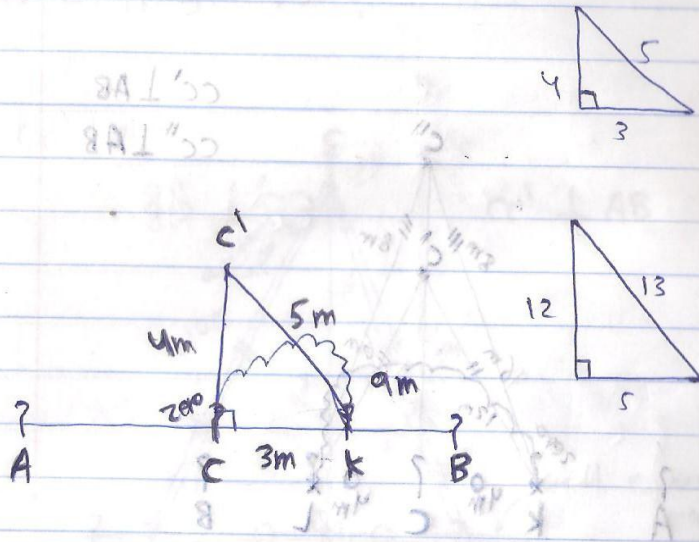
من مثلث متساوي الساقين ← المثلث متساوي الساقين
المثلث متساوي الساقين

b. Erecting a perpendicular.



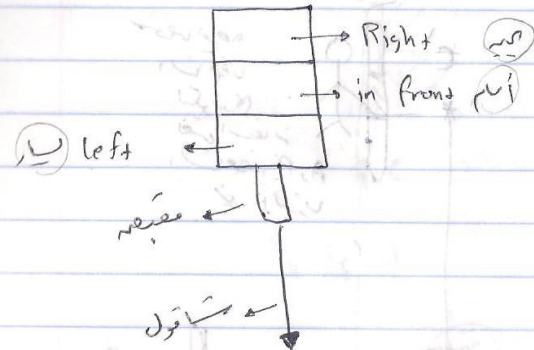
مفاتيح
إقامة

[3] Pythagoras (Erecting only)

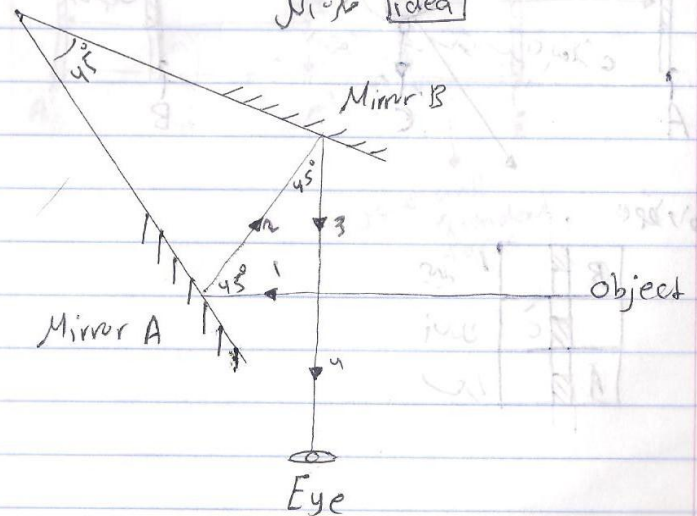


إقامة
سقوط

[4] The prisma (Erecting + Dropping)



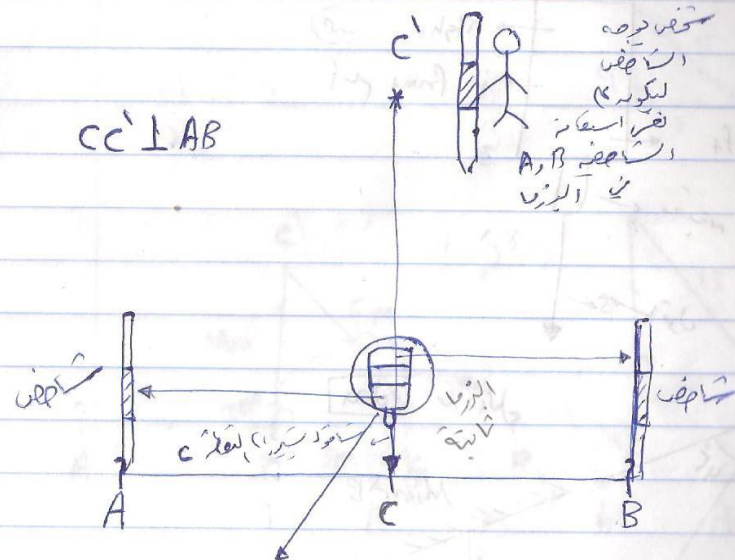
مفاتيح
idea



إقامة كود
a. Erecting.



$CC' \perp AB$

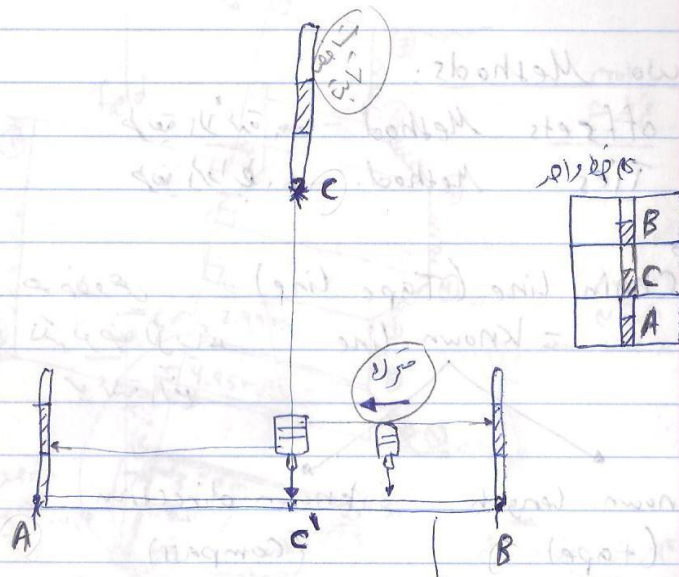


نقطة التقاطع

B		
	C	
A		

نقطة البداية
نقطة النهاية
نقطة التقاطع

b. Dropping.



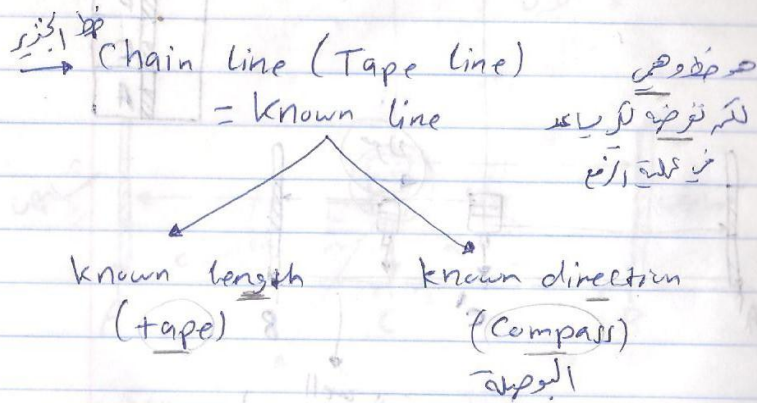
well extended tape.

B		
	C	
A		

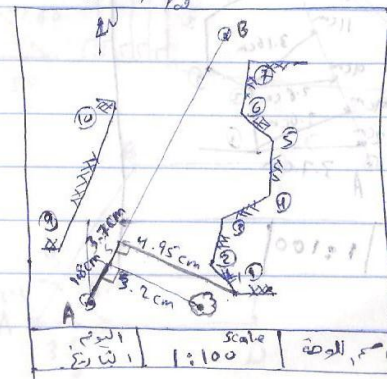
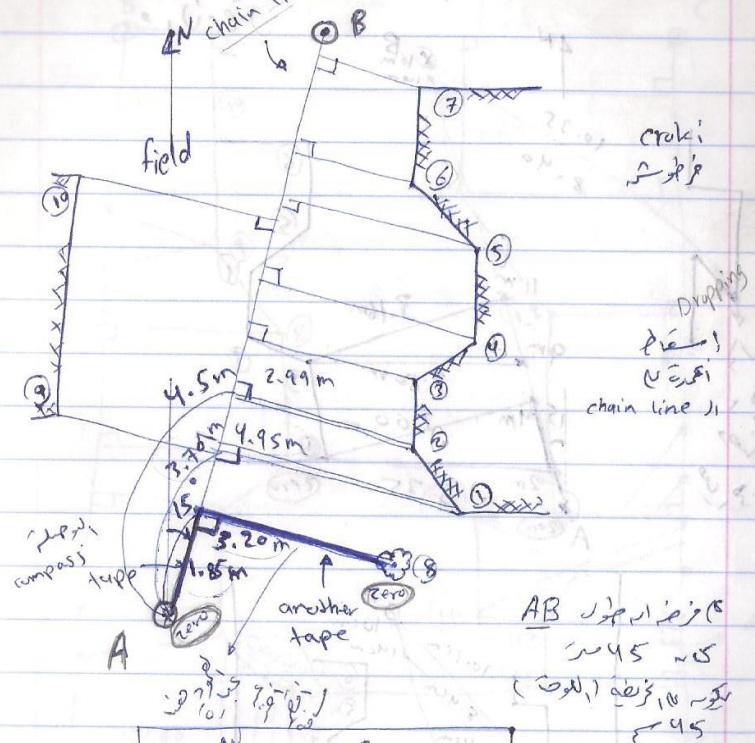
أدوات القياس لخطوط الاستقامة
 ⇒ Mapping Details Using Linear Measuring Equipment.

* Two Methods:

- ① offsets Method → طريقة الأعمدة
- ② Ties Method → طريقة الروابط

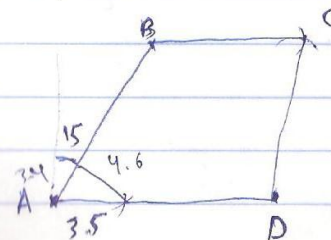
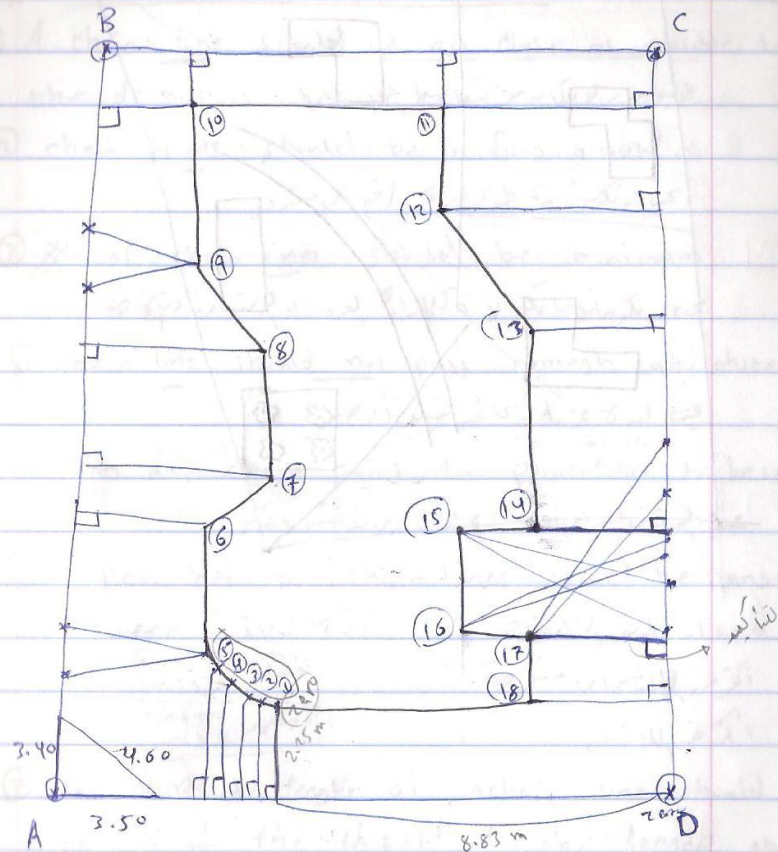
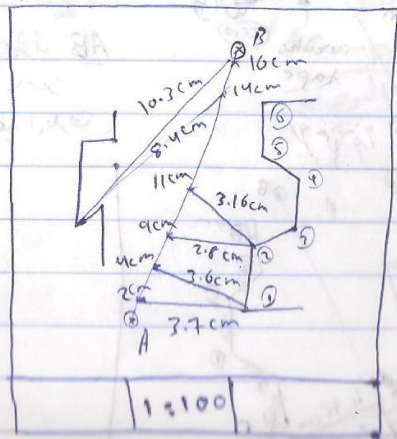
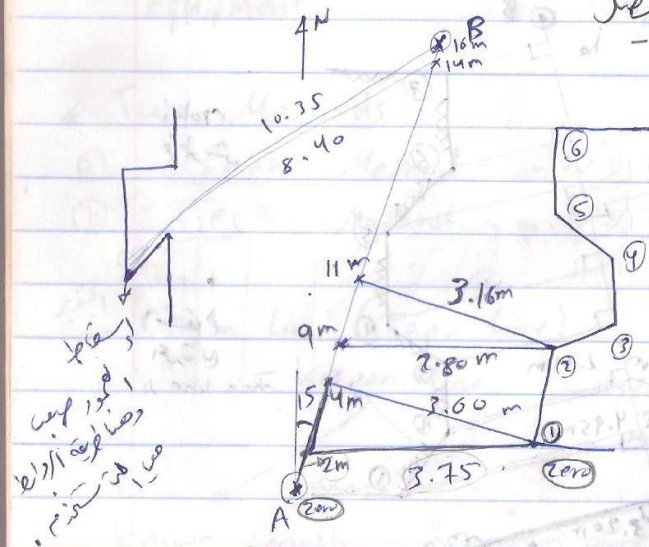


