Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere – 577 004
Department of Civil Engineering

Course File Check List

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Academic Calendar of EVEN semesters of UG Programmes for 2020-2021

Semesters EVENTS	IV semester B.E./B.Tech.	IV semester B.Arch./ B.Plan.	VI semester B.E./B.Tech.	VI semester B.Plan./B.Arch	VIII semester B.E./B.Tech.	VII semester B.Plan./B.Arch.
Commencement of EVEN Semester	19.04.2021	19.04.2021	19.04.2021	19.04.2021	19.04.2021	19.04.2021
Last Working day of EVEN Semester	07.08.2021	07.08.2021	07.08.2021	07.08.2021	20.07.2021	20.07.2021
Practical Examinations	09.08.2021 To 19.08.2021	09.08.2021 To 19.08.2021	09.08.2021 To 19.08.2021	—	—	—
Theory Examinations	23.08.2021 To 09.09.2021	23.08.2021 To 09.09.2021	23.08.2021 To 09.09.2021	10.08.2021 To 31.08.2021	#22.07.2021 To 30.07.2021	#22.07.2021 To 30.07.2021
Internship	—	—	—	—	—	—
Internship Viva-Voce	—	—	—	—	02.08.2021 To 06.08.2021	—
Professional training / Organization study	—	—	—	—	—	—
Commencement of ODD Semester	13.09.2021	13.09.2021	13.09.2021	13.09.2021	—	09.08.2021 (IX sem Arch)

- The classroom sessions for even the semester should commence from the dates mentioned above. The classroom sessions for all the semesters would be in **Offline /Online/blended mode** until further orders.
- The Institute needs to function for **six days** a week with additional hours **(Saturday is a full working day).** #if required the college can plan to have extra classes even on **Sundays also**.
- If any of the above dates are declared to be a holiday then the corresponding event will come into effect on the next working day.
- Notification regarding the Calendar of Events relating to the conduct of **University Examinations** will be issued by the Registrar (Evaluation) from time to time.
- The faculty/staff shall be available to undertake any work assigned by the University.
- Academic Calendar may be modified based on guidelines/directions issued in the future by MHRD/UGC/AICTE/State Government.
- Revised Academic Calendar is also applicable for **Autonomous Colleges.** In case if any changes are to be affected by Autonomous Colleges in the academic terms and examination schedule, they could do so with the approval of the University.

7/4/2021.

REGISTRAR

Academic Calendar of VTU, Belagavi for EVEN Semester of 2019-2020 (Jan 2020 – July 2020)

	II Sem B. E./ B. Tech./ B. Arch	IV & VI Sem B. E. /B. Tech. IV, VI&VIII Sem B. Arch.	VIII Sem B.E / B.Tech & X Sem B. Arch	IV Sem MCA	VI Sem MCA	IV Sem MBA	IV Sem M. Tech.	IV Sem M. Arch.	II Sem M. Tech.	II Sem MCA	II Sem MBA	II Sem M. Arch.
Commencement of EVEN Semester	10.02.2020	10.02.2020	10.02.2020	27.01.2020	27.01.2020	10.02.2020	27.01.2020	27.01.2020	05.03.2020	05.03.2020	14.02.2020	14.02.2020
Last Working day of EVEN Semester	01.06.2020	01.06.2020	01.06.2020	20.05.2020	20.05.2020	01.06.2020	20.05.2020	20.05.2020	22.06.2020	22.06.2020	05.06.2020	05.06.2020
Practical Examination	03.06.2020 To 13.06.2020	03.06.2020 To 13.06.2020	-	26.05.2020 To 30.05.2020	-	-	-	-	25.06.2020 To 30.06.2020	25.06.2020 To 30.06.2020	-	-
Theory Examinations	15.06.2020 To 04.07.2020	15.06.2020 To 20.07.2020	03.06.2020 To 11.06.2020	03.06.2020 To 18.06.2020	-	03.06.2020 To 28.06.2020	03.06.2020 To 10.06.2020	-	01.07.2020 To 11.07.2020	01.07.2020 To 11.07.2020	08.06.2020 To 20.06.2020	09.06.2020 To 20.06.2020
Viva Voce	-	-	15.06.2020 To 20.06.2020	-	-	-	-	-	-	-	-	-
Summer Project / Professional training	-	-	-	-	22.05.2020 To 30.05.2020 (Submission of report to VTU)	01.04.2020 To 15.04.2020 (Submission of report to VTU)	12.06.2020 To 25.06.2020 (Submission of report to VTU)	-	13.07.2020 To 31.07.2020	-	23.06.2020 To 21.07.2020	01.07.2020 To 25.08.2020
Commencement of ODD Semester	27.07.2020	27.07.2020	27.07.2020	27.07.2020	-	-	-	-	03.08.2020	27.07.2020	27.07.2020	28.08.2020

NOTE

1. College Time Table shall be arranged for five and a half week days and planned to accommodate EDUSAT transmission slots, the schedule of which will be notified separately.
2. The faculty/staff shall be available to undertake any work assigned by the university.
3. If any of the above date is declared to be a holiday then the corresponding event will come into effect on the next working day.
4. Notification regarding Calendar of Events relating to the conduct of University Examination will be issued by the Registrar (Evaluation) from time to time.

10.1.2020.

REGISTRAR

2019-2020 - even

Bapuji Institute of Engineering and Technology
CALENDAR OF EVEN SEMESTER: FEBRUARY 2020 to JULY-2020

PARTICULARS	II sem BE/B Tech	IV & VI sem BE/B Tech	VIII sem BE/B. Tech	II sem MCA	IV sem MCA	VI sem MCA	II sem M. Tech	IV sem M. Tech	II Sem MBA	IV Sem MBA
Commencement of EVEN semester	10-02-2020	10-02-2020	10-02-2020	05-03-2020	05-03-2020	27-01-2020	05-03-2020	27-01-2020	14-02-2020	10-02-2020
Last Working Day	01-06-2020	01-06-2020	01-06-2020	22-06-2020	22-06-2020	20-05-2020	22-06-2020	20-05-2020	05-06-2020	01-06-2020
1st IA Test Series	18-03-2020 24-03-2020	18-03-2020 24-03-2020	18-03-2020 24-03-2020	20-04-2020 22-04-2020	20-04-2020 22-04-2020	----	20-04-2020 22-04-2020	----	26-03-2020 28-03-2020	26-03-2020 28-03-2020
2nd IA Test Series	24-04-2020 30-04-2020	24-04-2020 30-04-2020	24-04-2020 30-04-2020	21-05-2020 23-05-2020	21-05-2020 23-05-2020	-----	21-05-2020 23-05-2020	----	27-04-2020 29-04-2020	27-04-2020 29-04-2020
3rd IA Test Series	23-05-2020 30-05-2020	23-05-2020 30-05-2020	23-05-2020 30-05-2020	18-06-2020 20-06-2020	18-06-2020 20-06-2020	-----	18-06-2020 20-06-2020	----	26-05-2020 28-05-2020	26-05-2020 28-05-2020
Practical Examination	03-06-2020 13-06-2020	03-06-2020 13-06-2020	-----	25-06-2020 30-06-2020	24-06-2020 29-06-2020	----	25-06-2020 30-06-2020	----	----	----
Theory Examination	15-06-2020 04-07-2020	15-06-2020 20-07-2020	03-06-2020 11-06-2020	01-07-2020 11-07-2020	03-07-2020 11-07-2020	----	01-07-2020 11-07-2020	03-06-2020 10-06-2020	08-06-2020 20-06-2020	03-06-2020 28-06-2020
Project Viva-Voce/ Summer Project/ Professional training	------	------	15-06-2020 20-06-2020	-------	------	22-05-2020 30-05-2020 (submission of report to VTU)	13-07-2020 31-07-2020	12-06-2020 25-06-2020 (Submission of report to VTU)	23-06-2020 21-07-2020	01-04-2020 15-04-2020 (Submission of report to VTU)
Commencement of Odd sem	27-07-2020	27-07-2020	27-07-2020	27-07-2020	27-07-2020	------	03-08-2020	------	27-07-2020	------

DEPARTMENT	EVENT	TENTATIVE DATE
Textile Technology	Special Lecture on English Communication	20-02-2020
	Industrial Visit for pre final year students	28/29-02-2020
	Yoga for Holistic life	02-03-2020
	Texcreative-20, National level Technical Symposium	13/14-03-2020
	Special Lecture on Garment Export	16-04-2020
	Expert Lecture on Position of Spinning Industry	27-04- 2020
	Waste Management	09-05-2020
Electronics & Instrumentation Engineering	Workshop on IoT	27/28/29-02-2020
	Technical Talk-I	28-03-2020
	Industrial Visit	03/04-04-2020
	INTECH -2020	29/30-04-2020
	Technical Talk-II	09-05-2020
Electrical & Electronics Engineering	Technical Talk	15/29-02-2020
	Three days Faculty Development Programme	06/08-03-2020
	Impulse State Level Technical Symposium	27-03-2020
	Technical Talk	18-04-2020
	Department Sports Events	02/05-05-2020
Bio Technology Engg.	Invited lecture	15-02-2020
	One week Hands on Training	03/09-03-2020
	Brainstorm Sessions every week	----------

DEPARTMENT	EVENT	TENTATIVE DATE
MCA	Seminar	20-03-2020
	Workshop	23-04-2020
	Student Seminar/Group Discussion	15-05-2020
	FDP	10-06-2020
Departments of Mathematics Physics, Chemistry	Student Induction Program (SIP) for First Year Students (II Semester) & AICTE Activity Points Program for First Year Students of 2019-20 batch. (II Sem)	10-02-2020 to 17-02-2020
	National Science Day	28-02-2020
	National Conference on "Recent Developments in Physical, Chemical One and Mathematical Sciences(NCRPCM-2020)"	20-03-2020
	"Technology Barrier Reduction Program (TBRP) 2020" for Rural Government High School 10th Standard Kannada Medium Students.	15-04-2020 to 05-05-2020
Chemical Engineering	Guest lecture - I	27-02-2020
	Industrial Visit	06-03-2020
	Guest lecture – II	20-03-2020
	Workshop on soft skills	03-04-2020
	Sports (Interdepartmental)	18-04-2020
Electronics & Communication Engineering	NB Cup Cricket Tournament Inauguration	24-02-2020
	Visit to IISc Open Day 2020 / Industrial Visit	29/02/2020 28/3/2020
	E-Utsav 2020, Papyrus-A State level paper presentation for UG and PG students	08-09/05/2020
	EC Forum valedictory	16-05-2020

Vision of BIET

To be a center of excellence recognized nationally and internationally, in distinctive areas of engineering education and research, based on a culture of innovation and invention.

Mission of BIET

BIET contributes to the growth and development of its students by imparting a broad based engineering education and empowering them to be successful in their chosen field by inculcating in them positive approach, leadership qualities and ethical values

VISION OF THE DEPARTMENT

To train the students to become Civil Engineers with leadership qualities, having ability to take up professional assignments and research with a focus on innovative approaches to cater to the needs of the society.

MISSION OF THE DEPARTMENT

1. To provide quality education through updated curriculum and conducive teaching learning environment for the students to excel in higher studies, competitive examinations and professional career.
2. To impart soft skills, leadership qualities and professional ethics among the graduates to handle the projects independently with confidence.
3. To deal with the contemporary issues and to cater to the socio-economic needs.
4. To build industry-institute interaction and to establish good rapport with alumni.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Core Competence: Graduates will be able to plan, analyse, design and construct sustainable Civil Engineering Infrastructure.

PEO 2: Professional Skills: Graduates will be professional engineers with a sense of ethics, creativity, leadership, self-confidence and independent thinking to cater to the needs of the society.

PEO 3: Societal Needs: Graduates will be able to contribute effectively for the development of industry and professional bodies.

PEO 4: Cognitive Intelligence: Graduates will be able to take up competitive examinations, higher studies and involve in research and entrepreneurship activities.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Students after the completion of the Program will be able to

1. Apply the fundamental concepts, software and codal provisions in the analysis, design and construction of sustainable civil engineering infrastructure.
2. Inculcate professional and leadership qualities, sense of ethics and confidence related to civil engineering.

Faculty will be able to

3. Contribute to the overall development of civil engineering community through the professional bodies and offer services to the society.

Name of the Faculty: Sri. Raghu M E

Time / Day	8 – 9	9 – 10	10.30 – 11.30	11.30 – 12.30	2 3	3 – 4	4 – 5
Mon					18CVL66 – A1 (MER+ADJ)		
Tue			18CV45 – B				
Wed		18CV45 – B	15/17CV63				
Thu	18CV45 – B			15/17CV63			
Fri			15/17CV63		18CVL66 – B2 (MER+CTG)		
Sat			15/17CV63				

1.
2.
Time Table Coordinator

HOD

Principal

Title & Code	**Advanced Surveying (18CV45)**
CO	**Statement**
18CV45.1	**Measure** horizontal and vertical angles by theodolite, and **determine** the elevations of points by trigonometric levelling
18CV45.2	**Apply** tachometric principles for distance and elevation measurements
18CV45.3	**Explain** the principles of triangulation
18CV45.4	**Calculate** the data for setting out of horizontal curves
18CV45.5	**Apply** the concept of aerial photogrammetry to **determine** the ground co-ordinates
18CV45.6	**Explain** modern surveying instruments, remote sensing and GIS for engineering applications.

Course Title	**Advanced Surveying**											
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
18CV45.1	2	2		1								2
18CV45.2	2	2		1								2
18CV45.3	2	2		1								2
18CV45.4	2	2		1								2
18CV45.5	2	2		1								2
18CV45.6	2	2		1	1							2
Average	2	2		1	1							2

CO	**PSO1**	**PSO2**
18CV45.1	2	2
18CV45.2	2	2
18CV45.3	2	2
18CV45.4	2	2
18CV45.5	2	2
18CV45.6	2	2
Average	2	2

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Assignment-1

Date	23	07	2021

Assignment No.	01	**Maximum Marks**	10
Course/Subject Title	Advanced surveying	**Course/Subject Code**	18CV45
Semester	IV	**Scheme**	CBCS - 18

Course Outcome Statements : After the successful completion of the course, the students will be able to	
CO1	To gain knowledge on theodolite surveying and to apply the principles of trigonometric levelling.
CO2	To apply the principles of Tachometry in the determination of horizontal distances and elevation of various objects.
CO3	To gain knowledge on geodetic survey.
CO4	To gain knowledge on setting out of horizontal and vertical curves.
CO5	To apply the concept of aerial photogrammetry to determine the ground co-ordinates.
CO6	To know the use of different modern surveying instrument for various civil engineering applications.

Q. No.	Questions	RBT Level	CO
1	**Define** the following terms a) The vertical axis, b)The horizontal axis , c) the line of sight or line of collimation, d) The axis of level tube, e) Transiting and f) Swing the telescope .	L1	1
2	**Derive** an expression when base of the object is inaccessible. Instrument stations not in the same vertical plane as elevated object.	L2	1
3	An instrument was set up at P and the angle of elevation to a vane 4m above the foot of the staff held at Q was 9°30′. The horizontal distance b/w P and Q was known to be 2000m. **Determine** the RL of Staff station Q, given that the RL of the instrument axis was 2650.38m.	L3	1
4	**Derive** an expression for distance and elevation formulae for staff vertical for inclined line of sight.	L2	2
5	**Define** triangulation. **Explain** the triangulation figures and layouts of triangulation.	L1	3
6	The elevation of a point P is to be determined by observations by two adjacent stations of a tacheometric survey. The staff was held vertically upon on the point, and the instrument is fitted within an anallactic lens, the constant of the instrument being 100. **Compute** the elevation of the point P from the following data, take both the observations as equally trustworthy.	L3	2

Instrument Station	Height of axis	Staff point	Vertical angle	Staff Reading	Elevation of Station
A	1.42	P	+2°24′	1.230,2.055, 2.880	77.750m
B	1.40	P	-3°36′	0.785,1.800, 2.815	97.135m

Q. No.	Questions	RBT Level	CO
7	Two tangents intersect at chainage of 59+60, the deflection angle being 50°30′. **Calculate** the necessary data for setting out a curve of 300m radius to connect the two tangents by the offset from chord produced method with peg interval of 20m. The chain is of 20m length.	L3	4
8	**Define** transition curve. **List** the functions and requirements of	L1	4

Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere-577 004
Department of Civil Engineering

Assignment-1

Date	23	07

USN

Q. No.	Questions	RBT Level	CO
	transition curve.		
9	Define vertical photograph, tilted photograph and oblique photograph.	L2	5
10	A vertical photograph was taken at an altitude of 1200m above the mean sea level. Determine the scale of photograph for terrain lying at elevation of 80m and 300m, if the focal length of camera is 15cm.	L3	5
11	What is GPS? Explain the basic principles of GPS and its application in surveying.	L2	6
12	Define remote sensing. Explain the stages of idealized remote sensing system.	L2	6
13	Explain the components of GIS.	L2	6

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
L1 : Remembering	L2 : Understanding	L3 : Applying
L4 : Analysing	L5 : Evaluating	L6 : Creating

Course Coordinator
(Raghu M E)

ASSISTANT PROFESSOR
Civil Engineering Department
B.I.E.T., Davangere.

Coordinator
DQAC

Program Coordinator
(HOD, Civil)

Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere-577 004
Department of Civil Engineering

USN										

Course/Subject Title	**Advanced Surveying**	**Course/Subject Code**	**18CV45**
Semester	**IV B**	**Scheme**	**CBCS – 18**
Date	**09/06/2021**	**CIE No.**	**01**
Time	**9:00 AM to 10:00 AM**	**Max. Marks**	**30**

Course Outcome Statements	
After the successful completion of the course, the students will be able to	
CO1	**Measure** horizontal and vertical angles by theodolite, and **determine** the elevations of points by trigonometric levelling
CO2	**Apply** tachometric principles for distance and elevation measurements
CO3	**Explain** the principles of triangulation
CO4	**Calculate** the data for setting out of horizontal curves
CO5	**Apply** the concept of aerial photogrammetry to **determine** the ground co-ordinates
CO6	**Explain** modern surveying instruments, remote sensing and GIS for engineering applications.

Q. No.	**Question**	**Marks**	**RBT Level**	**CO**
	NOTE: ANSWER ANY ONE FULL QUESTION FROM PART .			
	PART - A			
1a)	**Define** the following terms a) The vertical axis, b)The horizontal axis c) the line of sight or line of collimation, d) The axis of level tube, e) Transiting and f) Swing the telescope. **Explain briefly** the temporary adjustment of transit theodolite.	8	L1 & l2	1
1b)	**Derive** an expression when base of the object is inaccessible. Instrument stations in the different levels in the same vertical plane as elevated object.	7	L3	1
	OR			
2a)	**Explain briefly** the measurement of horizontal angle by repetition method. State what errors are eliminated. Tabulate the results.	8	L1 & l2	1
2b)	An instrument was set up at P and the angle of elevation to a vane 4m above the foot of the staff held at Q was 9°30'. The horizontal distance b/w P and Q was known to be 2000m. **Determine** the RL of Staff station Q, given that the RL of the instrument axis was 2650.38m.	7	L3	1
	PART - B			
3a)	**Derive** an expression for distance and elevation formulae for staff vertical for inclined line of sight.	8	L2	2
3b)	**Define** triangulation. **Explain** the triangulation figures and layouts of triangulation.	7	L2	3
	OR			
4a)	**Explain the** classification of triangulation system.	8	L2	3
4b)	The elevation of a point P is to be determined by observations by two adjacent stations of a tacheometric survey. The staff was held vertically upon on the point, and the instrument is fitted within an anallactic lens, the constant of the instrument being 100. **Compuate** the elevation of the point P from the following data, take both the observations as equally trustworthy.	7	L2	2

Instrument Station	Height of axis	Staff point	Vertical angle	Staff Reading	Elevation of Station
A	1.42	P	+2°24′	1.230,2.055, 2.880	77.750m
B	1.40	P	-3°36′	0.785,1.800, 2.815	97.135m

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
L1 : Remembering	L2 : Understanding	L3 : Applying
L4 : Analysing	L5 : Evaluating	L6 : Creating

Raghu 8/6/2024

Course Coordinator
(RAGHU M E)

ASSISTANT PROFESSOR
Civil Engineering Department
B.I.E.T., Davangere.

Coordinator
DQAC

Program Coordinator
(HOD, Civil)

Bapuji Educational Association ®
Bapuji Institute of Engineering and Technology, Davangere–577 004
Department of Civil Engineering

Scheme of Valuation

Course/Subject Title	Advanced surveying	**Course/Subject Code**	18CV45
Semester	IV B	**CIE No.**	01
Date	09.06.2021.	**Max. Marks**	30

Part - A.

①a Define Each Definition carries equal marks 1×5 = 5m. —5

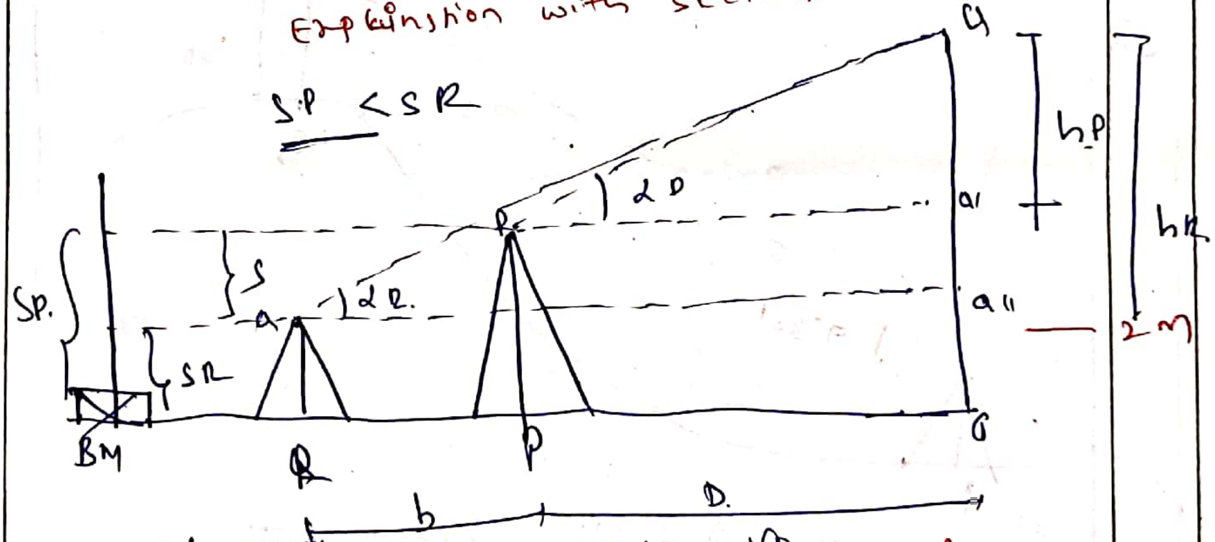
Temporary adjustment of Transit theodolite —3

- Setting up.
- levelling up. } 3M
- Elimination of parallel axis.

Explanation with sketch.

8m

①b.



2m

$$\text{al } aPa' = h_P = D\tan\alpha_P \quad \text{①}$$
$$\text{al } aRa'' = h_R\ (b+D)\tan\alpha_R \quad \text{②}$$

} 2m

$$\text{eq}② - \text{eq}① = \quad b = \frac{b\tan\alpha_R - s}{\tan\alpha_P - \tan\alpha_R}$$

$$\text{or} \quad \boxed{b = \frac{s - b\tan\alpha_R}{\tan\alpha_R - \tan\alpha_P}}$$ 2m

$$RL\ of\ Q = RL\ of\ BM + SP + D\tan\alpha_P$$

$$RL\ of\ Q = RL\ of\ BM + SR + (b+D)\tan\alpha_R.$$ 1m

7m

Course Coordinator
(Faculty in charge)

Coordinator
DQAC

Program Coordinator
(HOD, Civil)

Scheme of Valuation

S R > SD

$$\boxed{D = \frac{b \tan \alpha R \pm S}{\tan \alpha D - \tan \alpha R}}$$

(or)

2ⓑ. Repetition method with procedure & tabulation with fig – 8m

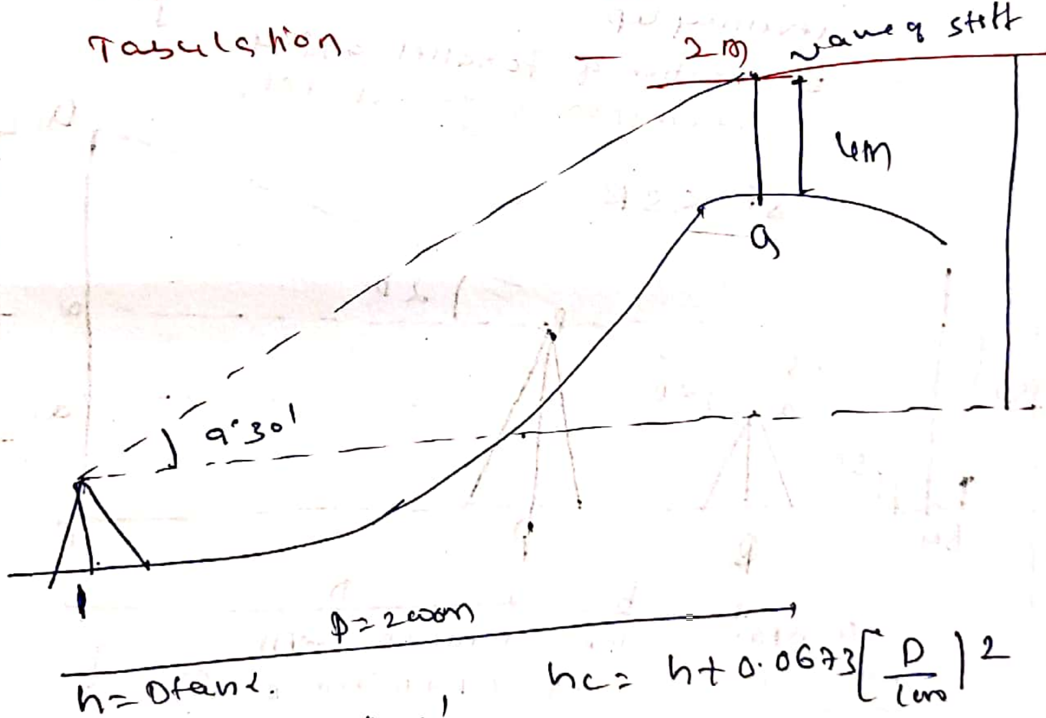
Repetition - Definition – 1m

Procedure – 4m

fig – 1m

Tabulation – 2m

2ⓑ 5m



h = D tan α.

h = 2000 tan 9°30'

$\boxed{h = 334.685 \text{ m}}$

hc = h + 0.0673 $\left[\frac{D}{1000}\right]^2$

hc = 334.954m

RL of vane = height of Instrument the
= 2650.380 + 334.954

$\boxed{\text{RL of vane} = 2985.334 \text{m}}$

RL of staff (a) = RL of vane – height of staff
= 2985.334 – 4 = 2981.334m

RL of a = 2981.334m

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Scheme of Valuation

Course/Subject Title		**Course/Subject Code**	
Semester		**CIE No.**	
Date		**Max. Marks**	

Part - B

3(a) Distance ~~eqution~~ for Inclined line of sight.

① Case - Angle of elevation.

$$\boxed{D = Ks\cos^2\theta + C\cos\theta.}$$

$$\boxed{V = K.S.\frac{\sin 2\theta}{2} + C\sin\theta}$$

RL of staff station = HI + V - h. With Sketches — 4m

Angle of Depression:

$$D = Ks\cos^2\theta + C\cos\theta.$$

$$V = K.s\frac{\sin 2\theta}{2} + C\sin\theta$$

RL of staff station = HI - V - h. } — 4m

8m

3(b) Definition of Triangulation — 1m

triangulation figures
- Single chain of triangles
- Double chain —11—
- Braced quadrilaterals
- Centered triangles with polygons

} 4m

layouts of triangulation
- Grid system
- central system

with Explaination } 2m

with sketches.

2m

(or)

4(a) Triangulation - classification.

1. Primary triangulation — 2m
2. Secondary —11— — 2m
3. Tertiary —11— — 2m

with Explaination } 6m { 6m

Course Coordinator
(Faculty in charge)

Coordinator
DQAC

Program Coordinator
(HOD, Civil)

Scheme of Valuation

4 ⑤

$D = KS\cos^2\theta$

$V = KS\dfrac{\sin 2\theta}{2}$

RL of P = ele of station = A + h + V - r

① observation from A to P → $\boxed{3.5}$ m 3.5

S = 1.65m D = 164.7m V = 6.903

$\boxed{\text{RL of P} = 84.018\text{m}}$

② observation from B to P → $\boxed{3.5}$ m

S = 2.03m D = 202.2m V = 12.721m 3.5

RL of P = 84.014m

Avg. elevation of P = 84.016m

7.5 m

10-6-2024

Course Coordinator (Faculty In charge)

ASSISTANT PROFESSOR
Civil Engineering Department
B.I.E.T., Davangere

Coordinator DQAC

Program Coordinator (HOD, Civil)

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Bapuji Institute of Engineering and Technology, Davangere–577 004
Department of Civil Engineering

USN										

Course/Subject Title	**Advanced Surveying**	**Course/Subject Code**	**18CV45**
Semester	**IV B**	**Scheme**	**CBCS – 18**
Date	**07/07/2021**	**CIE No.**	**02**
Time	**9:00 AM to 10:00 AM**	**Max. Marks**	**30**

Course Outcome Statements

After the successful completion of the course, the students will be able to

CO1	**Measure** horizontal and vertical angles by theodolite, and **determine** the elevations of points by trigonometric levelling
CO2	**Apply** tachometric principles for distance and elevation measurements
CO3	**Explain** the principles of triangulation
CO4	**Calculate** the data for setting out of horizontal curves
CO5	**Apply** the concept of aerial photogrammetry to **determine** the ground co-ordinates
CO6	**Explain** modern surveying instruments, remote sensing and GIS for engineering applications.

Q. No.	**Question**	**Marks**	**RBT Level**	**CO**
	NOTE: ANSWER ANY ONE FULL QUESTION FROM PART.			
	PART - A			
1a)	With the help of neat sketch of simple circular curve? **Explain**	15	L1 & l2	4
1b)	Two tangents intersect at chainage of 59+60, the deflection angle being 50°30'. **Calculate** the necessary data for setting out a curve of 300m radius to connect the two tangents by the offset from chord produced method with peg interval of 20m. The chain is of 20m length.	15	L3	4
	OR			
2a)	Two tangents interest at the chainage 1190m. The deflection angle being 36^{θ}. **Calculate** all data necessary for setting out a circular curve with radius of 300m by deflection angle method. Take peg interval is 30m. a) Rankine's deflection angle method. And b) offsets from chords produced method.	15	L3 [illegible]	4
2b)	Two straights AB & BC intersect at B with a chainage of 1234m. It is proposed to introduce a compound curve. With first arc of radius 65m and central angle 35°and second arc of radius 100m and central angle 40°. Make necessary calculations to set out the curve by Rankines deflection method. Take peg interval as 20m.	15	L3	4

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
L1 : Remembering	L2 : Understanding	L3 : Applying
L4 : Analysing	L5 : Evaluating	L6 : Creating

06/7/21
Course Coordinator
(RAGHU M E)

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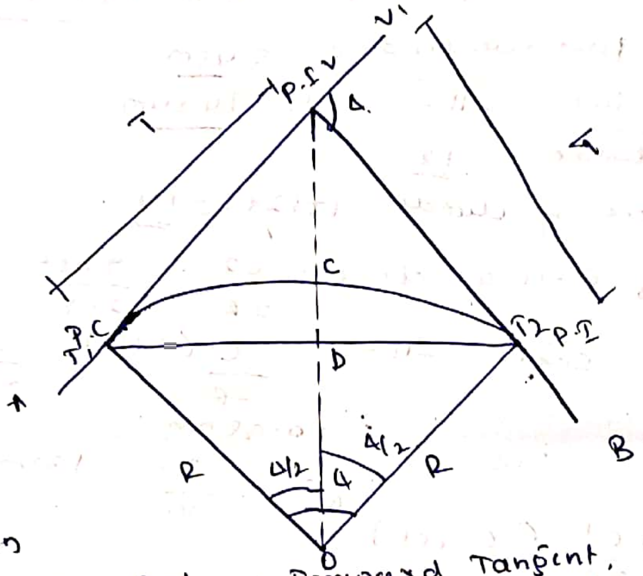
Scheme of Valuation

Course/Subject Title	Advanced Surveying	**Course/Subject Code**	18CV45
Semester	IV B	**CIE No.**	02
Date	07.07.2021	**Max. Marks**	30

Part - A

1a)



— 3m

Explan

1. Back Tangent, 2. Forward Tangent, 3. Point of Intersection. 4. Point of curve 5. Point of Tangency. 6. Intersection angle, 7 Tangent Distance 8. Length of curve ⑨ Long chord. ⑩ Mid-ordinate. 11 Normal chord 12. Sub. chord 13. Right hand curve. 14. ~~Right~~ Left hand curve. } 12.

Neat sketch with Explainetion at least
08 - Definition ~~10~~. ~~marks~~ 08×1.5 = 12
fig = 3
15 marks

1⑥ Tangent length T = $R\tan\Delta/_2$

R = 15
Δ = 50° 30'
P.I = 1192
Peg Interval = 20mts

$\boxed{T = 141.48m}$ - 2m

② length of curve $l = \frac{\pi R \Delta}{180}$

$\boxed{l = 264.41m}$ - 2m

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Chainage of PI = 1192 m

Chainage of PC = Chainage of PI − Tangent length — 2m

= 1192 − 141.48 = 1050.52

Chainage of P.T = 1050.52 + 264.41 = 1314.84 m — 2m

length of first subchord $c' = 9.48m$

—||— last —||— $c_1' = 14.84m$ } 2m

No of Normal chords = 12

Total no of chords = 1+12+1 = 14

length of first offset $O_1 = \frac{c^2}{2R} = \frac{9.48^2}{2\times300} = 0.149m$

—||— second —||— $O_2 = \frac{c}{2R}(c+c') = \frac{20}{2\times300}(20+9.41)$ } 5m

$= 0.98m$

$O_3, O_4 ---- O_{13} = \frac{c^2}{R} = \frac{20^2}{300} = 1.33m$

$O_{14} = \frac{c'}{2R}(c+c')$ — 15m

$= \frac{14.84}{2\times300}(20+14.84)$

$O_{14} = 0.87m$

(8) Rankines Deflection angle method

(25) Chainage of P.I = 1190m, $\Delta = 30°$ $R = 300m$

normal chord $C = 20m$

$T = R\tan\Delta/2 = 97.47m$ — 2m

length of curve $l = \frac{\pi R\Delta}{180} = 188.50m$

Chainage of T_1 = Chainage of PI − T 2m

= 1190 − 97.47

= 1092.53m

Chainage of T2 = chainage of P.C + length of curve

= 1092.53 + 188.50 = 1281.03m

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Scheme of Valuation

Course/Subject Title		Course/Subject Code	
Semester		CIE No.	
Date		Max. Marks	

length of first subchord c = 1110 − 1092-83
c = 17.47m

length of last sub chord c' = 1281.02 − 1260.00
c' = 21.02m
} 2m

~~Total~~ No of Normal Chords = $\frac{1260-1110}{30}$ = 5

Total No of ~~Chords~~ = 1+5+1 = 7 No
} 1m

$\delta_{1} min = \frac{1718.9 c}{R} = \frac{1718.9 \times 17.47}{300}$ = 100°.07
= 1° 40' 9.27" — 2m

δ_2 δ_3 δ_4 δ_5 δ_6 min = $\frac{1718.9 \times 30}{300}$ = 2° 51' 53.4" — 2m

$\delta_7 min = \frac{1718.9 \times 21.02}{300}$ ~~= 20° 0'~~
= 2° 0' 26.26" — 1m

Δn = 1° 40' 9.27" + 14° 19' 27" + 2° 0' 26.26"
= 36/2 = ok.

Point	Chainage m	Chord length m	Tangential angle δ.	Deflection angle	Theodolite reading
T1	1092.00	—	—	—	—
P	1110.00	17.48	1° 40' 9.27"	1° 40' 9.27"	1° 40' 00"
Q	1140.00	30.00	2° 51' 53.4"	4° 32' 26.2	4° 32' 20'
R	1170.00	30.00	2° 51' 53.4"	7° 23' 26.07"	7° 24' 00"
S	1200.00	30.00	2° 51' 53.4"	10° 15' 41.47"	10° 15' 40"
U	1230.00	30.00	2° 51' 53.4"	13° 7' 42.87	13° 7' 40"
V	1260.00	30.00	2° 51' 53.4"	15° 53' 36.27"	15° 55' 40"
T2	1281.02	21.02.	2° 00' 26.26	18° 0' 2.53"	18° 0' 00"

} 5m

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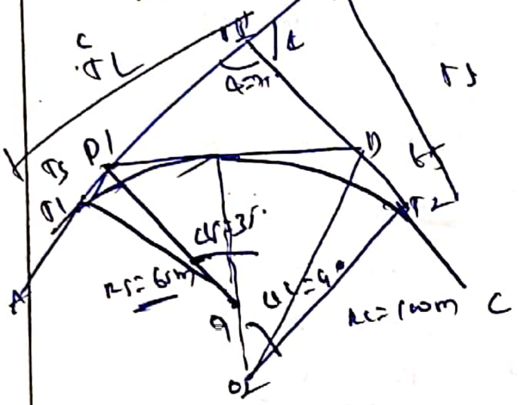
Scheme of Valuation

(26)

$\Delta = 75°$ Chainage of PI = 1234 m $R_s = 65$ $\Delta_s = 35°$

$R_L = 100m$ $\Delta_L = 40°$ $C = 20m$.