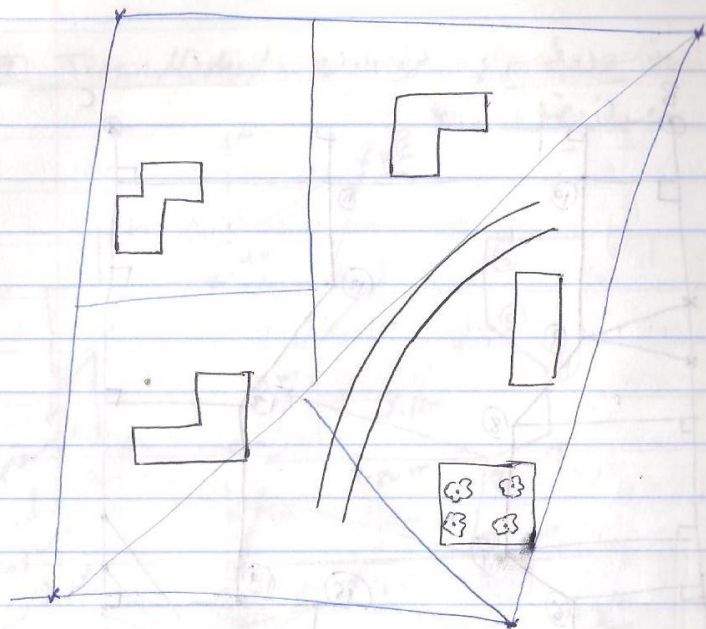
① offsets Method: طريقة الأعمدة



2] Ties Method: طريقة ارباط

الزحمة الرئيسية
و الزمير





* The choice of a chain line:

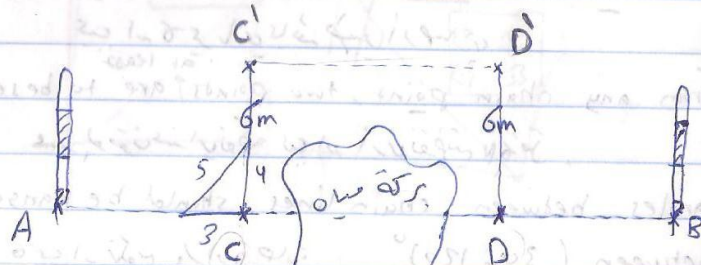
- ① A chain line should be as close as possible to the details.
خط زنجیر باید به جزییات بسیار نزدیک باشد.
- ② chain points should be in firm ground.
نقطه های زنجیر باید در زمین محکم باشد.
- ③ # of chain lines should be minimum.
تعداد خطوط زنجیر باید به کمترین حد ممکن باشد.
- ④ chain line should not pass through any obstacle.
خط زنجیر نباید از هیچ مانعی عبور کند.
- ⑤ From any chain point, two points are to be seen ^{at least}.
از هر نقطه زنجیر، حداقل دو نقطه دیگر باید دیده شود.
- ⑥ angles between chain lines should be ranged between $(30-120)^\circ$.
زاویه بین خطوط زنجیر باید در محدوده $(30-120)^\circ$ باشد.

$\sin 15^\circ =$	کوین
$\sin 14^\circ =$	کوین
$\sin 60^\circ =$	کوین
$\sin 61^\circ =$	کوین
- ⑦ the shortest length of a chain line should be $\geq \frac{1}{3}$ the length of the longest one.

* Chaining Obstacles: عوائق القياس

- ① Chaining is prevented but vision is allowed
- ② chaining is allowed but vision is prevented
- ③ Both chaining and vision are prevented.

① Chaining ^{القيد} is prevented but vision is ^{مسموح} clear.

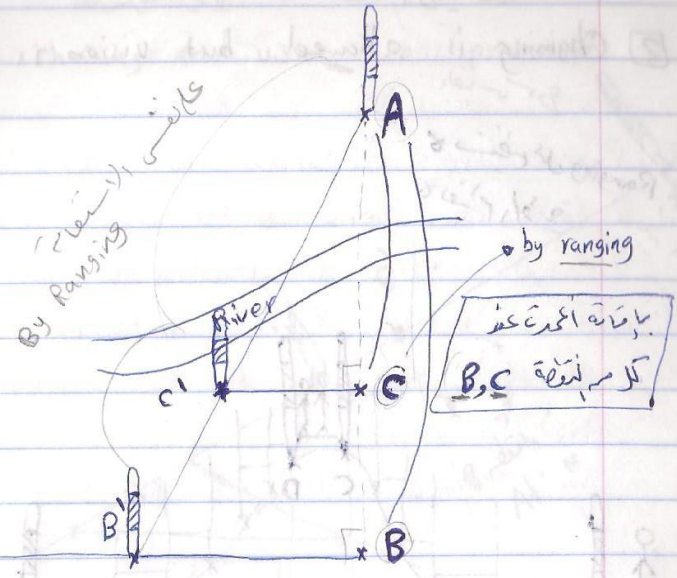


(C,D) by ranging

من طريقة القياس، أعمدة عند كل من نقطة C, D، يقيس طول

$$AB = AC + C'D' + DB$$

by the tape.



$$AC = AB - BC$$

$$\frac{AC}{AB} = \frac{CC'}{BB'}$$

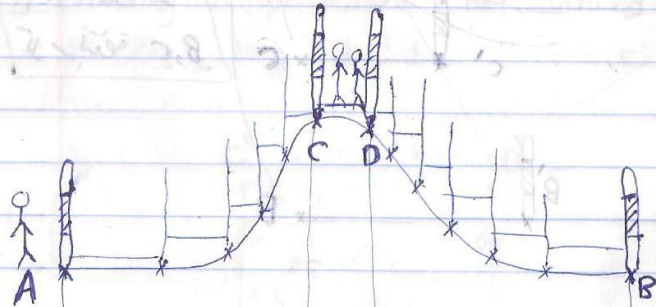
مرات بارتفاع

$$\frac{AB - BC}{AB} = \frac{CC'}{BB'}$$

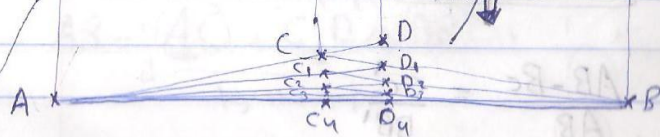
منع الرؤية فقط

② Chaining is allowed but vision is ^{prevented} obscured

منع الرؤية فقط
Ranging على
نقاط A و B



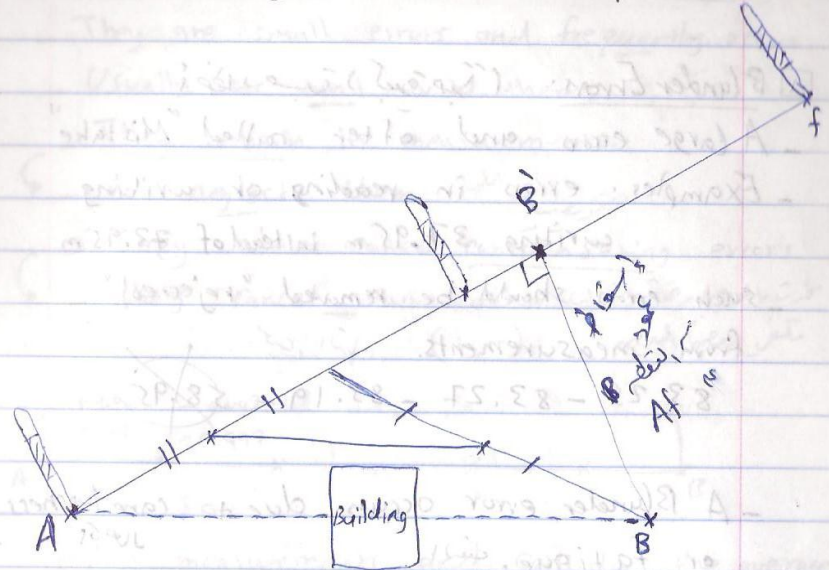
Stepping
then go to
Ranging



Horizontal plane

منع الرؤية والقياس

③ both chaining and vision are prevented



AB يكون
علاقة بين A و B
من خلال B'

$$AB = \sqrt{AB'^2 + BB'^2}$$

AB' , BB' by the tape.

* Chaining Errors: أخطاء لصف

□ Blunder Errors: أخطاء جسيمة (كبيرة جدًّا)

- A large error and often called "Mistake"
- Examples: error in reading or writing
writing 37.95 m instead of 73.95 m
- such error should be removed "rejected" from measurements. يجب إزالتها

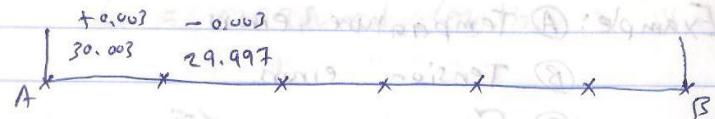
83.25 - 83.27 - 83.19 - ~~58.95~~

- A Blunder error occurs due to carelessness or fatigue. السبب

- To avoid such errors, try to make checks or repeat measurements.

[2] Random Errors: أخطاء عشوائية

- They are small errors and frequently occur.
- Usually we can't avoid them.
- They remain in measurements.
- ↳ - we neglect them. نقرضها
- They often called compensating errors
- ↳ - they cancel each other. تلتزم بعضهما البعض (+, -)

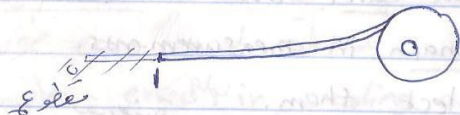


repeat measurements and consider the average.

← تكون نسبة الخطأ العشوائي أمراً ثابتاً.
← صواباً قريباً نتيجة للقيمة الحقيقية.

③ Systematic Errors: أخطاء منهجية

- Errors occur in a systematic "pattern" way.



- we can easily correct these errors.

نستطيع بسهولة تصحيح هذه الأخطاء

- Example: ① Temperature errors

② Tension errors

③ Sag errors

④ length errors

① Temperature Correction: تصحيح درجة الحرارة

$$C_T = 0.0000116 (T - T_0) L_m$$

C_T = Correction for Temp.

T = field Temp.

T_0 = nominal (calibrated) Temp.

L_m = measured length.

Ex. field temp. = 45°C calibrated temp. = 15°C
measured length = 985.65 m

$$C_T = 0.0000116 (45 - 15) 985.65 = 0.343$$

$$\text{corrected } L = L_m + C_T = 985.65 + 0.343 = 985.993 \text{ m}$$

pulling

(B) Tension Correction:

$$C_p = \frac{(P - P_0) L_m}{AE}$$

P = Pulling force in the field. kg, N

P_0 = Nominal pulling force. kg, N

L_m = measured length m

A = cross sectional area of the tape m^2



E = modulus of elasticity $\frac{\text{kg}}{\text{m}^2}$ $\frac{\text{N}}{\text{m}^2}$

Corrected $L_c = L_m + C_p$

(C) Length correction:

$$C_L = \left(\frac{L - L_0}{L_0} \right) L_m$$

C_L = correction for length.

L = actual tape length.

L_0 = nominal tape length.

L_m = measured length.

$$L_c = L_m + C_L$$

Ex.: nominal = $\overset{60}{50}$ m actual = $\overset{6}{49.85}$ m
 measured length = $\underset{L_m}{985.65}$ m

$$C_L = \frac{(\overset{60}{6} - \overset{60}{60}) L_m}{\overset{60}{60}}$$

$$= \frac{(49.85 - 50) 985.65}{50} = -2.96 \text{ m}$$

$$L_C = L_m + C_L = 985.65 + (-2.96)$$

$$= 982.70 \text{ m}$$

or

$$\begin{array}{l} 50 \rightarrow 985.65 \\ 49.85 \rightarrow L_C \end{array} \left\{ \begin{array}{l} L_C = 985.65 \times \frac{49.85}{50} \\ = 982.70 \text{ m} \end{array} \right.$$

$$\text{corrected length} = \text{measured length} \times \frac{\text{actual tape length}}{\text{nominal tape length}}$$

$$L_C = L_m \times \frac{L}{L_0}$$

$$\text{corrected area} = \text{measured area} \times \frac{\text{actual tape length}}{\text{nominal tape length}}$$

$$A_C = A_m \times \frac{L}{L_0}$$

④ Sag correction : $\text{تصحيح القوس لشرط القياس}$

$$C_s = -\frac{W^2 L_s}{24 P^2} = -\frac{w^2 L_s^3}{24 P^2} \quad W = w L_s$$

الوزن الكلي للشرط

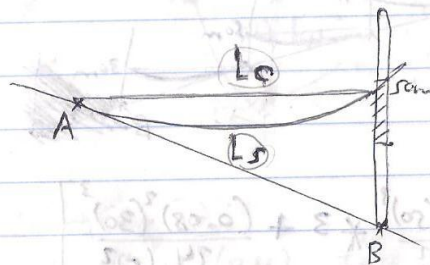
W = the total weight of the tape (kg) or (N)

L_s = the sagged length. $\text{الطول المنحرف للقوس}$

w = the unit weight (weight per meter length)

kg or N
m m

P = the pulling force (kg) or (N)

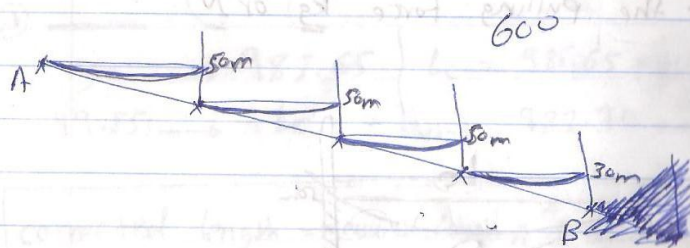


Ex. Tape = 50 m, measured distance = 180 m

$w = 0.08 \text{ kg/m}$, $p = 5 \text{ kg}$, Determine the corrected length??

$$C_s = -\frac{w^2 l^3}{24 p^2}$$

$$C_s = -\left[\frac{(0.08)^2 (180)^3}{24 (5)^2}\right] \times$$



$$C_s = -\left[\frac{(0.08)^2 (50)^3}{24 (5)^2} \times 3 + \frac{(0.08)^2 (30)^3}{24 (5)^2}\right]$$

$$= -4.12 \text{ m}$$

$$L_c = L_m + C_s + C_p + C_t + C_i$$

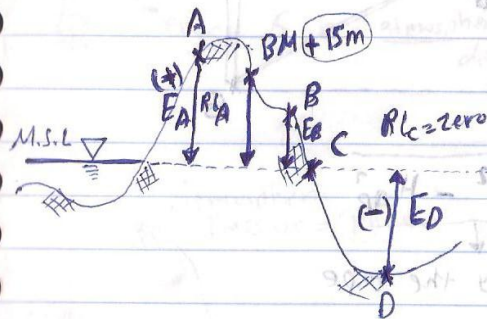
$$L_c = L_m + C_s$$

$$= 180 - 4.12 = 175.88 \text{ m}$$

Chapter 4: Leveling المراقبة

→ Leveling: the process of determining the elevation of a point or the difference in elevation between it.