$T_1D_1 = D_1O = R_s \tan\frac{\Delta s}{2}$

$= 65 \tan\frac{35°}{2} = 20.49m$ — 1m

$T_2O_2 = OD_2 = 36.39m$

$D_1D_2 = 26.41 + 36.38 = 56.85m$ — 1m

Tangent length $T_S = 58.353m$

$\boxed{TL = 70.165m}$ — 1m

length of small arc = 39.70m, length of large curve = 68.813m

Chainage of T_1 = PI − PS = 1175.647m — 1m

Chainage of D = 1215.347m

Chainage of TL = 1285.10m   C = 4.353m   c' = 15.347m

No of chord = 1   Total No of chords = 1+1+1=3 — 1m

$\delta_1 = \frac{1718.9 \times C}{R} = 1°55'6.8''$ $\delta_2 = \frac{1718.9 \times C}{R} =$ ~~1718.~~ $8°48'53.54''$ — 1m

$\delta_3 = 6°46'0.73$.

Point	Chainage m	Chord (m)	$\delta = \frac{1718.9C}{R}$	$\Delta = \Delta_{n-1} + \delta_n$	Theodolite readings
T1	1175.647	—	—	—	—
1	1180.000	4.53	1°55'6.8''	1°55'6.8''	1°55'00'
2	1200.000	20	8°48'53.54''	10°44'0.34''	10°44''00''
D.	1215.353	15.353	6°46'0.5''	17°30'0.84''	17°30'00'

} 3m

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Scheme of Valuation

Course/Subject Title		**Course/Subject Code**	
Semester		**CIE No.**	
Date		**Max. Marks**	

calculations for second curve:

c = 1220.00 − 1215.347 = 4.653m } 1m

c' = 1285.16 − 1280.00 = 5.166m

c' = 5.166m

No of Normal chords N = 3 — 1m

Total No of chords = 1+3+1 = 5. —

Deflection angle.

$\delta_1 = \frac{1718.9 \times c}{R}$ = 1°19° 58.53'' — 1m

$\delta_2 = \delta_3 = \delta_4 = \frac{1718.9 \times C}{R}$ = 5° 43' 46.8'' — 1m

$\delta_5 = \frac{1718.9 \times c'}{R}$ = 1°28' 47.9''

Point	Chainage in m	Chord in m	Tangential angle $\delta = \frac{1718.9 \times C}{R}$	Deflection angle	4
D	1215.353	—	—	—	—
1	1220.00	~~20.00~~ 4.647	1°19'52.6''	1°19' 52.6''	1°20' 00''
2	1240.00	20.00	5°43'46.8''	7°03' 35.4''	7°3' 40''
3	1260.00	20.00	5°43'46.8''	12°47' 26.2''	12°47' 20''
4	1280.00	20.00	5°43'46.8''	18° 31' 13''	18°31' 20''
T2	1285.166	5.166	1°28'47.9''	20°00' 0.9''	20°0' 0''

} 3m

2/7/21

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Department of Civil Engineering

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Course/Subject Title	Advanced Surveying	Course/Subject Code	18CV45
Semester	IV B	Scheme	CBCS – 18
Date	04/08/2021	CIE No.	03
Time	8:30 AM to 9:30 AM	Max. Marks	30

Course Outcome Statements

After the successful completion of the course, the students will be able to

CO1	**Measure** horizontal and vertical angles by theodolite, and **determine** the elevations of points by trigonometric levelling
CO2	**Apply** tachometric principles for distance and elevation measurements
CO3	**Explain** the principles of triangulation
CO4	**Calculate** the data for setting out of horizontal curves
CO5	**Apply** the concept of aerial photogrammetry to **determine** the ground co-ordinates
CO6	**Explain** modern surveying instruments, remote sensing and GIS for engineering applications.

Q. No.	Question	Marks	RBT Level	CO
	NOTE: ANSWER ANY ONE FULL QUESTION FROM PART.			
	PART - A			
1a)	Define a) vertical photograph, b) Tilted photograph c) Oblique photograph. d) Flying height e) principal plane	5	L1 & L2	5
1b)	Derive the expression for Scale of vertical photograph.	10	L3	5
	OR			
2a)	A vertical photograph was taken at an altitude of 1200 meters above mean sea level. Determine the scale of the photograph for terrain lying at elevations of 80 meters &300 meters. If the focal length of the camera is 15cm.	5	L3	5
2b)	A line AB 200m long, lying at an elevation of 500m measures 8.65cm on a vertical photograph for which focal length is 20cm . Determine the scale of the photograph in an area the average elevation of which is about 800m.	10	L3	5
	Part - B			
3a)	What are the advantages of LIDAR technology?	5	L1	6
3b)	Mention the advantages of total station and also discuss the working principles of the same.	10	L1 &L2	6
	OR			
4a)	What is GPS? Explain the basic principles of GPS and its application in surveying.	5	L1 &L2	6
4b)	Define remote sensing. Explain the stages of idealized remote sensing system.	10	L1 , L2	6

RBT (Revised Bloom's Taxonomy) Levels : Cognitive Domain		
L1 : Remembering	L2 : Understanding	L3 : Applying
L4 : Analysing	L5 : Evaluating	L6 : Creating

Raghu 2/8/21
Course Coordinator
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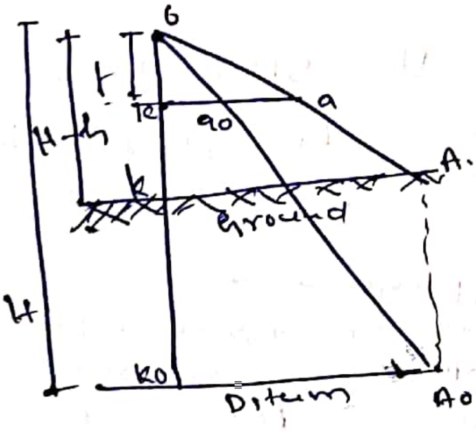
Scheme of Valuation

Course/Subject Title	Advanced Surveying	**Course/Subject Code**	18CV45
Semester	IV 'B' section	**CIE No.**	III
Date	04/08/2021	**Max. Marks**	30

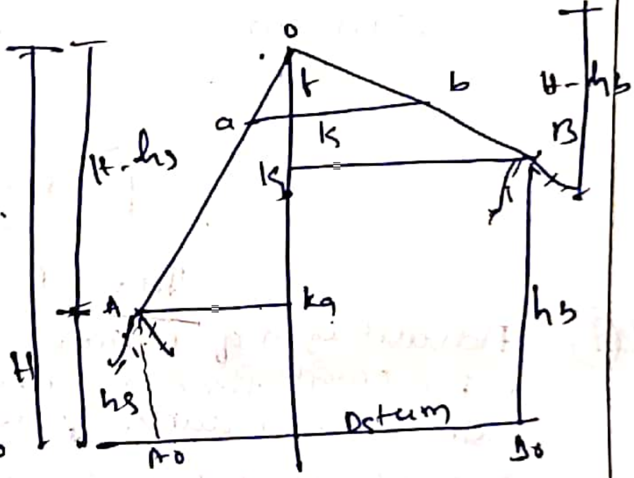
Part - A.

1 (a) Each Definition carries one mark 1×5 = 5M.

1(b)



(a)



(b)

(a) same elevation $\boxed{S = \frac{f}{H-h}}$

(b) Different elevation $\boxed{S = \frac{f}{H-h_s}}$ $\boxed{S = \frac{f}{H-h_b}}$

Each case 5Marks ×2 = 10marks

Fig - 1m
Explanation = 4m } 5m

(or).

2(a) Given H = 1200 m, h_s = 80 m h_b = 300 m, f = 0.15 m

$S_{80} = \frac{f}{H-h_s} = \frac{1}{7466.67}$ $\boxed{1cm = 74.67m}$ — 2.5M

$S_{300} = \frac{f}{H-h_b} = \frac{1}{6000} =$ $\boxed{1cm = 60m}$ - 2.5M

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Scheme of Valuation

2(b) given LAB = 2000m, h = 500m, lab = 8.65 cm, — 1m
f = 0.2m. hsv = 800m. Ssv = ?

$S = \frac{lab}{LAB} = \frac{86.5\,mm}{2000\,mr}$ } 4m

$S = \frac{1}{23121.3m}$

$S = \frac{f}{H-h}$

$\frac{1}{23121.3} = \frac{0.2}{H-500}$ } 5m

H = 5124.27m

$\boxed{S_{800} = 1 \text{ in } 21621.38\,m}$ — 10m

Part-B

3(a) Advantages of Lidar Technology
- Fieldwork time reduction.
- Field view upto 80° x 360°
- Site on your desktop concepts.
- Range upto 2km
- Avoids revisits to the site.
- Measurement rate of 11,000 pts/sec 1x5 = 5m
- Acquisition of data for inaccessible points

any five points.

3(b) Advantages of total station 1x4 = 4m
any 4 advantages
working principle 6marks = 6marks

4(a) GPS - definition —1m } 5m
Basic principle — 4m

4(b) Remote sensing — 1m } 10m
Stages of Idealized remote sensing system — 9m

Course Coordinator
(Faculty In charge)
2/8/2021
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Coordinator
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(HOD, Civil)

Period : From 19.04.2021 To Aug-2021 Semester : Odd/Even

Name of the Teacher : Raghu. M.E

Designation : Assistant Professor

Department : Civil Department

Sl. No.	Sem. / Sec. / Branch	Subject Name	Subject Code
1	IV Sem 'B' civil	Advance Surveying	18CV45
2	VI Sem Parallel Scheme	Highway Engineering	15CV63
3	VI Sem Parallel Scheme	Highway Engineering	17CV63
4			
5			
6			
7			

	Reviews at the end of the				End of Semester
	1st Month	2nd Month	3rd Month	4th Month	
Signature of Staff					
Signature of the Head of Department					
Signature of the Principal	PRINCIPAL Bapuji Institute of Engineering & Technology DAVANGERE.		PRINCIPAL Bapuji Institute of Engineering & Technology DAVANGERE.		PRINCIPAL Bapuji Institute of Engineering & Technology DAVANGERE.

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Class : IV B

Subject Code : 18CV45

Subject : Advanc Surveying

Total No. of Classes : 64

SI No.	USN	NAME	DATE 21/4/21	27/4/21	28/4/21	29/4/21	4/5/21	5/5/21	6/5/21	11/5/21	12/5/21	13/5/21	18/5/21	19/5/21	22/5/21	25/5/21	26/5/21	27/5/21	01/6/21	02/6/21	3/6/21	Test 7/6/21	10/6/21	15/6/21	16/6/21	17/6/21	22/6/21	23/6/21	24/6/21	29/6/21	No. of Days Present	% Max	Test Marks I 30	II 30	III 30	Average Avg	Remarks Total
1	4BD17CV065	Pavan K. G. D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	A	24	A	A	A	1	10.	30	30	08	23	33
2	4BD18CV024	Ganesh. B. G. A	A	A	1	2	3	4	5	A	6	7	8	9	10	11	12	13	14	15	16	17	18	A	19	20	21	22	A	23	2	10	25	30	25	27	37
3	4BD18CV047	Mohan A. H. A	A	1	2	3	A	4	5	6	7	8	9	10	11	A	12	13	14	15	A	16	17	18	19	20	21	22	A	A	3	10	30	30	AB	20	30
4	4BD18CV059	Prajwal Kumar. S. K A	A	1	2	3	4	5	6	7	8	9	10	11	A	12	13	A	14	15	16	17	18	19	20	21	22	23	A	A	4	10	30	30	AB	20	30
5	4BD18CV075	Shashank. N. B.	A	1	2	3	4	A	5	6	7	8	A	9	10	11	12	13	14	15	16	17	18	19	20	A	21	22	A	A	5	10	30	30	9	23	33
6	4BD18CV078	Siddesh Gowda. M. G.	A	1	2	A	3	4	A	A	5	6	7	A	8	A	A	9	10	11	12	13	14	A	A	15	16	17	18	19	6		23	30	10	21	31
7	4BD18CV090	Tejesh. B. R.	1	2	3	4	5	6	7	A	8	9	A	10	A	11	12	13	14	15	16	A	17	18	19	20	21	22	A	23	7	10	30	30	13	25	35
8	4BD18CV092	Uday K. H. A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	A	15	16	17	A	A	18	19	20	21	22	23	A	24	8	10	15	30	AB	15	25
9	4BD18CV[illegible]17	Sohaan. A	A	A	A	A	A	A	A	A	A	1	2	3	4	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	9	10	30	30	18	26	36
10	4BD18CV112	Darshan. D.	1	2	3	4	5	6	7	A	8	9	10	11	12	13	14	15	16	17	18	A	19	20	21	22	23	24	A	25	10	10	30	30	11	24	34
11	4BD19CV004	Ajay A Jajuri	1	2	3	4	5	A	A	6	7	8	9	A	10	11	12	A	13	14	15	16	A	17	18	19	20	21	A	22	11	10	30	30	22	27	37
12	4BD19CV008	Akshay. B. M.	A	1	A	A	2	3	A	4	5	6	A	A	7	8	9	A	10	11	12	13	14	15	A	16	17	18	A	19	12	10	30	30	15	25	35
13	4BD19CV010	Ali Akbar	A	1	2	3	A	A	A	4	A	A	A	A	A	5	A	A	6	7	8	9	10	11	12	13	A	14	A	15	13	10	30	30	12	24	34
14	4BD19CV014	B Sayyed Ismail Zabiull	A	A	A	A	A	A	A	A	A	A	1	2	3	4	A	A	5	6	7	8	9	10	A	11	A	A	A	12	14	10	30	30	AB	20	30
⑮	4BD19CV016	Bharathgouda. K. N. A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	15	A	left the course				
16	4BD19CV018	Chandan. B. V	A	A	1	2	3	4	A	A	5	6	A	7	8	A	9	A	10	11	12	13	14	15	A	16	17	18	A	19	16		20	30	17	23	33
17	4BD19CV022	Deepa. P	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	17	10	30	30	30	30	40
18	4BD19CV024	Harish. K. T	A	A	1	2	3	A	A	A	A	4	A	A	A	A	A	A	5	6	7	8	9	10	A	11	A	12	A	13	18	10	30	30	6	22	32
19	4BD19CV030	Lakshmi. B. S	A	A	1	2	3	4	A	A	5	A	6	A	7	A	8	A	9	10	11	12	13	14	A	15	A	16	A	17	19	10	30	30	17	26	36
20	4BD19CV032	Mallikarjun. T. M.	A	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	20	10	30	30	15	25	35
21	4BD19CV034	Manoj Swamy K. M	A	1	2	3	4	5	6	A	7	A	A	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	21	10	30	30	14	25	35
22	4BD19CV036	Mohammed Ameerkhan. D.	A	A	A	A	1	A	A	A	2	3	4	5	6	7	A	A	A	A	A	8	9	10	A	11	A	12	A	13	22	10	30	30	15	25	35
23	4BD19CV038	Mohit B. V	A	1	2	3	4	5	6	7	8	9	A	10	11	12	13	14	15	16	17	18	19	20	21	22	A	23	24	25	23	10	30	30	08	23	33
24	4BD19CV040	Namratha P Ram.	A	1	2	3	4	5	6	7	A	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	24	25	26	27	24	10	30	30	18	26	36
25	4BD19CV042	Nandini. K.	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	A	22	23	24	25	26	25	10	30	30	27	29	35
26	4BD19CV044	P. N. Mohammed Salauddin	A	1	2	3	4	5	6	7	8	9	10	11	12	13	A	14	15	16	17	18	19	20	A	A	A	A	A	A	26	10	23	30	16	23	33
27	4BD19CV046	Pooja. M. P.	A	1	A	A	2	3	4	5	6	7	8	9	10	11	A	12	13	14	15	16	17	18	19	20	21	22	23	24	27	10	30	30	17	26	36
28	4BD19CV048	Pradeep. K. B.	A	1	2	A	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	A	25	28	10	30	30	5	22	32
29	4BD19CV050	Prajwal G. T. Matad.	A	1	2	3	4	A	5	A	6	7	8	9	10	11	12	13	14	15	16	17	18	19	A	20	A	21	A	22	29	10	30	30	8	23	33
30	4BD19CV052	Prerana. V	A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	30.	10	30	30	17	26	36

Initials of Teacher

Initials of H.O.D.

Initial of Principal

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PRINCIPAL
Bapuji Institute of Engineering & Technology
DAVANGERE.

LESSON PLAN

Subject : Advance surveying Subject Code : 18CV45 Class : IV B.

Period	Date	Topics Planned	Date	Topics Covered	Remarks
1	21.4.2021	Module 1 Theodolite survey. Theodolite & types parts	21.4.2021	module 1 Theodolite survey Theodolite & types parts	covered
2	27.4.2021	Theodolite & types parts & definition Fundamental axes & parts	27.4.2021	Theodolite & types parts & definition Fundamental axes & parts	covered
3	28.4.2021	Uses & Temporary adjustment of Transit Theodolite.	28.4.2021	Uses & Temporary adjustment of Transit Theodolite.	covered
4	29.4.2021	Measurement of horizontal angle RAP & vertical angle	29.4.2021	Measurement of horizontal & vertical angle.	covered
5	4.5.2021	Permanent adjustment of Theodolite	4.5.2021	Permanent adjustment of theodolite.	covered
6	5.5.2021	Trigonometric levelling. single plane method When Base of the object is accessible	5.5.2021	Trigonometric levelling single plane method. + Base of the object is accessible	covered
7	6.5.2021	Base of the object is Inaccessible with Problem	6.5.2021	Base of the object is Inaccessible with problems	covered
8	11.5.2021	Problem on single plane method.	11.5.2021	Problem on single plane method	covered
9	12.5.2021	Double plane method with Derivation & Problems	12.5.2021	Double plane method with Derivation & Problem.	covered
10	13.5.2021	Module: 2 Tacheometry. Basic principles, types, Horizontal line of sight	13.5.2021	Module: 2 Tacheometry, Basic principles, types, Horizontal line of sight	covered
11	19.5.2021	Inclined line of sight with Problems	19.5.2021	Inclined line of sight with problems	covered
12	19.5.2021	Problems Horizontal line of sight	19.5.2021	Problems Horizontal line of sight	covered
13	20.5.2021	problems on Inclined line of sight	20.5.2021	Problems on Inclined line of sight	covered
14	25.5.2021	Geodetic surveying Principles & classification of triangulation	25.5.2021	Geodetic surveying Principles & classification of triangulation	covered
15	26.5.2021	selection of base line & stations. orders & figures triangulation. 1	26.5.2021	selection of base line & stations, orders & figures of triangulation	covered
16	27.5.2021	Reduction to centres selection & marking of stations	27.5.2021	Reduction to centres selection & marking stations	covered
17	1.6.21	Problems on Reduction to centres	1.6.21	Problems on Reduction to centres	covered

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LESSON PLAN

Subject : Advanced Surveying Subject Code : 18CV45 Class : IV B

Period	Date	Topics Planned	Date	Topics Covered	Remarks
18	2.6.21	Module: 3 curve setting Necessity - Types of simple curve, Elements	2.6.21	module: 3 curve setting Necessity - Types of simple curve, elements	covered
19	3.6.21	Designation of curve, setting out simple curves by linear method Problems	3.6.21	Designation of curve, setting out simple curve by linear method Problems	covered
20	9.6.21	Problems on long chord.	9.6.21	problems on long chord	covered
21	10.6.21	problems on chord produced method	10.6.21	Problems on chord produced method	covered
22	15.6.21	setting out curve by Rankine's deflection angle method.	15.6.21	setting out curve by Rankine's deflection angle method.	covered
23	16.6.21	Problems on Rankine's Deflection angle method	16.6.21	Problems on Rankine's Deflection angle method	covered
24	17.6.21	compound curve Elements, Design of compound curve & Problems	17.6.21	compound curve, elements, Design of compound curve & Problems	covered
25	22.6.21	Reverse curve b/w two Parallel straight with Problems.	22.6.21	Reverse curve b/w two Parallel straight with Problem	covered.
26	23.6.21	Transition curve characteristics, problem on Transition curve	23.6.21	Transition curve characteristics, Problem on Transition curve.	covered
27	24.6.21	Module: 4 Aerial Photogrammetry. Introduction uses & Definition	24.6.21	Module: 4 Aerial Photogrammetry Introduction. uses & Definition.	covered.
28	29.6.21	Scale of vertical photography with problems	29.6.21	Scale of vertical photograph with problems	covered
29	30.6.21	Scale of Tilted photograph with problems	30.6.21	Scale of Tilted photograph with problems.	covered.
30	1.7.21	Ground co-ordinates, with problems Relief Displacement	1.7.21	Ground co-ordinates with problems Relief Displacement	covered
31	7.7.21	Problems on Relief Displacement	7.7.21	Problems on Relief Displacement	covered
32	8.7.21	Problems on Relief Displacement	8.7.21	Problems on Relief Displacement	covered.
33	13.7.21	Procedure for Aerial Survey	13.7.21	Procedure for Aerial Survey.	covered
34	14.7.21	Overlaps. & mosaics	14.7.21	Overlaps & mosaics	covered.

LESSON PLAN

Subject : Advanced Surveying Subject Code : 18CV45 Class : IVB

Period	Date	Topics Planned	Date	Topics Covered	Remarks
34	15-7-21	Stereoscopy, Derivation of Parallax	18-7-21	Stereoscopy Derivation of Parallax	covered
36	22-7-21	Module: 5 Modern Surveying Instruments EDM	22-7-21	Module: 5 Modern Surveying Instruments EDM	covered
37	22-7-21	Total Station	22-7-21	Total Station.	covered
38	27-7-21	Lidar Scanners for topographical survey	27-7-21	Lidar scanners for topographical survey	covered
39	28-7-21	Remote Sensing Introduction principles	28-7-21	Remote Sensing Introduction & Principles	covered
40	29-7-21	Image Interpretation, Visual Interpretation, Digital image Processing	29-7-21	Image Interpretation, Visual Interpretation Digital Image Processing	covered
41	4-8-21	GIS: Definition of GIS, key components Function	4-8-21	GIS: Definition of GIS, key components functions.	covered
42	5-8-21	Spatial Data, Spatial Information System.	9-8-21	Spatial Data Spatial Information System	covered
43	10-8-21	Geospatial analysis, Integration of Remote Sensing	10-8-21	Geospatial analysis Integration of Remote Sensing	covered
44	11-8-21	GIS & Application in Civil Engg	11-8-21	GIS & Application in Civil Engg	covered

Raghu

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M.Tech in Structural Engg.
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Dept. of Civil Engg.

Text Books :

1. B.C. Punmia. Surveying Vol.2 Laxmi publicatio

2. Kanetkar & S.V. Kulkarni, Surveying & Level Part-2, 3. K.R. Arora, Surveying volume 1

Reference Books :

1. S.K. Duggal Surveying Vol I & volume 2, Tata Mcgraw publicatio

2. R. Subramanian, Surveying & Leveling Second ed

3. Sateesh Gopi. Global Positioning System. Tata Mcgraw publications

4. B Bhatia, Remote sensing & GIS, Oxford University Press. New Delhi.

5. James M Anderson & Adwara M Mikhail.

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Signature of Faculty

HOD

Model Question Paper-1 with effect from 2019-20 (CBCS Scheme)

USN | | | | | | | | | | |

Fourth Semester B.E. Degree Examination

Advanced Surveying

TIME: 03 Hours **Max. Marks: 100**

Note: 01. Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE**.

<table>
<tr><th colspan="3">Module -1</th><th>*Bloom's Taxonomy Level</th><th>Marks</th></tr>
<tr><td>Q.01</td><td>a</td><td>With the help of tabular column, explain the procedure of measuring horizontal angle by (i) Repetition method (ii) Reiteration method</td><td>L2</td><td>8</td></tr>
<tr><td></td><td>b</td><td>List the fundamental lines of a theodolite. Summarize the desired relationship between them.</td><td>L2</td><td>6</td></tr>
<tr><td></td><td>c</td><td>Define the following terms.
i) Transiting
ii) Swinging
iii) Trunnion axis</td><td>L2</td><td>6</td></tr>
<tr><td colspan="3">OR</td><td></td><td></td></tr>
<tr><td>Q.02</td><td>a</td><td>To find the elevation of the top(P) of a hill, a flag staff of height 1.5m was erected and the following observations were made from two stations A & B at considerably different elevations 156m apart. The angle of elevation from A to the top of the flag staff was $38^{0}24'$ and that from B to the same point $26^{0}12'$. A vane 1.2m above the foot of a staff held on A was sighted from B and the angle of elevation was observed to be $9^{0}54'$. The height of the instrument axis at A was 1.494m and the R.L. of the instrument axis at B was 45.00m. Find the horizontal distance P from B and the R.L. of P.</td><td>L3</td><td>10</td></tr>
<tr><td></td><td>b</td><td>Derive the expressions for the horizontal distance, vertical distance and the elevation of an object by double plane method, when the base is inaccessible.</td><td>L3</td><td>10</td></tr>
<tr><td colspan="3">Module-2</td><td></td><td></td></tr>
<tr><td>Q. 03</td><td>a</td><td>Derive distance and elevation formulae for stadia tachometry, when staff held normal to the line of sight, for both an angle of elevation and angle of depression.</td><td>L3</td><td>10</td></tr>
<tr><td></td><td>b</td><td>To find the gradient between two points A and B a tacheometer was set up to another station C and the following observations were made, keeping the staff vertical.
<table>
<tr><th>Staff at</th><th>Vertical angle</th><th>Staff readings (m)</th></tr>
<tr><td>A</td><td>+ $4^{0}20'00''$</td><td>1.300, 1.610, 1.920</td></tr>
<tr><td>B</td><td>+ $0^{0}10'40''$</td><td>1.100, 1.410, 1.720</td></tr>
</table>
If the horizontal angle ACB is $35^{0}20'$, determine the average gradient between A and B. K = 100, C = 0</td><td>L3</td><td>10</td></tr>
<tr><td colspan="3">OR</td><td></td><td></td></tr>
<tr><td>Q.04</td><td>a</td><td>List the various factors that are to be considered in the selection of site for baseline and station in triangulation survey.</td><td>L2</td><td>6</td></tr>
<tr><td></td><td>b</td><td>Write a note on classification of triangulation system.</td><td>L2</td><td>6</td></tr>
<tr><td></td><td>c</td><td>From a satellite station S, 5.8m from main triangulation station A, the following directions were observed.
<table>
<tr><td>A</td><td>0^{0}</td><td>0'</td><td>0"</td></tr>
<tr><td>B</td><td>132^{0}</td><td>18'</td><td>30"</td></tr>
<tr><td>C</td><td>232^{0}</td><td>24'</td><td>6"</td></tr>
<tr><td>D</td><td>296^{0}</td><td>6'</td><td>11"</td></tr>
</table>
The lengths of AB AC and AD were computed to be 3265.5m, 4022.2m and 3086.4m respectively. Determine the directions of AB, AC and AD.</td><td>L3</td><td>8</td></tr>
</table>

Module-3				
Q. 05	a	List the different methods of setting out simple circular curves. Explain the linear method of setting out simple curve by the method of offset from long chord.	L3	6
	b	A road bend which deflects 80^0 is to be designed for a maximum speed of 100km per hour, a maximum centrifugal ratio ¼ and a maximum rate to the change of acceleration of $30cm/sec^3$, the curve consisting of a circular arc combined with two spirals. Calculate i) The radius of circular arc ii) The required length of transition iii) the total length of composite curve and iv) The chainages of the beginning and end of transition curve, and of the junctions of the transition curves with the circular arc, if the chainage of the point of intersection is 42862m.	L3	10
	c	With the help of a neat sketch of a simple circular curve, explain i) Tangent length ii) Length of long chord iii) Point of curve iv) Forward tangent	L2	4
OR				
Q. 06	a	A compound curve consisting of two arcs of radius 350m and 550m connects two straights AB and BC, which are intersected by a line PQ. The angles APQ and BQP are $139^0 30'$ and $36^0 24'$ respectively. Determine the chainages of the tangent points if the chainage of the intersection point B is 5425.191m.	L3	8
	b	The first branch of a reverse curve has a radius of 200m. Find the radius of second branch so that the curve can connect parallel straights 18m apart. The distance between tangent points is to be 110m. Also calculate the length of two branches of the curve.	L3	8
	c	With a neat sketch, list any four vertical curves.	L2	4
Module-4				
Q. 07	a	Define vertical photograph, tilted photograph and oblique photograph.	L2	6
	b	A vertical photograph was taken at an altitude of 1200m above the mean sea level. Determine the scale of photograph for terrain lying at elevation of 80m and 300m, if the focal length of camera is 15cm.	L3	8
	c	List the reasons for keeping overlap in photographs.	L2	6
OR				
Q. 08	a	Derive the expression for relief displacement on a vertical photograph.	L3	8
	b	Explain the procedure for aerial survey.	L2	6
	c	Find the number of photographs (size 250 x 250mm) required to cover over a area of 20km x 16km, the longitudinal overlap is 60% and the side overlap is 30% scale of the photograph is 1cm = 150m.	L3	6
Module-5				
Q. 09	a	Define remote sensing. Explain the stages of idealized remote sensing system.	L2	8
	b	With neat sketch, explain the electromagnetic spectrum.	L2	6
	c	Explain the components of GIS.	L2	6
OR				
Q. 10	a	Mention the advantages of total station and also discuss the working principles of the same.	L2	8
	b	What are the advantages of LIDAR technology?	L2	4
	c	What is GPS? Explain the basic principles of GPS and its application in surveying.	L2	8

Model Question Paper-1 with effect from 2019-20 (CBCS Scheme)

USN

Fourth Semester B.E. Degree Examination
Advanced Surveying

TIME: 03 Hours **Max. Marks: 100**

Note: 01. Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE**.

<table>
<tr><th colspan="3">Module -1</th><th>*Bloom's Taxonomy Level</th><th>Marks</th></tr>
<tr><td>Q.01</td><td>a</td><td>Define the following terms with reference to the theodolite:
i) Transiting; ii) Swinging; iii) Changing of face; iv) Horizontal axis</td><td>L1</td><td>04</td></tr>
<tr><td></td><td>b</td><td>Describe the measurement of horizontal angle by repetition method. What are the errors eliminated by repetition method?</td><td>L2, L3</td><td>10</td></tr>
<tr><td></td><td>c</td><td>What are the fundamental lines of a theodolite? State the desired relationship between them.</td><td>L1, L3</td><td>06</td></tr>
<tr><td colspan="3">OR</td><td></td><td></td></tr>
<tr><td>Q.02</td><td>a</td><td>Explain the adjustment of horizontal axis of a transit theodolite by the spire test.</td><td>L4</td><td>06</td></tr>
<tr><td></td><td>b</td><td>Derive the expression for determining the distance and elevation of an inaccessible object by single plane method. Assume the instrument near the object is at higher level than faraway instrument position.</td><td>L5</td><td>06</td></tr>
<tr><td></td><td>c</td><td>Find the elevation of top of chimney from the following data
<table>
<tr><th>Instrument station</th><th>Reading on BM</th><th>Angle of elevation</th><th>Remarks</th></tr>
<tr><td>A</td><td>0.862</td><td>$18^0 36'$</td><td>RL of BM = 425.250 m</td></tr>
<tr><td>B</td><td>1.222</td><td>$10^0 12'$</td><td>Distance AB = 50m</td></tr>
</table>
Also calculate the distance of chimney from station B.</td><td>L4</td><td>08</td></tr>
<tr><td colspan="3">Module-2</td><td></td><td></td></tr>
<tr><td>Q. 03</td><td>a</td><td>Explain fixed hair method and movable hair method of tacheometry</td><td>L2</td><td>06</td></tr>
<tr><td></td><td>b</td><td>Derive the tacheometric equation for horizontal line of sight.</td><td>L5</td><td>06</td></tr>
<tr><td></td><td>c</td><td>A tacheometer is setup at an intermediate point on a traverse PQ. The following observations are made on the vertically held staff.
<table>
<tr><th>Staff station</th><th>Vertical angle</th><th>Staff intercept</th><th>Axial hair reading</th></tr>
<tr><td>P</td><td>$8^0 36'$</td><td>2.350</td><td>2.105</td></tr>
<tr><td>Q</td><td>$6^0 6'$</td><td>2.055</td><td>1.895</td></tr>
</table>
The instrument was fitted with an anallactic lens and having constant 100.
Compute the length of PQ and RL of Q. RL of P is 321.50m</td><td>L4</td><td>08</td></tr>
<tr><td colspan="3">OR</td><td></td><td></td></tr>
<tr><td>Q.04</td><td>a</td><td>What are the various points to be considered while selecting triangulation stations?</td><td>L2</td><td>06</td></tr>
<tr><td></td><td>b</td><td>With neat sketches briefly explain the various triangulation figures adopted in triangulation survey.</td><td>L2</td><td>08</td></tr>
<tr><td></td><td>c</td><td>Write a note on Satellite station and Reduction to centre.</td><td>L2</td><td>06</td></tr>
</table>

		Module-3		
Q. 05	a	Derive the expressions for the following elements of a simple circular curve. i) Tangent length, ii) Long Chord, iii) Mid ordinate	L5	06
	b	Two roads having a deviation angle of 45° at apex point *V* are to be joined by a 200 m radius circular curve. If the chainage of apex point is 1839.2 m, calculate necessary data to set the curve by ordinates from long chord at 10 m interval	L4	06
	c	Two tangents intersect at the chainage 1190 m, the deflection angle being 36°. Calculate all the data necessary for setting out a circular curve with radius of 300 m by Rankine's method of deflection angles method. The peg interval is 30 m.	L4	08
		OR		
Q. 06	a	Two parallel straights 12mts apart are to be connected by a reverse curve. If the distance between the tangent points is 75mts. Find the common radius of the two branches.	L4	06
	b	What are the functions and requirements of a transition curve?	L2	06
	c	A transition curve is required for a circular curve of 250metre radius. The gauge being 1.676m and the super elevation is restricted to 15cm. the transition is to be designed for a velocity such that no lateral pressure is imposed on rails and the rate of gain of radial acceleration is 30m/sec^3. Calculate the required length of transition curve and the design speed.	L4	08
		Module-4		
Q. 07	a	Explain briefly the different types of aerial photograph.	L2	06
	b	Derive the expression for scale of an aerial photograph	L5	04
	c	A line AB measures 11.00 cm on a photograph taken with a camera having a focal length of 21.5 cm. The same line measures 3 cm on a map drawn to scale of 1/45000. Calculate the flying height of the aircraft, if the average altitude is 350 m.	L4	10
		OR		
Q. 08	a	Briefly explain the procedure involved in aerial survey.	L3	06
	b	Write short note on (i) Stereoscope (ii) Parallax Bar.	L2	08
	c	The scale of an aerial photograph is 1 cm = 100 cm and photograph size is15 cm x 15 cm. Determine the number of photographs required to cover an area of 15 km x 15 km if longitudinal lap is 60% and side lap is 30%.	L4	06
		Module-5		
Q. 09	a	What is total station? What are the advantages and disadvantages of total station?	L1,L3	06
	b	Explain the various stages of idealized remote sensing system.	L2	08
	c	Explain the interaction of Electro Magnetic Waves with atmosphere.	L2	06
		OR		
Q. 10	a	What is GPS? Briefly explain the components of GPS.	L1,L2	10
	b	Briefly explain the components of GIS. Also list the applications of GIS.	L2,L3	10

*Bloom's Taxonomy Level: Indicate as L1, L2, L3, L4, etc. It is also desirable to indicate the COs and POs to be attained by every bit of questions.

B. E. CIVIL ENGINEERING		
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)		
SEMESTER - IV		
ADVANCED SURVEYING		
BE Course Code	**18CV45**	**CIE Marks 40**
Teaching Hours/Week(L:T:P)	**(3:0:0)**	**SEE Marks 60**
Credits	**03**	**Exam Hours 03**

Objectives : This course will enable students to
Apply geometric principles to arrive at solutions to surveying problems.
Analyze spatial data using appropriate computational and analytical techniques.
Design proper types of curves for deviating type of alignments
Use the concepts of advanced data capturing methods necessary for engineering practice

Module-1

Theodolite Survey and Instrument Adjustment: Theodolite and types, Fundamental axes and parts of Transit theodolite, uses of theodolite, Temporary adjustments of transit theodolite, measurement of horizontal and vertical angles, step by step procedure for obtaining permanent adjustment of Transit theodolite.

Trigonometric Levelling: Trigonometric leveling (heights and distances-single plane and double plane methods).

Module-2

Tacheometry: Basic principle, types of tacheometry, distance equation for horizontal and inclined line of sight in fixed hair method, problems.

Geodetic Surveying: Principle and Classification of triangulation system, Selection of base line and stations, Orders of triangulation, Triangulation figures, Reduction to Centre, Selection and marking of stations.

Module-3

Curve Surveying:

Curves – Necessity – Types, Simple curves, Elements , Designation of curves, Setting out simple curves by linear methods (numerical problems on offsets from long chord & chord produced method), Setting out curves by Rankines deflection angle method (Numerical problems). Compound curves, Elements, Design of compound curves, Setting out of compound curves (numerical problems). Reverse curve between two Parallel straights (numerical problems on Equal radius and unequal radius). Transition curves Characteristics, numerical problems on Length of Transition curve, Vertical curves & Types – (theory).

Module-4

Aerial Photogrammetry

Introduction, Uses, Aerial photographs, Definitions, Scale of vertical and tilted photograph (simple problem Ground Co-ordinates (simple problems), Relief Displacements (Derivation), Ground control, Procedure of aerial survey, overlaps and mosaics, Stereoscopes, Derivation Parallax.

Module-5

Modern Surveying Instruments

Introduction, Electromagnetic spectrum, Electromagnetic distance measurement, Total station, Lidar scanners for topographical survey.

Remote Sensing: Introduction, Principles of energy interaction in atmosphere and earth surface features, Image interpretation techniques, visual interpretation. Digital image processing, Global Positioning system.

Geographical Information System: Definition of GIS, Key Components of GIS, Functions of GIS, Spatial data, spatial information system Geospatial analysis, Integration of Remote sensing and GIS and Applications in Civil Engineering(transportation, town planning)

Course outcomes: After a successful completion of the course, the student will be able to:
Apply the knowledge of geometric principles to arrive at surveying problems
Use modern instruments to obtain geo-spatial data and analyse the same to appropriate engineering problems.
Capture geodetic data to process and perform analysis for survey problems with the use of electronic instruments
Design and implement the different types of curves for deviating type of alignments
Question paper pattern:
The question paper will have ten full questions carrying equal marks. Each full question will be for 20 marks. There will be two full questions (with a maximum of four sub- questions) from each module. Each full question will have sub- question covering all the topics under a module. The students will have to answer five full questions, selecting one full question from each module.
Textbooks:
B.C. Punmia, “Surveying Vol.2”, Laxmi Publications pvt. Ltd., New Delhi
Kanetkar T P and S V Kulkarni , Surveying and Leveling Part 2, Pune Vidyarthi Griha Prakashan
K.R. Arora, “Surveying Vol. 1” Standard Book House, New Delhi.
SateeshGopi, Global Positioning System, Tata McGraw Hill Publishing Co. Ltd. New Delhi
Reference Books:
S.K. Duggal, “Surveying Vol. I & II”, Tata McGraw H ill Publishing Co. Ltd. New Delhi.
R Subramanian, Surveying and Leveling, Second edition, Oxford University Press, New Delhi
David Clerk, Plane and Geodetic Surveying Vol1 and Vol2, CBSpublishers
B Bhatia, Remote Sensing and GIS, Oxford University Press, New Delhi.
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Module-1

Theodolite Survey and Instrument Adjustment

Theodolite and types, Fundamental axes and parts of Transit theodolite, uses of theodolite, Temporary adjustments of transit theodolite, measurement of horizontal and vertical angles, step by step procedure for obtaining permanent adjustment of Transit theodolite.

INTRODUCTION ON THEODOLITE

The theodolite is a precise instrument used for the measurement of horizontal and vertical angles. It is widely used for

i) laying off horizontal angles
ii) locating points on the line
iii) prolonging survey lines
iv) establishing grades
v) determining difference in elevation
vi) setting out curves etc.

Theodolites may be classified as ***transit theodolite*** and ***non-transit theodolite***. A transit theodolite (or simply a transit) is the one in which the line of sight can be reversed by revolving the telescope through 180° in the vertical plane. This feature does not exist in non-transit theodolite. Transit theodolites are mainly used. Theodolites are also classified as ***Vernier theodolite***, ***Optic Theodolite*** and ***Electronic Theodolite.*** The improvements from one another have been made to ensure ***ease of operation***, ***better accuracy*** and ***speed***. Electronic theodolites display and store angles at the press of a button. These data can also be transferred to a computer for further processing.

PARTS OF TRANSIT THEODOLITE:

1. **Telescope:** The telescope consisting of ***eye piece*** and ***objective lens***, is mounted on a ***spindle*** known as ***horizontal axis*** or ***trunnion axis***. The telescope may be internal focusing type or external focusing type. Most of the transits have ***internal focusing*** type of telescope. The ***diaphragm*** carrying cross hairs is placed in front of the eye piece.
2. **Vertical Circle:**The vertical circle is a graduated arc attached to the trunnion axis of the telescope and hence the circle rotates with the telescope about the trunnion axis. The telescope can be set accurately in any desired position in the vertical plane by means of ***vertical circle clamping screw*** and ***vertical circle tangent screw***. The vertical circle is graduated 0° to 90° in four quadrants.
3. **Index Frame:** The index frame, also called **T-frame** or **vernier frame** consists of vertical leg called ***clipping arm*** and a horizontal bar called ***index arm*** or ***vernier arm***. At the two extremities of index arm, two verniers designated as ***C*** and ***D*** are fitted to read the vertical circle. The index arm is centred on the trunnion axis in front of vertical circle and remains fixed. The index arm can be rotated slightly with the help of a ***clip screw***. ***Glass magnifiers*** are placed in front of each vernier to magnify the reading. A bubble tube called ***altitude bubble*** is placed on the top of the index frame.

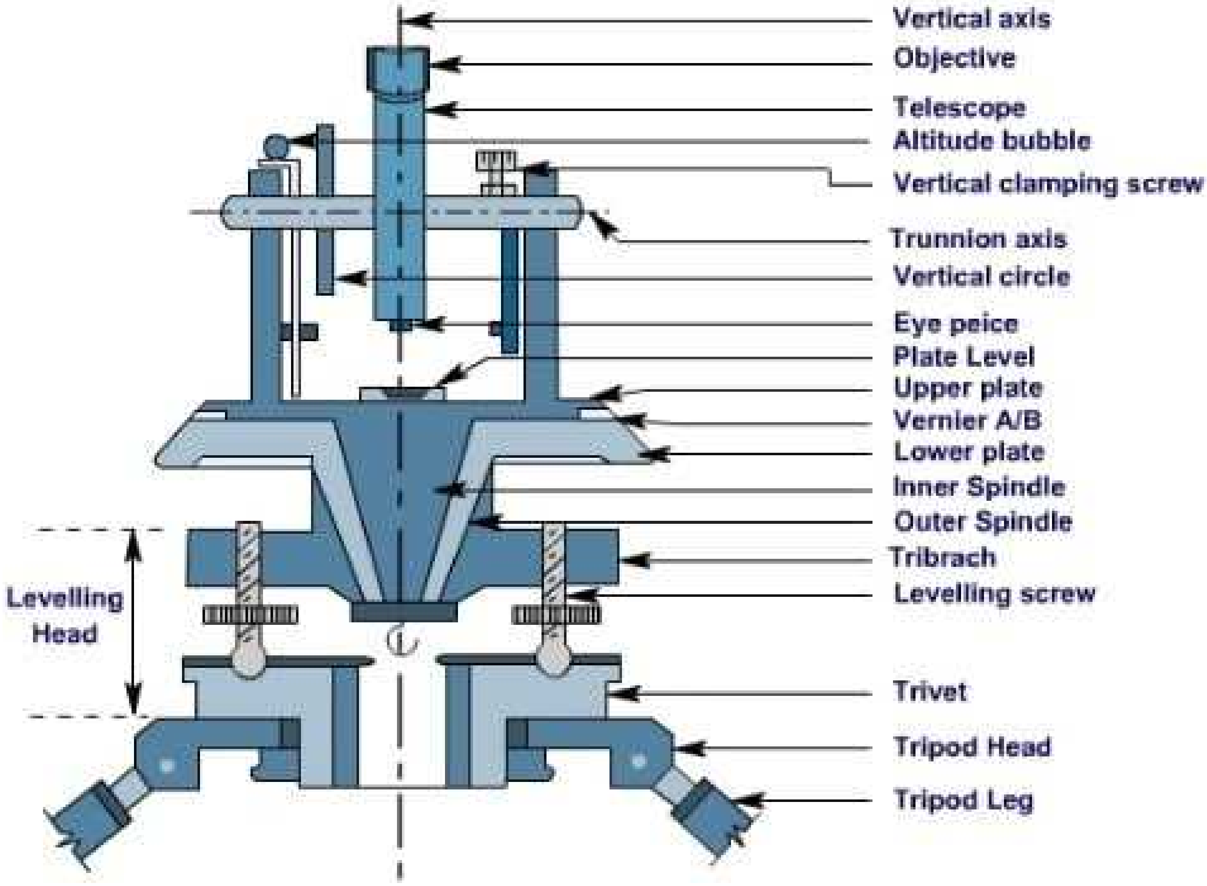
4. **Standards:** Two standards resembling letter A (hence called A – frame) are mounted on top plate. The trunnion axis of the telescope is supported on the standards. The T-frame and the arm of the vertical circle clamping screw are also attached to the A-frame
5. **Two Spindles:** There are two spindles, one is called **inner spindle** and the other **outer spindle**. The inner spindle is solid and conical. This fits into the outer spindle which is hollow. The inner spindle carries ***vernier or upper plate*** with two verniers ***A*** and ***B*** placed diametrically opposite to each other with magnifiers. The upper plate can be fixed in any position by means of ***upper plate clamping screw*** and ***upper plate tangent screw*.** The outer spindle is attached with lower plate carrying horizontal circle, graduated from 0° to 360° in clockwise direction. This lower plate can be fixed in any position by means of ***lower plate clamping screw*** and ***lower plate tangent screw*.**
6. **Plate Level:** A bubble tube called plate level, placed parallel to trunnion axis is fixed on the top plate
7. **Levelling Head:** The levelling head consists of two parallel triangular plates known as ***tribrach plates***. The ***upper tribrach*** plate has three arms each carrying a ***levelling screw***. The ***lower tribrach plate*** or ***foot plate*** has a circular hole through which a plumb bob may be suspended.

   The functions of levelling head are

   i) To support the main part of the instrument
   ii) To fix the theodolite to tripod and
   iii) To provide a means of levelling the theodolite
8. **Tripod:** Tripod helps in supporting the theodolite during its use. At the lower ends of the legs of tripod, pointed steel shoes are provided. The tripod head carries at its upper surface an external screw to which the lower tribrach or foot plate of the levelling head can be screwed
9. **Plumb Bob:** A plumb bob is suspended from the hook fitted to the bottom of the inner spindle, to centre the instrument over a station
10. **Striding Level:** Some theodolites are fitted with a striding level (a bubble tube) for testing the horizontality of the trunnion axis.

TERMS and DEFINITIONS

1. **Centring:** Process of setting the theodolite exactly over the station mark using plumb bob.
2. **Transiting:** Process of turning the telescope in vertical plane through 180° about trunnion axis.
3. **Swinging the telescope:** Process of turning the telescope in horizontal plane about the vertical axis.
4. **Face Left:** Observation taken with vertical circle to the left of the observer. This position is also known as ***telescope normal***.
5. **Face Right:** Observation taken with vertical circle to the right of the observer. This position is also known as ***telescope inverted.***
6. **Changing Face:** Process of bringing the face of the telescope from ***left to right*** and **vice versa.**



FUNDAMENTAL AXES OR LINES

1. **Vertical Axis:** This is the axis about which the instrument can be rotated in horizontal plane.
2. **Horizontal Axis:** This is the axis about which the telescope and the vertical circle can be rotated in vertical plane. This is also known as ***Trunnion axis***.
3. **Line of Collimation:** This is the line passing through the intersection point of cross wires of the diaphragm and the optical centre of object glass and its continuation.
4. **Axis of Telescope:** This is the line passing through the optical centre of eye piece and the optical centre of object glass and its continuation.
5. **Bubble Axis:** This is the straight line tangential to longitudinal curve of the level tube at its centre.

TEMPORARY ADJUSTMENTS

The adjustments made at every instrument station are known as temporary adjustments, whereas the adjustments made to establish the desired relationships between various axes of the theodolite are referred to as permanent adjustments. The temporary adjustments are made in the following stages

i) Setting Up
ii) Levelling up
iii) Elimination of Parallax

Setting Up: The operation of setting up includes ***centring*** using plumb bob or optical plummet and ***approximate levelling*** with the help of tripod legs. Some instruments are provided with ***shifting head*** with which accurate centring can be done easily. The approximate levelling is done either with reference to a small circular bubble provided or by eye judgment.

Levelling Up: Accurate levelling is achieved by means of levelling screws with reference to longitudinal bubble. (Refer Figure)

a) **Position 1:** Bubble is placed parallel to a pair of levelling screws. The two levelling screws forming the pair are turned together either inwards or outwards till the bubble comes to centre of its run.
b) **Position 2:** Bubble is now placed perpendicular to the position1 and the third levelling screw is turned clockwise or counterclockwise until the bubble comes to centre of its run.
c) The Bubble is returned to position 1 and step a) is repeated. Step b) is then repeated. Steps a) and b) are repeated till bubble remains central in the two positions. Instrument is rotated through 180°. If the instrument is in correct adjustment the bubble remains central.

***Note: It is essential to keep the same quarter circle for the changes in direction and not to swing through the remaining three quarters of a circle to the original position*.**

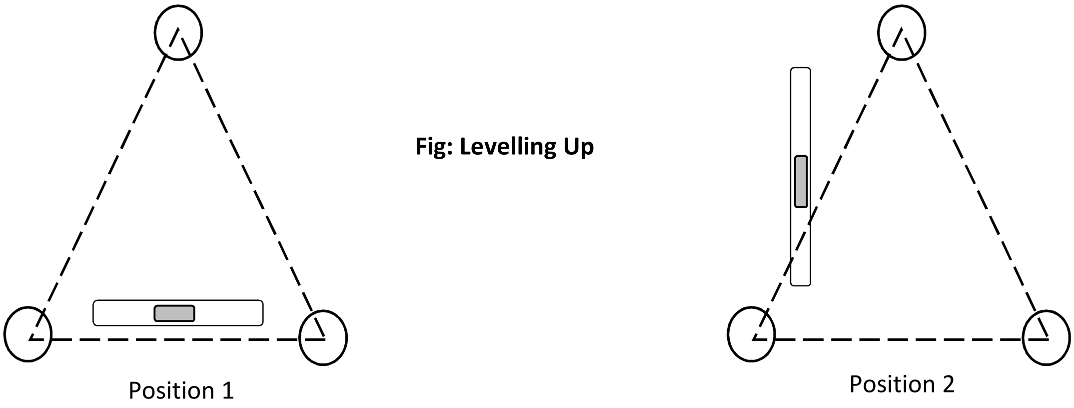


Fig: Levelling Up

Position 1

Position 2

Elimination of Parallax: The apparent movement of the object with the movement of the eye is known as parallax. This parallax exists when the image of the object does not lie in the plane of the cross hairs. This can be eliminated by ***focussing the eye piece*** and by ***focussing the object glass.***

a) **Focussing the Eye Piece:** A white sheet of paper is held in front the object glass and eye piece is turned clockwise or anticlockwise till the cross hairs are seen clearly and distinctly. (Sharp and black) It should be noted that the correct position of eye piece depends only upon the eyesight of the observer.

b) **Focussing the object Glass:** The telescope is directed towards the object and the focussing screw is turned till the image appears clear and sharp

LEAST COUNT OF THE THEODOLITE:

The smallest value that can be measured accurately by the measuring instrument (here it is theodolite) is called its **least count**. Measured values are good only up to this value. It is determined by the following formula

$$\mathrm{L\ C} = \frac{\mathrm{M}}{\mathrm{N}}$$

Where M = value of one (smallest) division on main scale
and N = Number of divisions on the vernier scale.

(Note:
L C = 1 MSD – 1 VSD
= 1 MSD – (N-1/N) MSD
= (1 MSD/N)
= M/N **)**

MEASUREMENT OF ANGLES USING THEODOLITE

a) Horizontal Angle by Repetition Method

Aim: To measure the horizontal angle by Repetition Method

Apparatus: Theodolite

Theory: Repetition method is used for very accurate works. In this method the angle is mechanically added several times and the value of the angle is obtained by dividing accumulated reading by the number of repetitions. In repeating the angle several times, the vernier A is kept clamped each time at the previous reading when the back sight is taken. The method of repetition consists in measuring the angle clockwise any desired number of times (usually six), half of which are made with face left and the other half with face right. By this, angles can be obtained to a finer degree of accuracy than that obtainable with the least count of the theodolite.

Procedure: The horizontal angle POQ by method of repetition is measured as follows.

1. The theodolite is set up over O. (Centred over O using plumb bob and approximately levelled by adjusting the legs of the tripod) It is levelled accurately with respect to plate level using levelling screws. A white sheet of paper is held in front of the object glass and the eye piece is turned till the cross hairs are seen clearly and distinctly.
2. By rotating the upper and lower plates in opposite directions, the index of vernier A is made to coincide exactly with 360° of the main scale using upper plate clamping screw and its tangent screw. (Index of vernier B will coincide exactly with 180°) In this condition and with Face Left, the instrument is turned in the horizontal plane to sight the station P. The station P is bisected exactly using the lower plate clamping screw and its tangent screw. (The reading of vernier A should be checked to see that no slip has occurred)
3. Upper plate clamping screw is released. The instrument is turned clockwise and the station Q is bisected exactly using upper plate clamping screw and its tangent screw. Readings on both the verniers A and B are noted (Total reading on A and Total reading on B minus 180°). The object of noting the two vernier readings is to obtain the approximate value of the angle, which is the average of Verniers A and B readings.
4. Lower plate clamping screw is released. The instrument is turned clockwise and the station P is bisected exactly using Lower plate clamping screw and its tangent screw.
5. Upper plate clamping screw is released. The instrument is turned clockwise and the station Q is bisected exactly using upper plate clamping screw and its tangent screw. Readings on both the verniers A and B are noted (Angle is measured for the second time ie repetition number two)
6. Lower plate clamping screw is released. The instrument is turned clockwise and the station P is bisected exactly using Lower plate clamping screw and its tangent screw.
7. Upper plate clamping screw is released. The instrument is turned clockwise and the station Q is bisected exactly using upper plate clamping screw and its tangent screw. Readings on both the verniers A and B are noted (Angle is

measured for the third time ie repetition number three). The average of Verniers A and B readings is obtained, which divided by the number of repetitions that is 3 to get average angle with face left.

8. The face of the instrument is changed (Face right) and the above steps are repeated to get another average value of the angle with face right The angle POQ is the mean of two average angles obtained in the two faces.

(Refer Fig 1 for the procedure and Table 1 for the entry of readings and calculation of the angle)

NOTE: ***Any number of repetitions may be made. For ordinary work three repetitions with telescope normal (Face Left) and three with telescope inverted (Face right) are quite sufficient. But for measuring an angle to the highest degree of precision, several sets of repetitions are usually taken.***

Errors eliminated by repetition method

1. Errors due to eccentricity of verniers are eliminated by taking both vernier readings.
2. Errors due to improper adjustments of line of collimation and trunnion axis are eliminated by taking both face readings.
3. Errors due to inaccurate graduations are eliminated by taking readings at different parts of the circle.
4. Errors due to inaccurate bisections of the object and eccentric centring may be counterbalanced in different observations.

TABLE 1: METHOD OF REPETITION

Inst at	Station Sighted	Face: **LEFT**			Swing**: Right**		Face: RIGHT			Swing**: Right**		Mean of Average
		A	B	Average Reading	Repetit-ion No	Average Angle	A	B	Average Reading	Repetit-ion No	Average Angle	
O	P											
	Q				1					1		
	Q				2					2		
	Q				3					3		

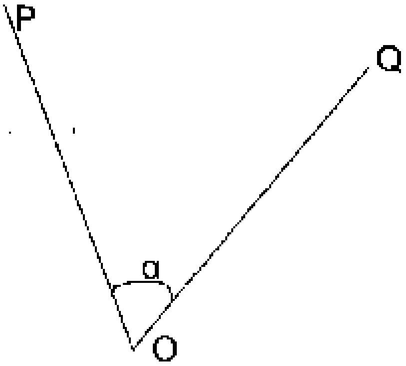


Fig: Repetition method

Horizontal Angle by Reiteration Method or Direction Method

Aim: To measure the horizontal angle by Repetition Method

Apparatus: Theodolite

Theory: Reiteration method is suitable for the measurement of angles of a group having a common vertex point. Several angles are measured successively and finally the horizon is closed.

The horizontal angles POQ, QOR, ROS etc. by method of reiteration are measured as follows.

1. The theodolite is set up over O. (Centred over O using plumb bob and approximately levelled by adjusting the legs of the tripod) It is levelled accurately with respect to plate level using levelling screws. A white sheet of paper is held in front of the object glass and the eye piece is turned till the cross hairs are seen clearly and distinctly.
2. By rotating the upper and lower plates in opposite directions, the index of vernier A is made to coincide exactly with 360° of the main scale using upper plate clamping screw and its tangent screw. (Index of vernier B will coincide exactly with 180°) In this condition and with Face Left, the instrument is turned in the horizontal plane to sight the station P. The station P is bisected exactly using the lower plate clamping screw and its tangent screw. (The reading of vernier A should be checked to see that no slip has occurred)
3. Upper plate clamping screw is released. The instrument is turned clockwise and the station Q is bisected exactly using upper plate clamping screw and its tangent screw. Readings on both the verniers A and B are noted (Total reading on A and Total reading on B minus 180°). The object of noting the two vernier readings is to obtain the approximate value of the angle, which is the average of Verniers A and B readings.
4. Upper plate clamping screw is released. The instrument is turned clockwise and the station R is bisected exactly using upper plate clamping screw and its tangent screw. Readings on both the verniers A and B are noted.
5. Similarly, the points S and P are successively bisected exactly. When the point P is bisected, the horizon is closed. Readings on both the verniers A and B are noted after each bisection. Since the graduated circle remains in a fixed

position throughout the entire process, each included angle is obtained by taking the difference between the two consecutive readings.

6. On a final sight to P, the reading on the vernier should the same as the original setting (That is Zero on A and 180 on B). If not, the error is noted. If the error is small, it is distributed equally to all the angles measured. But if the error is large, the procedure is repeated to take a fresh set of readings.

TABLE 2: METHOD OF REITERATION

Inst at	Station Sighted	Face: **LEFT**		Swing**: Right**		Face: RIGHT		Swing**: Right**		Mean of Average
		A	B	Average Reading	Average Angle	A	B	Average Reading	Average Angle	
O	P									
	Q									
	R									
	S									
	P									

b) Measurement of Vertical Angle

Aim: To measure the vertical angle
Apparatus: Theodolite
Theory: Vertical angle is the angle which the inclined line of sight to an object makes with the horizontal. It may be angle of elevation or angle of depression depending upon whether the object is above or below the horizontal line of sight. Angle of elevation is normally prefixed with ***plus*** sign whereas angle of depression is prefixed with ***minus*** sign.

The vertical angle α is measured as follows.

1. The theodolite is set up over O. (Centred over O using plumb bob and approximately levelled by adjusting the legs of the tripod) It is levelled accurately with respect to altitude bubble using levelling screws. A white sheet of paper is held in front of the object glass and the eye piece is turned till the cross hairs are seen clearly and distinctly.
2. With the face of the instrument LEFT, the telescope is turned to sight the object A, approximately and vertical circle clamping screw and horizontal plate clamping screws are tightened. Object A is bisected exactly using vertical circle tangent screw and any one of the horizontal plate tangent screws. The readings on the verniers C and D are noted and the average of the two readings is obtained. This represents the vertical angle with face left.
3. With the face of the instrument RIGHT, the telescope is turned to sight the object A, approximately and vertical circle clamping screw and horizontal plate clamping screws are tightened. Object A is bisected exactly using vertical circle tangent screw and any one of the horizontal plate tangent screws. The readings on the verniers C and D are noted and the average of the two readings is obtained. This represents the vertical angle with face right.
4. The mean of thevalues of face left and face right gives the vertical angle α.

Table 3: Measurement of vertical angle

Inst. at	Sighted to	Face: LEFT (FL)			Face: RIGHT (FR)			Mean of FL and FR
		C	D	Average Vertical angle	C	D	Average Vertical angle	
O	A							α =
	B							β =

Trigonometric Levelling: Trigonometric leveling (heights and distances-single plane and double plane methods).

Trigonometrically Levelling is the process of determining the differences of elevations of stations from the observed vertical angles and known distances, which are assumed to be either horizontal or geodetic lengths at mean sea level. The vertical angles may be measured by means of an accurate theodolite and the horizontal distances may either be measured (in the case of plane surveying) or computed (in the case of geodetic observations).

Trigonometrical levelling under two heads:

1. Observations for heights and distances, and
2. Geodetical observations

Heights and Distances

The difference in elevation b/w the instrument station and object under observation,
We shall consider the following cases;
Case 1: Base of the object accessible.
Case 2: Base of the object inaccessible: Instrument stations in the same vertical plane as the elevated object.
Case 2: Base of the object inaccessible: Instrument stations not in the same vertical plane as the elevated object.

1. **Base of the object Accessible**
2.

Module: 2

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Tacheometry.

Basic principles, types of tacheometry, distance equation for horizontal and Inclined line of sight in fixed hair method. problems.

Tacheometry is the branch of angular surveying in which horizontal and vertical [Elevations distance of points are obtained by the readings of the Instrument only. [Measurement of distance is completely avoided]. The method is also known as "Tachymetry ⓞ Telemetry.

Advantages and Disadvantages:

The advantages of Tacheometry surveying over the direct method of measuring horizontal distances and difference in elevations are.

1. Speed of surveying is very high.
2. Accuracy of surveying is quite satisfactory in normal condition -ns and even superior in difficult terrain.
3. cost of surveying is less
4. Not tedious as chain, tapes, ranging rods etc are avoided.
5. The method is more advantageous in the following ~~[illegible]~~ works:
    1. Preparation of topographic plans.
    2. Reconnaissance surveys for roads and railways
    3. H~~ydraulic~~ Hydrographic surveys
    4. Checking already measured distances
    5. For filling in details in a traverse.

Disadvantages:

It is less accurate as compared to chainage. The accuracy decreases with increase in the distance. Thus the method does not give satisfactory results when the areas to be surveyed are extensive.

Applications / uses :

1. The main application of tacheometry is in the preparation of contour map of an area particularly. when it is rough and uneven.

2. The tacheometric method is more rapid than taping and hence it can be used for [the traverse] (or) filling detailing of traverse.

3. It is convenient for reconnaissance survey of roads, railways etc.

4. It is useful for checking of the distance measured with tape (or) checking of the elevations determined with a level.

Different systems of Tacheometric measurements:

Basically, there are three types of tacheometric measurements. which is further divided into

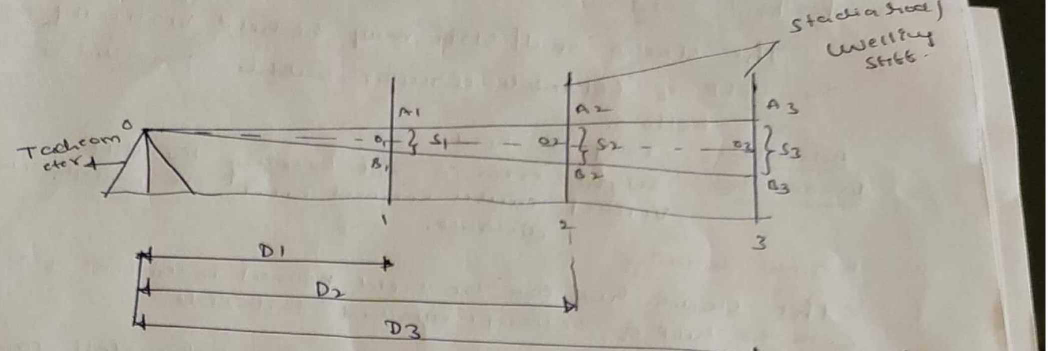
1. Stadia system
   - a] Fixed Hair method.
   - b] Movable Hair method.
2] Tangential method of Tacheometry and
3] Substance Bar method of Tacheometry.

1] Stadia method :

The horizontal and vertical distance elevantation of a point may be determined by the fixed hair ~~method~~ commonly known as Stadia method.

a] Fixed hair method:

Principle: In Isosceles triangles the ratio of ee perpendiculars from vertex on their bases to the "bases" is constant. when angle at the vertex is same.



In fig as per above principle ~~[illegible]~~ similar triangles

$$\frac{OO1}{A1B1} = \frac{OO2}{A2B2} = \frac{OO3}{A3B3} = \text{constant.}$$

D1, D2 & D3 = horizontal distance from the Instrument

$$\frac{D1}{S1} = \frac{D2}{S2} = \frac{D3}{S3} = \text{constant} = \frac{f}{i}$$

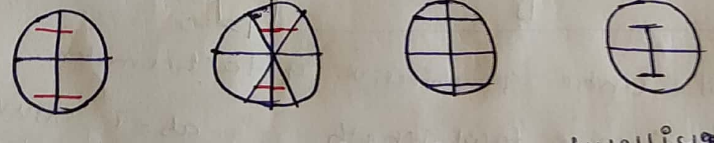
S1, S2 & S3 = Vertical staff reading from top vertex to bottom vertex

f = focal length of object
i = stadia intercept.

$\left[\frac{f}{i}\right]$ = multiplying constant.

Instruments used:

1. Tacheometer: This is a Vernier Theodolite fitted with stadia diaphragm. In the diaphragm, In addition to the central horizontal hair, there are two "stadia wires" "one is above and the other below" and equidistance from the central horizontal hair. Some patterns of stadia diagram are shown in fig 1.



Stadia Rod: It is like a levelling staff, generally in one piece, 3-5 m long and 50 - 150mm wide. The graduations are bold and simple. so that the readings can be taken from long distances. For small distances say upto 100m. an ordinary lev staff may be used. The stadia rod (or) staff can held vertical (or) normal to the line of sight.

1. **Vertical holding:**

The stadia rod/ staff may be held vertically with the help of foldable circular bubble, provided at the bottom.

Advantage: Easy to hold.

disadvantage: Slight error in not keeping the staff vertical causes serious error in computation of distance.

2. **Normal holding:**

The stadia rod can be held normal to the line of sight with the help of telescope attached to its side.

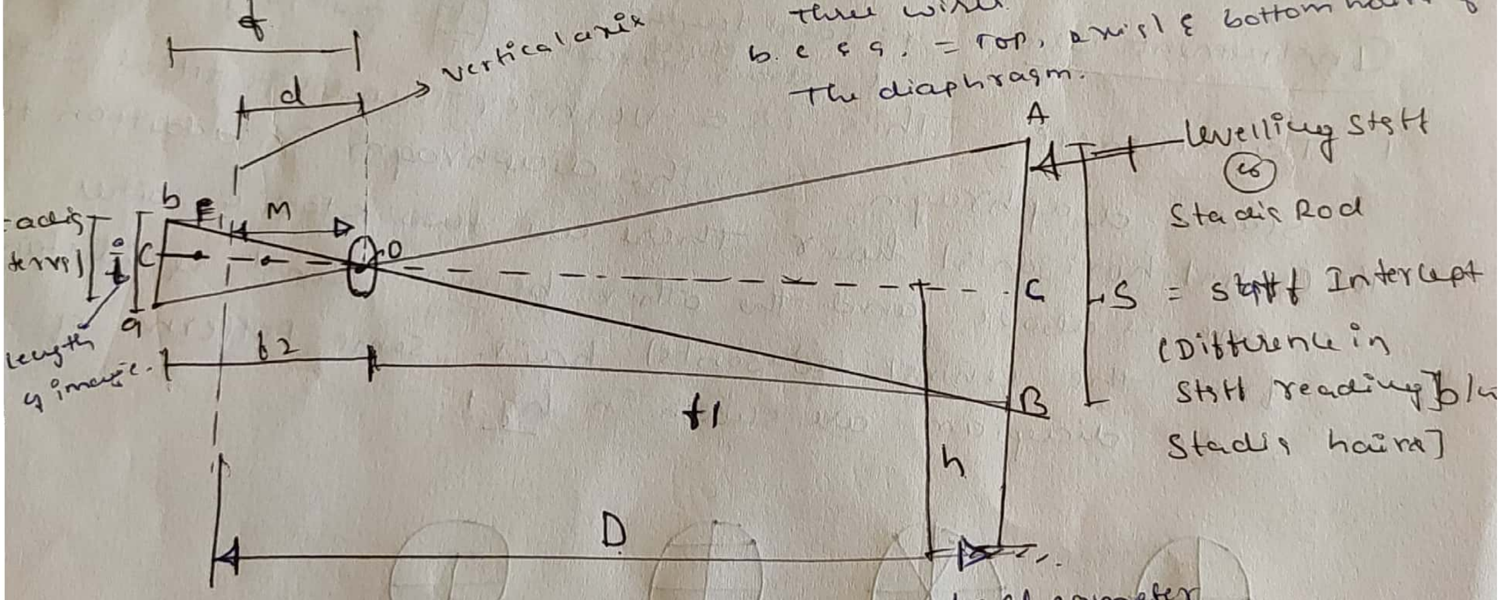
Advantage: Accuracy of the direction of the staff can be judged by the transitman.

disadvantage: Difficult to hold the stadia rod ⊥r to the Inclined line of sight

Distance equation for horizontal line of sight:

Let A, C & B = The points cut by the three lines of sight corresponding to the three wires.

b, c & a = Top, axial & bottom hairs of the diaphragm.



O = optical centre of objective of tacheometer

f1 & f2 = conjugate focal length

F = principal focus of objective.

f = focal length of objective

ab = i = interval b/w the stadia hairs

AB = S = staff intercept.

M = Point corresponding to vertical axis of tacheometer.

d = distance b/w Vertical axis and optical centre of objective.

D = distance b/w vertical axis of tacheometer & Stadia rod.

From fig, $D = f_1 + d \rightarrow$ ①

From the principle of fixed hair stadia method. [Ratio of 1r to
base is constant]

$$\frac{f_1}{f_2} = \frac{s}{i} \rightarrow ②$$

Also from lens formula.

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f}$$

multiplying by f1

$$\frac{f_1}{f_1} + \frac{f_1}{f_2} = \frac{f_1}{f}$$

$$1 + \frac{f_1}{f_2} = \frac{f_1}{f}$$

But from eq 2②

$$\frac{f_1}{f_2} = \frac{s}{i}$$

$$\frac{1}{f_1} + \frac{s}{i} = \frac{f_1}{f}$$

$$1 + \frac{s}{i} = \frac{f_1}{f}$$

$$f_1 = \left(\frac{s}{i}\right) f + f$$

Substituting the value of f_1 in eq ①

We get

$$D = \left(\frac{s}{i}\right) f + f + d$$

$$= \left(\frac{s}{i}\right) f + (f+d)$$

$$\boxed{D = \left(\frac{f}{i}\right) s + \underline{(f+d)}}$$

– Distance equation for horizontal line of sight & staff vertical]

$\left(\frac{f}{i}\right)$ and $[f+d]$ are called constant of ~~tacheome~~ tacheometer.

$\frac{f}{i}$ = multiplying constant (written generally as K)

$(f+d)$ = Additive constant [written generally as C]

Hence = $\boxed{D = KS + C}$

RL of staff station = HI − h.

h = staff reading corresponding to central horizontal hair]

1. The following readings were taken with a tacheometer with line of sight horizontal on a staff held vertical. 0.950, 1.285, 1.620. Determine the horizontal ~~line~~ of distance from the Instrument station to the staff station if K = 100, and C = 0.15 m. Also Determine the RL of the staff station. if the RL of Instrument station is 101.580 m and the height of trunnion axis is 1.460 m.