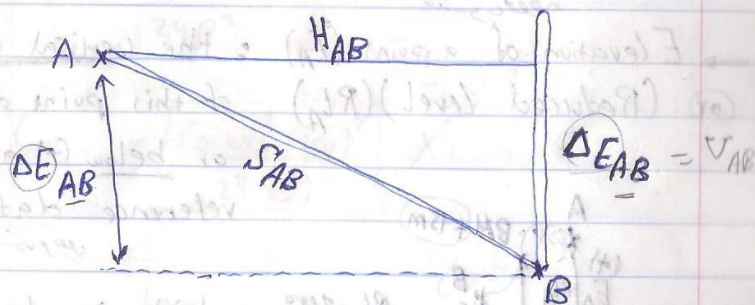
→ Elevation of a point (E_A): the vertical distance (or) (Reduced level) (R_L) of this point above (+) or below (-) a certain reference datum, which is often taken as the Mean Sea Level (M.S.L) [Geoid]



→ Bench Mark (BM): It's a permanent point that is located by municipalities which is of known elevation and used as a reference for engineering projects.

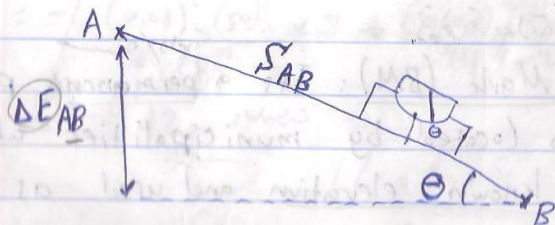
* Methods of leveling *

① chain leveling:



$$\Delta E_{AB} = \sqrt{S_{AB}^2 - H_{AB}^2}$$

by the tape



$$\Delta E_{AB} = S_{AB} \sin \theta$$

tape clinometer

② Barometric leveling:

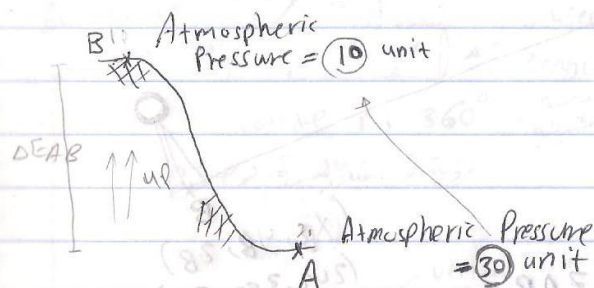
→ [Barometer or Altimeter] measures the atmospheric pressure.

→ Is not accurate.

Atmospheric pressure decrease
↑↑↑ up

Ex. every 5 m up atmospheric pressure decrease → 1 unit

?? → 20 unit



$$\Delta E = 20 \times 5 = 100 \text{ m}$$

$$\Delta E = (DP) \times \text{distance decrease per unit pressure}$$

المقياس

$$= (30 - 10) \text{ unit pressure} \times \frac{5 \text{ m}}{\text{unit pressure}}$$

$$= 100 \text{ m}$$

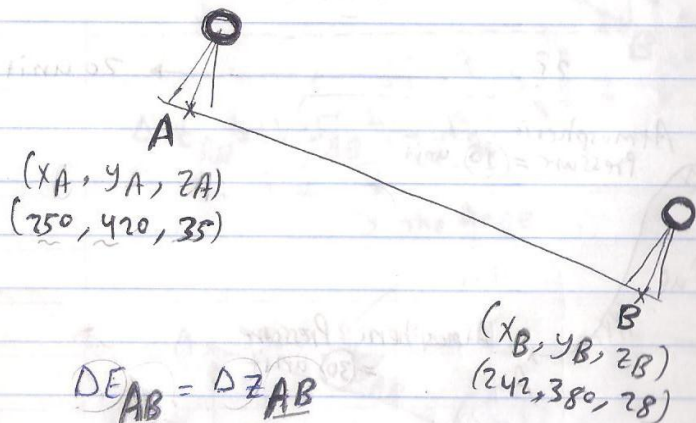
③ Trigonometric leveling:

- leveling by trigonometric

vertical angles by the theodolite

- distance " " or tape

④ GPS leveling:

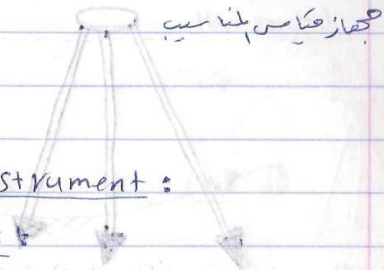


$$\begin{aligned} \Delta z_{AB} &= z_A - z_B \\ &= 35 - 28 \\ &= +7m \end{aligned}$$

الأفق كالأفق

⑤ Differential leveling:

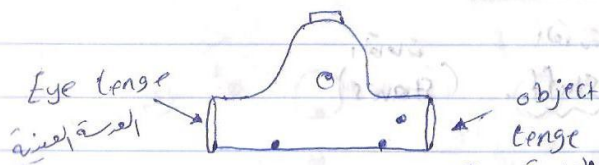
the method of performing leveling for a piece of land by using the "level" instrument.



the "level" Instrument:

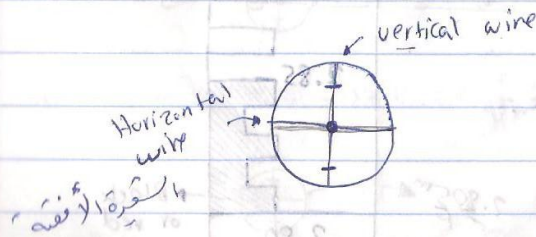
① Its components:

* the telescope



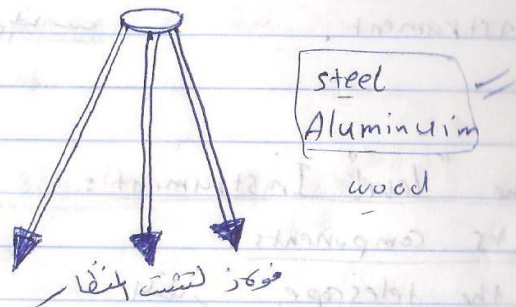
rotate in 360°

دوران في 360 درجة



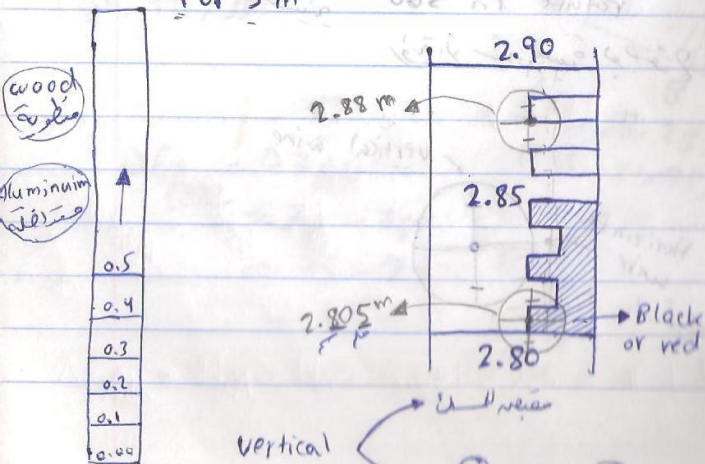
باسم زم مسوب به نقشه
اوسه مسوب نقشه (BM)

* B * the tripod. اكان ثلاثي الارجل

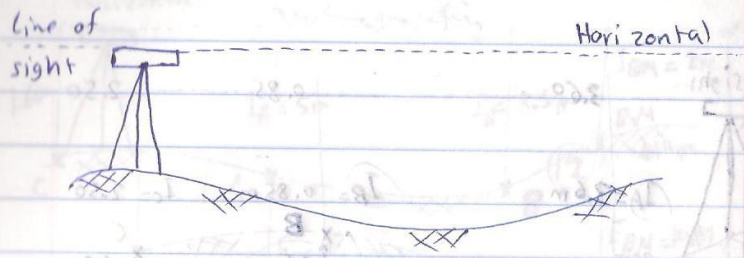


* C * the staff. (staves) القامة الخشبية

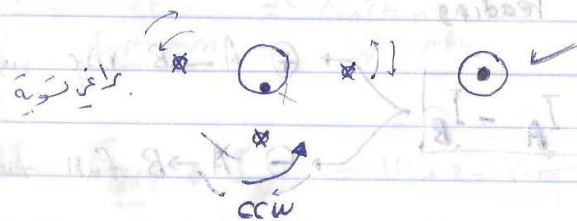
4 or 5 m



② The "level" set up:



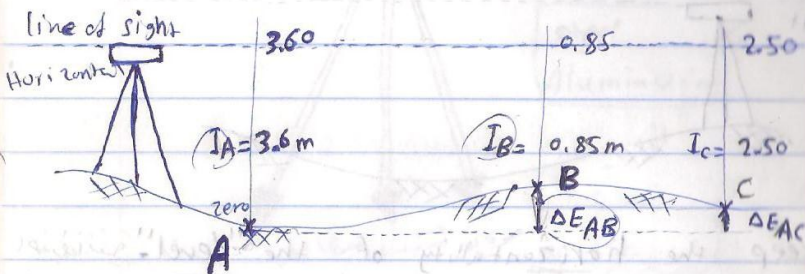
→ keep the horizontality of the "level".
→ the line of sight is horizontal.



→ Location @ any suitable point.

* The "level" uses

① difference of elevation between two points:



I = staff reading

$$\Delta E_{AB} = I_A - I_B$$

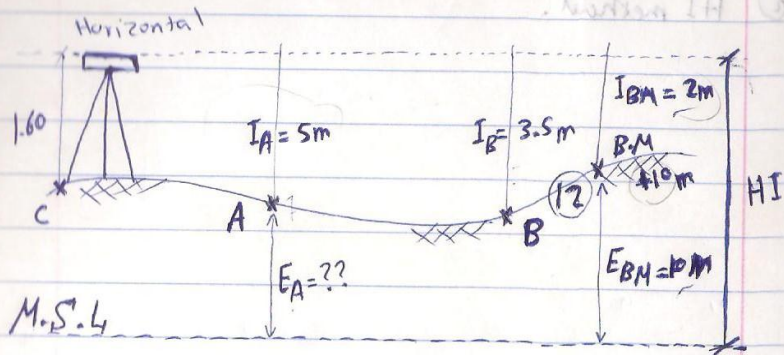
⊕ A → B rise
⊖ A → B fall

$$\Delta E_{AB} = 3.60 - 0.85 = +2.75 \text{ m}$$

$$\Delta E_{BA} = I_B - I_A = 0.85 - 3.60 = -2.75 \text{ m}$$

$$\Delta E_{AC} = I_A - I_C = 3.60 - 2.50 = +1.10 \text{ m}$$

② Elevation of a point:



HI = Height of Instrument = constant

$$HI = E_{BM} + I_{BM} = 10 + 2 = 12 \text{ m}$$

$$E_A = HI - I_A = 12 - 5 = +7 \text{ m}$$

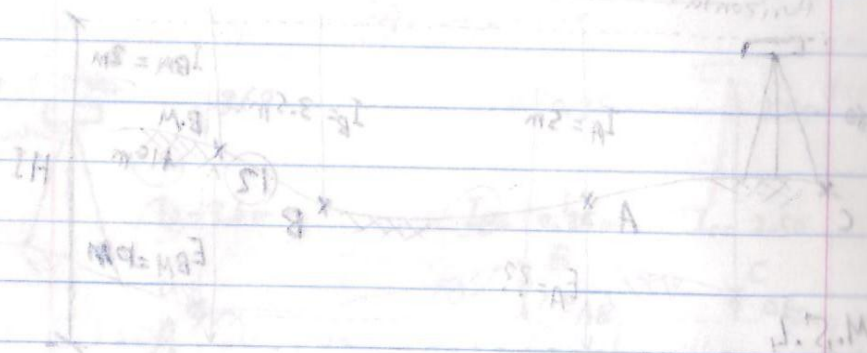
$$E_B = HI - I_B = 12 - 3.5 = +8.5 \text{ m}$$

$$E_C = HI - I_C = 12 - 1.6 = +10.4 \text{ m}$$

⇒ Methods of leveling

① Rise and Fall method

② HI method.



HI = staff reading + height of point

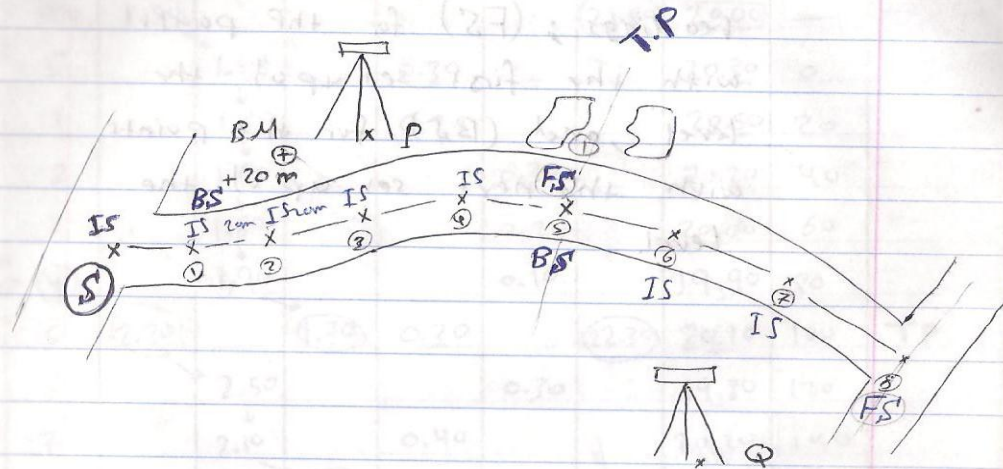
HI = BS + HA

HI = 15.2 + 2.5 = 17.7

HI = 15.2 + 2.5 = 17.7

HI = 15.2 + 2.5 = 17.7

⇒ General Procedure:



⊛ BS' = Backsight قراءة
 = The 1st staff reading taken
 just after setting up the level.

⊛ FS' = Foresight قراءة
 = The last staff reading taken
 just before moving the level.

⊛ IS' = Intermediate sight قراءة
 = The staff reading (IS') between
 (BS') and (FS') readings.

* TP = Turning Point.

= The point that have two staff readings; (FS) for the points with the first set up of the level, and (BS) for the points with the next set up of the level.

الارتفاع في القياس الأول الارتفاع في القياس الثاني

Point	BS	IS	FS	Rise	Fall	HI	Elev.	Dist.	Remarks
BM	1.80					21.80	20.00	—	BM #15
5		1.50		0.30			20.30	0	
1		1.30		0.20			20.50	20	
2		1.60			0.30		20.20	40	
3		1.80			0.20		20.00	60	
4		1.90			0.10		19.90	80	
5	2.20		1.70	0.20		22.30	20.10	100	TP
6		2.50			0.30		19.80	120	
7		2.10		0.40			20.20	140	
8			2.00	0.10			20.30	160	
Σ	4.00	12.70	3.70	1.20	0.90				

⇒ Rise and Fall checks:

$$\textcircled{1} \quad \# \text{ of } \underline{BS} \text{ readings} = \# \text{ of } \underline{FS} \text{ readings}$$

$$2 = 2 \quad (\text{ok})$$

$$\textcircled{2} \quad \sum \underline{BS} - \sum \underline{FS} = \sum \text{Rise} - \sum \text{Fall} = \text{last elev.} - \text{1st elev.}$$

$$4.00 - 3.70 = 1.20 - 0.90 = 20.30 - 20.00$$

$$= 0.30 \quad (\text{ok})$$

⇒ HI checks:

$$\textcircled{1} \quad \# \text{ of } \underline{BS} \text{ readings} = \# \text{ of } \underline{FS} \text{ readings}$$

$$2 = 2 \quad (\text{ok})$$

$$\textcircled{2} \quad \sum \underline{BS} - \sum \underline{FS} = \text{last elev.} - \text{1st elev.}$$

$$4.00 - 3.70 = 20.30 - 20.00$$

$$0.30 = 0.30 \quad (\text{ok})$$

$$\textcircled{3} \quad \sum (\text{elevations}) \text{ except the first} =$$

$$\sum (\text{HI} \times \# \text{ of } \underline{IS} \text{ and } \underline{FS}) - \sum \underline{IS} - \sum \underline{FS}$$

$$181.3 = (21.80 \times 6 + 22.30 \times 3) - 12.70 - 3.70$$

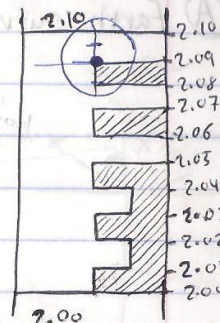
$$181.3 = 181.3 \quad (\text{ok})$$

✓ leveling Errors:

① Blunder Errors "Mistakes":

→ Mis reading the staff.

→ the staff is 2.9 instead of 2.09



→ Mis adjustment of the level.

→ Recording 2.19 instead of 2.91m.

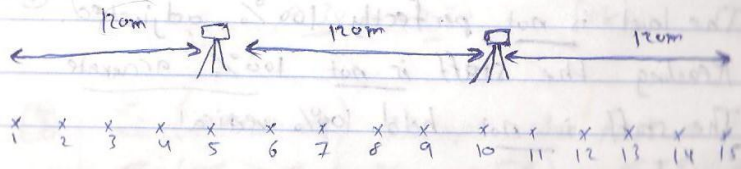
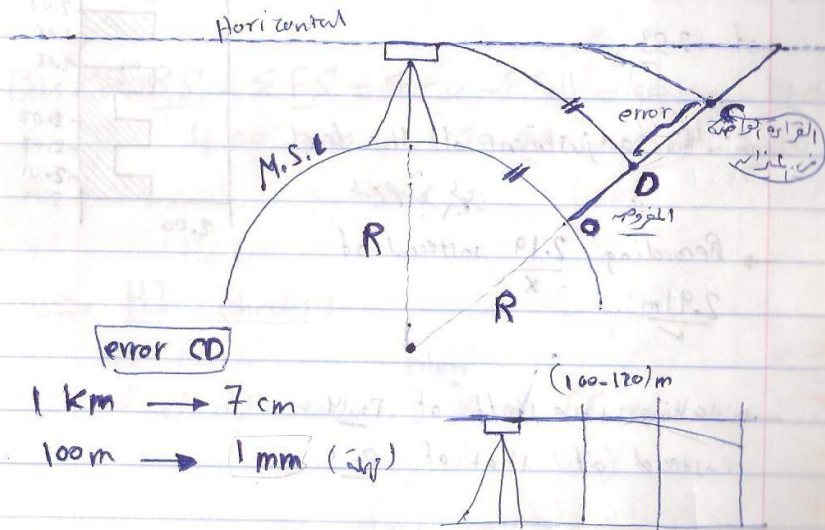
→ taking the staff of Pt. 4 instead of that of Pt. 5.

② Random Errors:

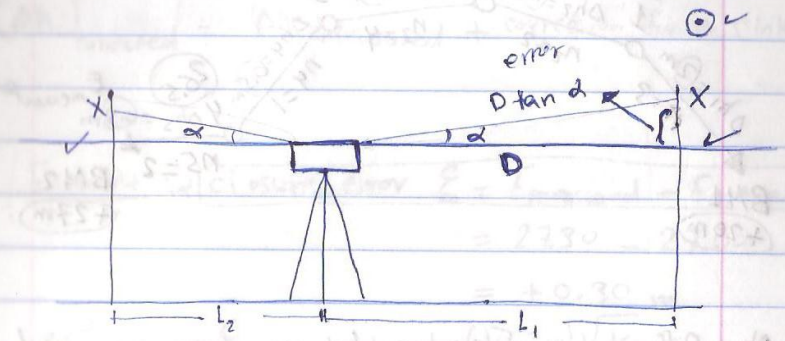
- The level is not perfectly 100% adjusted. ✓
- Reading the staff is not 100% accurate
- The staff is not held 100% vertical.
- wind
- others.

3] Systematic Errors :

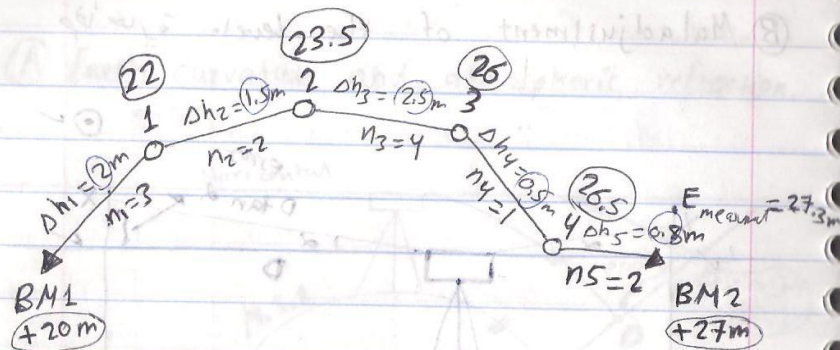
(A) Earth curvature and atmospheric refraction.



(B) Maladjustment of the level.



* Closure Error: Δ



Δh = Difference in Elevation between previous and next pt.

n = # of the times of setting up the level

$$\text{closure error } \Delta = E_{\text{measured}} - E_{\text{actual}}$$

$$\text{allowable error } \Delta_a = x\sqrt{k} \text{ mm}$$

factor = $(10-30)$

k = distance km

if $\Delta \leq \Delta_a \Rightarrow$ correction is needed
else $\Rightarrow$ measurement is required.

In case of correction:

$$\text{correction for each interval} = \frac{-n_i}{\sum n_i} \Delta$$

$$(\Delta h_i)_{\text{corrected}} = (\Delta h_i)_{\text{measured}} + \text{correction for this interval}$$

$$\text{Example: } \Delta = E_{\text{measured}} - E_{\text{actual}}$$

$$= 27.30 - 27.00$$

$$= +0.30 \text{ m}$$

$$\Delta_{\text{allowable}} = (10-30)\sqrt{k}$$

$$= 30\sqrt{120}$$

$$= 0.328$$

$$= \frac{-n}{\sum n} \Delta$$

$$(\Delta h_1)_{\text{corrected}} = (2) + \left(\frac{-3}{12} \times 0.3 \right) = 1.925 \text{ m}$$

$$(\Delta h_2)_{\text{corrected}} = (1.5) + \left(\frac{-2}{12} \times 0.3 \right) = 1.35 \text{ m}$$

$$(\Delta h_3)_{\text{corrected}} = (2.5) + \left(\frac{-4}{12} \times 0.3 \right) = 2.15 \text{ m}$$

$$(\Delta h_4)_{\text{corrected}} = (0.5) + \left(\frac{-1}{12} \times 0.3 \right) = 0.425 \text{ m}$$

$$(\Delta h_5)_{\text{corrected}} = (0.8) + \left(\frac{-2}{12} \times 0.3 \right) = 0.65 \text{ m}$$

* Types of leveling:

① Ordinary leveling:

* in most engineering projects such as:

→ Topographic maps.

→ Contour maps.

→ profiles.

→ cross sections.

$$C_a = ((10-30)\sqrt{k})_{mm}$$

② Precise leveling:

* ① In projects that require high precision such as the ② establishment of B.M. points.

* ③ use a special level and staff.

* ④ use field procedures to ensure checks and thus accuracy.

$$C_a = ((2-5)\sqrt{k})_{mm}$$

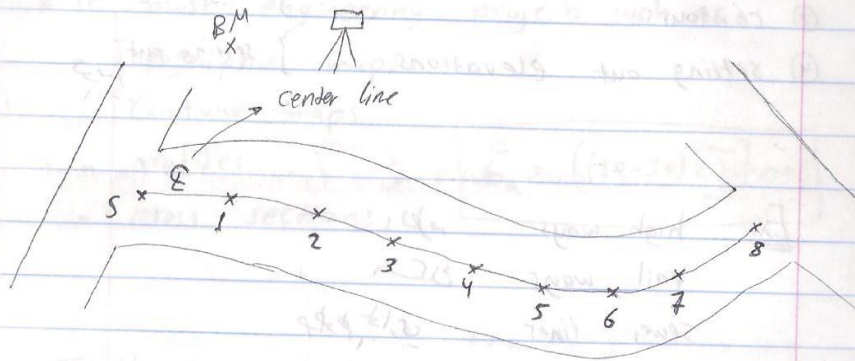
* leveling applications:

- | | |
|------------------------------------|----------------------|
| ① Longitudinal sections (profiles) | } mapping elevations |
| ② cross sections. | |
| ③ contours. | } setting out |
| ④ setting out elevations. | |

Ex. high ways الطريق
 rail ways السكك
 sewer lines خطوط الصرف

1 Longitudinal sections (profiles): مقاطع طولية

هو علامة بيانية بين نقطتين بنقاط ومناخية

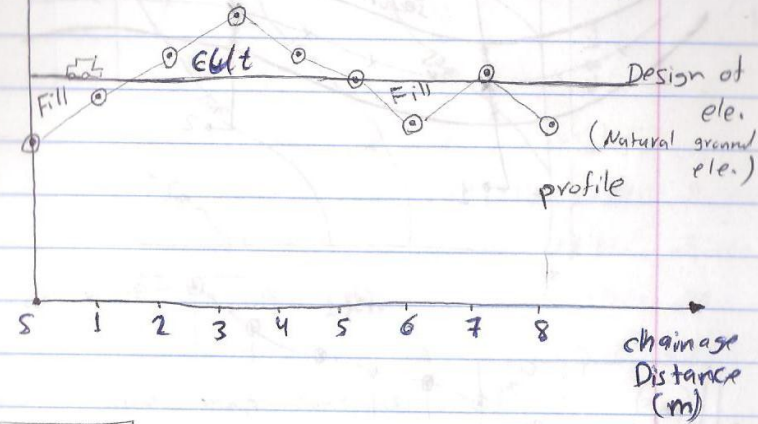


St.	5	1	2	3	4	5	6	7	8
Dist. chainage	0	20	40	60	80	100	120	140	160
Elev.	15	15.50	15.80	16.20	15.90	15.70	15.50	15.80	15.20

Elevation (m)

Design Profile

- * Cut = fill
- * slope (0.7-7)%
- * 12% كسبة



H. scale

1:1000 / 1:500

V. scale

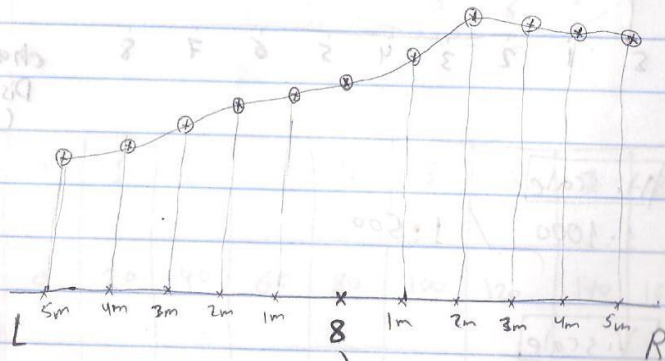
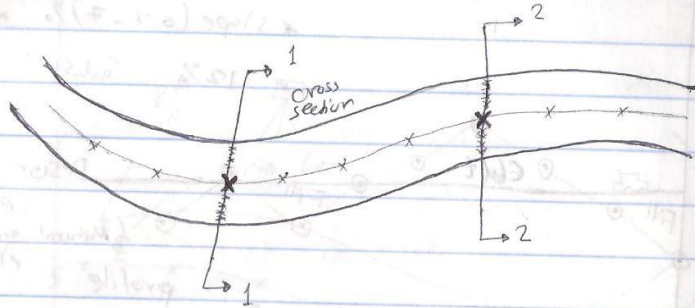
1:100 / 1:50

we use here for this graph.

$$\frac{1:500}{20} = 4 \text{ cm}$$

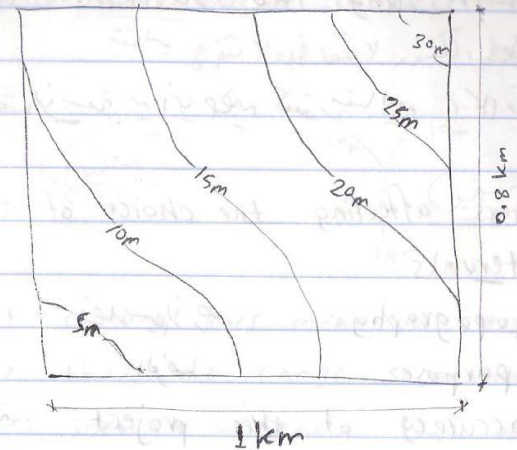
2] Cross sections :

المقاطع العرضية : علاقة بارتفاعه في المساحة من المقام من حيث يكون من الجاه الارتفاع .