Soln

$D = KS + C$

$D = 100[1.620 - 0.950] + 0.15$

$\boxed{D = 67.15 m}$

RL of staff station = HI − h

$= [101.580 + 1.460] - 1.285$

RL of staff station = $\underline{101.755 m}$

A tacheometer was setup at station P and observations were made to a staff held at Q, the vertical circle readings being zero. The readings were 1.980 m, 1.660 m, and 1.340 M. The reading from P to a staff held on a BM of elevation 1020.500 m was 2.850 m. Find the distance PQ and the elevation of point Q. The Instrument constants were 100 & 0.5.

b/w the Instrument station P and

$D = KS + c.$

$D = 100[1.980 - 1.340] + 0.5$

$\boxed{D = 64.5 m}$

Elevation of Q = HI − h

= RL of BM + (staff reading on BM) − h

= (1020.500 + 2.850) − 1.660

Elevation of Q = 1021.69 m

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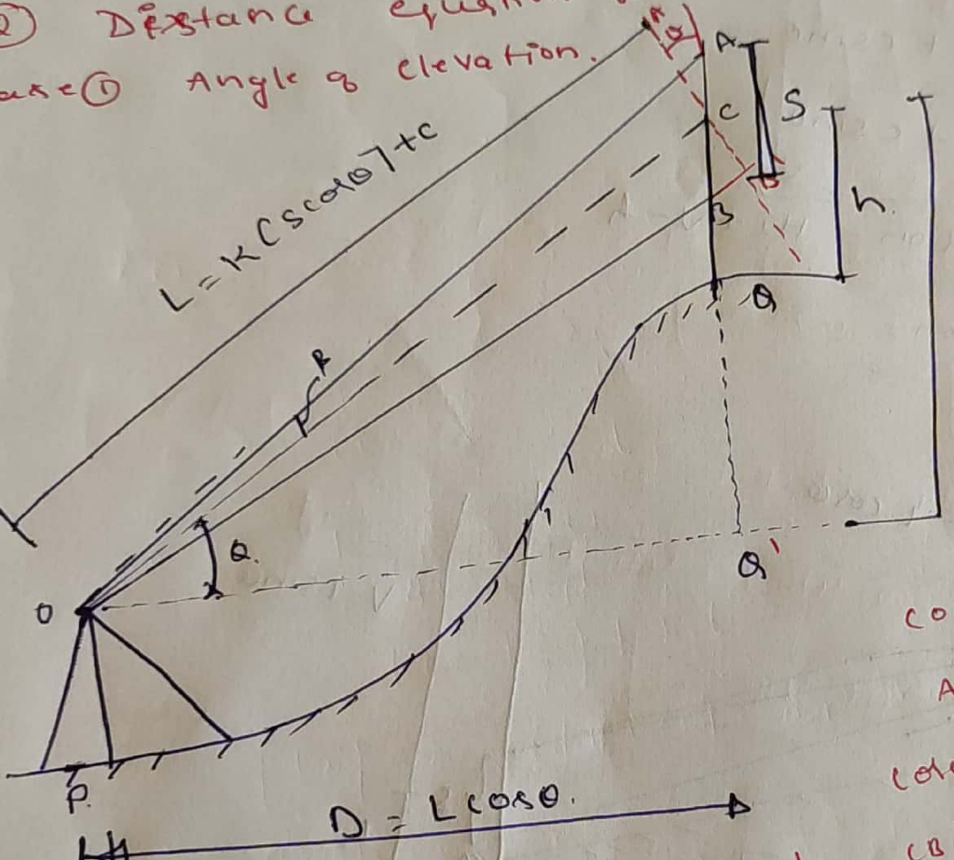
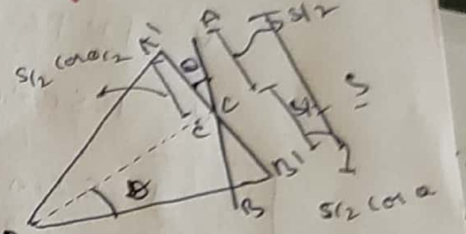
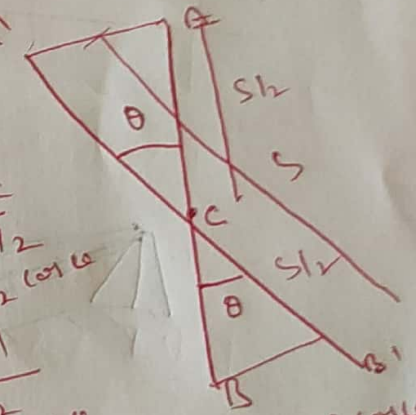
② Distance equation for Inclined line of sight, staff vertical.

case ① Angle of elevation.





$V = L\sin\theta.$



$\cos\theta = \frac{A'C}{S/2}$

$A'C = S/2 \cos\theta$

$\cos\theta = \frac{CB'}{S/2}$

$CB' = S/2 \cos\theta$

$A'B' = A'C + CB' = \frac{S}{2}\cos\theta + S/2 \cos\theta = \underline{S\cos\theta}$

Ref. fig.

The distance b/w P and Q and the elevation of Q is to be found with Instrument at P with staff held vertical at Q.

Let θ be the Inclination of line of sight (observations along central hair] & β the stadia angle.

D be horizontal distance b/w P and Q stadia readings be A and B on the staff & central hair reading at C.

S be the stadia intercepts AB.

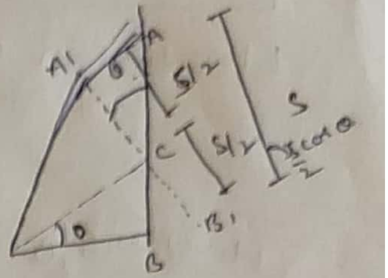
ance b/w the Instrument
dsts.

If A'B' is drawn at an angle to vertical through C it will be right angles to the line of sight. Let L be the Inclined distance (OC = L)

$$D = L\cos\theta$$

$$= [K[S\cos\theta] + C]\cos\theta$$

$$\boxed{D = KS\cos^2\theta + C\cos\theta}$$



$$V = L\sin\theta$$

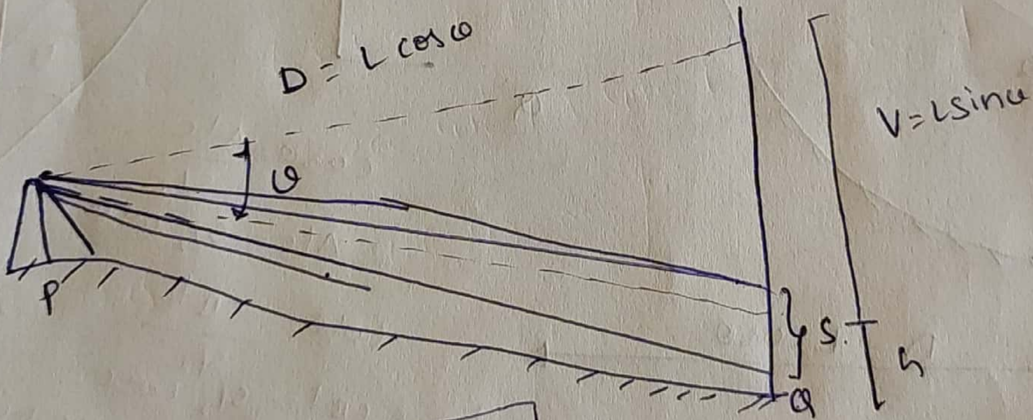
$$V = [K[S\cos\theta] + C]\sin\theta$$

$$V = KS\cos\theta\sin\theta + C\sin\theta$$

$$\boxed{V = K \cdot S\frac{\sin 2\theta}{2} + C\sin\theta}$$

RL of staff station = HI + V − h.

Angle of depression:



$$\boxed{D = KS\cos^2\theta + C\cos\theta}$$

$$\boxed{V = K \cdot S\frac{\sin 2\theta}{2} + C\sin\theta}$$

RL of Staff Station = HI − V − h

1. Determine the distance b/w the Instrument station P and the staff station Q from the following data.

Height of Instrument = 1.490m.

Vertical angle = +4° 30'

Staff reading (staff vertical) = 0.645, 1.000, 1.355)

Also determine the RL of Q if that of P is 200.410m.

Take K=100 & C=0.2

→

$D = KS\cos^2\theta + C\cos\theta$

$D = 100 \times [1.355 - 0.645] \cos^2 4°30' + 0.2 \cos 4°30'$

$\boxed{D = 70.762m}$

$V = KS \frac{\sin 2\theta}{2} + C \sin\theta$

$V = 100 \times [1.355 - 0.645] \frac{\sin(2 \times 4°30')}{2} + 0.2 \sin 4°30'$

$\boxed{V = 5.570\ m}$

RL of Q = [RL of P + Height of Instrument] + V - h

= 200.410 + 1.490 + 5.570 - 1

$\boxed{\text{RL of Q} = 206.470\ m}$

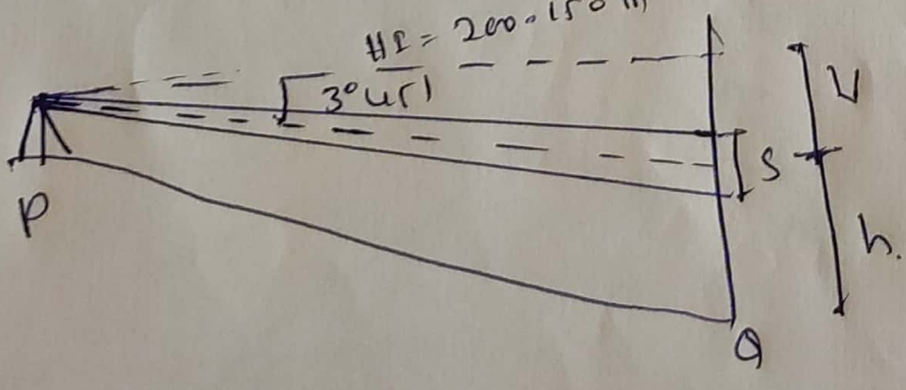
② Determine the distance b/w the Instrument station P and staff Station Q from the following data.

RL of the Instrument axis = 200.150m.

Vertical angle = -3° 45'

Staff readings = 1.450, 0.900, 0.350

Also find RL of Q = Take K=100 C=0.



$D = KS\cos^2\theta + C\cos\theta$

$D = 100[1.450 - 0.350]\cos^2 3^\circ 45' + 0$

$$\boxed{D = 109.530\text{m}}$$

$V = KS\frac{\sin 2\theta}{2} + C\sin\theta$

$V = 100[1.450 - 0.350]\,\sin\frac{(2\times 3^\circ 45')}{2}.$

$$\boxed{V = 7.179\text{m}}$$

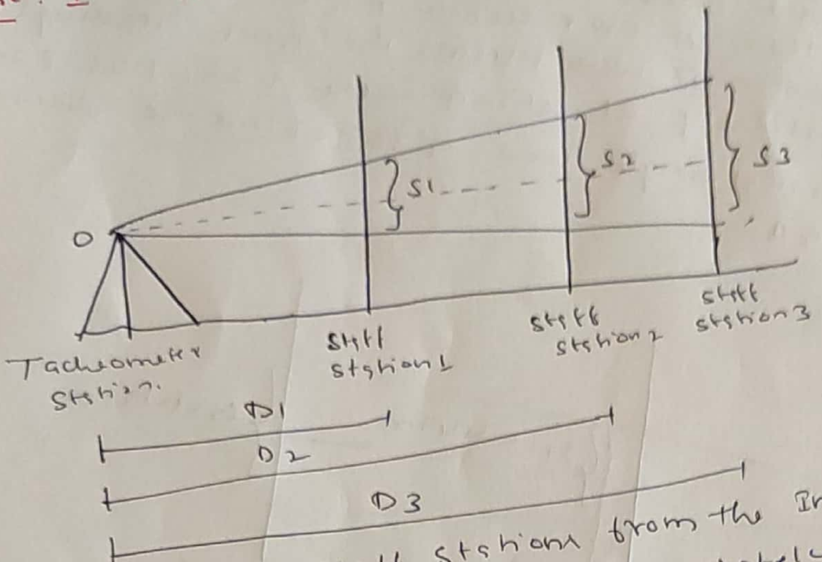
RL of Q = HI − V − h

= 200.150 − 7.179 − 0.900

$$\boxed{\text{RL of Q} = 192.071\text{m}}$$

Determination of constants of a Tacheometer.

Case: 1 Horizontal line of sight.



1. Distances of staff stations from the Instrument stations D1, D2 and D3 are measured accurately.
2. Staff Intercepts S1, S2 and S3 are obtained by taking staff readings on Station 1, 2 & 3. respectively.

$D_1 = KS_1 + C \rightarrow ①$

$D_2 = KS_2 + C \rightarrow ②$

$D3 = KS3 + C \rightarrow ③$

Solving eq ① & ② We get K1 and C1 are obtained

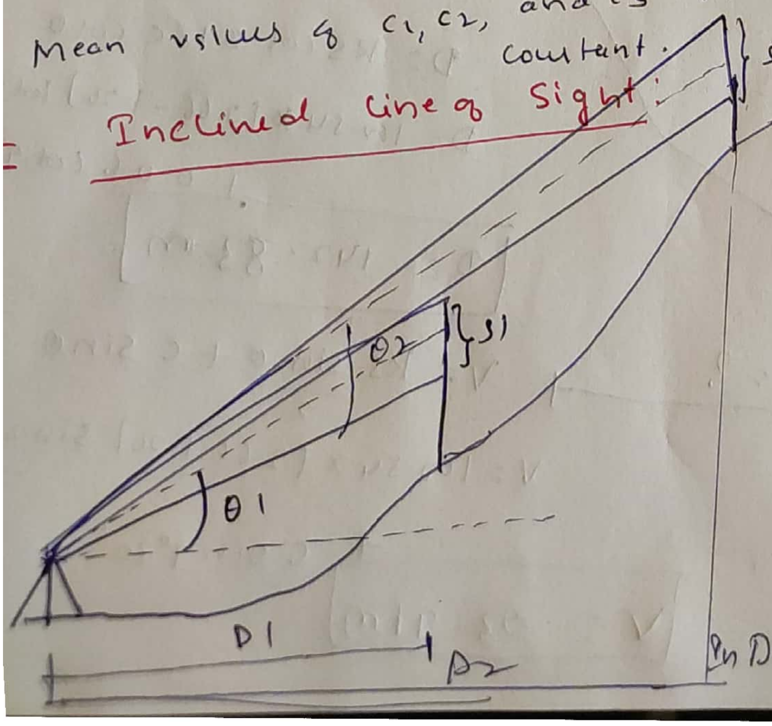
solving eq ② & ③ K2 & C2 are obtained

solving eq ③ & ① K3 & C3 are obtained.

Mean values of K1, K2 and K3 is taken as multiplying constant.

Mean values of C1, C2, and C3 is taken as C - additive constant.

Inclined line of sight:



$D_1 = KS_1 \cos^2\theta_1 + C\cos\theta_1 \rightarrow ①$

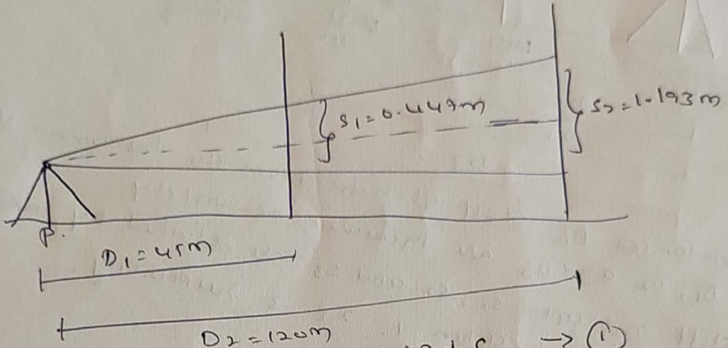
$D_2 = KS_2 \cos^2\theta_2 + C\cos\theta_2 \rightarrow ②$

Solving eq ① & ② ~~[illegible]~~ K, C can be obtained

Here D1 & D2 are the horizontal distances to be measured accurately by stepping method (or) any other In Direct method.

1. A staff was held vertically at distance of 45m & 120m from the centre of theodolite fitted with stadia hairs. the staff intercepts were 0.447m and 1.193m respectively. the Instrument was then set over station P of RL. 500.25m and the height of Instrument axis was 1.45m. The hair readings on a staff held vertically at station Q. were 1.20, 1.93 & 2.66m. while the vertical angle was 9°30'. Find the distance PQ and RL of Q.

Sol



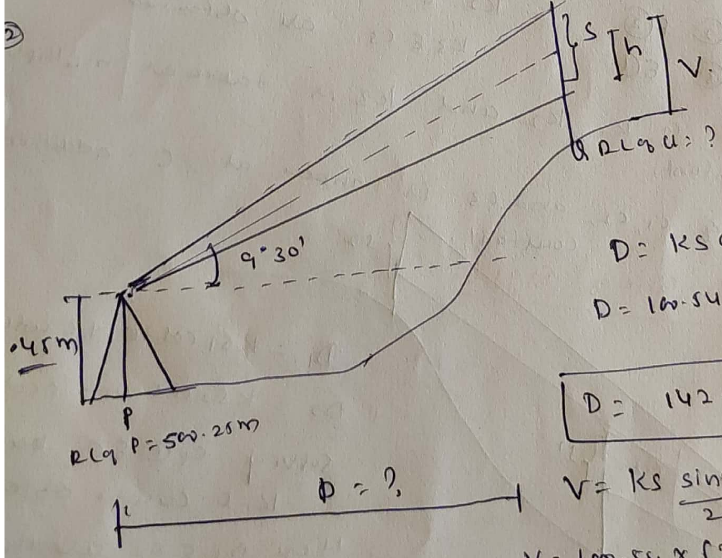
$D_1 = KS_1 + C_1$ $45 = K \times 0.447 + C \rightarrow ①$

$D_2 = KS_2 + C$ $120 = K \times 1.193 + C \rightarrow ②$

solving eq ① & ② K. and c are obtain

$\boxed{K = 100.54 \qquad C = 0.06m}$

②



$D = KS\cos^2\theta + C\cos\theta$

$D = 100.54 * [2.66 - 1.20] \cos^2 9°30' + 0.06 \cos 9°30'$

$\boxed{D = 142.83 m}$

$V = KS \frac{\sin 2\theta}{2} + C \sin\theta$

$V = 100.54 \times [2.66 - 1.20] \frac{\sin 2 \times 9°30'}{2} + C \sin 9°30'$

$\boxed{V = 23.91m}$

RL of Q = [RL of P + height of Instrument axis] + V − h

RL of Q = 500.25 + 1.45 + 23.91 − 1.93

$$\boxed{\text{RL of Q} = 523.68\ \text{m}}$$

Advanced Surveying

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Assistant Professor.
BIET Davanagere

Module: 1.

Curve setting [Simple curves]

Curves are generally used on highways and railways. Where it is necessary to change the direction of motion. A curve may be circular, parabolic (or) spiral and is always tangential to the two straight directions.

* Circular curves are further divided into three classes
* Simple curves * Compound curves and Reverse curve

* Simple curves: It is the one which consists of a single arc of a circle. It is tangential to both the straight lines. (fig 1)

* Compound curves: It consists of two (or) more simple arcs that turn in the same direction and joining at common tangent points. (fig. 2)

* A Reverse curve: It is the one which consists of two circular arcs of same (or) different radii, having their centres to the different sides of the common tangent. Both the arcs thus bend in the different directions with a common tangent at their junction. (fig. 3)

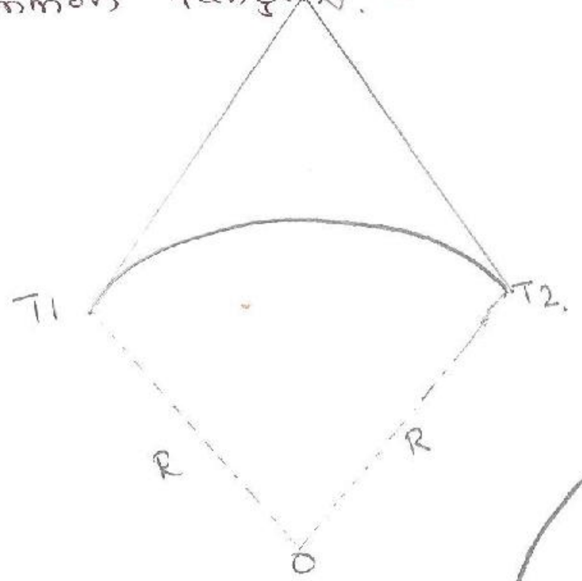


fig 1 Simple curve.

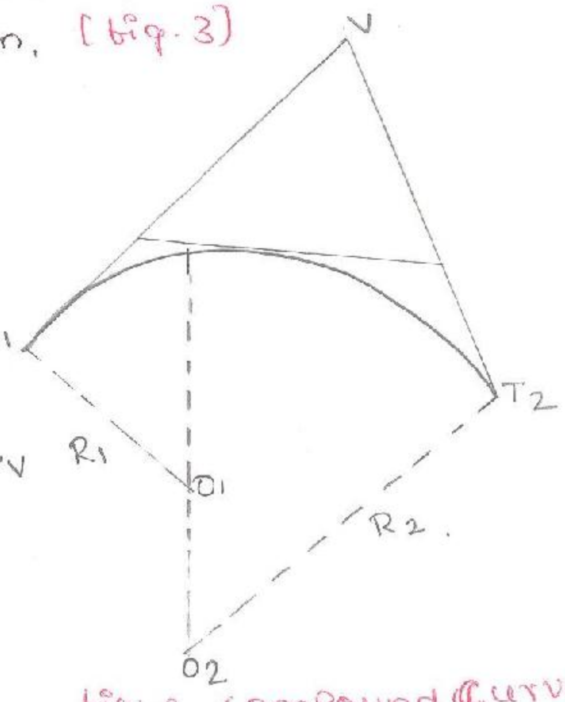


fig: 2 Compound Curve.

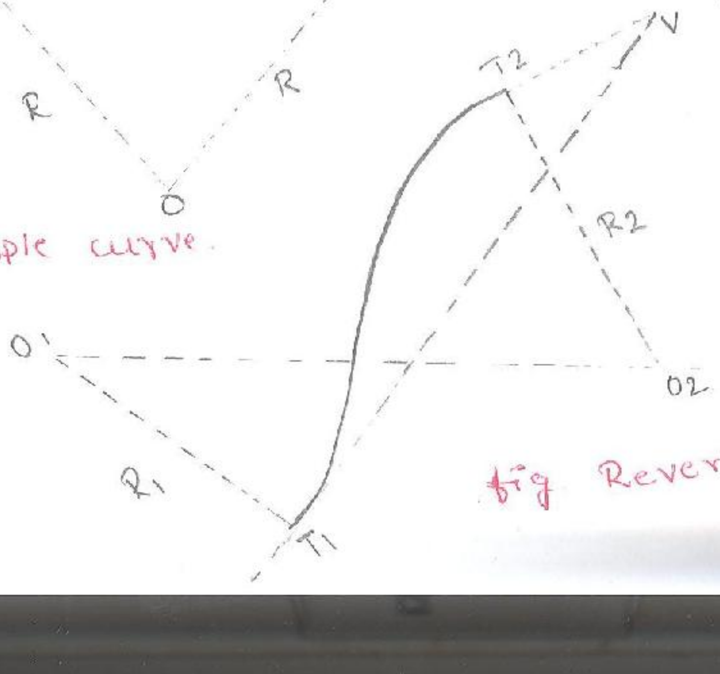


fig Reverse curve.

Classification of curves:

1. Based on the plane of location:

1. Horizontal curves. [curves in horizontal plane]
2. Vertical curves [curves in vertical plane]

Horizontal curves are further classified as simple, circular, compound, reverse, transition, combined, and broken back curves.

Vertical curves are usually parabolic and are classified as summit and sag vertical ~~Sa~~ curve.

* Transition curve: It is a curve usually introduced b/w a simple circular curve and a straight, (or) b/w two simple circular curves. It is also known as an easement curve.

A transition curve has a radius, gradually changing from a finite to infinite values (or) vice versa. It is widely used on highways and railways. Since its radius increases (or) decreases in a very gradually manner.

In fig:4 T_1TD is the transition curve introduced b/w the simple curve $T_4DD'T_5$ and the straight T_1I.

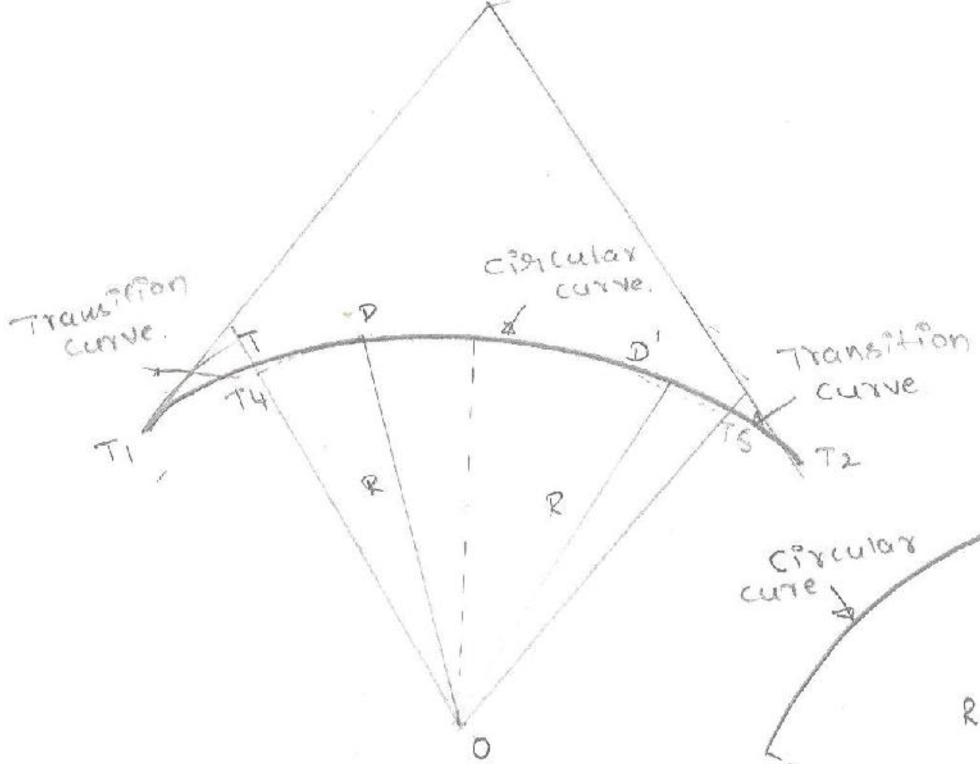


fig:4 Transition curve.

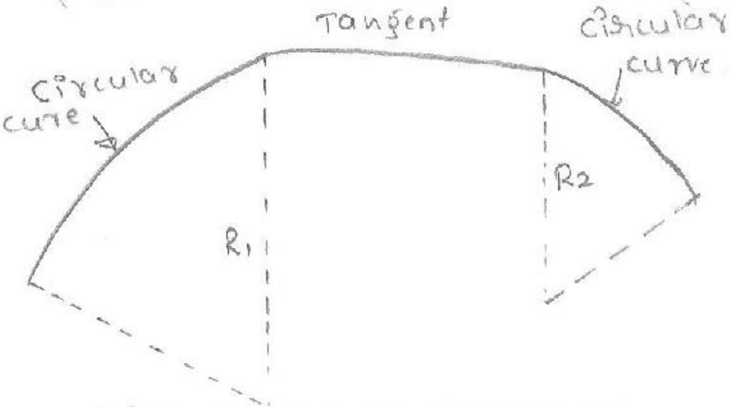
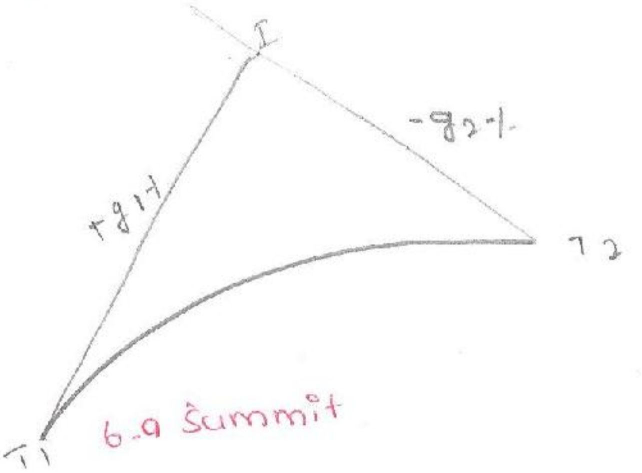


Fig: 5. Broken Backcurve

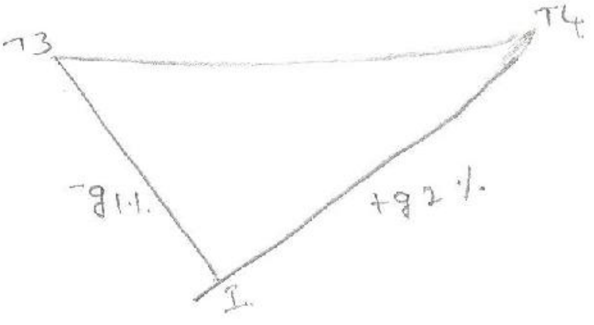
Combined curve: It is a combination of simple circular curves and transition curves and are preferred in railways and high-ways.

Broken-Back curve: Two circular curves having their centre on the same side and connected with a short tangent length were used for railroad traffic. Since these are not suitable for high speeds, they are not in use nowadays.

Vertical curve: These are curves in a vertical plane used to Join two intersecting grade lines. The reduced level of these curves change from point to point in a gradual and systematic manner. A vertical summit curve is provided when a rising grade (T1I) Joins falling grade (T2I) as shown in fig. 6(a) and a vertical sag curve is provided when a falling grade (T3I) Joins a rising grade (T4I) as shown in fig 6b



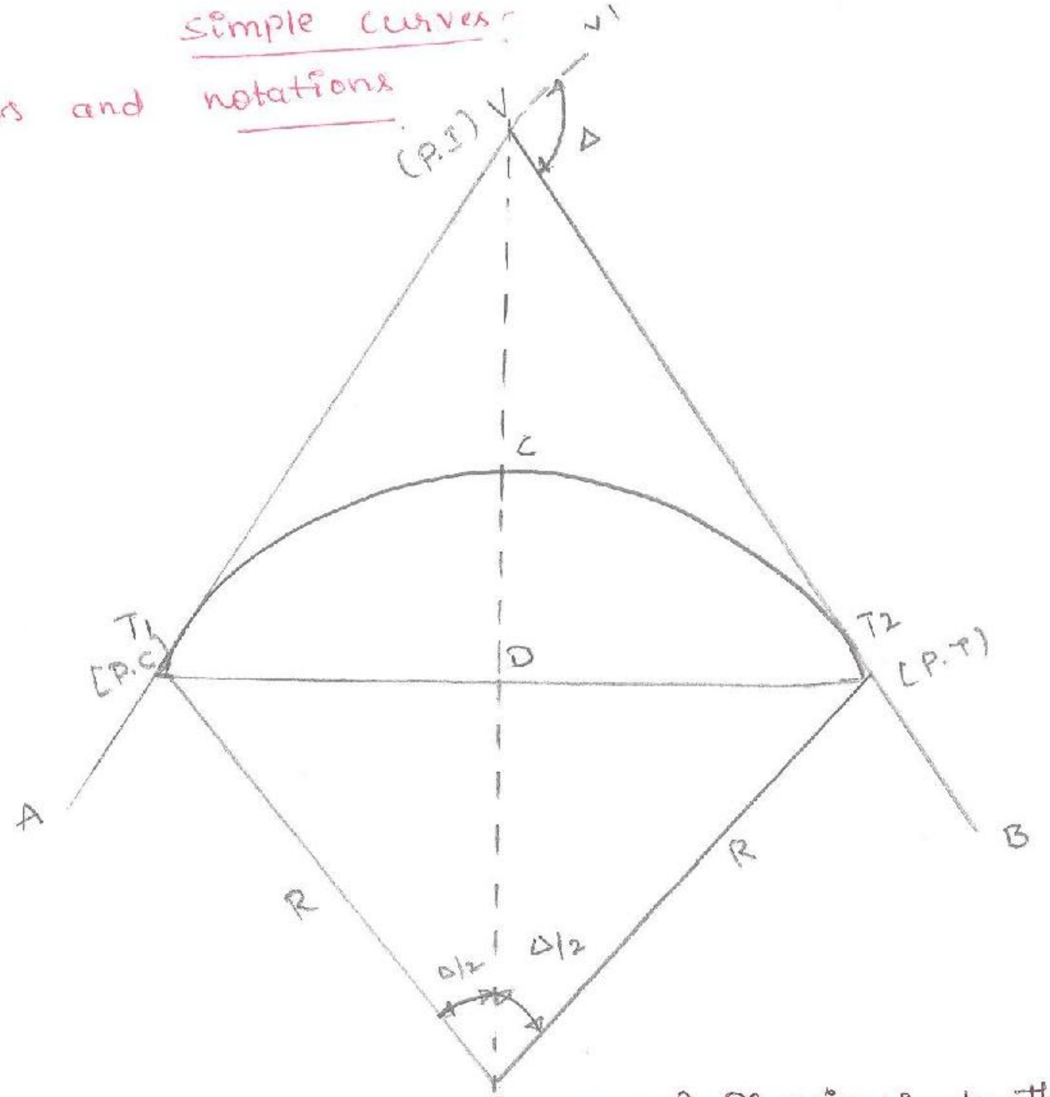
6.a Summit



6b. Sag

Simple Curves:

Definations and notations



① **Back Tangent** : The tangent (AT_1) Previous to the curve is called Back tangent (or) first tangent.

② **Forward tangent**: The tangent [T_2B] following the curve is called Forward tangent (or) Second tangent.

3. **Point of Intersection**: If the two tangents AT_1 and BT_2 are Produced, they will meet in a Point, called the Point of Intersection [P. I) (or) Vertex, [V).

④ **Point of curve [PC]**: It is the begining of the curve where the alignment changes from a tangent to a curve.

⑤ **Point of tangency [P.T]**: It is the end of the curve where the alignment changes from a curve to tangent

⑥ **Intersection angle(Δ)**: The angle V'VB b/w the tangent AV produced and VB is called Intersection angle.(Δ)

⑦ **Deflection angle at any Point**: The deflection angle at any Point on the curve is the angle at P.C b/w the back tangent & the chord from P.C. to Point on the curve.

⑧ **Tangent distance[T]**: It is the distance b/w P.C to P.I (also the distance from P.I to P.T)

⑨ External distance [E]: It is the distance from the mid-point of the curve to P.I. E = CV

⑩ Length of curve [L]: It is the total length of the curve from PC to P.T.

⑪ Long chord: It is chord Joining P.C to P.T.

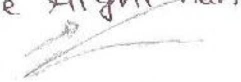
12. Mid-ordinate [M]: It is the ordinate from the mid-point of the long chord (11) to the mid-point of the curve (C)
M = CD

13. Normal chord [C]: A chord b/w two successive regular stations on a curve.

14. Sub-chord [c]: Sub-chord is any chord shorter than the normal chord.

15. Right hand curve: If the curve deflects to the right of the direction of the progress of survey, it is called the right hand curve.

⑮



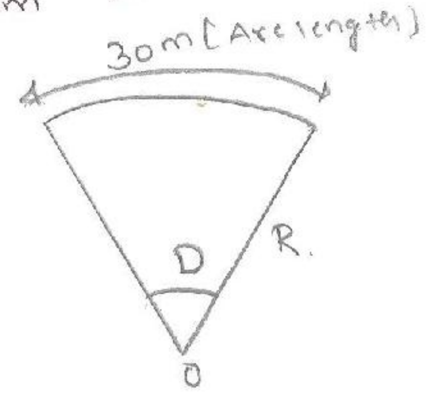
16. Left hand curve:
If the curve deflects to the left of the direction of the progress of survey. it is called the left hand curve.

⑯

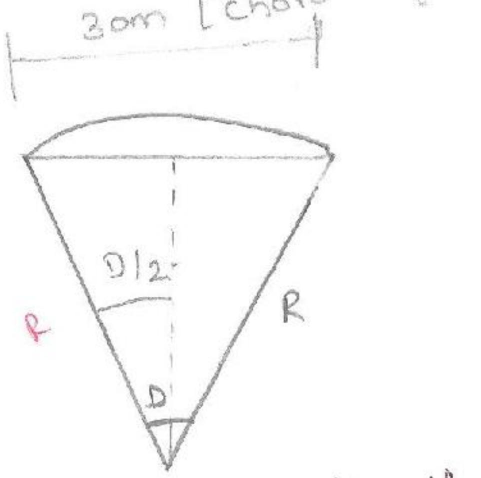
Designation of a circular curve

A curve can be designated in terms of either radius (R) (or) the degree (D) of the curve.

The Degree of curve [D] is the angle subtended at the centre by an arc or a chord of a specified length." In metric units the specified length can be 30m [or one chain length] (or) 20m



* Arc length.



* chord length.

Relationship b/w Radius and Degree of Curves

(a) Arc Definition:

Let R be the radius

- S be standard length.
- D be the degree of curve.

$$\frac{30}{D} = \frac{2\pi R}{360} \text{ (Property of cle)}$$

$$\boxed{R = \frac{1718.9}{D}}$$ for 30m length

|||ly for 20m tape (or) chain

$$\frac{20}{D} = \frac{2\pi R}{360}$$

$$\boxed{R = \frac{1146}{D}}$$ for 20m length.

(b) Chord definition: Let D be degree of curve as per chord definition and S be the standard chord length

$$\sin\frac{D}{2} = \left[\frac{30}{2}\right]\left[\frac{1}{R}\right]$$

$$R = \frac{30}{2\sin\frac{D}{2}}$$

Since: sin D. is small. $\sin D/2 = D/2$ radians

$$R = \frac{30}{2 \times D/2} = \frac{30}{D}$$

If D is in degrees. then

$$R = \frac{30 \times 180}{D \times \pi}$$

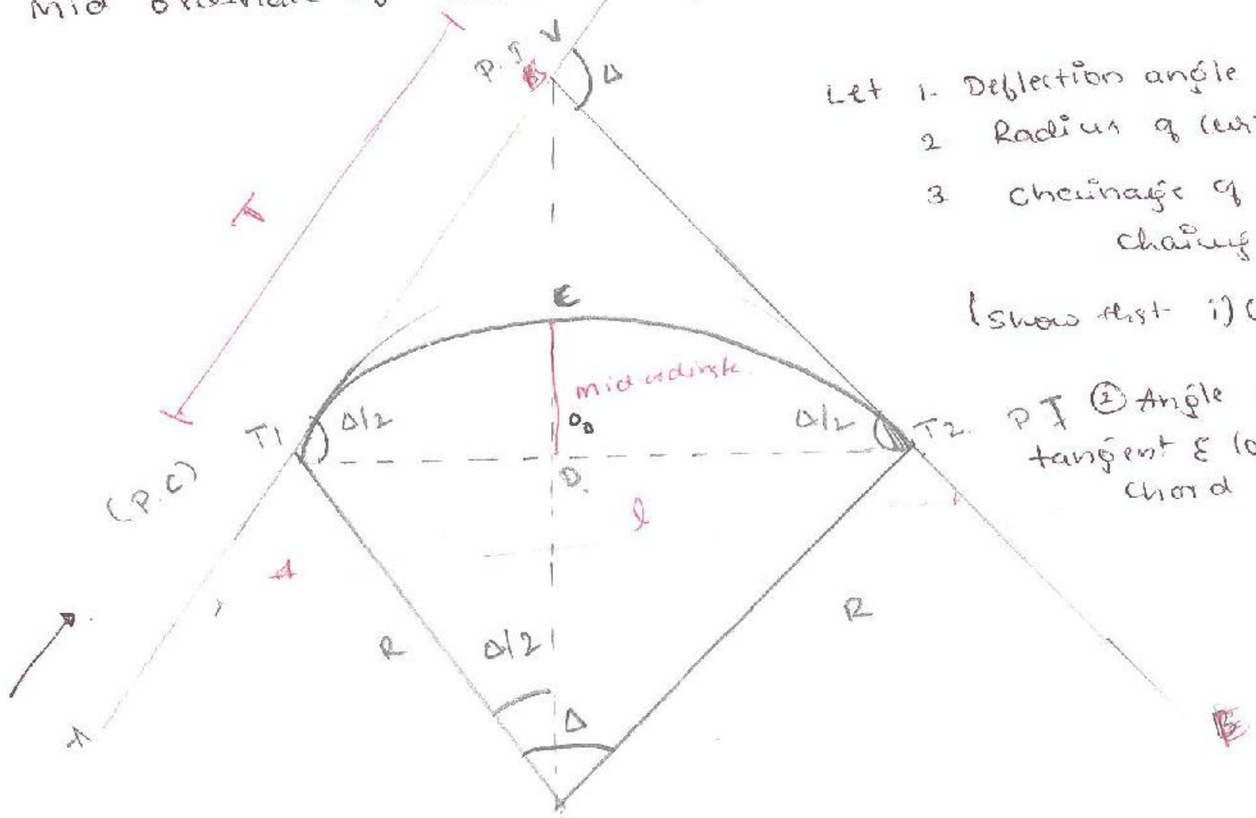
$$\boxed{R = \frac{1718.9}{D}}$$ for 30m length

|||ly.

$$\boxed{R = \frac{1146}{D}}$$ for 20 m length

Elements of simple curve:

1. Tangent length, T 2. Lengths of curve.
3. chainage of tangent Point. 4. length of long chord (L)
5. Mid ordinate O_0 and 6. Apex distance.



Δ

Let 1. Deflection angle = Δ = degrees
2 Radius of curve = R m
3. Chainage of P.I = Chainage of B

(Show that i) Central angle = Δ
② Angle b/w tangent & long chord = Δ/2)

1. Tangent length, T: In $\triangle$ OT_1B

$$\tan \Delta/2 = \frac{T_1B}{OT_1} = \frac{T}{R}$$

$T = T_1V = VT_2$

$$\boxed{T = R \tan \Delta/2}$$

(T_1B, BT_2)
(P C to P I & P I to P T)

② length of curve, l

Arc length $l = R \times \Delta$ If Δ is in radians

$l = R \times \left(\Delta \times \frac{\pi}{180}\right)$ where Δ is in degrees

$$\boxed{l = \frac{\pi R \Delta}{180}}$$

3. Chainage of tangent Points:

Chainage of T_1 [Point of curvature) = Chainage of P.I − Tangent length
(or Point of curve) = Chainage of B − T

Chainage of T2 [Point of tangency) = Chainage of Point curve + length of curve
= Chainage of T_1 + l

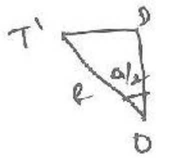
4. length of long chord : L

$L = T_1D + DT_2 = 2T_1D$ But in Δ^{le} OT_1D

$\sin a/_2 = \frac{T_1D}{OT_1}$

$= \frac{T_1D}{R}$

$T_1D = R\sin a/_2$



$$\boxed{L = 2R\sin a/_2.}$$

5. Mid ordinate O_0 Δ^{le} OT_1D

$O_0 = M = CD = CO - DO$

$= R - R\cos a/_2$

$$\boxed{O_0 = R[1 - \cos a/_2)}$$

$\cos\frac{a}{2} = \frac{OD}{OT_1}$

$$\boxed{OD = R\cos a/_2}$$

~~External distance~~ (or)

$O_0 = OC - OD.$

$= OC - \sqrt{OT_1^2 - T_1D^2}$

$O_0 = R - \sqrt{R^2 - (4_2)^2}$

⑥ Apex distance [A.D] (or) External distance

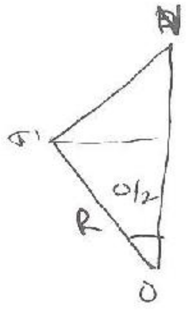
$EV = A.D = OV - OC$ Δ^{le} OT_1V

$\cos a/_2 = \frac{OT_1}{OV} = \frac{R}{OV}$

$OV = \frac{R}{\cos a/_2} = R\sec a/_2$

$AD = R\sec a/_2 - R$

$$\boxed{AD = R(\sec a/_2 - 1)}$$



Problems

① Two straights intersect at a chainage 1150-50m the deflection angle being 60°. If the radius of curve is 500m, find the values for the elements of curve. Also Kalculate the chainage of two tangents point.

→ Given Data: Chainage of P.I = 1150-50m

$\Delta = 60°$ R = 500m. P.C = ? P.T = ?

Mid-ordinate = ? Apex distance = ? T = ? l = ?

1. Tangent length . $T = R \tan \Delta/2 = 500 \tan 60/2 = 288 \cdot 67m$

2. Length of curve $l = \frac{\pi R \Delta}{180} = \frac{\pi \times 500 \times 60}{180} = 523 \cdot 59m$

3. Chainage of T_1 = Chainage of P.I − Tangent length

$= 1150 \cdot 50 - 288 \cdot 67 = 861 \cdot 83m$

Chainage of T_2 = Chainage of T_1 + length of curve (l)

$= 861 \cdot 83 + 523 \cdot 59 = 1385 \cdot 42m$

4. Long chord length $L = 2R \sin \Delta/2 = 2 \times 500 \times \sin 60/2$

$\boxed{L = 500m}$

5. Mid-ordinate $= O_0 = R[1 - \cos \Delta/2] = 500[1 - \cos 60/2] = 66 \cdot 98m$

6. Apex distance $= AD = R[\sec \Delta/2 - 1]$
$= 500(\sec 60/2 - 1) = 77 \cdot 35m$

② If the tangent distance of a curve is 235·6m and the deflection angle is 42°. calculate the other elements.

→ Given $T = 235 \cdot 6m$. $\Delta = 42°$.

$T = R \tan \Delta/2$ $= 235 \cdot 6 = R \tan \frac{42}{2}$

$\boxed{R = 613 \cdot 75m}$. Radius of curve.

Length of curve $l = \frac{\pi R \Delta}{180} = \frac{\pi \times 613 \cdot 75 \times 42}{180} = 449 \cdot 90m$

$O_0 = R(1 - \cos \Delta/2) = 613 \cdot 76[1 - \cos 42/2] =$ ~~439.90m~~
$= 40 \cdot 77m$

$L =$ ~~2RS~~ $2R\sin(\Delta/2)$

$L = 2 \times 613 \cdot 76 \times \sin \frac{42}{2} = 439 \cdot 90m$

A.D = ~~6t~~ $R[\sec \Delta/2 - 1] = 613 \cdot 76[\sec \frac{42}{2} - 1]$
$= 43 \cdot 67m$

~~setting out~~

Methods of setting out a simple curve.

The methods of setting out curves can be mainly divided into two heads depending upon instruments used.

1. Linear methods
2. Angular methods

1. Linear methods: In linear methods, only a tape or chain is used, These are used when the curve is short and high degree of accuracy is not required.

The commonly used linear methods are

1. offsets ⓞⓡ ordinates from the long chord.
2. successive bisection of Chords.
3. offsets from tangents.
4. offsets from chords Produced.

② Angular method: In angular methods Instrument such as a theodolite is used with ⓞⓡ without a chain ⓞⓡ tape. These are used when the

① curve is long, and

② high degree of accuracy is required

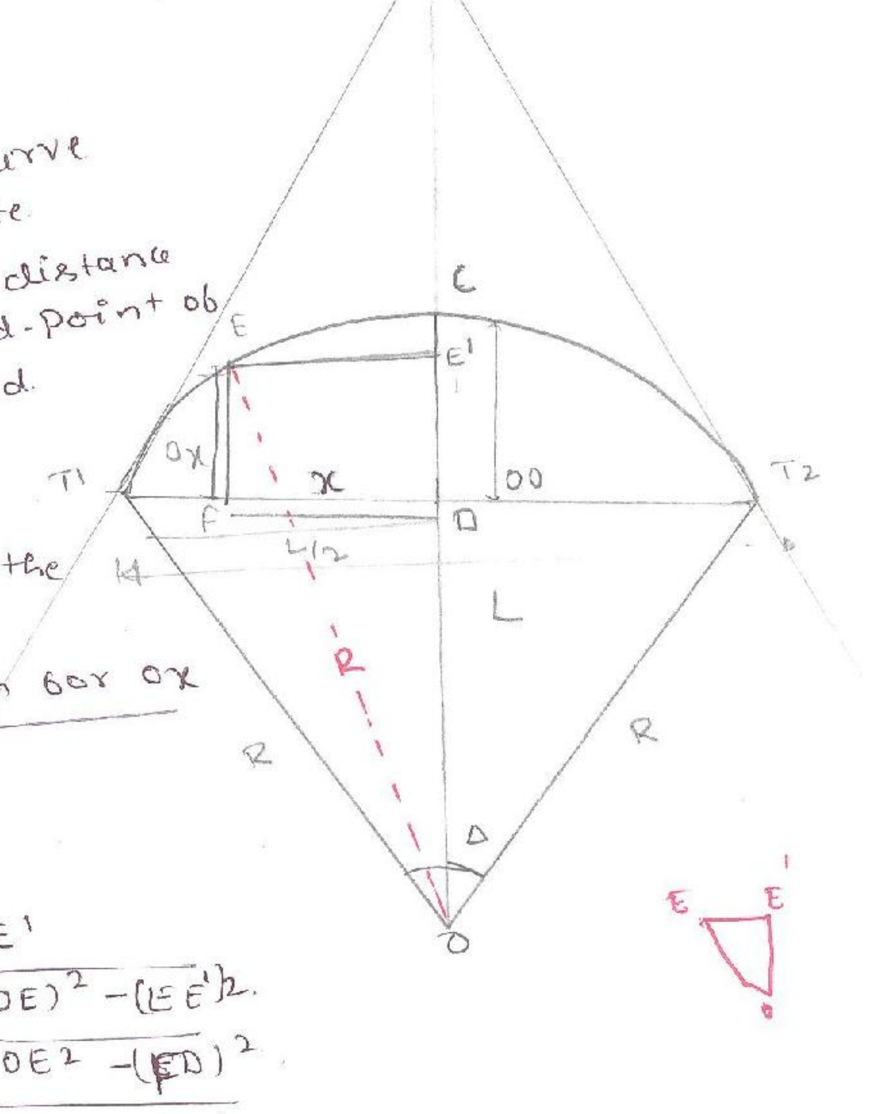
The commonly used methods are

1. Rankines deflection angle method. [one Theodolite method]
2. Two theodolite method.
3. Tacheometer method.

Linear methods

1. Ordinates from the long chord:

In This method, long chord is divided into an even number of equal parts. Taking centre of long chord as origin, for various values of x, the perpendicular offsets are calculated to the curve and the curve is set in the field by driving pegs at these offsets.



Referring fig.

R = Radius of curve

O_0 = Mid-ordinate

O_x = ordinate at distance x from the mid-point of the long chord.

L = Length of the long chord.

D = Mid point of the long chord.

To obtain Expression for O_x

$O_x = EF = E'D$

$= OE' - OD$

But from Δ^{le} OEE'

$OE' = \sqrt{(OE)^2 - (EE')^2}.$

$OE' = \sqrt{OE^2 - (FD)^2}$

$OE' = \sqrt{R^2 - (x)^2}$

& $OD = OC - CD$

$$\boxed{OD = R - O_0}$$

$O_x = \sqrt{R^2 - x^2} - [R - O_0]$

Here $O_0 = R. - \sqrt{R^2 - (L/2)^2}$

(or)

$R = R[1 - \cos\Delta/2]$

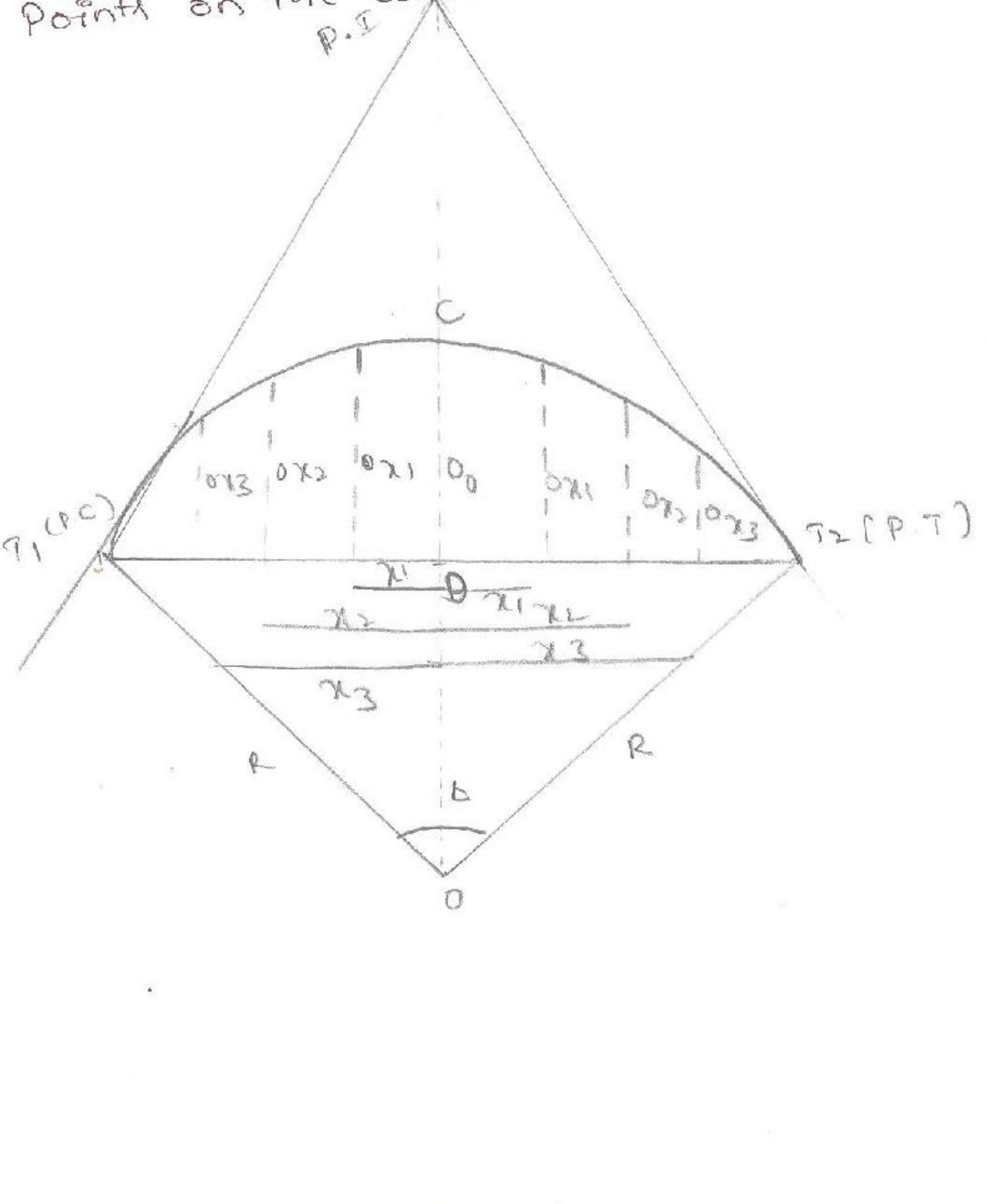
Procedure for setting out curve:

1. From the intersection point, the tangent length T (from equation $(T = R \tan Δ/2)$ is measured on both back and forward tangents. to locate the tangent points T_1 (Point of curve) and T_2 [Point of tangency)

2. The line b/w T_1 and T_2 represents the long chord. The mid-points D of the long chord is located. At this point D, a perpendicular offsets, that is the mid-ordinates O_0 [given by $O_0 = R[1-\cos Δ/2)$ (or) $O_0 = R - \sqrt{R^2-(L/2)^2}$] is set out to locate C. which is the mid point on the curve.

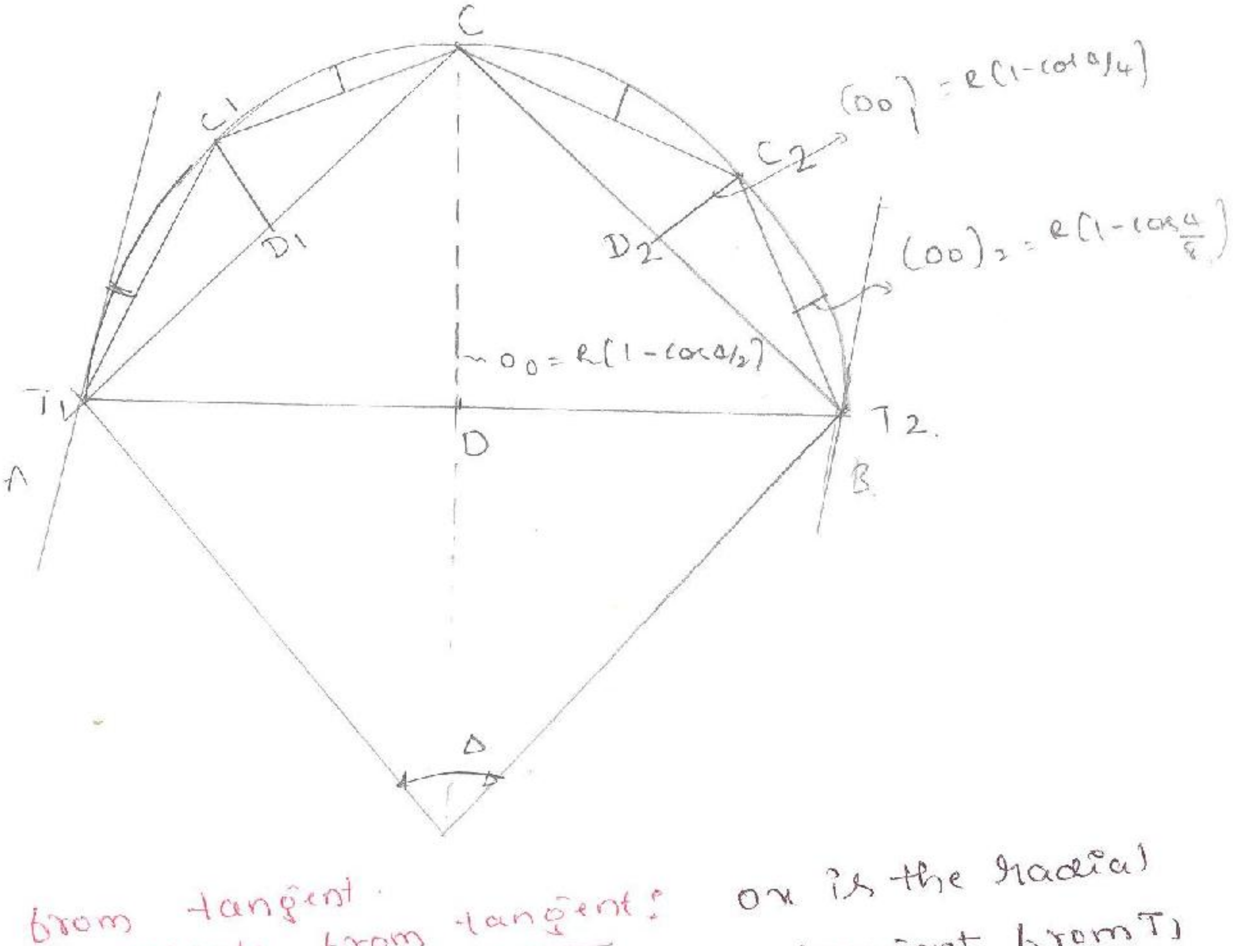
3. Based on the length of the long chord, suitable interval for x (say x_1, x_2 ----) is selected and marked on either side of the mid-point of the long chord.

4. At these marked points the ⊥r offsets O_x (calculated from the equation $O_x = \sqrt{R^2 - x^2} - [R - O_0]$ say O_{x_1} - O_{x_2} ---). are set out to locate points P, Q ---- which are the points on the curve.



(02) Successive bisection of arcs (or) Chords:

Let T_1 and T_2 be the tangent points. The long chord. The long chord T_1T_2 is bisected at D. mid-ordinate is equal to $R[1-\cos a/2]$. Thus point C is established in fig. T_1C and T_2C are joined. T_1C and T_2C are bisected at D_1 and D_2, respectively. Perpendicular offsets D_1C_1 and D_2C_2 each will be equal to $R[1-\cos a/4]$. These offsets are set out giving points C_1 and C_2 on the curve. By the successive bisection of the chords T_1C_1, C_1C, CC_2 and C_2T_2 more points may be obtained which when Joined produce the required curve.

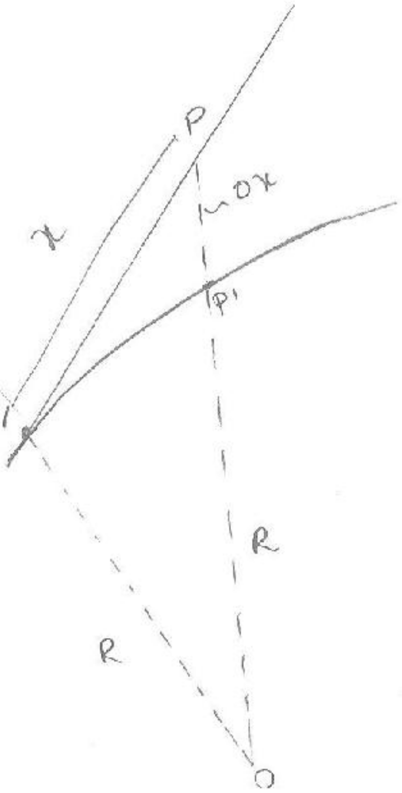


③ Offsets from tangent:

(a) Radial offsets from tangent:

Ox is the radial offsets PP_1 at any distance x along the tangent from T_1

* Radial offset:



From the △le OT_1P

$$OP^2 = OT_1^2 + T_1P^2$$

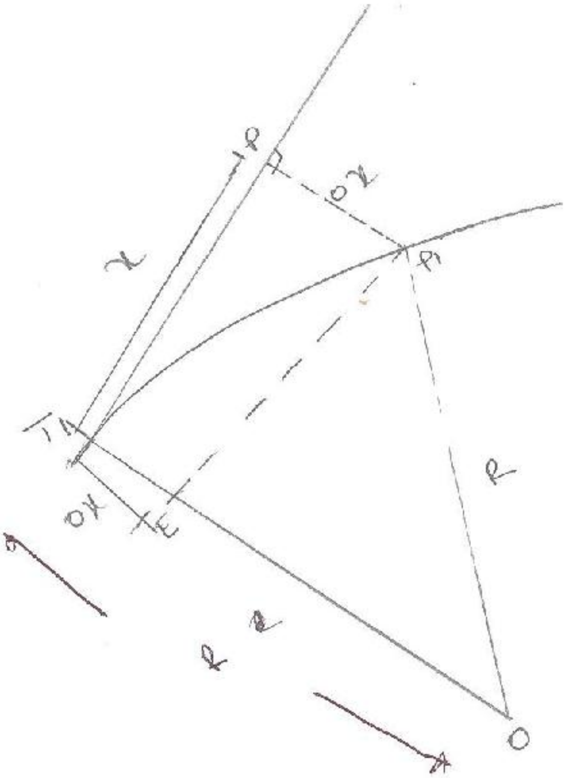
$$(R+Ox)^2 = R^2 + x^2$$

$$R + Ox = \sqrt{R^2+x^2}$$

$$\boxed{Ox = \sqrt{(R^2+x^2)} - R}$$

* Perpendicular offset:

This method is suitable for small values of the radius, length of curve and deflection angle. In fig Ox is the offset perpendicular to the tangent at a distance x from the Point of curve T_1



From △le OEP_1'

$$P'O^2 = OE^2 + P_1E^2$$

$$R^2 = (R - Ox)^2 + x^2$$

$$\sqrt{R^2 - x^2} = R - Ox$$

$$\boxed{Ox = R - \sqrt{R^2-x^2}}$$

$$\boxed{Ox = R - \sqrt{R^2-x^2}}$$

Problems on Linear methods

1. calculate the ordinates at 5m distances for a circular curve having a long chord of 40m and a versed sine (mid-ordinate) of 2m

Soln: Given $L = 40m$ $O_0 = 2m$ $x_1 = 5m$, $x_2 = 10m$ $x_3 = 15m$, $x_4 = 20m$, $x_5 = 25m$, $x_6 = 30m$, $x_7 = 35m$, $x_8 = 40m$

$$O_x = \sqrt{R^2 - x^2} - [R - O_0]$$

To find R

$$O_0 = R - \sqrt{R^2 - [L/2]^2}$$

$$2 = R - \sqrt{R^2 - (40/2)^2}$$

$$2 = R - \sqrt{R^2 - 20^2}$$

$$(R-2)^2 = R^2 - 20^2$$

$$\cancel{R^2} - 20^2 = \cancel{R^2} - 4R + 4$$

$$4R = 20^2 + 4 - 404$$

$$\boxed{R = 101m}$$

$$(R - O_0) = [101 - 2] = 99.$$

$$O_5 = \sqrt{(101)^2 - 5^2} - 99 = 1.876m$$

$$O_{10} = \sqrt{[101)^2 - 10^2} - 99 = 1.504m$$

$$O_{15} = \sqrt{(101)^2 - 15^2} - 99 = 0.880m$$

$$O_{20} = \sqrt{(101)^2 - 20^2} - 99 = 0$$

(02) Determine the offsets to be setout at 1/2 chain interval along the tangents to locate a 16 chain curve, the length of each chain being 20m

Soln: 1 chain = 20m   Interval = 1/2 Chain = 10m

R = 16 chain   R = 16×20 = 320m

① Radial offsets

$$O_x = \sqrt{R^2 + x^2} - R$$

$$O_{10} = \sqrt{320^2 + 10^2} - 320 = 0.156m$$

$$O_{20} = \sqrt{320^2 + 20^2} - 320 \quad \boxed{O_{20} = 0.624m}$$

$$O_{30} = \sqrt{320^2 + 30^2} - 320 = 1.403m$$

etc

⑤ Perpendicular offsets:

$O_x = R - \sqrt{R^2 - x^2}$

$O_{10} = 320 - \sqrt{320^2 - 10^2} = 0.156m$

$O_{20} = 320 - \sqrt{320^2 - 20^2} = 0.626m$

$O_{30} = 320 - \sqrt{320^2 - 30^2} = 1.409m$

etc

③ Two roads having a deviation angle of 45° at apex point V are to be joined by a 200m radius circular curve. If the chainage of apex point is 1839.2m, calculate necessary data to set the curve by

① ordinates from long chord at 10m interval.

② method of bisection to get every eighth point on curve.

③ radial & perpendicular offsets from every full station of 30m along tangent

Sol: $R = 200m$ Chainage of P.I = 1839.2m

$\Delta = 45°$

Length of tangent $T = R \tan \Delta/2$

$= 200 \tan 45/2$

$\boxed{T = 82.84m}$

Length of curve $l = \frac{\pi R \Delta}{180} = \frac{\pi \times 200 \times 45}{180}$

$l = 157.08m$

Chainage of T_1 = Chainage of P.I - Tangent length

$= 1839.2 - 82.84$

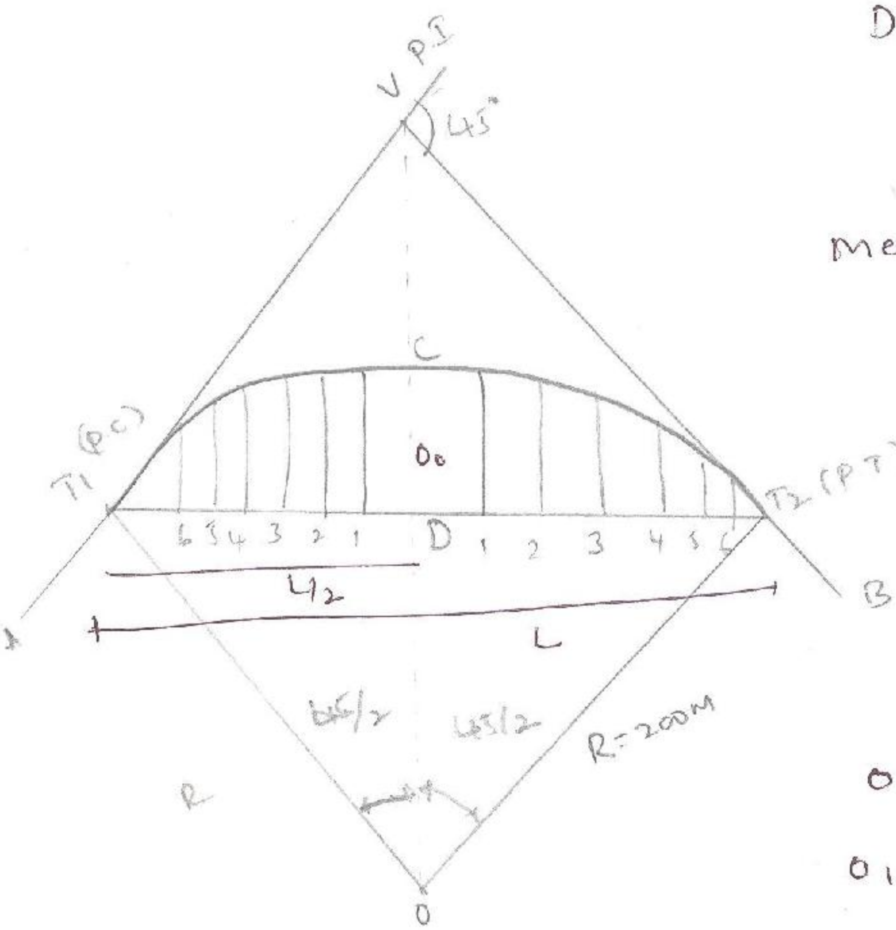
$\boxed{\text{Chainage of } T_1 = 1756.36m}$

Chainage of T_2 = Chainage of T_1 + length of curve

$= 1756.36 + 157.08$

$\boxed{\text{Chainage of } T_2 = 1913.44m}$

① offsets from long chord .



Distance of $DT_1 = L/2 = R\sin Δ/2$

$DT_1 = 200 \sin 45/2$

$\boxed{DT_1 = 76.54m}$

Measuring 'x' from D

$Y = \sqrt{R^2 - x^2} - \sqrt{R^2 - (L/2)^2}$

$x = 0$

at

$O_0 = R - \sqrt{R^2 - (L/2)^2}$

$O_0 = 200 - \sqrt{200^2 - (76.54)^2}$

$\boxed{O_0 = 15.22m}$

$O_1 = \sqrt{R^2 - Ox_1} - \sqrt{R^2 - (L/2)^2}$

$O_1 = \sqrt{200^2 - 10^2} - 184.78 = 14.97m$

$O_2 = \sqrt{200^2 - 20^2} - 184.78 = 14.22m$

$O_3 = \sqrt{200^2 - 30^2} - 184.78 = 12.96m$

$O_4 = \sqrt{200^2 - 40^2} - 184.78 = 11.18m$

$O_5 = \sqrt{200^2 - 50^2} - 184.78 = 8.87m$

$O_6 = \sqrt{200^2 - 60^2} - 184.78 = 6.01m$

$O_7 = \sqrt{200^2 - 70^2} - 184.28 = 2.57m$

at T_1 $0 = 0.00$

② <u>method of bisection</u> :

Central ordinate at D $= R[1 - \cos Δ/2]$

$= 200[1 - \cos 45/2]$

$= 15.22m$

ordinate at $D_1 = R(1 - \cos a/4) = 200[1 - \cos \frac{45}{4})$

$D_1 = \underline{3.84m}$

ordinate at $D_2 = R[1 - \cos \frac{a}{8}] = 200\ [1 - \cos \frac{45}{8}]$

$D_2 = 0.96m$.

③ Offsets from tangents.

Radial offsets: $O_x = \sqrt{R^2+x^2} - R$

Chainage of T_1 = 1756.36m

For 30m chain it is at

= 58 chain + 16.36m

$x_1 = 30 - 16.36 = 13.64$

$x_2 = 43.64m$

$x_3 = 73.64m$

x_4 = tangent length = 82.84m

$O_1 = \sqrt{200^2+13.64^2} - 200 = 0.46m$

$O_2 = \sqrt{200^2+43.64^2} - 200 = 4.71m$

$O_3 = \sqrt{200^2+73.64^2} - 200 = 13.13m$

$O_4 = \sqrt{200^2+82.84^2} - 200 = 16.48m$

* By offsets from the chords produced. [Deflection distances method]

This method can be used even for long curves, when a theodolite is not available. The Expressions for offsets from chords produced are obtained as follows.

Procedure of setting

In fig BT_1 - is the Back tangent [B - Point of Intersection & T_1 - Point of curve]

P.Q.R - are Points on the curve.

T_1P - First chord of length C_1

PQ - second chord of length C_2

QR - Third chord of length C_3 etc.

$2\delta_1$ - central angle corresponding to chord C_1

$2\delta_2$ - central angle corresponding to chord C_2

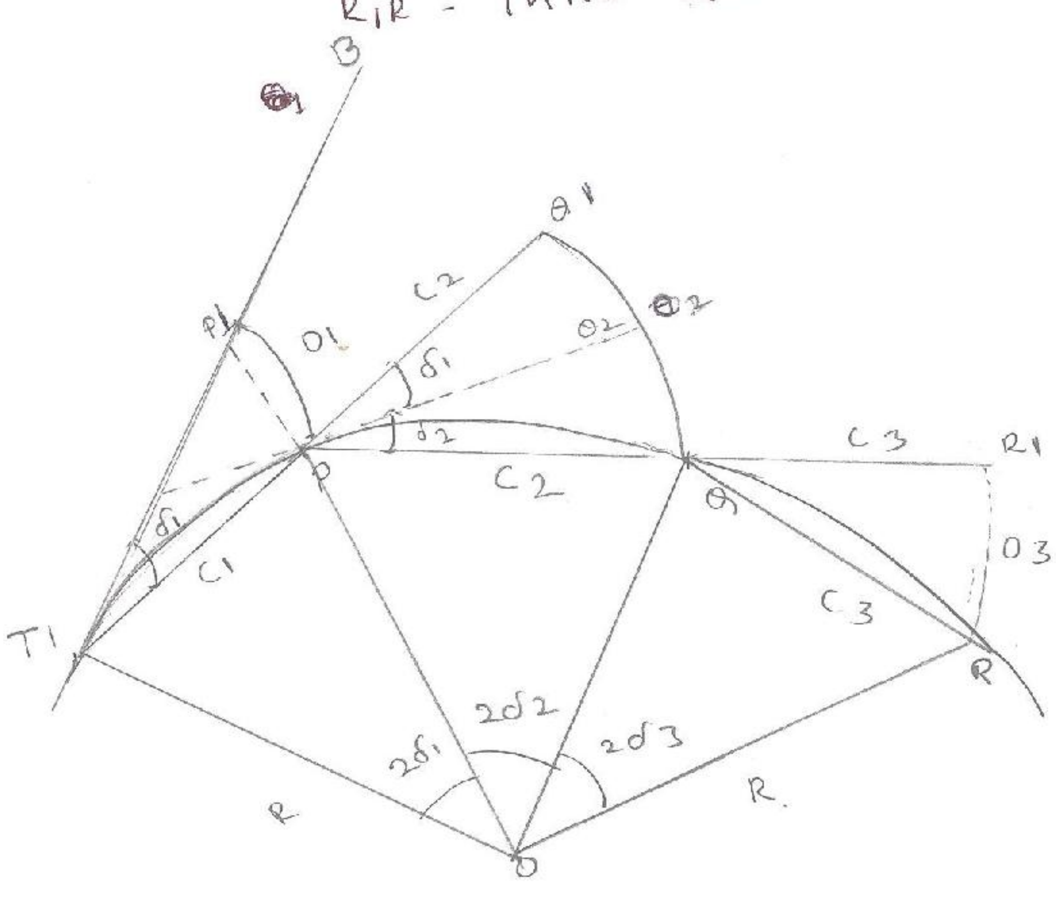
$2\delta_3$ = central angle corresponding to chord C_3

R = Radius of curve.