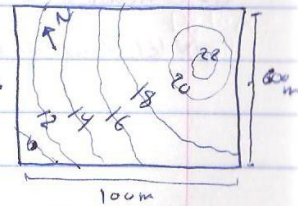
رقم النقطة من المقام (طول ي)

3] Contouring :



* Any Contour map contains:

- 1- Contour lines planimetric map
- 2- Contour intervals



* A contour line : is an imaginary line that connects points in the area of the same elevation.

خط وهمي يربط جميع النقاط في نفس الارتفاع في المكان .

* A contour interval: is the vertical distance between any two successive contour lines.

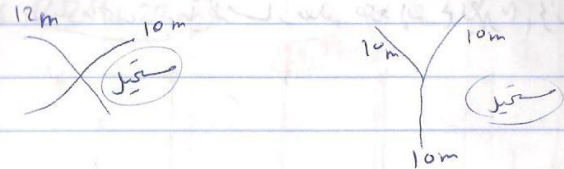
المسافة الرأسية بين أي خطين متتاليين ، كلما قلّت هذه المسافة ، كلما كان التضاريس أكثر انحداراً

* factors affecting the choice of contour intervals:

- 1- topography تضاريس الأرض
- 2- purpose الغرض
- 3- accuracy of the project الدقة
- 4- scale المقياس (مقياس الخطة)

* Contour lines characteristics:

① contour lines doesn't intersect or split.
خطوط الكنتور لا تتقاطع ولا تنقسم.



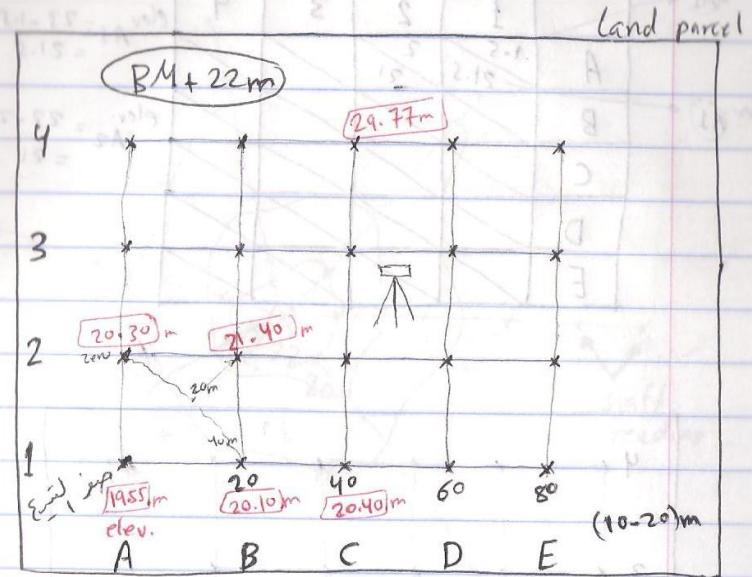
② closet contour lines mean a steepest ground while the wide range separation between lines mean a nearly flat area
إذا كانت الخطوط قريبة تكون انحداراً (تدريسي)
أما إذا كانت متباعدة تكون انحداراً ضعيفاً (تدريسي)

- ③ contour line should take a closed path whenever it doesn't appear on the map.

خط الكنتور يجب ان يأخذ مسار مغلق اذا لم يظهر على الخريطة.

* Contouring methods: طرق مسح الكنتور

① Griding: شبكة



Lowest elev. = 19.55m

linear interpolation

highest elev. = 29.77m

لترتيب الارتفاع

Difference = 10.22m

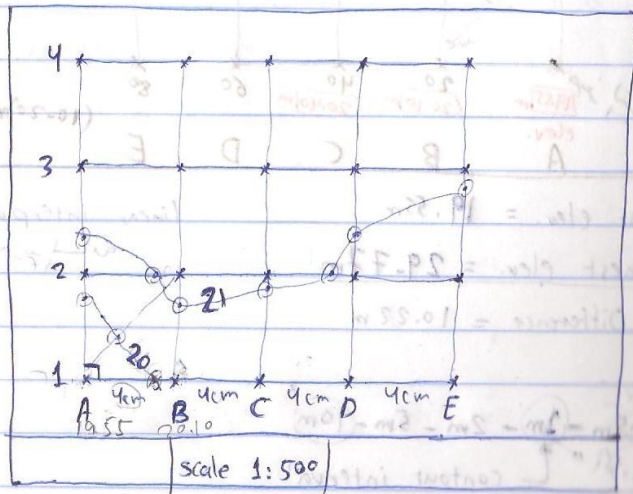
0.5m - 1m - 2m - 5m - 10m

contour interval

Contour lines: 20-21-22-23-24-25-26-27-28-29

EBM = 22 m, IRM = 1 m, HI = 23

	1	2	3	4	
A	1.5 21.5	2 21			elev. $A_1 = 23 - 1.5 = 21.5$
B					elev. $A_2 = 23 - 2 = 21$
C					
D					
E					

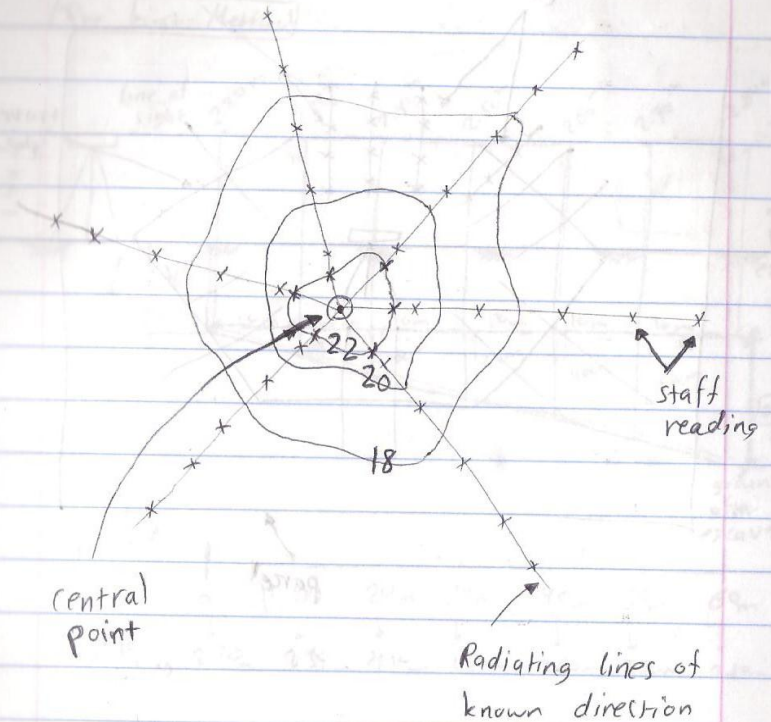


المساحة بين النقطتين (A, B) : $55 \text{ cm} : 4 \text{ cm}$

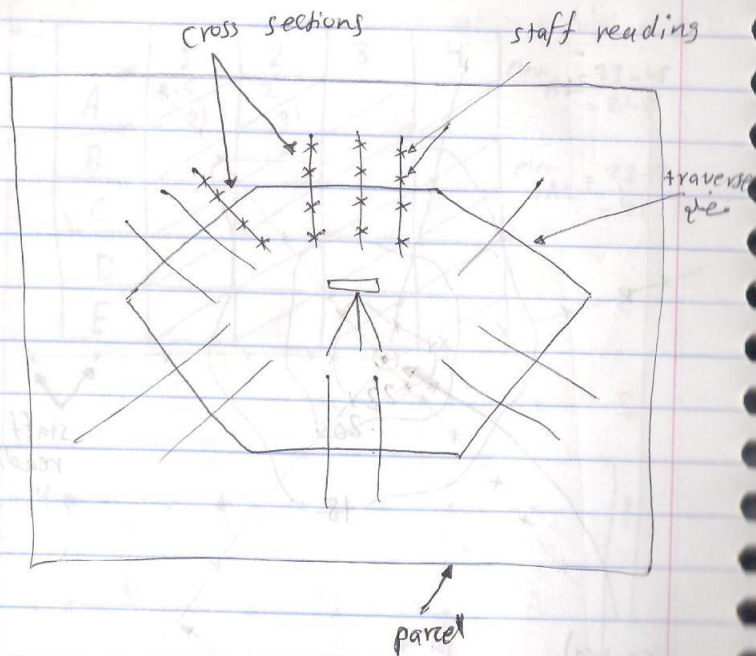
$(20 - 19.55) \times 45 \text{ cm} : ??$

$$X = \frac{4 \times 45}{55} = 3.27 \text{ cm}$$

② Radiating Lines: نقاط



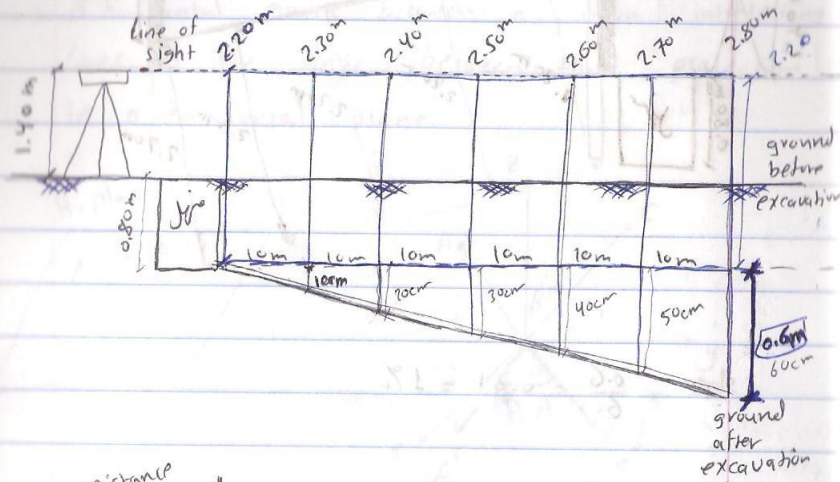
③ Cross Sections Method: اجزاء پر کیے



⇒ leveling application continue:

4. Setting Out elevations:

(The first Method)



Distance	0	10m	20m	30m	40m	50m	60m
Staff reading	2.20m	2.30m	2.40m	2.50m	2.60m	2.70m	2.80m

$$\text{slope} = \frac{0.6}{60} = 0.01 = 1\%$$

The Second Method

Diagram illustrating the second method for finding the height of a tower. The diagram shows a horizontal line with a vertical line segment of 0.80m on the left. A dashed horizontal line extends from the top of this segment. A solid line starts at the top of the dashed line and goes to the top of a vertical line on the right. The horizontal distance between the vertical lines is 60m. The vertical line on the right has a height of 0.6m. The solid line is divided into five segments, each labeled 2.20m. The total height of the tower is the sum of the 0.80m segment and the 0.6m segment.

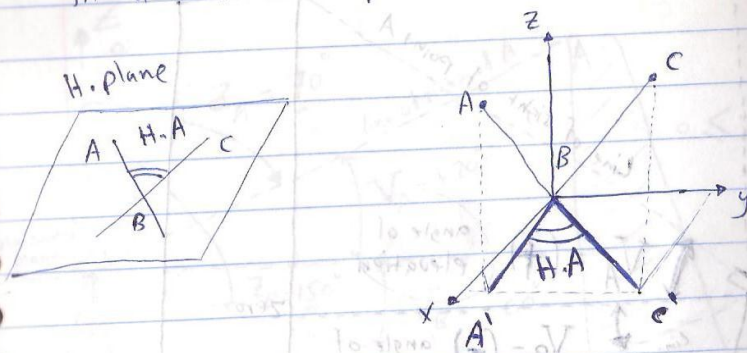
$$\text{slope} = \frac{0.6}{60} = 0.01 = 1\%$$

Angles and directions

⇒ Types of Angles :

① Horizontal Angles: (H.A.)

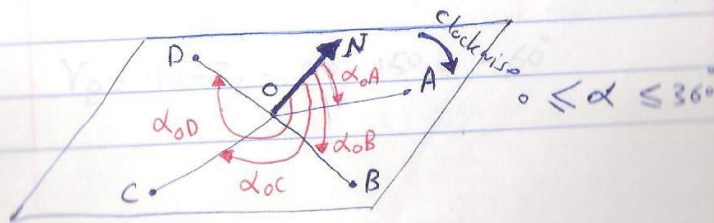
→ A horizontal angle between any two intersecting lines is the angle between their projection in a horizontal plane.



zero $\leq H.A \leq 360$

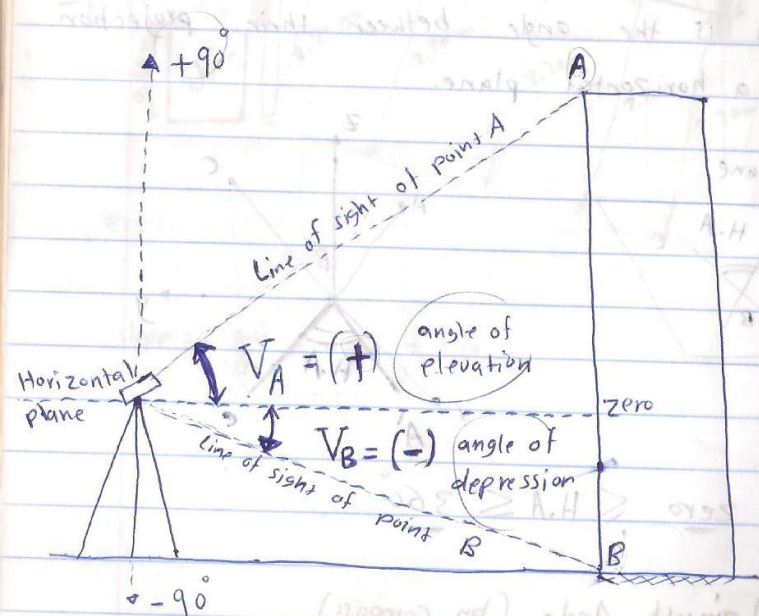
→ Azimuth Angle (by compass) _{that}

→ The clockwise angle ^{that} the line makes with the north direction. $\geq 0^\circ$



2. Vertical Angles (V):

→ A vertical angle of a point is the angle between the line of sight of this point and a horizontal reference plane.