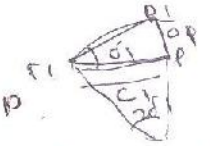
Arc P_1P - first offsets from tangent O_1

Q_1Q - second offsets from chord T_1P produced O_2

R_1R - Third offsets from chord PQ. Produced O_3



From Δle ~~OT_1P~~, T_1P_1P Now arc $P_1P = O_1 = T_1P \cdot \delta$
$P_1P = O_1 = C_1 \cdot \delta_1$



$O_1 = C_1\delta_1$ [δ - angle b/w back tangent & chord T_1P
→① ∴ Angle b/w tangent & long chord = $\frac{1}{2}$ the central angle)

Also $C_1 = R \cdot 2\delta_1$ [Arc $T_1P \simeq$ chord of T_1P]

$$\boxed{\delta_1 = \frac{C_1}{2R}}$$

Substituting the value of δ_1 in the equation O_1

$$O_1 = C_1 \times \frac{C_1}{2R}$$

$$\boxed{O_1 = \frac{C_1^2}{2R}}$$ - offset value from tangent at T_1

$O_2 = QQ_2 + Q_2Q_1$ where Q_2 is the intersection point b/w arc QQ_1 and tangent at P.

But $QQ_2 = \frac{C_2^2}{2R}$ [offset value from tangent at P]

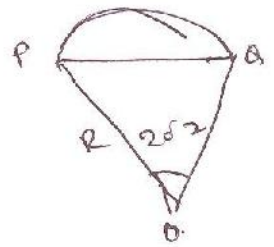
$$\& \; Q_2Q_1 = C_2\,\delta_2$$
$$= C_2 \cdot \delta_1$$
$$= C_2 \cdot \frac{C_1}{2R}$$

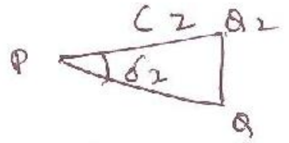
$$O_2 = QQ_2 + Q_2Q_1$$

$$O_2 = \frac{C_2^2}{2R} + C_2 \cdot \frac{C_1}{2R} \quad (\text{or}) \quad \frac{C_2}{2R}\left[C_2 + C_1\right]$$

Hly $O_3 = \frac{C_3}{2R}(C_3 + C_2)$

In general $O_n = \frac{C_n}{2R}\left[C_n + C_{n-1}\right)$



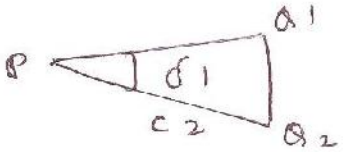


$O_2 Q = C_2 \cdot \delta_2$

Arc $PQ = C_2 = R \cdot 2\delta_2$

$$\boxed{\delta_2 = \frac{C_2}{2R}}$$

$Q_2 Q = C_2 \cdot \frac{C_2}{2R} = \frac{C_2^2}{2R}$



$Q_2 Q_1 = C_2 \cdot \delta_1$

But $\delta_1 = \frac{C_1}{2R}$ $Q_2 Q_1 = C_2 \cdot \frac{C_1}{2R}$

Arc $QQ_1 = O_2 = \frac{C_2^2}{2R} + \frac{C_2 C_1}{2R}$

$O_2 = \frac{C_2}{2R}\left[C_2 + C_1\right]$

$|||^{ly}$ it can be shown $O_3 = \frac{C_3\left[C_3 + C_2\right]}{2R}$

In general Expression for offsets from Chords Producing ~~generally~~

$$\boxed{O_n = \frac{O_n}{2R}\left[O_n + O_{n-1}\right]}$$

In curve setting, first chord will be a Subchord say C and the last Subchord will also be a subchord say C' and remaining chords are normal chords say C. Thus the offsets are as follows.

$O_1 = \frac{\overset{\text{small } c}{C}}{2R}\left[c + 0\right]$ $O_1 = \frac{c^2}{2R}$

$O_2 = \frac{C}{2R}\left[C + c\right]$ $O_2 = \frac{C}{2R}\left[C + c\right]$

$O_3 = \frac{C}{2R}\left[C + C\right] = O_4 \cdots\cdots O_{n-1}$

$O_n = \frac{C'}{2R}\left[c' + C\right]$

Methods of finding length of subchords and no of normal chords:

Chainage of tangent points are found.

i.e chainage of T_1 = Chainage PI - Tangent length

& Chainage of T_2 = chainage of T_1 + l (length of curve)

Chainage of T_1 is rounded off to higher value and the first subchord length c is found.

$$C = \text{Rounded value} - \text{chainage of } T_1 \quad [\, c \not> C \,]$$

hainage of T_2 is rounded off to lower value and the last subchord length c' is found

c' = ~~Rounded value - cha~~

Chainage of T_2 - Rounded value. $[c' \not> C]$

he No of normal chords is found as follows,

$$\text{No of normal chords} = N = \frac{\text{Difference in Rounded value}}{C}$$

[N = should be a whole number, if not the values of c (or) c' is to be adjusted.]

Total no of chords = 1+N+1 = n.

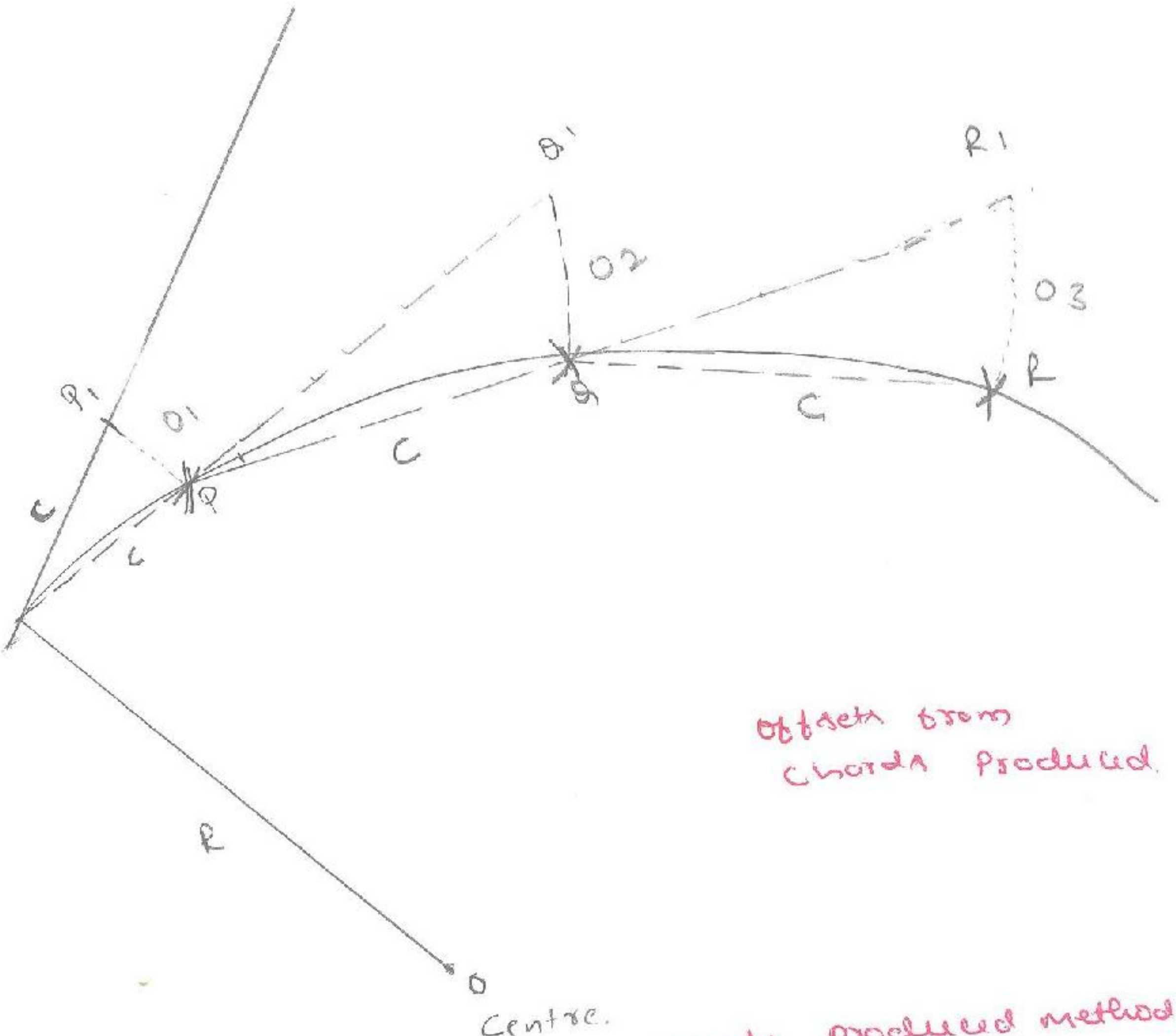
ure of setting out simple curve by offsets from s produced method. [Ref txs]

two tangents T_1 [P C] & T_2 [P.T] are located based on length from Point of Intersection (or) based on their ages.

Point P_1 is marked on the back tangent at a distan first subchord length c from T_1, with P_1 as and radius equal to offset O_1, an arc is drawn. Zero end of tape at T_1 and radius equal to ord c, another arc is drawn to cut the previous arc P, which is the first point on the curve after T_1

(3.) The line T1P is prolonged to Q1 such that PQ1 is equal to normal chord C. with Q1 as Centre and radius equal to offset O_2 an arc is drawn. with P as Centre and radius equal to normal chord C. another arc is drawn to cut the previous arc at Q which is the second point on the curve.

(4.) The above Procedure is repeated to locate the remaining points on the curve.



Offsets from Chords Produced.

Problems on offsets from chords produced method.

1. Two Straights Intersects at a Chainage of 1950m. the deflection angle being 40°. It is proposed to Introduced a simple curve of radius 200m in b/w the straight. Make necessary calculations to set out the curve by " offsets from Chords produced method. Take Peg interval as 30m.

Chainage of P.I = 1950m, $\Delta = 40°$ Radius of curve = 200m ws Tangent length $T = R\tan\frac{\alpha}{2} = 200\tan\frac{40}{2} = 72.79m$

length of curve $l = \frac{\pi R\alpha}{180} = \frac{\pi \times 200 \times 40}{180} = 139.62m$

Chainage of T_1 = chainage of PI - Tangent length

= 1950 - 72.79

$\boxed{\text{Chainage of T1} = 1877.21m}$

Chainage of T_2 = Chainage of T1 + l

= 1877.21 + 139.62

$\boxed{\text{Chainage of T2} = 2016.83m}$

First subchord = c = Rounded value of Chainage T1 - Chainage of T1

= 1900 - 1877.21

c = 22.79 (<30m. OK.)

last Subchord = c' = ch of T_2 - Rounded value of ch T_2

= 2016.83 - 1990

= 26.83 (<30m ok).

No of Normal chords = N = $\frac{\text{difference in Rounded value}}{C}$

$= \frac{1990 - 1900}{30} = 3$

Total no of chords = 1+3+1 = 5

$O_1 = \frac{c^2}{2R} = \frac{22.79^2}{2\times200} = 1.29m.$

$O_2 = \frac{C[C+c]}{2R} = \frac{30(30+22.79)}{2\times200} = 3.96m$

$O_3 = O_4 = \frac{C^2}{R} = \frac{30^2}{200} = 4.5m$

$O_5 = \frac{c'[c'+C]}{2R} = \frac{26.83[26.83+30]}{2\times200} = 3.81m$

② Two tangents intersect at the chainage 1190m. the deflection angle being 36° calculate all the data necessary for setting out a circular curve with radius of 300m by deflection angle method. Take peg interval is 30m.

⇒ Chainage of P.I = 1190m , deflection angle $\Delta = 36$

$R = 300m$. $C = 30m$.

Tangent length $T = R \tan \Delta/2 = 300 \tan 36/2$

$$\boxed{T = 97.47m.}$$

length of the curve $l = \frac{\pi R \Delta}{180} = \frac{\pi \times 300 \times 36}{180} = 188.49m.$

Chainage of T1 = Chainage of P.I - Tangent lengths

= 1190 - 97.47

= 1092.53 m

Chainage of T2 = Chainage of T1 + length of curve.

= 1092.53 + 188.49

Chainage of T2 = 1281.02m

First Sub chord = c = Rounded value of chainage T1 - chainage of T1

c = 1110 - 1092.53

c = 17.48 m (17.48 ≯ 30m)

last Sub chord = c' = chainage of T2 - Rounded value of chainage T2

= 1281.02 - 1260

= 21.02m [21.02m ≯ 30m]

No of Normal chords $N = \frac{\text{Difference in Rounded value}}{C}$

$N = \frac{1260 - 1110}{30} = 5$

Total no of chords = n = 1+5+1 = 7

$O_1 = \frac{c^2}{2R} = \frac{17.48^2}{2 \times 300} = 0.50m$ $O_2 = \frac{C[C+c]}{2R}$

$O_2 = \frac{30[30+17.48]}{2 \times 300} = 2.37m$

$O_3 = O_4 = O_5 = O_6 = \frac{C^2}{R} = \frac{30^2}{300} = 3.0m.$

$O_7 = \frac{c'[c'+C]}{2R} = \frac{21.02[21.02+30]}{2 \times 300} = 1.79m$

Assignment

③ Make a necessary calculations to set out a right handed simple circular curve of 250m connecting two straights having a point of intersection at a chainage of 3450m by offsets from chords produced method. the deflection angle is 50°. Take Peg interval of 20m.

* Angular methods:

① Rankine's Method of deflection angle ~~method~~ [One-Theodolite method]

This method is useful for setting out a circular curve of long length and of a large radius. It yields good results except when the chords are long as compared to the radius, so that the variation b/w the length of an arc and its chord becomes considerable. It is quite accurate and is frequently used on highways & railways. It is quite accurate and is frequently used on highways and railways

* Deflection angle to any point on the curve i.e the angle at P.C b/w the tangent and the chord from P.C to the point. According to Rankine's method this deflection angle is equal to half the angle subtended by the arc at the centre,

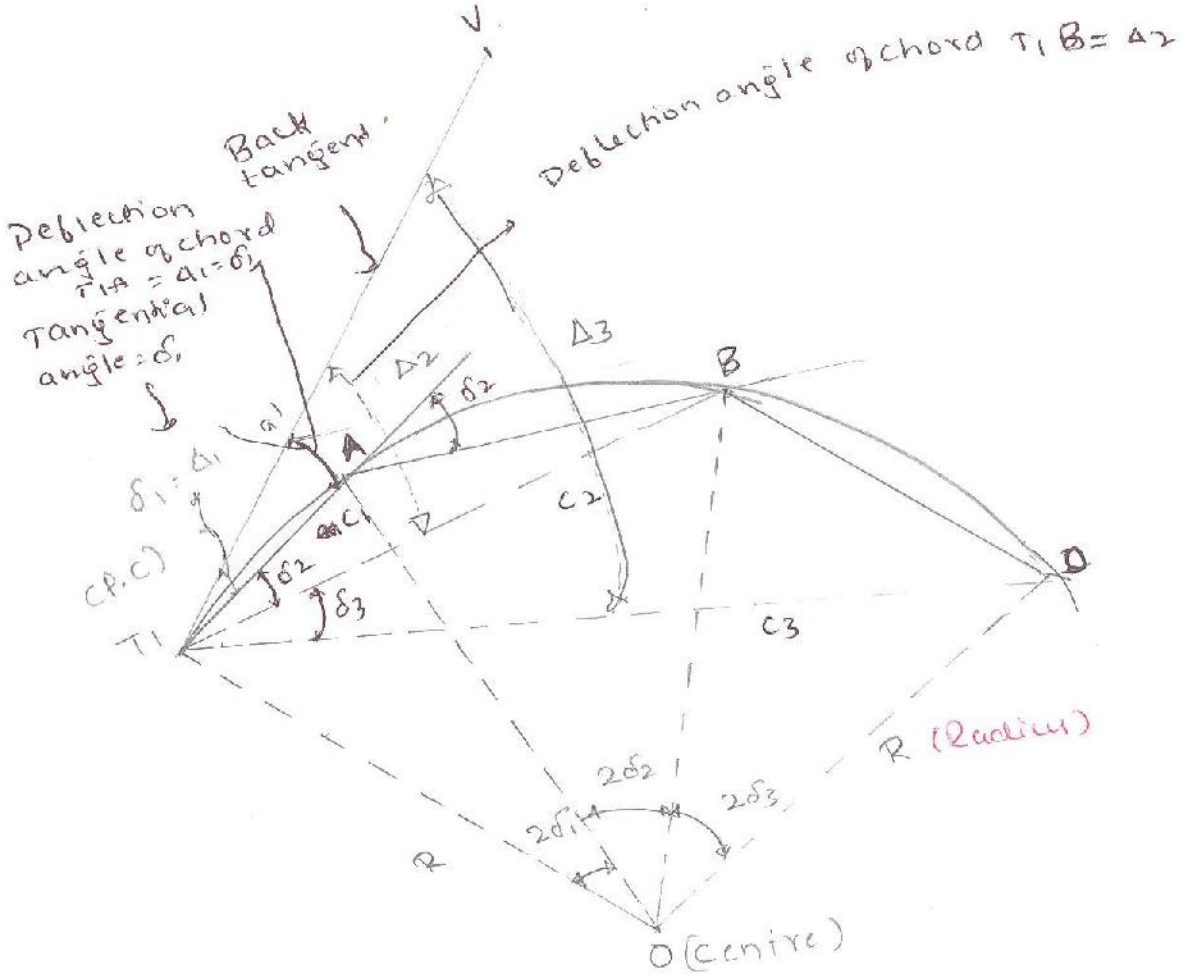


Fig: Rankines Deflection angle.

In fig. T_1 is the point of curve, A, B, & D etc are the points on the curve, δ_1 δ_2 and δ_3, etc are the respective deflection angles b/w the chords and the respective tangents at T_1, A, B etc. $\Delta_1, \Delta_2, \Delta_3$ etc are the total deflection angles to the point A, B, D etc.

From the property of a circle that the angle subtended by a chord at the centre is twice the angle b/w the tangent and the chord.

Then Arc T_1A = chord $T_1A = C_1$

Arc AB = Chord AB $= C_2$

Arc BD = Chord BD $= C_3$ etc.

From $\triangle$le T_1OA Here δ_1 is in radians

$$T_1A = R \cdot 2\delta_1$$

$$C_1 = R \cdot 2\delta_1$$

$$\boxed{\delta_1 = \frac{C_1}{2R}}$$

If δ_1 is required in minutes

then $$\delta_1 = \frac{c_1}{2R} \times \left[\frac{180}{\pi} \times 60\right]$$

$$\boxed{\underset{(\text{minutes})}{\delta_1} = \frac{1718 \cdot 9 C_1}{R}}$$

similarly it can be shown that $\underset{\text{minutes}}{\delta_2} = \dfrac{1718 \cdot 9 C_2}{R}$

$$\underset{\text{minutes}}{\delta_3} = \frac{1718 \cdot 9 c_3}{R}$$

etc.

Deflection angles for different chords :

Chord T_1A w.r.t back tangent $= \Delta_1 = \delta_1$

Chord T_1B w.r.t back tangent $= \Delta_2 = \frac{1}{2}\left[2\delta_1 + 2\delta_2\right]$

$= \delta_1 + \delta_2$

$$\boxed{\Delta_2 = \Delta_1 + \delta_2}$$

(or)

$\Delta_2 = V\hat{T_1}B = \frac{1}{2}\left[T_1\hat{O}B\right]$

$\Delta_2 = \frac{1}{2}\left[T_1\hat{O}A + T_1\hat{O}B\right]$

$= \frac{1}{2}\left[2\delta_1 + 2\delta_2\right]$

$= \left[\delta_1 + \delta_2\right]$

$$\boxed{\Delta_2 = \Delta_1 + \delta_2}$$

Chord T_1D w.r.t back tangent $= \Delta_3 = \frac{1}{2}\left[2\delta_1 + 2\delta_2 + 2\delta_3\right]$

$= \delta_1 + \delta_2 + \delta_3$

$= \Delta_1 + \delta_2 + \delta_3$

$$\boxed{\Delta_3 = \Delta_2 + \delta_3}$$

(or)

$\Delta_3 = V\hat{T_1}D = \frac{1}{2}\left[T_1\hat{O}D\right]$

$= \frac{1}{2}\left[T_1\hat{O}A + A\hat{O}B + B\hat{O}D\right]$

$= \frac{1}{2}\left(2\delta_1 + 2\delta_2 + 2\delta_3\right)$

$= \delta_1 + \delta_2 + \delta_3$

$= \Delta_1 + \delta_2 + \delta_3$

$$\boxed{\Delta_3 = \Delta_2 + \delta_3}$$

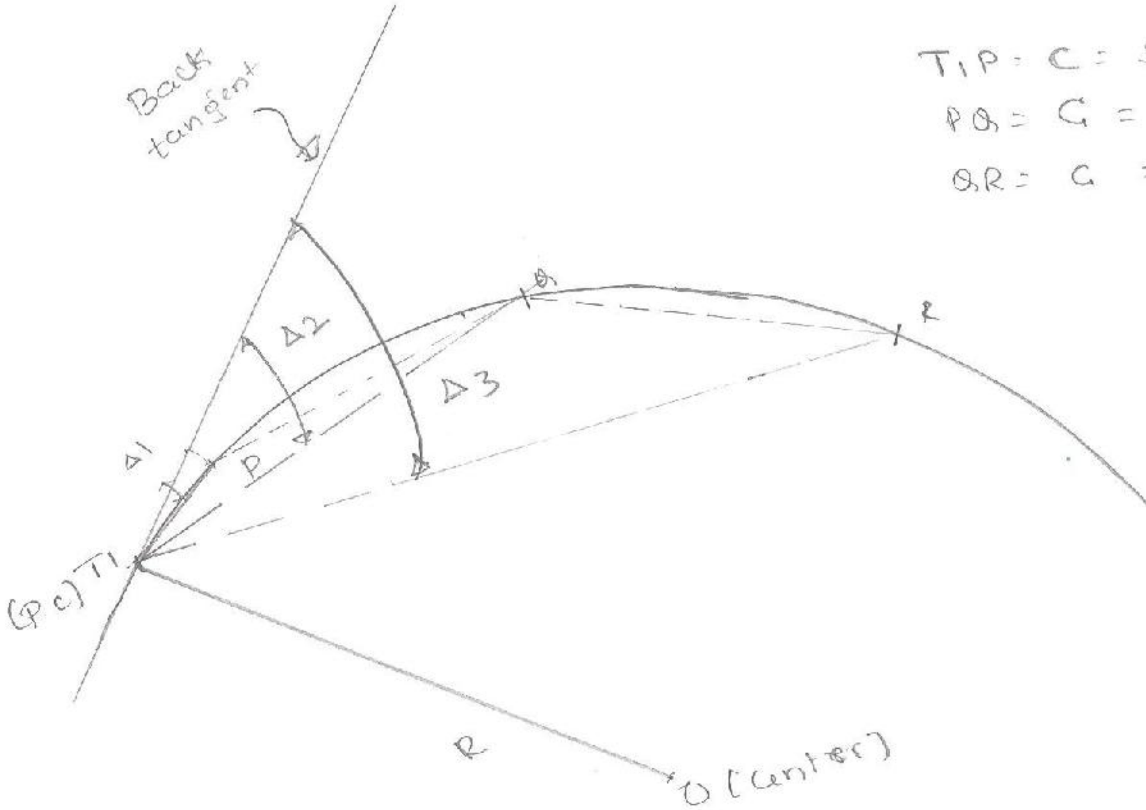
In general

$$\boxed{\Delta_n = \Delta_{n-1} + \delta_n}$$

Δ_n will be for the long chord $T_1 T_2$ &

Hence $\boxed{\Delta_n = \Delta/2}$

Procedure of Setting out simple curve by Rankines method:



T_1P = C = Sub chord.
PQ = C = Normal chord
QR = C = Normal chord

1. The two tangents Points T_1 and T_2 are located based on tangent length from P.I or based on Their chainages.
2. The theodolite is set up and centred over T_1, VA is set zero Releasing the lower plate clamp, the instrument is levelled w.r.to plate bubble. the eye piece is adjusted to get the clear image of cross wires.
3. The telescope is turned to sight the P.I. The Exact bisection is achieved by lower plate tangent screw and vertical circle tangent screw.
4. upper plate clamp is relased, and the vernier A is set to deflection angle Δ_1 exactly by upper plate ~~clamping~~ tangent screw. Along this line of sight a point P is located at a distance of subchord c from T1
5. upper plate clamp is released and the vernier A is set to deflection angle Δ_2 exactly by upper plate tangent screw. Along this line of sight, a Point Q is located at a distance of normal chord C from previously located point P
6. The above procedure is repeated to locate the remaining points on the curve.

Problems:

① Two tangents intersect at a chainage of 1190m. the deflection angle being 36°. compute all the data necessary for setting out a simple curve of radius 300m by Rankines deflection angle method. Take Peg interval of 30m. Tabulate the results showing deflection angle to be set in a 20'' [theodolite]

June-July 2017 08m

Sol

Chainage of P.I = 1190m. Deflection angle $\Delta = 36°$

Radius of curve $R = 300m$. Peg interval = Normal chord = $C = 30m$

Tangent length $T = R\tan\Delta/2 = 300 \tan\frac{36}{2} = 97.47m$

length of curve $= l = \frac{\pi R\Delta}{180} = \frac{\pi \times 300 \times 36}{180} = 188.50m$

Chainage of T_1 = chainage of PI − T

= 1190 − 97.47

= $\underline{1092.53m}$

Chainage of T_2 = chainage of T_1 + length of curve (l)

= 1092.53 + 188.50

Chainage of T_2 = 1281.02m

length of first sub chord = Chainage of T_1 (Rounded to higher value)] − Chainage of T1

$c = 1110 - 1092.53$

$= \underline{17.47m}$

length of last sub chord = 1281.02 − 1260.00

[chainage of T_2 − Rounded to lower value of ch. T_2]

$c' = \underline{21.02m}$

Total no of normal chord $= \frac{1260 - 1110}{30} = 5$

Total no of chord = $1+5+1 = \underline{7}$

$$\delta_1 = \frac{1718.9c}{R} = \frac{1718.9 \times 17.47}{300} = 100'.09$$
min

$= 1° 40' 9.27''$

$$\delta_2 = \delta_3 \cdots \delta_6 = \frac{1718.9 \times 30}{300} = 2° 51' 53.4'' \times 5 = 14° 19' 27''$$

$$\delta_7 = \frac{1718.9 \times 21.02}{300} = 2° 0' 26.26''$$

$$\Delta_7 = 1° 40' 9.27'' + 14° 19' 27'' + 2° 0' 26.26'' = 18° 0' 2.53''$$

$= \frac{36}{2}$ = OK

Tabular column

Point	Chainage m	Chord length m	Tangential angle δ	Deflection angle Δ	Theodolite reading
T1	1190.000	-	-	-	-
1. P	1110.00	17.48	1° 40' 9.27"	1° 40' 9.27"	1° 40' 00"
2 Q	1140.00	30.00	2° 51' 53.4"	4° 32' 26.7	4° 32' 20"
3 R	1170.00	30.00	2° 51' 53.4"	7° 23' 56.07"	7° 24' 00"
4 S	1200.00	30.00	2° 51' 53.4"	10° 15' 49.47"	10° 15' 40"
5. U	1230.00	30.00	2° 51' 53.4"	13° 7' 42.87"	13° 7' 40"
6 V	1260.00	30.00	2° 51' 53.4"	15° 59' 36.27"	15° 59' 40"
T2	1281.02	21.02	2° 00' 26.26"	18° 0' 2.53"	18° 0' 00"

OK

(02) Tabulate the necessary data to set out a right handed simple circular curve of 250m radius connecting two straights having a point of intersection at a chainage 3450m. The deflection angle is 50°. Take Peg by Rankine method. The intervals of 20m.

Radius of curve = 250m, Chainage of PI = 3450m, Δ = 50°

us Normal chord C = 20m

Tangent length $T = R \tan \Delta/2 = 250 \tan 50/2 = 116.58m$

length of curve $= l = \frac{\pi R \Delta}{180} = \frac{\pi \times 250 \times 50}{180} = 218.17m$

Chainage of T1 = Chainage of PI − T

= 3450 − 116.58 = 3333.42m

Chainage of T2 = Chainage of T1 + length of curve

= 3333.42 + 218.17 = 3551.59m

length of first sub chord c = 3340 − 3333.42 = 6.58m

length of last sub chord c' = 3551.59 − 3540

c' = 11.59m.

Total No of normal chords $= \frac{3540 - 3340}{20} = 10$

Total No of chords = 1 + 10 + 1 = 12

$$\underset{min}{\delta_1} = \frac{1718.9c}{R} = \frac{1718.9 \times 6.58}{250} = 0° 45' 14.5''$$

$$\delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = \delta_{11} = \frac{1718.9C}{R} = \frac{1718.9 \times 20}{250}$$

$$= 2° 17' 30.7''$$

$$\delta_{12} = \frac{1718.9c'}{R} = \frac{1718.9 \times 11.59}{250} = 1° 19' 41.3''$$

Check total angle = $0° 45' 14.5'' + [10 \times 2° 17' 30.7'') + 1° 19' 41$

$= 25° 0' 2.8'' = \Delta/2$ = OK.

Point	Chainage in M	Chord M	Tangential angle δ	Deflection angle Δ	Theodolite Setting 20"
T1	3333.42	-	-	-	-
1	3340.00	6.58	0° 45' 14.5"	0° 45' 14.5"	0° 45' 20"
2	3360.00	20.00	2° 17' 30.7"	3° 2' 45.2"	3° 02' 40"
3	3380.00	20.00	2° 17' 30.7"	5° 20' 45.9	5° 20' 20"
4	3400.00	20.00	2° 17' 30.7"	7° 37' 46.1"	7° 37' 40"
5	3420.00	20.00	2° 17' 30.7"	9° 55' 17.3"	9° 55' 20"
6	3440.00	20.00	2° 17' 30.7"	12° 12' 48"	12° 12' 40"
7	3460.00	20.00	2° 17' 30.7"	14° 30' 13.7"	14° 30' 20"
8	3480.00	20.00	2° 17' 30.7"	16° 47' 49.4"	16° 47' 40"
9	3500.00	20.00	2° 17' 30.7"	19° 5' 20.1"	19° 5' 20"
10	3520.00 ~~350~~	20.00	2° 17' 30.7"	21° 22' 50.8"	21° 23' 00"
11	3540.00	20.00	2° 17' 30.7"	23° 40' 21.5'	23° 40' 20"
T2	3551.59	11.59	1° 19' 41.3'	25° 0' 2.8"	25° 0' 0"

$\Delta/2 = 50/2$

$= 25°$ OK

Compound curve:

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A compound curve consists of two (or) more simple arcs that bend (or) turn in the same direction.

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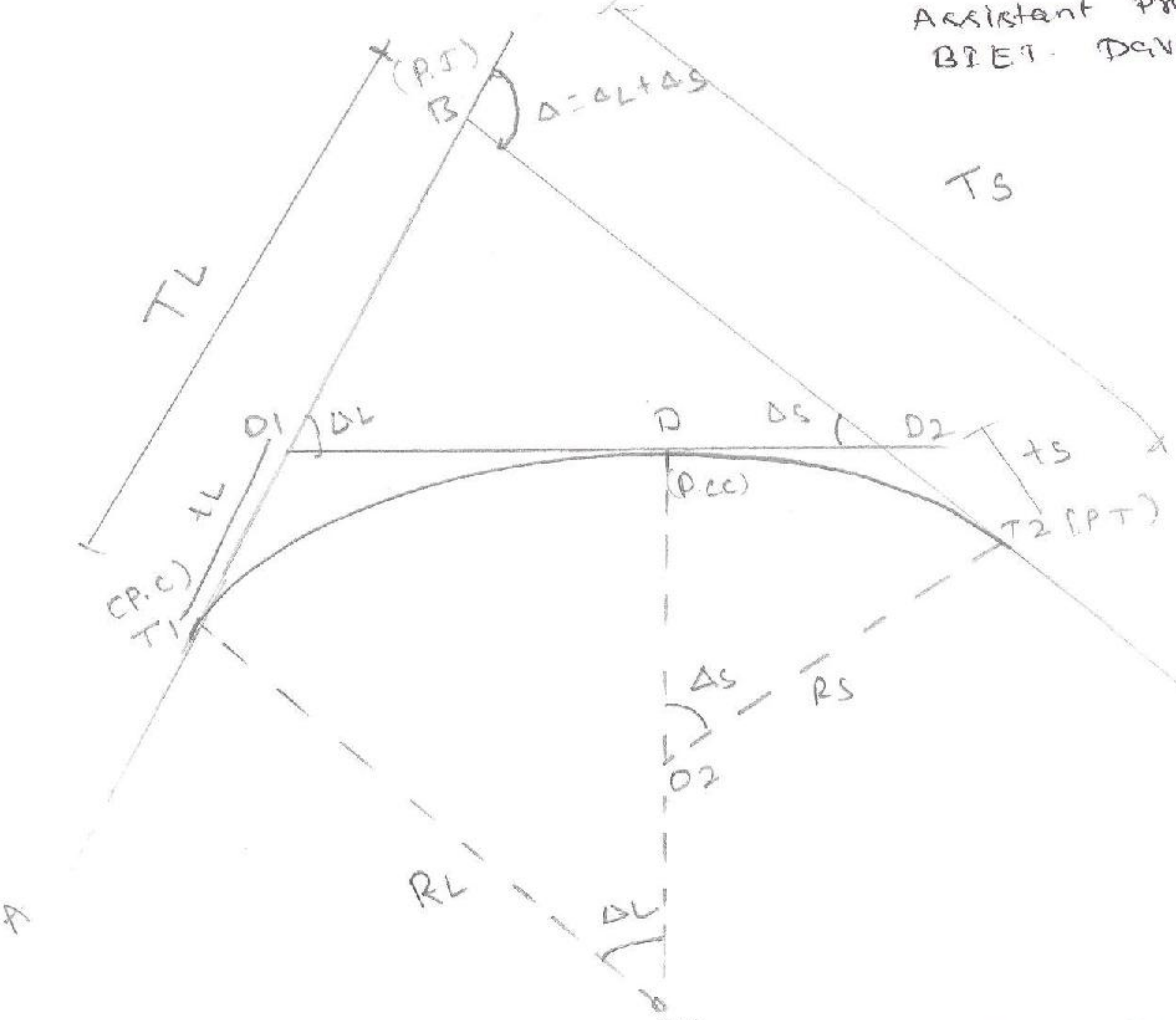
Assistant Professor.
BIET. Davanagere.



In fig. AB and BC are two straights b/w which a compound curve is introduced.

- Arc T_1DT_2 is the compound curve with first arc of larger radius RL and central angle ΔL followed by second arc of smaller radius RS and central angle ΔS.
- T_1 is the Point of curve (P.C), D is the point of compound curvature [PCC] and T_2 is the Point of tangency (P.T)
- D_1D_2 is the common tangent for both arcs drawn at D [P.C.C]
- Δ is the deflection angle b/w two straights

Important Relation:

$$\Delta = \Delta_L + \Delta_S$$

Tangent length.

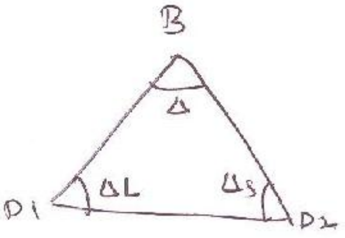
$T_1D_1 = D_1D = R_L \tan\frac{\Delta_L}{2}$ & $DD_2 = R_S \tan\frac{\Delta_S}{2}$

$D_1D_2 = D_1D + DD_2$

$$\boxed{\text{Length of common Tangent} = R_L\tan\frac{\Delta_L}{2} + R_S\tan\frac{\Delta_S}{2}}$$

In Δle BD_1D_2

Applying the sine rule.



$$\frac{BD_1}{\sin\Delta_S} = \frac{D_1D_2}{\sin\Delta} = \frac{BD_2}{\sin\Delta_L}$$

$$BD_1 = \frac{D_1D_2 \times \sin\Delta_S}{\sin\Delta\ \cancel{\sin\Delta}}$$

$$BD_2 = \frac{D_1D_2 \times \sin\Delta_L}{\sin\Delta}$$

Initial tangent length for compound curve is

$$BT_1 = T_1D_1 + D_1B$$

$$\boxed{T_L = R_L\tan\frac{\Delta_L}{2} + \frac{D_1D_2}{\sin\Delta}\cdot\sin\Delta_S}$$

second tangent length for compound curve is

$$BT_2 = T_2D_2 + D_2B$$

$$\boxed{T_S = R_S\tan\frac{\Delta_S}{2} + \frac{D_1D_2}{\sin\Delta}\cdot\sin\Delta_L}$$

length of arc of larger radius $l_L = \frac{\pi R_L\Delta_L}{180}$

length of arc of smaller radius $l_S = \frac{\pi R_S\Delta_S}{180}$.

3. Chainage of tangent Points & P. C. C. (Point of compound curvature)

Chainage of T_1 [P.C] = chainage of B [P.I] – TL

Chainage of D [P.C.C] = chainage of T_1 [Pc] + length of arc of larger radius (lL)

Chainage of T_2 [P.T] = Chainage of D [P.C.C] + ls

Procedure for Setting a compound curve:

1. The two tangent Points T_1 and T_2 are located based on the tangent lengths. [Ts and TL]
2. Theodolite is centred over T_1 and levelled w.r.t to plate level. Eye piece is focused. the horizontal plates are adjusted to set index of vernier A to 360° Exactly using UPCS & UPTS.
3. with lower plate clamp released the line of sight is directed towards the P.I. The P.I is bisected Exactly using lower plate tangent screws.
4. Releasing upper plate clamp the line of sight is turned to set the angle Δ_1 of the first arc Exactly using UPCS and UPTS. Along this line of sight Point 1 is located at a distance of Subchord c from Point T_1
5. Releasing upper plate clamp, the line of sight is turned to ~~the~~set the angle Δ_2 of the second arc exactly using UPCS and UPTS. Along this line of sight Point 2 is located at a distance of normal Chord C from Point 1.
6. The above procedure is repeated till the Point D [Pcc] is located.

Direction of common tangent

Note! The second arc is located wrt to tangent DD_2 at PCC.

⑦ Theodolite is now shifted and centred over D. it is levelled w.r.t plate bubble. eye piece is focussed.

⑧ Horizontal plates are adjusted to set "Index" of Vernier A to $[360-\frac{as}{2})$. exactly by upper plate tangent screw. Release the lower plate clamp. the line of sight is turned to bisect T_1 exactly using lower plate tangent Screw

9. Release the upper plate clamp. the index of Vernier A is set to 360° Exactly by UPTS. The telescope is plunged (Transited). The line of sight is now along the common tangent DD_2.

Setting out of second arc

The second arc is now set in the same way as that of the first arc wr. to common tangent.

Problem on compound curve.

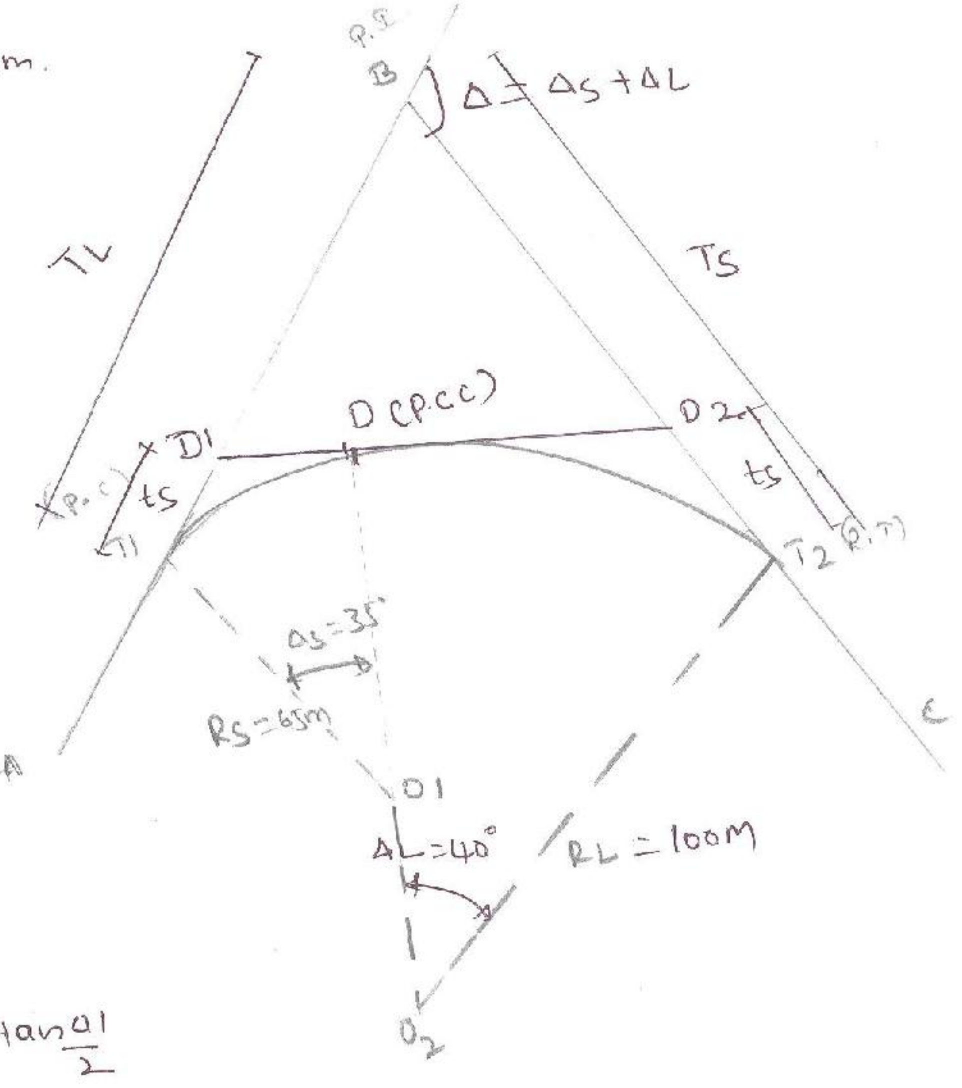
* Two straignts AB and BC intersect at B with a chainage of 1234m. It is proposed to introduce a compound curve with firstarc of radius 65m and central angle 35° and secondarc of radius 100m and central angle 40°. make necessary calculations to set out the curve by Rankines deflection Method. Take peg interval at 20m.

Chainage of P.I = 1234m.

$R_S = 65m$. $\Delta_S = 35°$

$R_L = 100m$ $\Delta_L = 40°$

$C = 20m$



Here

$\Delta = \Delta_S + \Delta_L$

$\Delta = 35 + 40$

$\boxed{\Delta = 75°}$

Δle O_1T_1D

~~$T_1D_1 = ts = R$~~

$$\tan\frac{\Delta_1}{2} = \frac{T_1D_1}{R_S}$$

$$T_1D_1 = t_S = R_S \times \tan\frac{\Delta_1}{2}$$

$$T_1D_1 = ts = 65 \times \tan\frac{35}{2} = 20.49m$$

Δle O_2T_2D

$$\tan\frac{\Delta_2}{2} = \frac{T_2D_2}{R_L}$$

$$T_2D_2 = ts = R_L \tan\frac{\Delta_2}{2} = 100 \tan\frac{40}{2}$$

$$\boxed{T_2D_2 = 36.39m}$$

Where

$\boxed{D_1D_2 = T_1D + T_2D_2}$ $D_1D_2 = 20.49 + 36.39$

$\boxed{D_1D_2 = 56.88m}$

Tangent length - First tangent length

$$D_1B = \frac{D_1D_2}{\sin \Delta} \times \sin \Delta s$$

$$BT_1 = T_1D_1 + D_1B = T_1D_1 + \frac{D_1D_2}{\sin \Delta} \times \sin \Delta s$$

$$BT_1 = T_S = R_S \tan \frac{\Delta s}{2} + \frac{D_1D_2}{\sin \Delta} \times \sin \Delta s$$

$$BT_1 = TS = 65 \tan \frac{35}{2} + \frac{56.891}{\sin 75} \times \sin 35^\circ$$

$$TS = 20.494 + 37.858$$

$$\boxed{TS = BT_1 = 58.353 m}$$

$$BT_2 = T_L = T_2D_2 + D_2B$$

$$= R_L \tan \frac{\Delta L}{2} + \frac{D_1D_2}{\sin \Delta} \times \sin \Delta L$$

$$= 100 \tan \frac{40}{2} + \frac{56.891}{\sin 75} \times \sin 40$$

$$= 36.39 + 37.858$$

$$\boxed{BT_2 = TL = 74.24 m}$$

$$\text{Length of small arc} = \frac{\pi \times R_S \times \Delta_S}{180} = \frac{\pi \times 65 \times 35}{180} = 39.70 m$$

$$\text{length of large arc} = \frac{\pi R_L \times \Delta L}{180} = \frac{\pi \times 100 \times 40}{180} = 69.813 m$$

Chainage of T_1 = chainage of P.I - Tangent Length

= P.I - TS

= 1234.000 - 58.353

$$\boxed{\text{Chainage of } T_1 = 1175.647 m}$$

Chainage of D = Chainage of T_1 + length of small arc

1175.647 + 39.70

$$\boxed{\text{Chainage of D} = 1215.347 m.}$$

Chainage of T2 = chainage of D + length of larc arc

= 1215.347 + 69.813

$\boxed{\text{Chainage of T2} = 1285.16\text{m}}$

Calculations for first ⓞⓓ (Small arc) are $T_1 D$

C = Higher Rounded value of Chainage of T_1 − chainage of T_1

= 1180 − 1175.647

$\boxed{C = 4.353\text{m}}$ First arc sub chord.

c' = Chainage of D − Lower Rounded value of Chainage of T2

$c' = 1215.347 - 1200$

$\boxed{c' = 15.347\text{m}}$ last sub chord.

No of Normal chords $= \frac{1200 - 1180}{20} = 1$

Total no of Chords = n = 1 + 1 + 1 = 3

$$\delta_1 = \frac{1718.9 \times c}{R} = \frac{1718.9 \times 4.353}{65} = \frac{115.1134}{60} = 1^\circ 55' 6.8''$$

$$\delta_2 = \frac{1718.9 \times C}{R} = \frac{1718.9 \times 20}{65} = \frac{528.89}{60} = 8^\circ 48' 53.54''$$

$$\delta_3 = \frac{1718.9 \times c'}{R} = \frac{1718.9 \times 15.347}{65} = \frac{406.094}{60} = \frac{6^\circ 46' 08.73}{17^\circ 30'}$$

$$\frac{\Delta s}{2} = \frac{36}{2} = 17^\circ 30' 00''$$

Point	Chainage (m)	Chord(m)	δ (min) $= \frac{1718.9C}{R}$	Deflection angle $\Delta = \Delta_{n-1} + \delta n$	Δ for ~~ator~~ Theodolite readings
T1	1175.647	−			
1	1180.000	4.53	1° 55' 6.8''	1° 55' 6.8''	1° 55' 00''
2	1200.000	20	8° 48' 53.54''	10° 44' 0.34''	10° 44' 00''
D	1215.353	15.353	6° 46' 0.5''	17° 30' 0.84''	17° 30' 00''

calculations for second (or large) arc [DT2]

C = ~~1220.00~~ Rounded to higher value of chainage of D − chainage of D

C = 1220.00 − 1215.347 = 4.653m

c' = chainage of T2 − Rounded to lower value of chainage of T2

= 1285.16 − 1280.00 = 5.166m

$\boxed{c' = 5.166m}$

~~Total~~ No of Normal Chords N = (Rounded value of chainage of T2 − Rounde d value of chainage of D) / Peg interval

$$N = \frac{1280 - 1220}{20} = 3.$$

Total no of chords = 1 + 3 + 1 = 5 No

deflection angle. δ

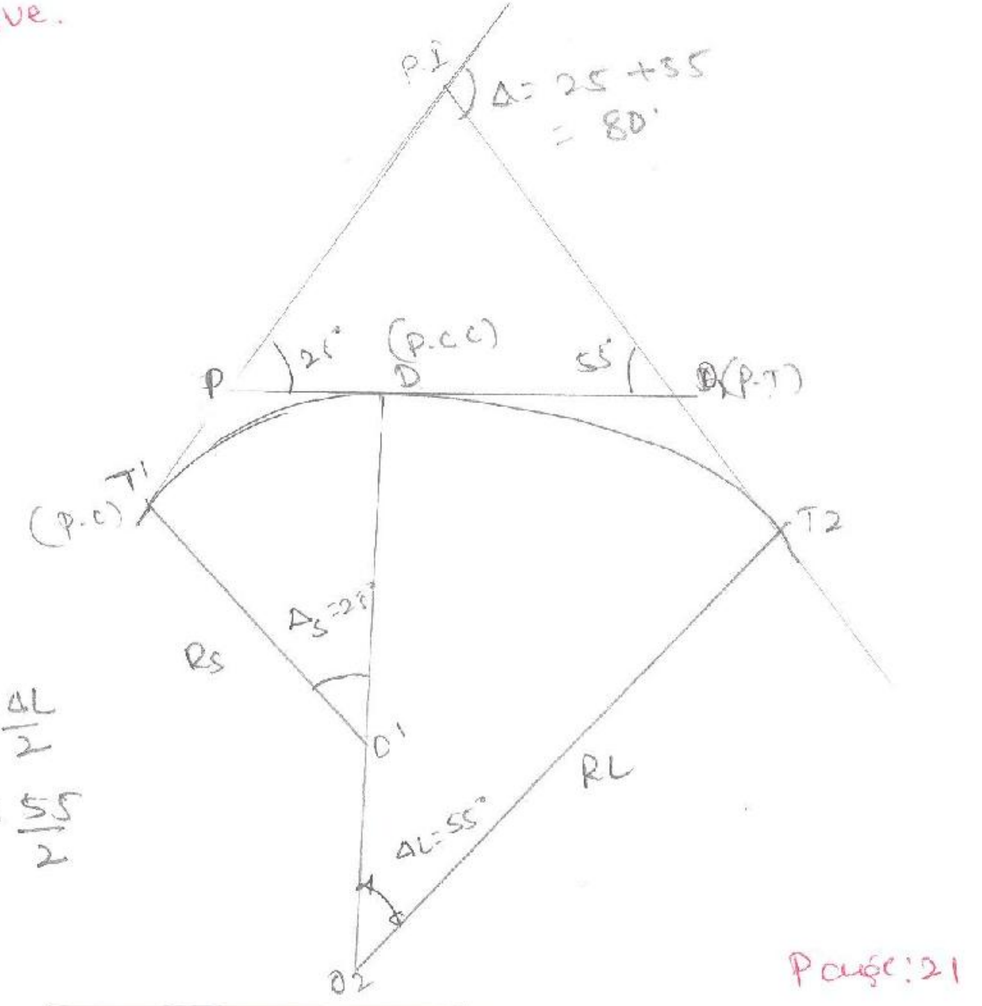
$$\delta_1 = \frac{1718.9 \times C}{R} = \frac{1718.9 \times 4.653}{100} = \frac{79.98}{60} = 1^\circ 19' 58.83''$$

$$\delta_2 = \delta_3 = \delta_4 = \frac{1718.9 \times C}{R} = \frac{1718.9 \times 20}{100} = \frac{343.78}{60} = 5^\circ 43' 46.8''$$

$$\delta_5 = \frac{1718.9 \times c'}{R} = \frac{1718.9 \times 5.166}{100} = \frac{88.79}{60} = 1^\circ 28' 47.9''$$

Point	Chainage in M	Chord in M	Tangential angle $\delta = \frac{1718.9 \times C}{20}$	Deflection angle	Δ for Theodolite.
D	1215.353	–	–		
1	1220.000	4.647	1° 19' 52.6''	1° 19' 52.6''	1° 20' 00''
2	1240.000	20.000	5° 43' 46.8''	7° 03' 39.4''	7° 3' 40''
3	1260.000	20.000	5° 43' 46.8''	12° 47' 26.2''	12° 47' 20''
4	1280.000	20.000	5° 43' 46.8''	18° 31' 13''	18° 31' 20''
T2	1285.166	5.166	1° 28' 47.9''	20° 00' 0.9''	20° 00' 00''

(02) A compound curve consisting of two simple circular curves of radii 350m and 500m. is to be laid out b/w two straights. The angle of intersection b/w the tangents and the two straight are 25° and 55°. calculate the various elements of the compound curve.



Soln

$R_S = 350m$

$R_L = 500m$

$\Delta S = 25°$

$\Delta L = 55°$

$\Delta = \Delta S + \Delta L$

$\Delta = 25° + 55°$

$\Delta = 80°$

$PQ = PD + DQ$

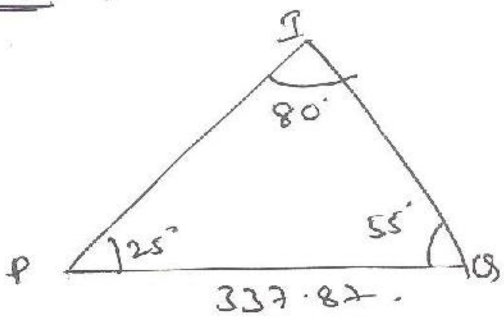
$= R_S \tan \frac{\Delta S}{2} + R_L \tan \frac{\Delta L}{2}$

$= 350 \tan \frac{25}{2} + 500 \tan \frac{55}{2}$

$= 77.59 + 260.28$

$PQ = 337.87 \, M$

From Δ^{le} $P\hat{I}Q$ $\qquad$ $PQ = \underline{337.87}\,m$



$$\frac{IP}{\sin 55} = \frac{PQ}{\sin 80} = \frac{IQ}{\sin 25}$$

$$IP = \frac{337.87 \times \sin 55}{\sin 80}$$

$$\boxed{IP = 281.036m}$$

$$IQ = \frac{PQ \times \sin 25}{\sin 80} = \frac{337.87 \times \sin 25}{\sin 80} =$$

$$\boxed{IQ = 144.99\ m}$$

length of tangent $IT_1 = IP + PT_1$

$= 281.036 + R_s \tan\frac{\Delta_s}{2}$

$= 281.036 + 350 \tan\left(\frac{25}{2}\right)$

$= 281.036 + 77.59$

$$\boxed{\text{length of tangent } IT_1 = \underline{358.62m}}$$

length of second tangent $IT_2 = IQ + QT_2$

$= 144.99 + R_L \tan\frac{\Delta_L}{2}$

$= 144.99 + 500 \tan\frac{55}{2}$

$= 144.99 + 260.28$

$$\boxed{\text{length of second tangent } IT_2 = \underline{405.27m}}$$

Reverse curves:

A Reverse curve is a combination of two simple circular curves having opposite directions, Joining at a common tangent Point called the Point of reverse curvature.

Reverse curves are used when either the two straights are parallel (or) their angle of intersection is too small. These are used in hilly terrains and in railways sidings as cross-overs. These are also used on highways and railways designed for low speed. As far as Possible, they should not be used on main highways and railways designed for high speed because of the following reasons.

1. sudden change of superelevation is needed from one edge to the other one, near the Point of reverse curvature.
2. The sudden change of curvature and direction reduces the life of the vechicle and gives discomfort to the Passengers.
3. on highways, steering becomes uncomfortable.
4. It is not Possible to provide Proper Superelevation at the Point of reverse curvature.

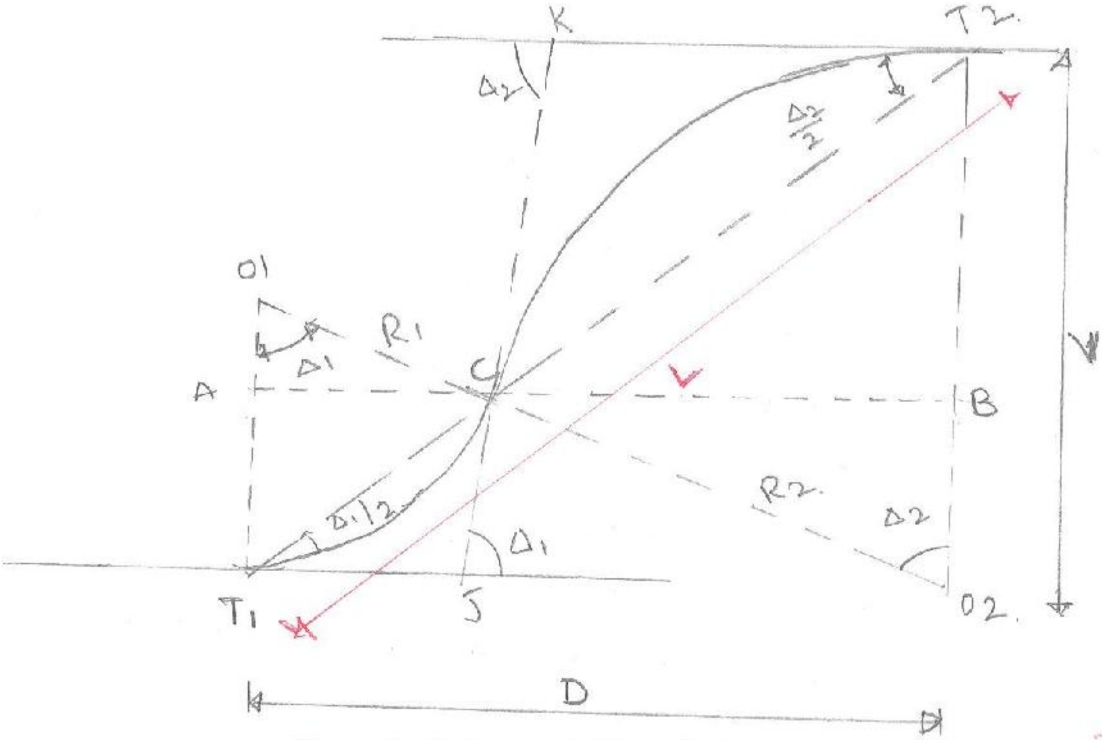
under such situation it is always advised to introduce a straight length (or) a reversed transition curve b/w two branches of the reverse curve.

Elements of a Reverse curve:

The various elements of a reverse curve are.

① Radii R_1 and R_2 of the two circular arcs.
2. Angle of total deflection Δ b/w straights.
3. central angle (or) angle of deflection [Δ_1 & Δ_2) of the common tangents
④ Angle (δ_1 and δ_2) b/w the straight and the line T_1T_2.

Two - Parallel Straight Reverse curve.



Reverse curve [Parallel straight]

In fig T_1CT_2 be the reverse curve with two arcs b/w parallel straights.

1. First arc of radius R_1 and central angle Δ_1
2. Second arc of radius R_2 and central angle Δ_2

T_1 = Point of curve [P.C]

C = Point of Reverse curvature [PRC]

T_2 = Point of tangency [P.T]

JK = common tangent.

V = Perpendicular distance b/w two straights

L = Distance b/w two tangent points T_1 and T_2

D = Distance b/w tangents points measured parallel to the straights.

T_1J and T_2K are two parallel straights at a distance of V passing through T_1 and T_2 respectively. They have to be joined by a reverse curve b/w T_1 and T_2. C is the point of reverse curvature. Let the two arcs have radii R_1 and R_2 and central angles Δ_1 and Δ_2. Distance T_1T_2 is L.

and distance b/w T_1 and T_2 along the tangent is D as shown in fig. JK is the common tangent drawn at C.

$\Delta_1 = \Delta_2 = \Delta$, Hence O_1T_1 and O_2T_2 are Parallel and O_1CO_2 Joins them.

$$V = T_1A + BT_2$$

$$V = [O_1T_1 - O_1A] + [O_2T_2 - O_2B]$$

$$V = [R_1 - R_1\cos\Delta_1] + [R_2 - R_2\cos\Delta_2]$$

$$V = [R_1[1-\cos\Delta_1] + R_2[1-\cos\Delta_2]$$

$$\boxed{V = (R_1+R_2)[1-\cos\Delta]} \rightsquigarrow ①$$

$$T_1T_2 = L = T_1C + CT_2$$

$$= 2R_1\sin\left(\frac{\Delta_1}{2}\right) + 2R_2\sin\left[\frac{\Delta_2}{2}\right]$$

$$\boxed{L = 2[R_1+R_2]\sin[\Delta/2]} \rightsquigarrow ②$$

using $\sin\frac{\Delta}{2} = \frac{V}{L} \rightarrow ③$ $\tan\frac{\Delta}{2} = \frac{V}{h}$ - ④

eq substituting $\sin\frac{\Delta}{2} = \frac{V}{L}$ in eq ②

$$L = 2[R_1+R_2] \times \frac{V}{L}$$

$$L^2 = 2[R_1+R_2] \times V. \rightsquigarrow ④$$

$$L = \sqrt{2V \times [R_1+R_2]}$$

Also, $D = AC + CB$

$$D = R_1\sin\Delta_1 + R_2\sin\Delta_2 \rightsquigarrow ⑤$$

$$D = (R_1+R_2)\sin\Delta$$

Special case: If as a special case $R_1 = R_2 = R$. The above equations are transformed to

$$V = 2R(1-\cos\Delta) \rightsquigarrow ①$$

$$L = 4R\sin[\Delta/2] \rightarrow ②$$

$$L = 2\sqrt{RV} \rightarrow ③ \qquad D = 2R\sin\Delta \rightarrow ④$$

Problems on Reverse curve :-

① A reverse curve connects two Parallel tangents 30m apart. If the radii of the two branches are 120m and 150m. determine the following

① Distance b/w the two tangent points.

② Total length of curve

③ Chainage of point of Reverse curvature & second tangent point if the chainage of first tangent point is 1988m.

Soln

V = 30m $R_1 = 120m$ $R_2 = 150m$.

chainage of P.I = 1988m.

①
$$V = [R_1 + R_2][1-\cos\Delta]$$
$$30 = [120+150][1-\cos\Delta]$$
$$30 = 270[1-\cos\Delta]$$
$$\frac{30}{270} = [1-\cos\Delta]$$
$$\cos\Delta = [1-0.111]$$
$$\cos\Delta = 0.88$$
$$\Delta = \cos^{-1}[0.88]$$
$$\boxed{\Delta = 27.27^{\circ}}$$

Distance b/w two tangents $L = 2[R_1+R_2]\sin\frac{\Delta}{2}$
$$L = 2[120+150]\sin\frac{27.27}{2}$$
$$\boxed{L = 127.27m}$$

② Total length of curve.
$$l = l_1 + l_2 = \frac{\pi R_1 \Delta}{180} + \frac{\pi R_2 \Delta}{180}$$
$$= \frac{\pi\times120\times27.27}{180} + \frac{\pi\times150\times27.27}{180}$$
$$= 57.11 + 71.39$$
$$\boxed{l = 128.50m}$$

③ chainages.

Chainages of Point of Reverse curve $= 1988 + 57·11$

$= 2045·11\,m$

Chainage of T_2 $= 2045·11 + 71·39$

$= \underline{2116·50\,m}$

⑫ The first branch of a reverse curve has a radius of 200m. Find the radius of second branch so that the curve can connect parallel straight 18m apart. The distance b/w the tangent points is to be 110m. Also calculate lengths of two branches.

Sol) $R_1 = 200m, \quad V = 18m, \quad L = 110m.$

$$\sin\frac{\Delta}{2} = \frac{V}{L} = \frac{18}{110}$$

$$\frac{\Delta}{2} = \sin^{-1}\left[\frac{18}{110}\right] = \frac{\Delta}{2} = 9·42$$

$$\boxed{\Delta = 18·84}$$

$$V = [R_1 + R_2](1 - \cos\Delta)$$

$$18 = [200 + R_2][1 - \cos 18·84]$$

$$\frac{18}{[1 - \cos 18·84]} = (200 + R_2)$$

$$335·97 = 200 + R_2$$

$$335·97 - 200 = R_2$$

$$\boxed{R_2 = 135·97\,m}$$

$$l_1 = \frac{\pi R_1 \times \Delta}{180} = \frac{\pi \times 200 \times 18·84}{180} = 65·76\,m$$

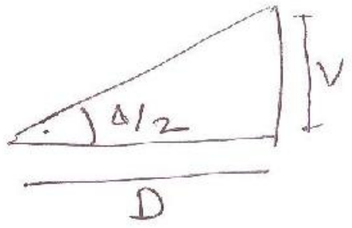
$$l_2 = \frac{\pi \times 135·97 \times 18·84}{180} = 44·71\,m$$

(Q3) Two Parallel railway lines are to be connected by a reverse curve, each section having the same radius. If the lines are 12m apart and the maximum distance b/w tangent points measured parallel to the straights is 48m. Find the maximum allowable radius. If however, both the radius are to be different calculate the radius of the second branch if that of first branch is 68m. Also calculate the length of both branches.

Soln $V = 12m$. $D = 48m$.

Case ①   Both Branches are of same radius

$$\tan\frac{\Delta}{2} = \frac{V}{D} = \frac{12}{48}$$



$$\frac{\Delta}{2} = \tan^{-1}\left[\frac{12}{48}\right]$$

$$\frac{\Delta}{2} = 14.03$$

$$\boxed{\Delta = 28.08}$$

$$V = [R_1 + R_2]\,[1 - \cos\Delta)$$

$$12 = 2R\,[1 - \cos 28.08]$$

$$\boxed{R = 50.97m}$$

Case : ②   Both Branches are different radii

$R_1 = 68m$ $R_2 = ?$

$$V = [R_1 + R_2]\,[1 - \cos\Delta]$$

$$12 = [60 + R_2]\,[1 - \cos 28.08]$$

$$101.94 = (60 + R_2)$$

$$\boxed{R_2 = 41.94m}$$

$$l_1 = \frac{\pi \times R_1 \times \Delta}{180} \qquad l_2 = \frac{\pi \times R_2 \times \Delta}{180}$$

$$l_1 = \frac{\pi \times 60 \times 28.08}{180} \qquad l_2 = \frac{\pi \times 41.94 \times 28.08}{180}$$

$$l_1 = 29.405m \qquad l_2 = 20.55m$$

④ A reverse curve is to be set out to connect two Parallel railway line 30m apart. The distance b/w the tangent points is 150m. Both the arcs have the same radius. The curve is set out by method of ordinates from the long chord taking a peg interval of 10m. Calculate the necessary data for setting the curve.

08M

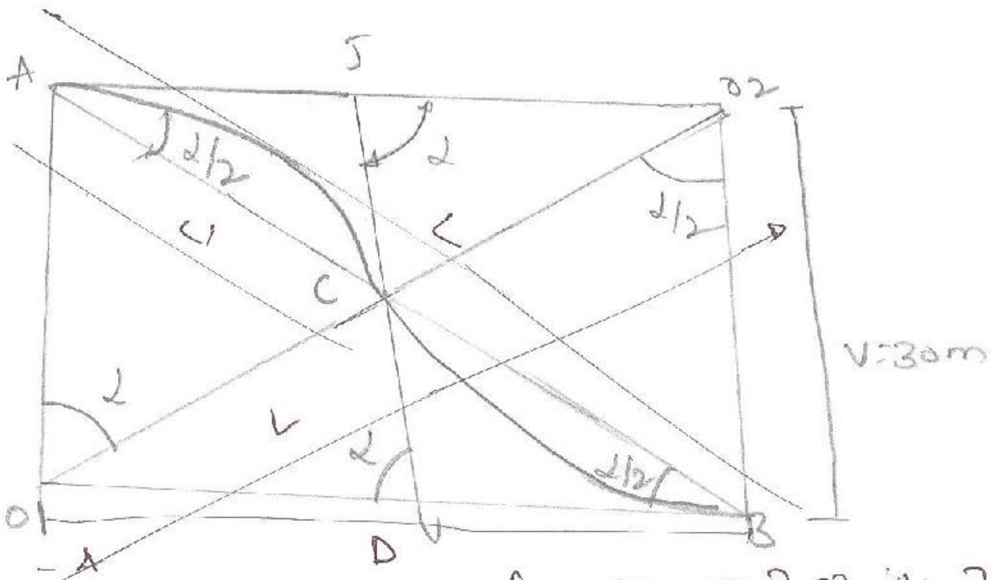
June July 2017

~) Let $V = 30m$ $L = 150m$. $R_1 = R_2 = R$

Peg Interval = 10m.

Distance b/w AB = L = 150m.

Distance b/w two parallels V = 30m.



$R_1 = R_2 = R$

We know that $L = [2 \times [R_1 + R_2] \sin \alpha/2]$

We know that

$\sin\frac{\alpha}{2} = \frac{V}{L}$

$L = 2 \times 2R \sin\alpha/2$

$L = 4R \sin\frac{\alpha}{2}$

$L = \frac{4RV}{L}$

$L^2 = 4RV$

$\frac{L^2}{4V} = R$

$R = \frac{150^2}{4 \times 30}$

$\boxed{R = 187.5m}$

Now length of long chord AC, $L' = \underline{75m}$

Offsets from AB at a distance of 0, 75 and 150m from A are equal to zero.

<u>Note:</u>

The maximum ordinates at a mid-point AC & BC is given by

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$O_0 = 187.5 - \sqrt{187.5^2 - \left(\frac{150}{2}\right)^2}$$

$$O_0 = 187.5 - 171.84$$

$$\boxed{O_0 = 15.65m}$$

$$(R - O_0) = \underline{171.85}$$

$$O_x = \sqrt{R^2 - x^2} - [R - O_0]$$

$$O_{10} = \sqrt{\overset{\cancel{200}^2}{(187.5)^2} - (10)^2} - [\overset{187.5}{\cancel{200}} - 15.65)$$

$$O_{10} = 187.23 - 171.85$$

$$\boxed{O_{10} = 15.38m}$$

$$O_{20} = \sqrt{(187.5)^2 - (20)^2} - 171.85 = 186.43 - 171.85 = \underline{14.58m}$$

$$O_{30} = \sqrt{(187.5)^2 - [30)^2} - 171.85 = 185.08 - 171.85 = 13.23m$$

$$O_{40} = \sqrt{[187.5]^2 - [40]^2} - 171.85 = 11.\underline{34}m$$

$$O_{50} = \sqrt{[187.5]^2 - (50)^2} - 171.85 = 8.86m$$

$$O_{60} = \sqrt{(187.5)^2 - (60)^2} - 171.85 = 5.79m$$

$$O_{70} = \sqrt{(187.5)^2 - (70)^2} - 171.85 = 2.09m$$

$$O_{75} = \sqrt{[187.5)^2 - [75)^2} - 171.85 = \underline{0m}$$

The ordinates of the other arc are same as above. for each curve the offsets are ~~0.00~~ 15.65, 15.38, 14.58, 13.23, 11.34, 8.86, 5.79, 2.09 & 0m.

Transition curves

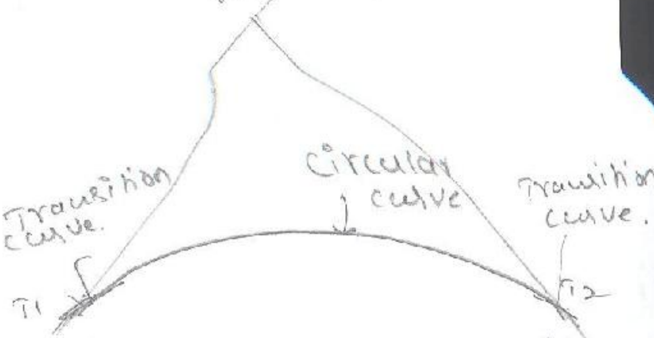
Definition :- Transition curve is a curve of varying radii.

Provided b/w ① straight and circular curve.

② two branches of compound curve.

③ two branches of Reverse curve.

is known as Easement curve (or) Transition curve.



objects (or) Functions

When a transition curve is not provided on a road, and a vechicle passes from a straight into a circular curve, the passengers and the vehicle experience a shock or a jerk at the junction point because at this point the curvature changes abruptly from zero to a definite quantity and centrifugal force comes into play. If this centrifugal force exceeds a certain limit the vechicle may even over turn.

In case of railways, the side thrust will be taken by the outer rails and will cause wear of the rail at the tangent point.

objects (or) functions (or) advantages of Transition curve.