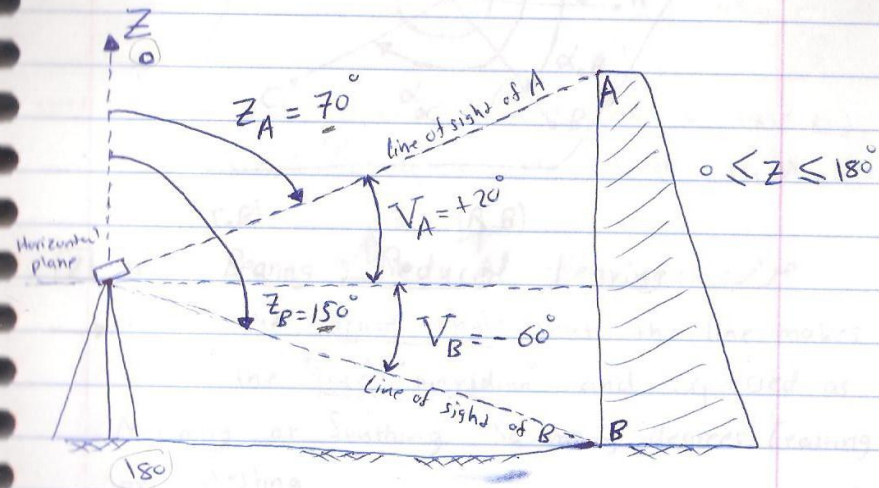


$$-90^\circ \leq V \leq 90^\circ$$

→ Zenith Angle (Z) - (زاوية الزنيث) :

→ the vertical angle between the "Zenith" direction and the line of sight

→ Zenith direction = vertically upward $\uparrow Z$



$$V = 90^\circ - Z$$

$$V_A = 90 - 70 = +20^\circ$$

$$V_B = 90 - Z_B = 90 - 150 = -60^\circ$$

③ Inclined Angles:

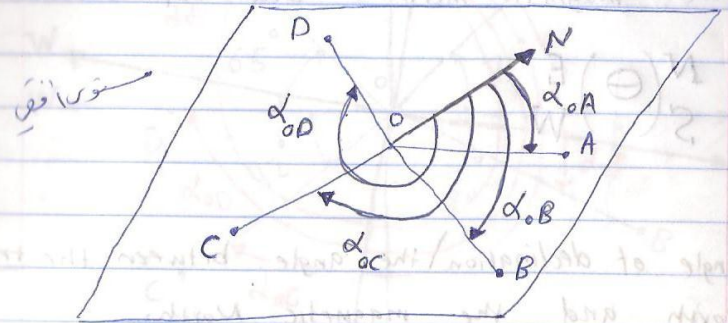
→ not important in most surveying applications

$[X, Y, Z]$

زاوية ميل
زاوية

→ Bearing Angles: (زاوية بکمان)

II A Zimuth Angle:



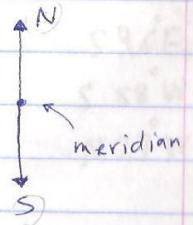
(T.B)

(R.B)

② True Bearing - Reduced Bearing: (حقیقی)

→ It is the acute angle that the line makes with the "true" "meridian" and expressed as Northing or Southing So many degrees Easting or Westing.

N (θ) E
S (θ) W



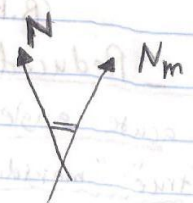
θ is an acute angle
 $0 \leq \theta \leq 90^\circ$

③ Magnetic Bearing (M.B): مغناطیسی

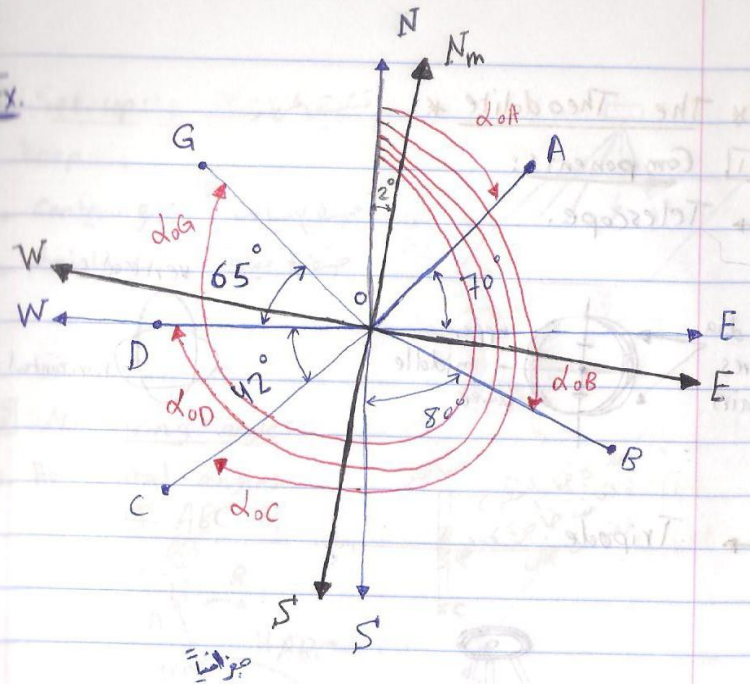
→ The acute angle that the line makes with the "magnetic meridian" and expressed as

$$\begin{matrix} N & (\ominus) & E \\ S & & W \end{matrix}$$

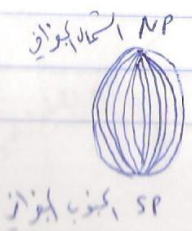
→ angle of declination / the angle between the True North and the magnetic North.



Ex.



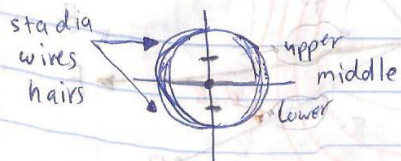
Line	True Bearing T.B	True azimuth α	Magnetic Bearing M.B
OA	N 20° E	20°	N 18° E
OB	S 80° E	100°	S 82° E
OC	S 48° W	228°	S 46° E
OD	N 90° W S 90° W	270°	S 88° W
OG	N 25° W	335°	N 27° W



* The Theodolite *

1 Components:

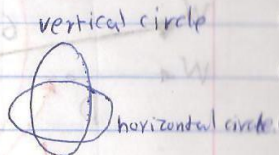
→ Telescope.



→ Tripode



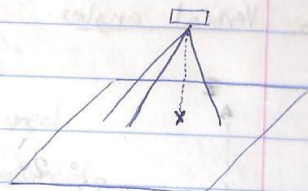
→ Staff 2 or/and ranging rods.



2 Set up: تنبئة الجيار

keep:

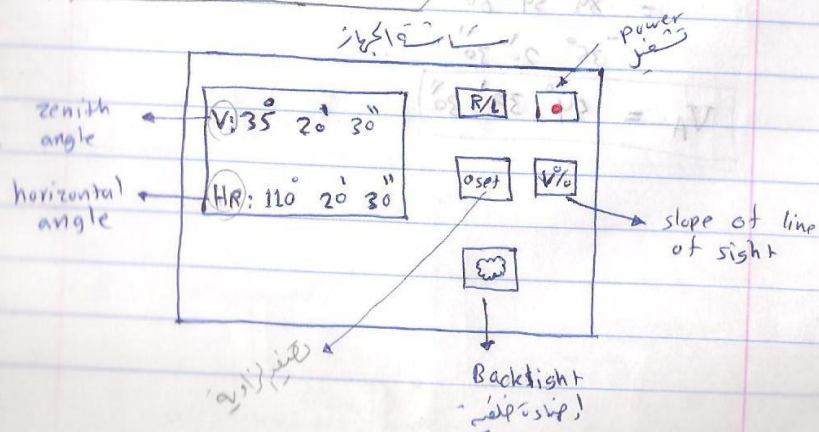
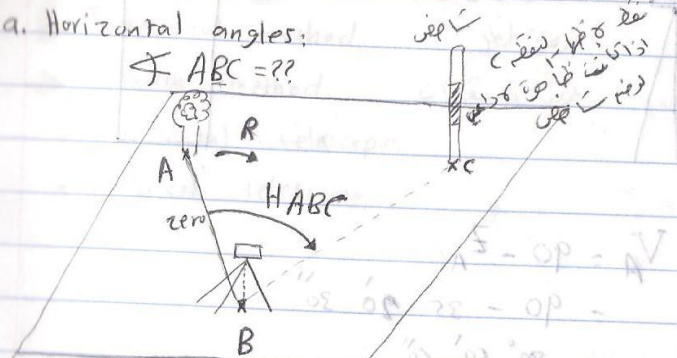
- Centering ضبط بياض
- Leveling ضبط أفقية



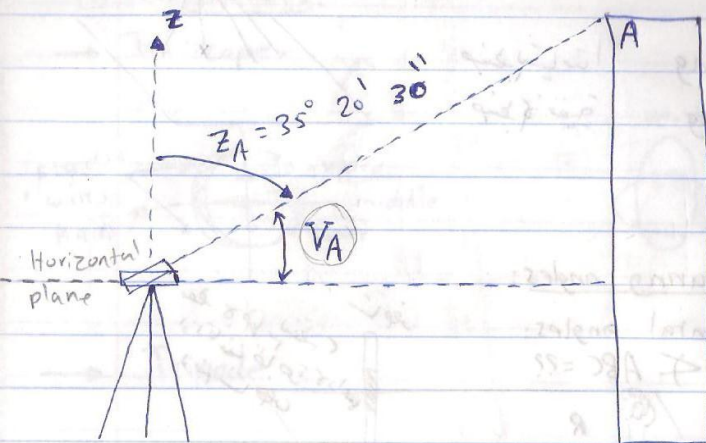
3 Measuring angles:

a. Horizontal angles:

$$\angle ABC = ??$$



b. Vertical angles.



$$\begin{aligned} V_A &= 90 - Z_A \\ &= 90 - 35^\circ 20' 30'' \\ &= 54^\circ 39' 30'' \end{aligned}$$

$$V_A = 54^\circ 39' 30''$$

[4] Theodolite Applications :

(A) measuring objects heights

1. Distance can be measured.
2. Distance can't be measured.

(B) Tacheometry:

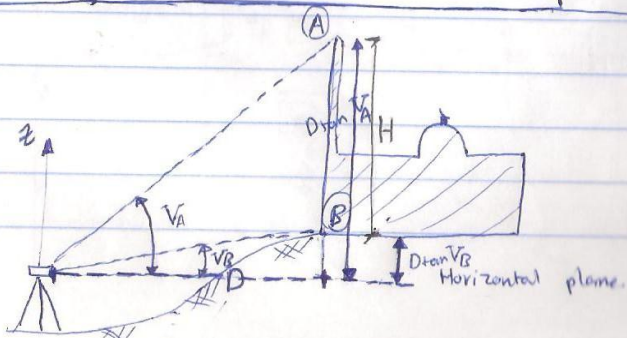
على مسافة نوبس لولا صفات انصاف باستخدام (theodolite)

1. Tangential method. طريقة التماس
 2. Stadia method. طريقة السقاط
- * horizontal telescope.
 - * inclined telescope.

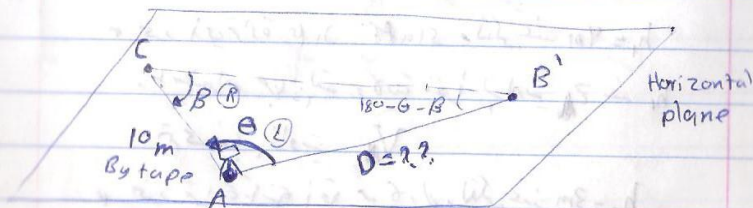
A diagram showing a camera on a tripod. A vertical z -axis is shown. The camera's optical axis is represented by a dashed line. Angles Z_A and Z_B are indicated between the z -axis and the optical axis. Points A and B are marked on the optical axis. Distances D_A and D_B are labeled. A vertical line segment is labeled H . A small circle is labeled ϕ .

$$\textcircled{B} \rightarrow z_B \rightarrow V_B = 90 - z_B$$

In general $H = D (\tan V_A - \tan V_B)$



$$E_B = E_A + i_A + D \tan V_B$$

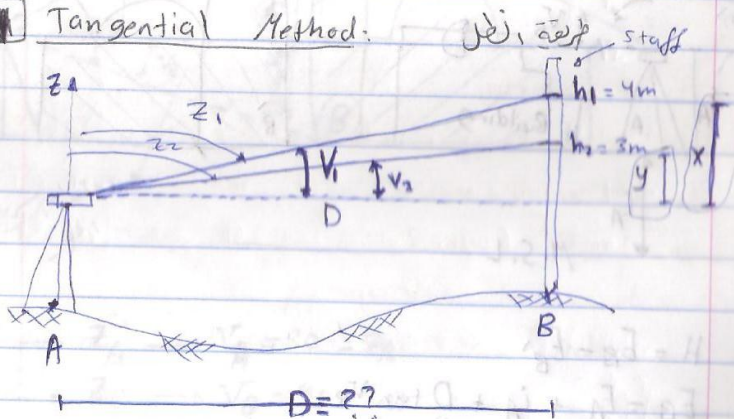


$$\frac{D}{\sin \beta} = \frac{10}{\sin(180^\circ - 60^\circ - \beta)}$$

رقم التوردة عند A وثوقه للسيار
 عند زركا هار عند النقطة C وسجل
 الزاوية θ
 رقم التوردة عند C وثوقه للسيار
 عند زركا هار عند A وسجل
 الزاوية β

② Tacheometry: A branch of surveying by which horizontal distances can be measured using the theodolite.

③-1 Tangential Method.



• عند أي قراءة $h_1 = 4m$ staff مذكر عند Z_1

• باستخدام جهاز التودوليت نقرأ الزاوية V_1 عند Z_1

• ثم حسب الزاوية V_1

• عند قراءة ثانية أقل من الأولى، ولكن عند $h_2 = 3m$

• باستخدام جهاز التودوليت نقرأ الزاوية V_2 عند Z_2

• ثم حسب الزاوية V_2

$$X = D \tan V_1$$

$$Y = D \tan V_2$$

$$X - Y = D \tan V_1 - D \tan V_2$$

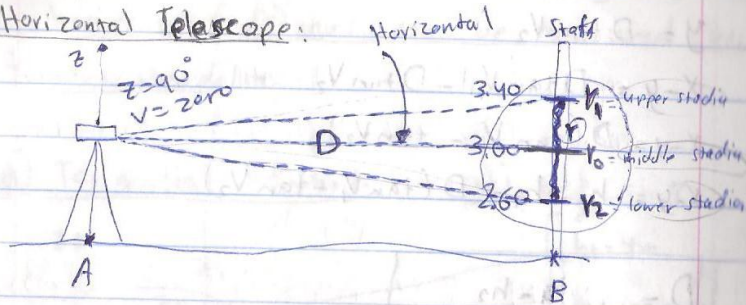
$$X - Y = D (\tan V_1 - \tan V_2)$$

$$X - Y = h_1 - h_2 = D (\tan V_1 - \tan V_2)$$

$$D = \frac{h_1 - h_2}{\tan V_1 - \tan V_2}$$

B-2 Stadia Method: $\sin, \cos$

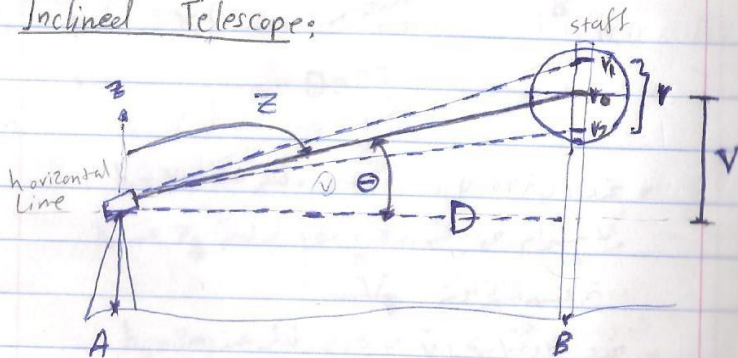
* Horizontal Telescope:



$$r = r_1 - r_2, \quad k = \text{theodolite constant} = 100$$

$$D = kr \Rightarrow D = 100(3.40 - 2.60) = 80\text{m}$$

* Inclined Telescope:



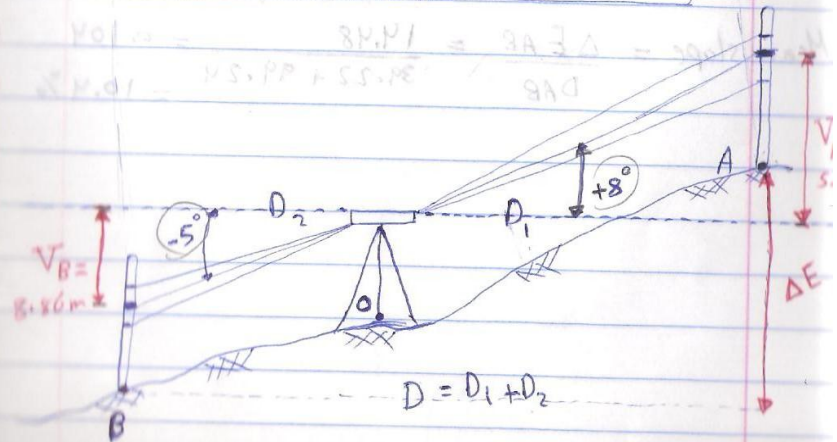
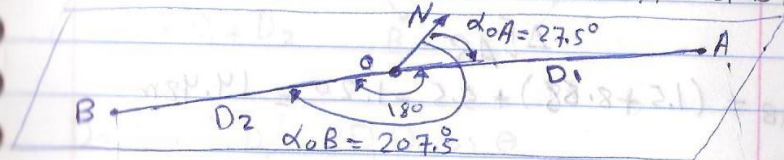
$$D = kr \cos^2 \theta$$

$$V = \frac{1}{2} kr \sin 2\theta$$

Ex. Theodolite @ O, $k=100$.

Staff station	Azimuth	Stadia Readings			Vertical angle
A	$27^\circ 30'$	1.00	1.20	1.40	$+8^\circ$
B	$207^\circ 30'$	1.00	1.50	2.00	-5°

calculate the mean slope between A and B:



Soln.

inclined
telescope

Staff @ A

$$D_1 = kr \cos^2 \theta = 100 (1.40 - 1.00) \cos^2 78^\circ = 39.22 \text{ m}$$

$$V_A = \frac{1}{2} kr \sin 2\theta = \frac{1}{2} (100) (1.40 - 1.00) \sin 16^\circ = 5.5 \text{ m}$$

Staff @ B

$$D_2 = kr \cos^2 \theta = 100 (2.00 - 1.00) \cos^2 10^\circ = 99.24 \text{ m}$$

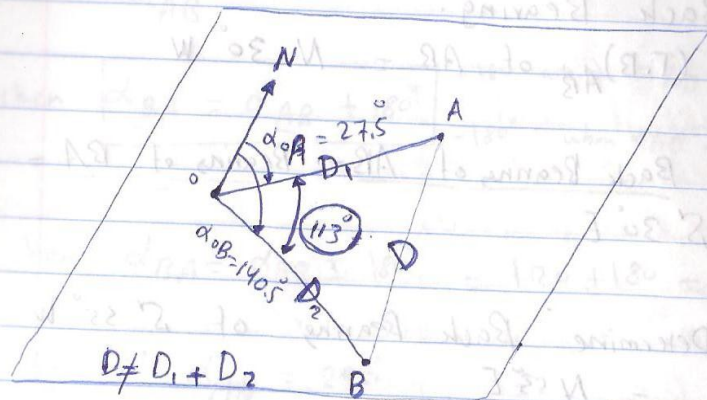
$$V_B = \frac{1}{2} kr \sin 2\theta = \frac{1}{2} (100) (2.00 - 1.00) \sin (-10^\circ) = -8.68 \text{ m}$$

ΔE_{AB}

$$\Delta E_{AB} = (1.5 + 8.68) + 5.5 - 1.20 = 14.48 \text{ m}$$

$$\text{Mean slope} = \frac{\Delta E_{AB}}{D_{AB}} = \frac{14.48}{39.22 + 99.24} = 0.104 = 10.4\%$$

180 ft A, B in 21/2 min



$$D = \sqrt{D_1^2 + D_2^2 - 2D_1 D_2 \cos \theta}$$

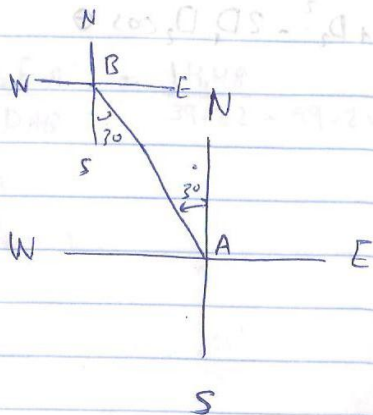
* Back Bearing and Back Azimuth.

□ Back Bearing.

if (T.B)_{AB} of AB = N 30° W

then Back Bearing of AB = Bearing of BA = S 30° E

Ex: Determine Back Bearing of S 55° W = N 55° E



□ Back Azimuth

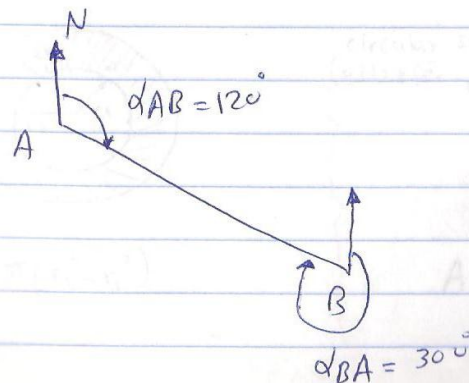
if $\alpha_{AB} = 120^\circ$

then $\alpha_{BA} = \alpha_{AB} \pm 180^\circ$
 $\begin{matrix} +180^\circ & \text{when } \alpha_{AB} < 180^\circ \\ -180^\circ & \text{when } \alpha_{AB} > 180^\circ \end{matrix}$

Here $\alpha_{BA} = \alpha_{AB} \pm 180^\circ = 120 + 180 = 300^\circ$

Ex: if $\alpha_{MN} = 290^\circ$

then $\alpha_{NM} = \alpha_{MN} \pm 180^\circ$
 $= 290 - 180$
 $= 110^\circ$

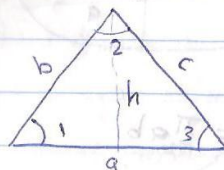


Chapter 8 Areas and Volumes

x Part One : Areas:

- ① Areas for basic figures
- ② Areas by the method of coordinates for irregular polygons.
- ③ Areas by the planimeter.
- ④ Areas for irregular figures.
 - Ⓐ Give and take method.
 - Ⓑ Graphical method.
 - Ⓒ Trapezoidal method.
 - Ⓓ Simpson one third method.

① Areas for basic figures: [Book (239-241)]



$$\rightarrow A = \frac{1}{2} ah$$

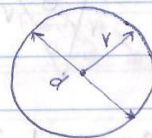
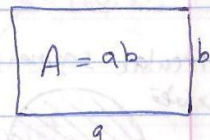
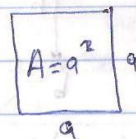
$$\rightarrow A = \frac{1}{2} ab \sin 1$$

$$= \frac{1}{2} bc \sin 2$$

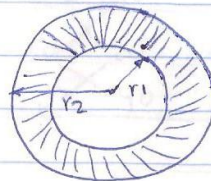
$$= \frac{1}{2} ac \sin 3$$

$$\rightarrow S = \frac{a+b+c}{2}$$

$$A = \sqrt{S(S-a)(S-b)(S-c)}$$



$$A = \pi r^2 = \frac{\pi d^2}{4}$$

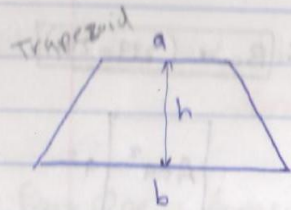


$$A = \pi (r_2^2 - r_1^2)$$

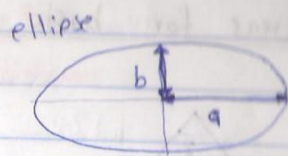
circular sector
ایک دائرہ



$$A = \frac{\pi r^2 \theta}{360}$$



$$A = \frac{(a+b)}{2} h$$



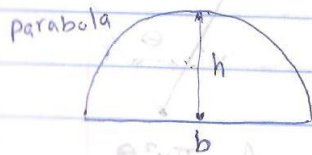
$$A = \pi ab$$

circular segment



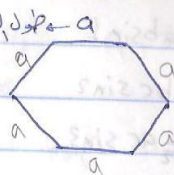
$$A = \frac{\pi r^2 \theta}{360} - \frac{1}{2} r^2 \sin \theta$$

$$= \frac{1}{2} r^2 \left(\frac{\pi \theta}{180} - \sin \theta \right)$$



$$A = \frac{2}{3} bh$$

regular Polygon



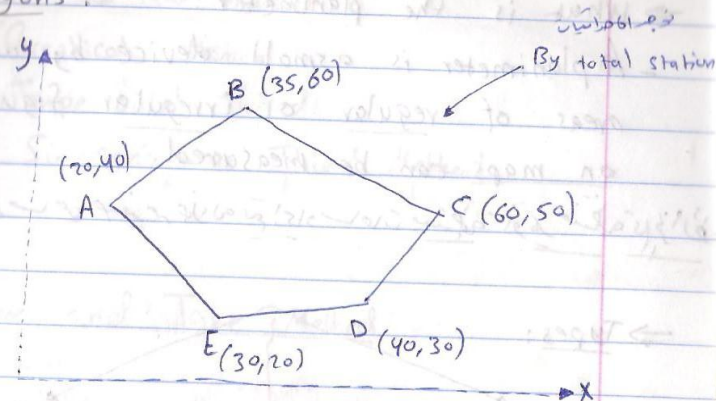
side length = n

$$A = \frac{1}{4} n a^2 \cot \left(\frac{180}{n} \right)$$



$$\left(\frac{\theta}{360} \right) \pi r^2 = A$$

[2] Area by the method of coordinates for irregular Polygons:



	X	Y	Product one	Product two
A	20	40		
B	35	60	1400	1200
C	60	50	3600	1750
D	40	30	2000	1800
E	30	20	900	800
A	20	40	400	1200
			8300 m ²	6750 m ²
			SUM one	SUM two

$$A = \frac{1}{2} | \text{SUM one} - \text{SUM two} |$$

$$= \frac{1}{2} | 8300 - 6750 | = 775 \text{ m}^2$$

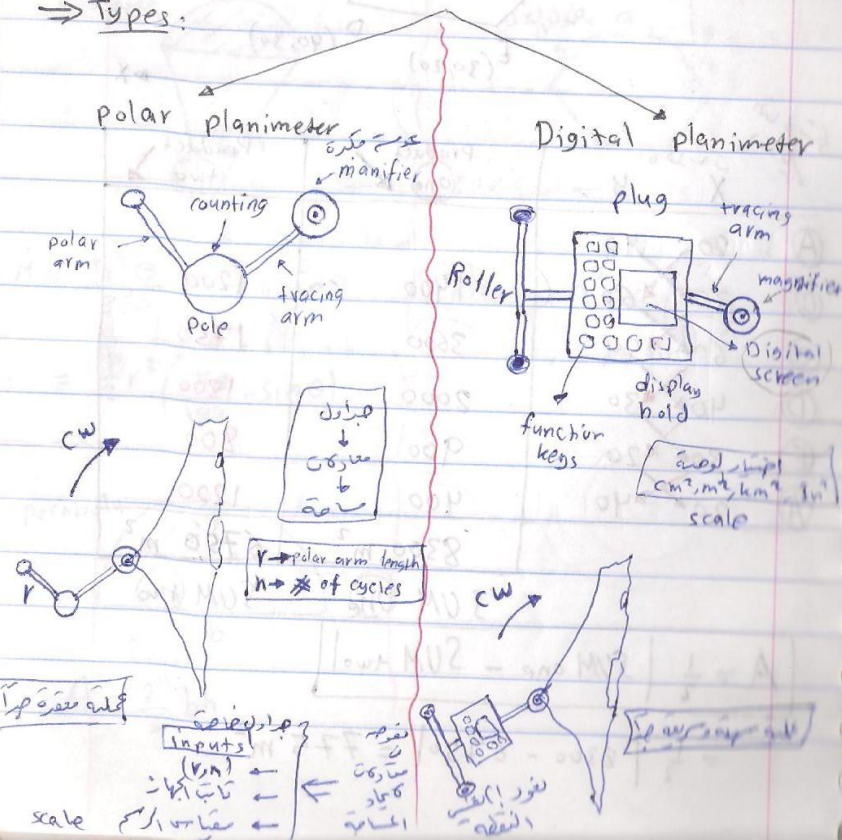
3) Area by the Planimeter:

→ What is the planimeter?

- A planimeter is a small device by which areas of regular or irregular figures on maps can be measured.

جهاز صغير جداً يتم به إيجاد مساحات منتظمة أو غير منتظمة في الخرائط

→ Types:

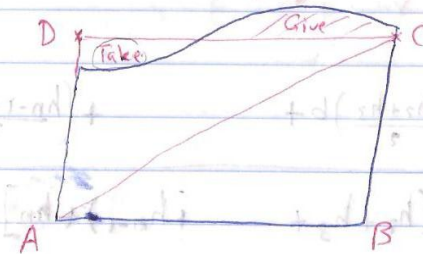


4) Areas for irregular figures:

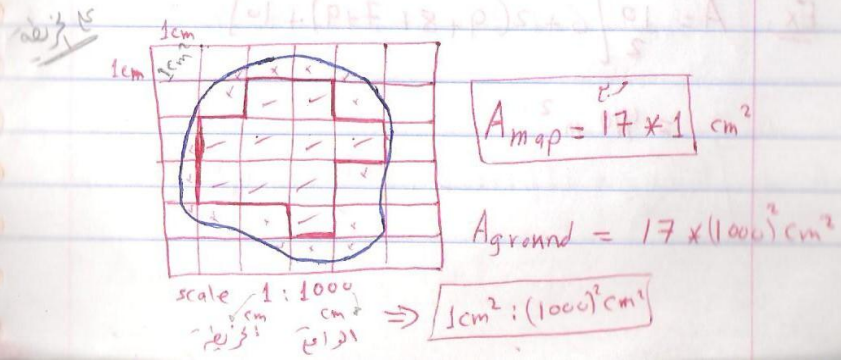
- a) Give and Take Method.
- b) Graphical Method.
- c) Trapezoidal Method.
- d) Simpson's one Third Method.

a) Give and Take Method.

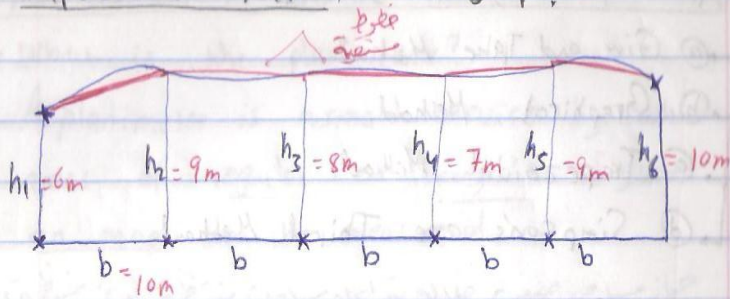
تقريباً مقاسيد
Give = Take



b) Graphical Method.

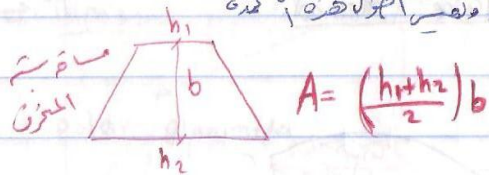


③ Trapezoidal Method. شبه المثلث



① تقسيم المساحة متساوية متساوية على النقط (المساحة زائفة)

② تقسيم المساحة بطريقة معينة ونفسية المثلثات



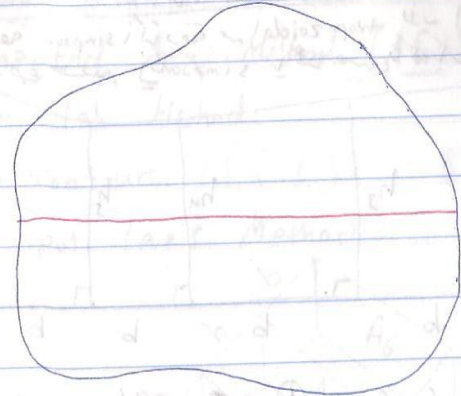
$$A = \left(\frac{h_1 + h_2}{2} \right) b$$

$$A = \left(\frac{h_1 + h_2}{2} \right) b + \left(\frac{h_2 + h_3}{2} \right) b + \dots + \left(\frac{h_{n-1} + h_n}{2} \right) b$$

$$A = \frac{b}{2} [h_1 + 2(h_2 + h_3 + \dots + h_{n-1}) + h_n]$$

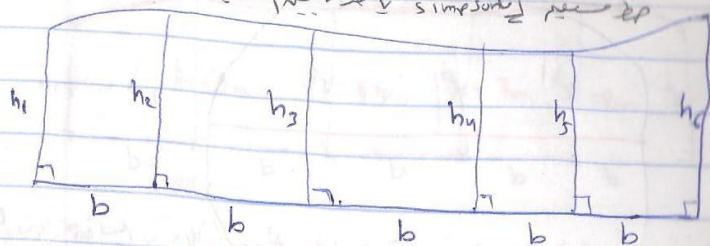
Ex: $A = \frac{10}{2} [6 + 2(9 + 8 + 7 + 9) + 10]$

$$= 410 \text{ m}^2$$



④ Simpson's One Third Method.

تقريب + trapezoidal في Simpson
(parabolic) في Simpson



condition: * of offsets (h/n) is odd

$$A = \frac{b}{3} [h_1 + 2O + 4E + h_n] \quad \begin{cases} O = \sum \text{odd offsets} \\ E = \sum \text{even offsets} \end{cases}$$

for $n=6$

$$A = \frac{b}{3} [h_1 + h_5 + 2(h_3) + 4(h_2 + h_4)] + \frac{(h_5 + h_6)b}{2}$$

for $n=9$ ✓

$$A = \frac{b}{3} [h_1 + h_8 + 2(h_3 + h_5 + h_7) + 4(h_2 + h_4 + h_6)] + \frac{(h_8 + h_9)b}{2}$$

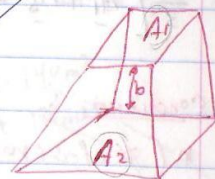
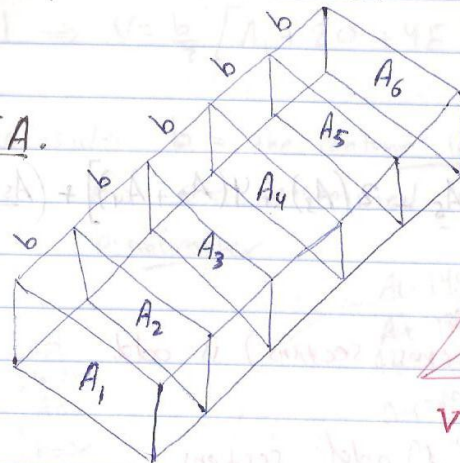
for $n=8$

$$A = \frac{b}{3} [h_1 + h_7 + 2(h_3 + h_5) + 4(h_2 + h_4 + h_6)] + \frac{(h_7 + h_8)b}{2}$$

* Part two: Volumes:

- ① Average End Area Method. (AEA)
- ② Prismoidal Method.
- ③ From contours.
- ④ By spot levels Method.

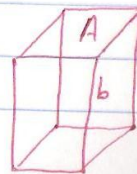
① AEA.



$$V = \left(\frac{A_1 + A_2}{2} \right) b$$

$$V = \left(\frac{A_1 + A_2}{2} \right) b + \left(\frac{A_2 + A_3}{2} \right) b + \dots + \left(\frac{A_{n-1} + A_n}{2} \right) b$$

$$V = \frac{b}{2} [A_1 + 2(A_2 + A_3 + \dots + A_{n-1}) + A_n]$$



$$V = Ab$$

② Prismoidal Method.

condition n is odd

$$V = \frac{b}{3} [A_1 + 2O + 4E + A_n]$$

for $n=6$:

$$V = \frac{b}{3} [A_1 + A_5 + 2(A_3) + 4(A_2 + A_4)] + \frac{(A_5 + A_6)b}{2}$$

* Condition :

n (# of cross sections) is odd.

O = Sum of odd sections

between 1 and n

E = Sum of even sections

between 1 and n

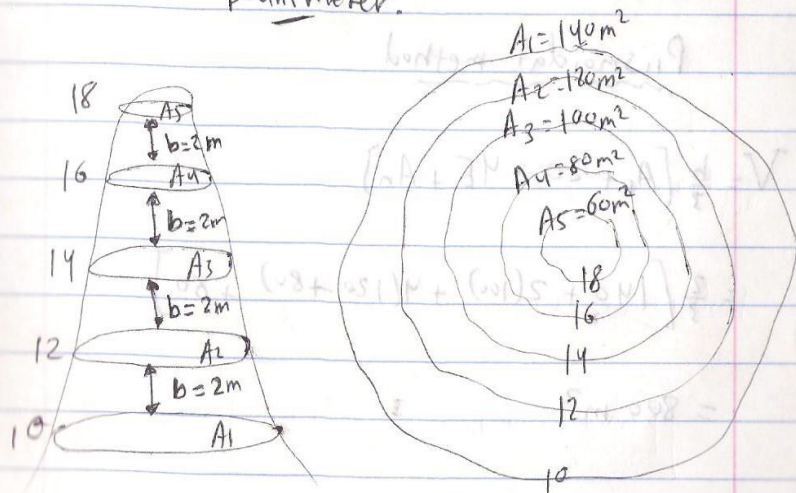
③ Volumes from contours:

Use either the AEA or Prismoidal method to determine the volume.

$$AEA \Rightarrow V = \frac{b}{2} [A_1 + 2(A_2 + A_3 + A_4 + \dots + A_{n-1}) + A_n]$$

$$\text{prismoidal} \Rightarrow V = \frac{b}{3} [A_1 + 2O + 4E + A_n] \quad n \text{ is odd.}$$

Here: consider b = the contour interval
 A_i 's are determined using the planimeter.



Ex. AEA method

$$V = \frac{b}{2} [A_1 + 2(A_2 + A_3 + \dots + A_{n-1}) + A_n]$$

$$= \frac{b}{2} [A_1 + 2(A_2 + A_3 + A_4) + A_5]$$

$$= \frac{2}{2} [140 + 2(120 + 100 + 80) + 60]$$

$$= 800 \text{ m}^2$$

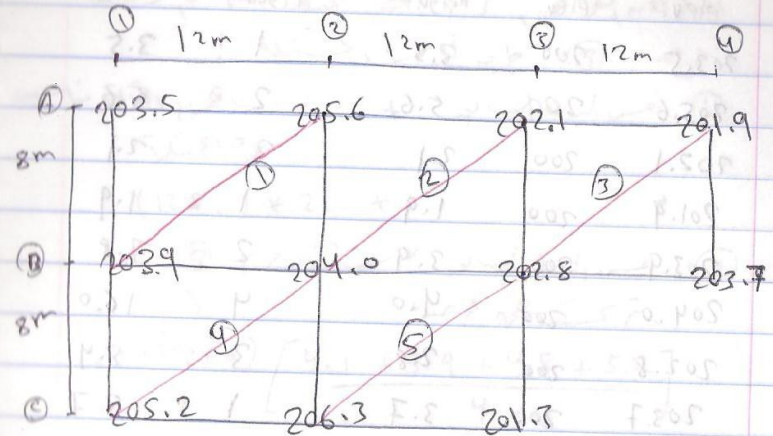
Prismoidal method

$$V = \frac{b}{3} [A_1 + 2O + 4E + A_n]$$

$$= \frac{2}{3} [140 + 2(100) + 4(120 + 80) + 60]$$

$$= 800 \text{ m}^2$$

④ Spot levels Method:



$$V = V_1 + V_2 + V_3 + V_4 + V_5$$

$$= (12 \times 8) \left(\frac{3.5 + 5.6 + 3.9 + 4}{4} \right) +$$

$$(12 \times 8) \left(\frac{5.6 + 2.1 + 4 + 2.8}{4} \right) +$$

* The area is to be leveled to an elevation of 200m

Point	old elev.	New elev.	Cut height (C)	# of figures (n)	C x n
A ₁	203.5	200	3.5	1	3.5
A ₂	205.6	200	5.6	2	11.2
A ₃	202.1	200	2.1	2	4.2
A ₄	201.9	200	1.9	1	1.9
B ₁	203.9	200	3.9	2	7.8
B ₂	204.0	200	4.0	4	16.0
B ₃	202.8	200	2.8	3	8.4
B ₄	203.7	200	3.7	1	3.7
C ₁	205.2	200	5.2	1	5.2
C ₂	206.3	200	6.3	2	12.6
C ₃	201.3	200	1.3	1	1.3

75.8

SUM

Volume = Area of the figure $\times$ SUM

(4)

$$V = 12 \times 8 \times \frac{75.8}{4} = 1819.2 \text{ m}^3$$

عدد جوان السطح = 4
لأنه من 4 اتجاهات
(3)

إذا كانه الجوان 4 اتجاهات
لأنه من 4 اتجاهات

(1) نفس الجوان 4 اتجاهات
لأنه من 4 اتجاهات

$$(12 \times 8) \times 2 +$$

(2) نفس الجوان 4 اتجاهات
لأنه من 4 اتجاهات

$$V = (12 \times 8) \left[\frac{4.1 + 3.9 + 4.8 + 5.7}{4} \right]$$

(3) نفس الجوان 4 اتجاهات
لأنه من 4 اتجاهات

A ₃	202.1	2.1	1
A ₃	202.1	4.1	1
B ₃	202.8	2.8	
B ₃	202.8	4.8	1
A ₄	201.9	3.9	1
B ₄	203.9	5.9	1