1. It allows a gradual transition of curvature from the tangent to the circular curve (or) from the circular curve to the tangent.
2. The radius of curvature increases (or) decreases gradually.
3. It is provided for the gradual changes in super-elevation in a convenient manner.
4. It eliminates the danger of derailment, overturning (or) side-slipping of vechicles and discomfort to passangers

Requirements of a transition curve. [June-July - 2016] 4m

1. It should be tangential to the straight.
2. It should meet the circular curve tangentially.
3. Its curvature should be zero. at the origin on straights.
4. Its curvature at the junction with circular curve. should be same as that of the circular curve.
5. The rate of increase of curvature and the rate of increase of superelevation (or cant) should be same.
6. Its length should be such that full superelevation is attained at the junction with the circular curve.

Centrifugal Force and Centrifugal Ratio:

when a vehicle negotiates a circular curve. centrifugal force through centre of gravity of vechicle acts horizontally in outward direction.

It is given by $P = \frac{Wv^2}{gR}$

where
P = centrifugal force, N
W = weight of vehicle, N
v = speed of vehicle, m/s
g = acceleration due to gravity, m/s² &
R = Radius of curve, m.

The ratio of centrifugal force (P) to the weight (W) is called centrifugal ratio.

i.e. $\frac{P}{W} = \frac{v^2}{gR}$

The maximum value of centrifugal ratio is 1/4 on roads and 1/8 on railways.

i.e on roads $\frac{v^2}{gR} = \frac{1}{4}$ or $v = \sqrt{\frac{gR}{4}}$

& on railways $\frac{v^2}{gR} = \frac{1}{8}$ (or) $v = \sqrt{\frac{gR}{8}}$.

The above equations may be used to find the minimum radius for a given speed.

Length of transition curve:

The following three methods are generally adopted to find the designed length. The maximum of three values is taken as the length of transition curve.

Method 1: By rate of change of radial acceleration.

Radial acceleration is given by $\frac{v^2}{R}$ where v = speed m/s.

R = Radius. m.

Rate of change of radial acceleration = $\alpha = \frac{v^2}{Rt}$

Here t = time taken for the vechicle to travel a distance equal to the length of transition curve.

$$t = \frac{L}{v}$$

$$\alpha = \frac{v^2}{R \cdot \frac{L}{v}}$$

$$\alpha = \frac{v^3}{R \cdot L}$$

$$\boxed{L = \frac{v^3}{\alpha \cdot R}} \qquad \boxed{\alpha = \frac{v^3}{R \cdot L}}$$

Passengers do not experience any sensation of discomfort, when the vechicle is negotiating a curve.

Note: Generally $\alpha = 0.3 m/s^3$

Method 2: By rate of introduction of superelevation

Let e m be the superelevation. [Amount by which outer edge is raised with respect to the inner edge]
If super elevation is introduced at the rate of 1 in N.
Then the length of transition curve (L) to provided superelevation of E is given by

$$\boxed{L = Ne}$$

for 1 unit of superelevation, length is N unit.
for e m of superelevation, length L = Ne

Note: Generally N varies b/w 300 to 1200.

Method: III By time rate of Introduction of super elevation

Let r be the time rate of Introduction of superelevation.

i.e In 1s, the superelevation attained. is r m.

In ts. the superelevation attained i.e $e = t \cdot r$.

i.e In ts, the superelevation

But t = time taken by vehicle to move over L with speed of v m/s $= \frac{L}{V}$

$$e = \frac{L}{V} \cdot r \quad (\text{or}) \quad \boxed{L = \frac{ev}{r}}$$

① for ~~roads~~ roads $e = B\left[\frac{v^2}{gR} - f\right]$

B = width of pavement on curves. m

v = speed m/s

R = Radius m.

f = coefficient of friction = 0.15.

② for railways $e = \frac{Gv^2}{gR}$ G = gauge of track. m

Problems

① A ~~tr~~

Problems on transition curve:

Raghee. M.E
Assistant Professor
BIET. Davangere.

① A transition curve is required for a circular curve of 400m radius. The gauge of track is 1.5m and the superelevation is restricted to 12cm. The transition curve is to be designed for a speed such that no lateral pressure is imposed on the rails and the rate of radial acceleration is 0.3 m/s³. calculate the length of the transition curve.

Soln

$$L = \frac{V^3}{\alpha R}$$

$L = ?$ $V = ?$ $\alpha = 0.3 \, m/s^3$
$R = 400m.$
$e = 0.12m$ $G = 1.5m$

But $e = \frac{G v^2}{g R}$

$$0.12 = \frac{1.5 \times v^2}{9.81 \times 400} =$$

$$\boxed{v = 17.72 m/s}$$

$$L = \frac{17.72^3}{0.3 \times 400} = 46.4M$$

$$\boxed{L = 46.4m}$$

② Find the length of transition curve using the following data. speed = 100 kmph.
make centrifugal Ratio $= \frac{1}{4}$,
Rate of change of radial acceleration $= 30cm/s^3$

Soln: centrifugal Ratio $= \frac{v^2}{gR}$

$V \, kmph = \left(\frac{V \times 1000}{60 \times 60}\right)$
$= 0.278V$

$$\frac{1}{4} = \frac{(0.278 \times 100)^2}{9.81 \times R}$$

$$\boxed{R = 315.1m}$$

$$L = \frac{v^3}{\alpha R} = \frac{(0.278 \times 100)^3}{0.3 \times 315.1} = \underline{227.3m}$$

Length of transition curve is $\underline{227.3m}$

(4M) Types of vertical curve.:

With a neat sketches, write the types of vertical curve

~~June July~~. 2012
~~Jan 2018~~

There are two types of vertical curve.

① Summit curve. ② Sag curve.

Summit curve: This is provided in either of the following three cases.

① when an upgrade is followed by a downgrade fig 1.

② when a steeper upgrade is followed by a milder upgrade fig.2.

③ when a milder downgrade is followed by a steeper downgrade. fig.3.

Sag curve: This is provided in either of the following three cases.

① when a downdrade is followed by an upgrade fig 4

② when a steeper downgrade is followed by a milder downgrade fig 5

③ when a milder ~~ab~~ upgrade is followed by a steeper upgrade fig 6

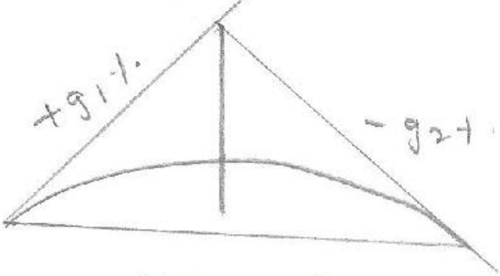


fig. 1.

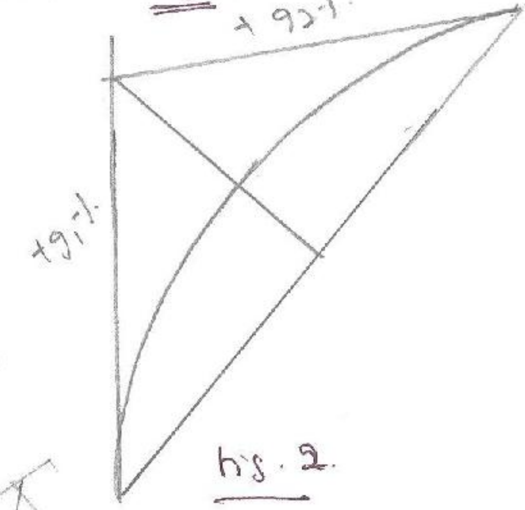


fig. 2.

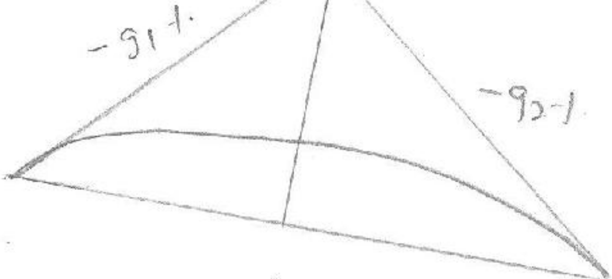


fig. 3

Summit curve.

Sag curves

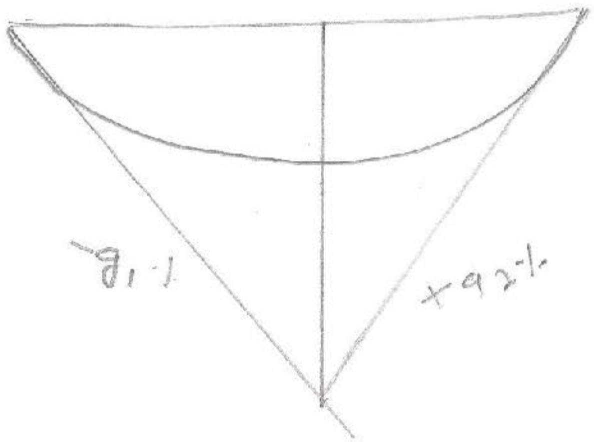


fig 4

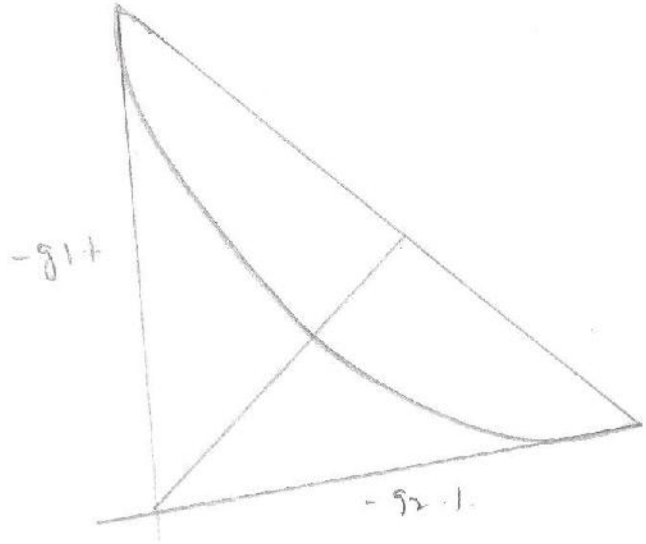


fig 5

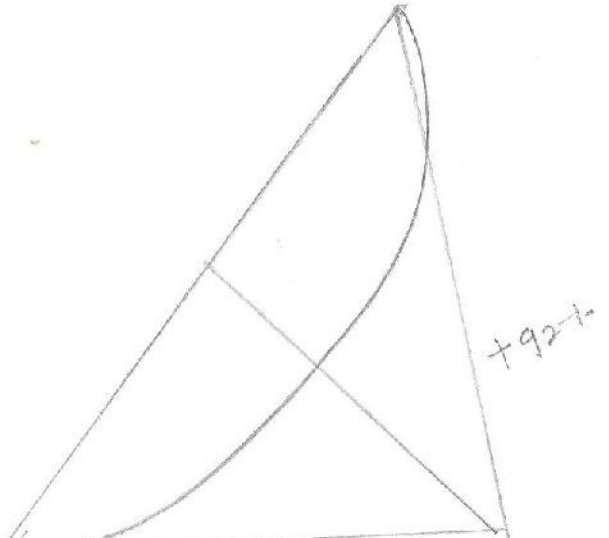


fig 6

Module: 4

Aerial Photogrammetry

Syllabus

Introduction. uses, Aerial Photographs, Definiations. Scale of vertical and tilted photographs. [simple problems]. Ground co-ordinates [simple problems], Relif Displacements. [Derivstions], Ground control, Procedure of aerial survey. overlaps and mosaics, Steroscopes. Derivstion parallax.

Introduction

- Photogrammetric surveying ⓞⓡ photogrammetry is the Science and art of obtaining accurate measurements by use of Photographs. for various purposes such as the the construction of planimetric and topographic maps, Classification of soils, interpretation of geology, acquisition of military intelligence and the preparation of composite pictures of the ground.

- The Photographs are taken either from the air ⓞⓡ from station on the ground.

Their are two types of photogrammetry.

They are ① Terrestial Photogrammetry.
② Aerial Photogrammetry.

1. **Terrestial Photogrammetry**: It is the branch of Photogrammetry wherein photographs are taken from a fixed Positions on ⓞⓡ near the ground.

2. **Aerial Photogrammetry**: It is the branch of Photogrammetry wherein the Photographs are taken by a Camera mounted in a aircraft flying over the area. Mapping from aerial photographs is the best mapping Procedure yet developed for large Projects and are Extremely useful invaluable for military intelligence.

The major users of aerial mapping methods are the civilian and military mapping agencies of the government.

Photogrammetry is derived from 3 greek words.

1. Photos → Light
2. Gramma — Drawn.
3. Metron -— Measure.

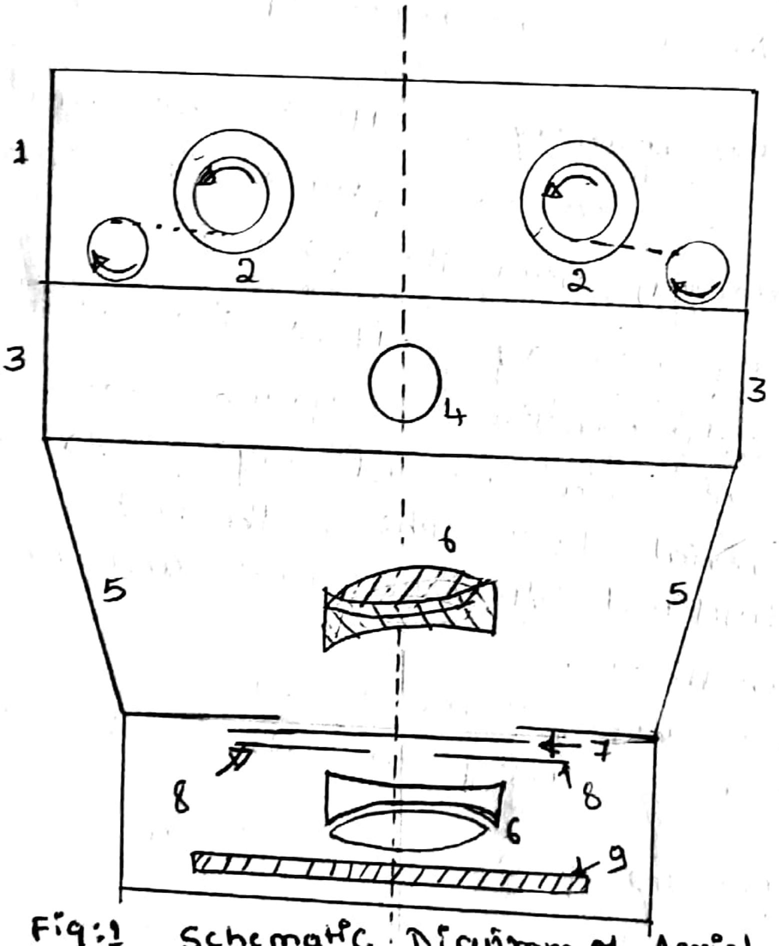
Aerial camera

The primary function of the terrestrial camera as well as the aerial camera is the same, i.e that of taking pictures.

However, since the aerial camera is mounted on a fast moving aeroplane, its requirements are quite different

The aerial camera requires 1. fast lense,
2. High speed and efficient shutter.
3. High speed emulsion for the film. and
4. A magazine to hold large rolls of film.

As such an aerial camera may be considered to be a surveying instrument of great precision.



1. Magazine.
2. Focal Plane
3. Body.
4. Trunnion.
5. Cone.
6. Lense.
7. Shutter.
8. Diaphragm.
9. Filter.

Fig:1 Schematic Diagram of Aerial Camera.

An Aerial camera consists of the following essential parts:
1. The lens assembly [Including lens, diaphragm, shutter and filter]
2. The camera cone
3. The focal plane. 4. The camera body. 5. The drive mechanism 6. The magazine.

The Shutter: The camera shutter controls the interval of time during which light is allowed to pass through the lens. Since ~~the~~ the aircraft moves at a high speed, a fast speed. Shutter is required to prevent blurring of the image caused by camera vibrations and the forward motion of the aircraft. The shutter speed generally varies from 1/100 seconds to 1/1000 seconds.

There are Three types of shutters used in aerial camera.

Ⓐ B/w the lens type. Ⓑ Focal plane type.
Ⓒ louvre type.

Ⓐ **Between the lens type** - the Shutter is fixed in the space b/w the elements of the lens system, the space being equal to the fraction of an inch. With this type of Shutter, the film is exposed only during the interval the shutter is open.

② **The focal plane type:** Shutters operate near the focal plane of the camera. These types of shutters permit higher shutter speeds and Provided in the cameras used for military operations. The film is progressively exposed throughout the time of ~~exp~~ passage of slit across the focal plane. This type of Shutter is not usefull for mapping purposes.

③ **Louvre type Shutters:** are usually employed for large lense aperture with high speed. It consists of a number of metal strips about 5mm wide supported on a metal frame and is placed either in front of the lens (or) at its back.

The Diaphragm: It is placed b/w the lens elements and acts as a Physical opening of the lens system. It consists of a series of leaves which can be rotated to increase (or) decrease the size of the openings to restrict the size of the bundle of rays to pass through the lens. diaphragm opening is larger, the shutter speed has to be greater.

Definitions and Nomenclature.

1. **Vertical photograph:** A vertical Photograph is an aerial Photograph made with the camera axis [or optical axis] coinciding with the direction of gravity.

2. **Tilted Photograph:** A tilted Photograph is an aerial Photograph made with the camera axis [or optical axis] unintentionally tilted from the vertical by a small amount, usually less than 3°. 1±3°

3. **Oblique Photograph:** An oblique Photograph is an aerial Photograph taken with the camera axis directed intentionally b/w the horizontal and the vertical. If the ~~hori~~ apparent horizon is shown in the photograph. It is said to be high oblique. 3 to 15° low oblique Phot greater 15°. high oblique photos

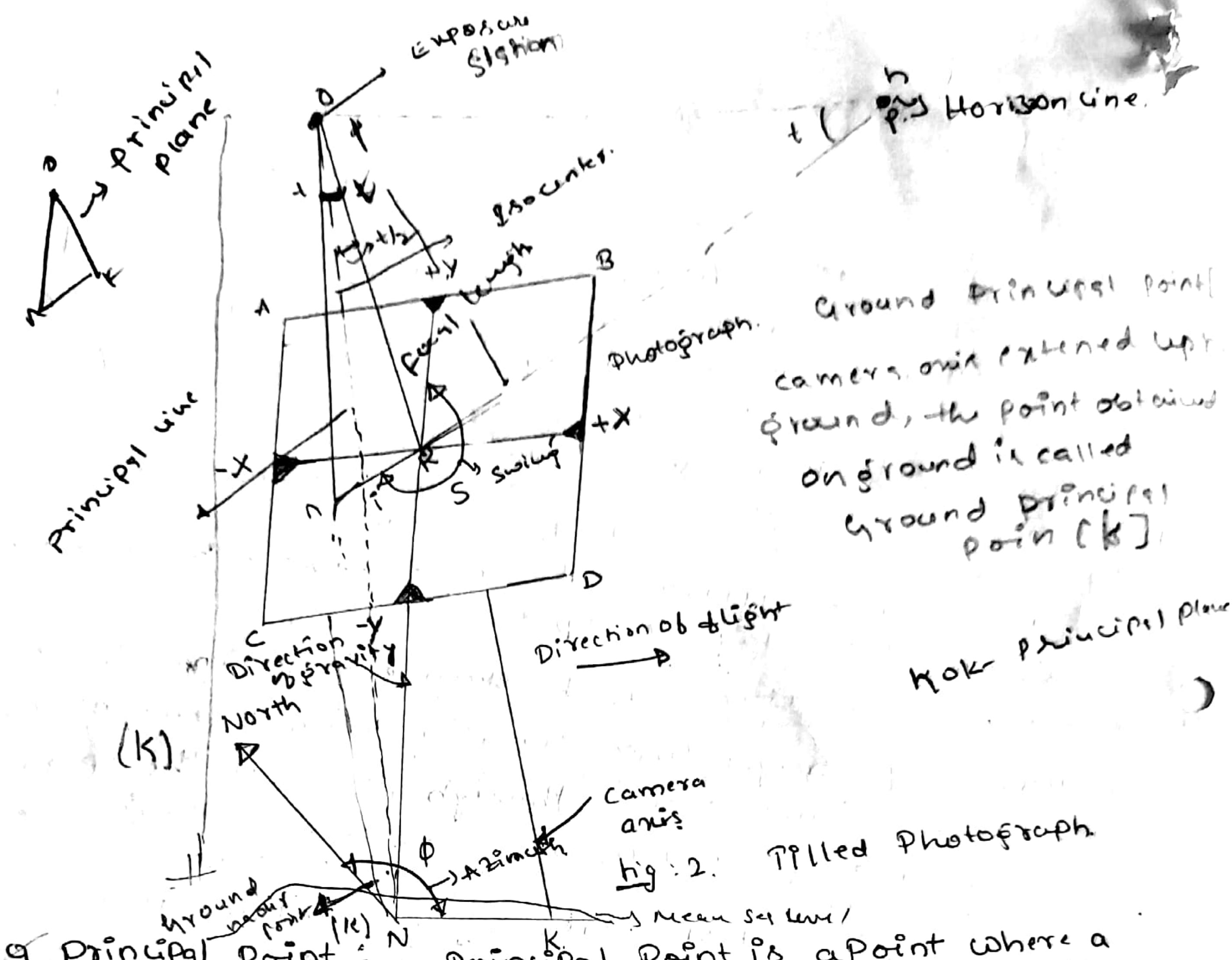
4. **Perspective Projection:** A Perspective Projection is the one Produced by straight lines radiating from a common [or selected] point and passing through point on the sphere to the plane of Projection. A Photograph is a perspective projection.

5. **Exposure station:** Exposure station is a point in space in the air, occupied by the camera lens at the instant of exposure; precisely it is the space position of the front nodal point at the instant of exposure.

6. **Flying height:** It is the elevation of the exposure station above the mean sea level (or) any other selected datum. vertical distance b/w the exposure station to the mean sea level

7. **Flight line:** It is the line drawn on a map to represent the track of the aircraft. traced

8. **Focal length:** It is the distance from the front nodal point of the lense to the plane of the photograph. [OK in fig.] It is also the distance of the image plane from the rear nodal point. Equivalent focal length is the distance of the image plane from the rear nodal point.



Ground Principal Point: camera axis extened up ground, the point obtained on ground is called Ground Principal Point (K)

KOK principal plane

Fig : 2. Tilled Photograph

9. <u>Principal Point</u> : Principal Point is a Point where a Perpendicular dropped from the front nodal Point strikes the Photograph. (Also it is the foot of a perpendicular to the image plane from the rear nodal Point in a camera lens system free from manufacturing errors).

This Principal Point is consider to coincide with the intersection of the x-axis & y-axis. In Fig. 2. K is the Principal Point. The Point K is known as the ground Principal Point. where the line OK produced meets the ground.

⑩ photo <u>Nadir Point</u> (n) Nadir point is a point where a Plumb line dropped from the front nodal Point pierces the Photograph. Thus in Fig 2 n is the nadir Point, which is a point on the Photograph vertically beneath the Exposure Station. This Point is also known as the photo-nadir (or) photo plumb point.

(n) It is a Point on Photograph obtained by dropping vertical line from camera centre. That plumb line extended up to ground given Ground Nadir Point (N)

(11) Ground nadir Point: [Ground plumb Point] : It is the datum intersection with the plumb line through the front nodal point. It is the point on the ground vertical beneath the exposure station such a point (N) in fig 2

(12) Tilt: It is the vertical angle defined by the intersection, at the exposure station of the optical axis with the plumb line. In fig 2 ∠Kon = t = tilt.

(13) Principal Plane : ~~It is defined as the Plane~~ Exposure Station the lens [O].

Principal plane is the plane defined by the the ground nadir point [N] & the principal point Produced to the ground [K]. It is the thus a vertical plane containing the optical axis, such as the plane nok NOK in fig 2. (or) exposure station (o), Ground nadir point (N) & ground principal point (P) plane NOK

(14) Principal line: A principal line is the line of intersection of the principal plane with the plane of the photograph. It is thus the line on a photograph obtained by joining the principal point and the photo nadir point. Such as the line nK in fig 2. (or) line of intersection of principal plane with photograph plane.

(15) Isocentre: Isocentre is the point in which the bisector of the angle of tilt meets the photographs. In fig 2. oi is the bisector and i is the Isocentre. the angle of tilt lies in the principle plane and hence the Isocentre (i) lies on the principal line at a distance of f tan t/2 from the principal point. On a vertical photograph, the Isocentre and the photo-nadir point coincide with the principal point.

(16) Azimuth of the principal plane: The azimuth of the principal plane [sometimes also known as the azimuth of the photograph] is the clockwise horizontal angle measured about the ground ~~naidr~~ nadir point from the ground survey north merdians to the principal ~~Point~~ plane of the photograph. such as the angle ϕ fig 2 It is thus the ground survey direction of the tilt.

(17) Swing: It is the angle measured in the plane of the photograph from positive y-axis clockwise to the nadir point. Thus in fig 2 s is the swing.

(18) **Axis of tilt:** It is a line in the plane of the photograph and is perpendicular to the principal line at the Isocenter

(19) Horizon point (h) : It is point of intersection of horizontal line through center of cunses & principal line (np) on photograph

Axis of tilt :

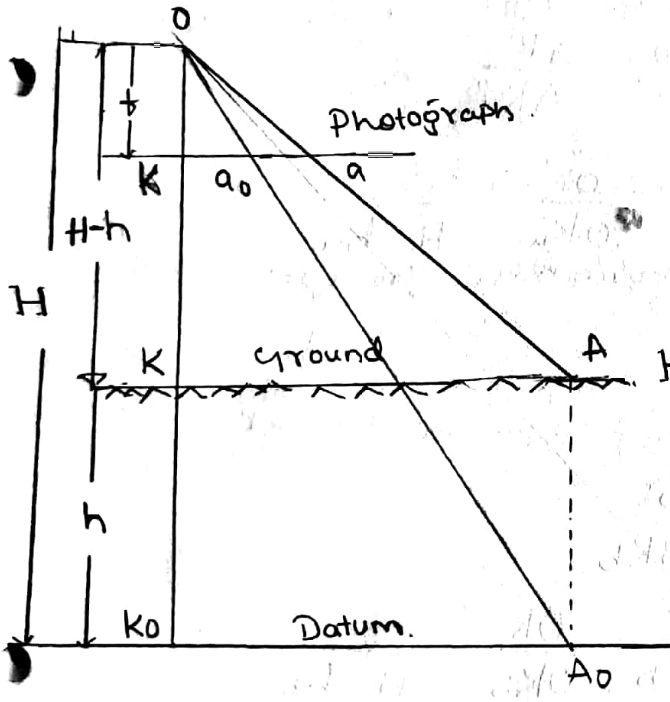
Isocenter (i) : ~~it is~~ the Point on photo where bisection of tilt falls on photo. [dotted line in sketches]

(5) **Flying height :** it is the vertical distance b/w the Exposure station to the Mean sea level.

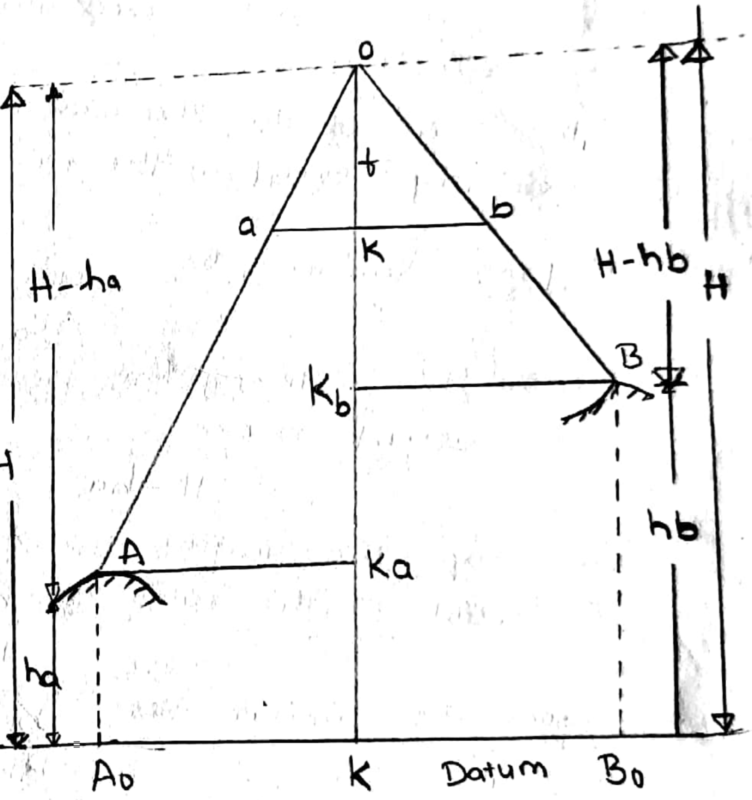
6) Azimuth (A) ; Clockwise horizontal angle measured about ground nadir point from true to the Principal plane of Photograph (ϕ)

Scale of Vertical Photograph

Since a Photograph is the Perspective, the image of ground Points are displaced where there are variations in the ground elevation. Thus in fig. The image of two Points A and Ao, Vertically above each other, are displaced on a vertical Photograph and are represented by a and ao respectively.. Due to this displacement, there is no uniform scale b/w the points on such a photograph. Except when the ground Points have the same elevation. If the elevation of Points vary, the scale of the vertical Photograph will vary from the point to Point on the photograph.



(a)



[b]

fig (a). Case [1] when the ground is horizontal, all the Points are having the same elevation.

$$S = \text{Scale} = \frac{\text{Map distance}}{\text{Ground distance}} = \frac{Ka \text{ (Photograph)}}{KA \text{ Ground}}$$

From the similar △les

△le OKa & △le OKA are similar △les

$$S = \frac{ak}{Aka} = \frac{OK}{OKa} = \frac{f}{(H-h)} \qquad S = \frac{OK^{(small)}}{KA(OK)} = \frac{f}{(H-h)}$$

$$\therefore S = \frac{ak}{Aka} = \frac{f}{(H-h)}$$

$$\boxed{S = \frac{f}{(H-h)}} \rightarrow 1$$

Where, H = height of the Exposure Station (or the c
Plane) above the mean sea level. (datum)

f = focal length of camera. lense

h = height of the ground above mean sea level.

O : Exposure station.

fig (b) case 2. When the Points are not having the same elevation.

Let A and B be two points having elevations ha and hb respectively above mean sea level. They are represented by a and b respectively on the map. K (small) is the Principal Point of the vertical Photograph taken at height H above the mean sea level.

The scale of the photograph at the elevation ha is evidently equal to the ratio, $\frac{ak}{AKa}$

From similar Δles $\frac{ak}{AKa} = \frac{ok}{OKa} = \frac{f}{H-ha}$

Hence the scale of the Photograph at the elevation ha is equal to : $\frac{f}{H-ha}$.

Similarly, the scale of the photograph at the elevation hb is equal to the ratio $\frac{bk}{BKb}$

from the similar Δles $\frac{bk}{BKb} = \frac{Ok}{OKb} = \frac{f}{H-hb}$

Hence the scale of the Photograph at the elevation hb is equal to = $\frac{f}{H-hb}$

In general, the scale of vertical Photograph is given by

$$\boxed{S_h = \frac{f}{H-h}}$$

Where S_h = Scale ~~of~~ at the elevation h.

The scale of the Photograph can also be designated by the representative fraction [Rh]. i.e

$$\boxed{Rh = \frac{1}{\left(\frac{H-h}{f}\right)}}$$

where (H-h) & f are Expressed in the same unit. ie (metres).

Datum scales [Sd] : The datum scale of a Photograph is that scale which would be effective over the entire Photograph, If all the ground Points are Projected vertically downwards on the mean sea level before being Photographed. (h=0)

Thus fig (a) Datum scale = $Sd = \frac{Ka}{KA_0} = \frac{ok}{OK} = \frac{f}{H}$

where K and A_0 are the Projections of K & A on the datum plane.

Average Scale [Sav] :

If all the ground Points were Projected vertically downward or upward on a plane representing the average elevation of the terrian before being Photographed.

Thus fig (b) $Sav = \frac{f}{H-h_{aver}}$

where h_{aver} = average elevation of the terrian.

$Sd = \frac{f}{H}$ where h=0

$Sav = \frac{f}{H-h_{av}}$

To Find the Scale of a Photograph.

If the images ~~of~~ ~~at~~ to ground Points of equal elevation and known horizontal distance appear on the Photograph, the scale of the Photograph can be determined by comparing the ground length and the corresponding length on the Photograph. Thus, if l is the distance on the Photograph b/w the two points A and B having the same elevation h and the horizontal distance [ground) b/w them to be L.

The scale at the height h is given by

$$\boxed{S_h = \frac{l}{L}}$$

The distance L measured on the ground either directly or by the triangulation, or it it can be taken from the existing maps, if available.

To find the average Photograph several known lines on the photograph should be measured and compared and the average scale should be adopted.

In case a reliable map of the area is avialable, The photographic scale can be found by comparing the photo distance and the map distance b/w two well defined points at the same elevation.

Thus $\frac{\text{Photo Scale}}{\text{Map Scale}} = \frac{\text{Photo distance}}{\text{Map distance}}$.

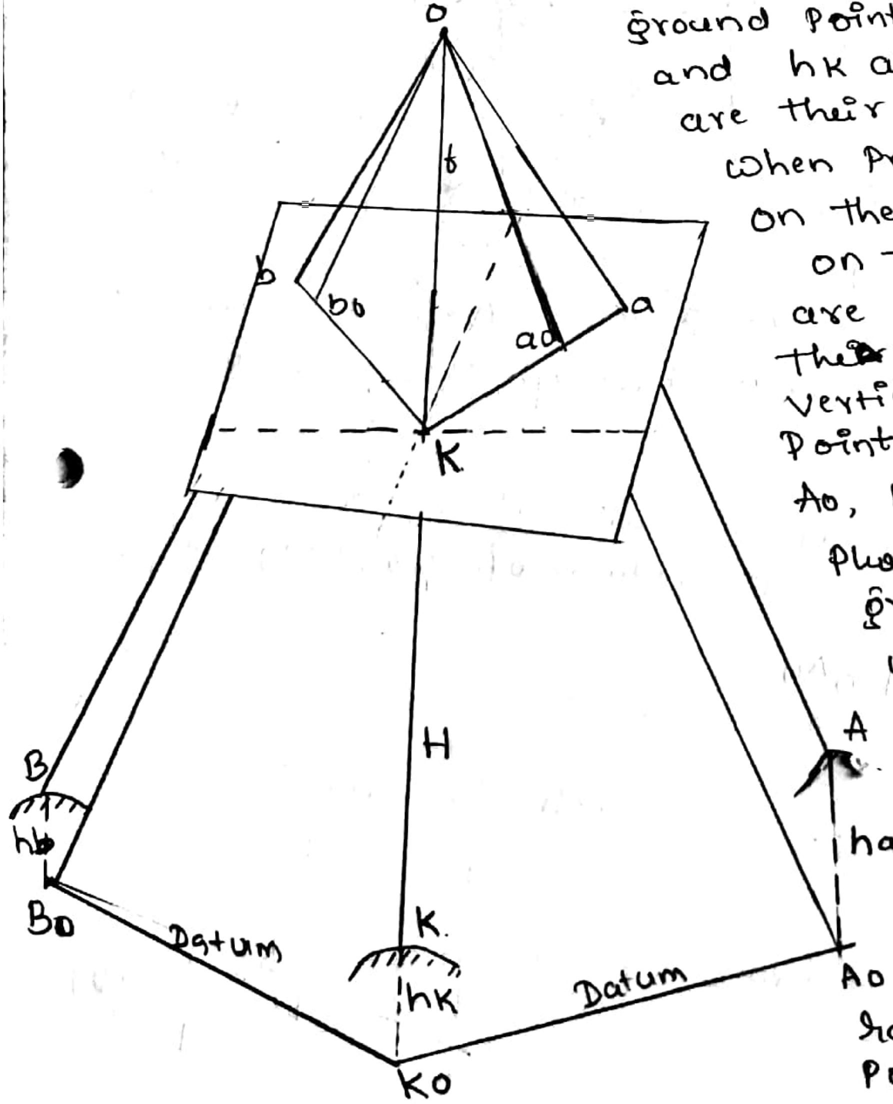
If the focal length of the lens and the flying height above mean sea level is known the scale can be found from the relation.

$$\boxed{S_h = \frac{f}{H-h}}$$

Relife Displacment on a Vertical Photograph

If the Photograph is truly vertical and the ground is horizontal, and the other sources of errors are neglected, the scale of the photograph will be uniform. such a photograph represents a true orthographic projection and hence the true map of the terrain.

In actual practice however, such conditions are never fulfilled. when the ground is not horizontal, the scale of the photograph varies from point to point and is not constant. Since the photograph is the perspective view, the ground is shown in perspective on the photograph. Every point on the photograph is therefore, displaced from their true orthographic position, This displacement is called relife displacement.



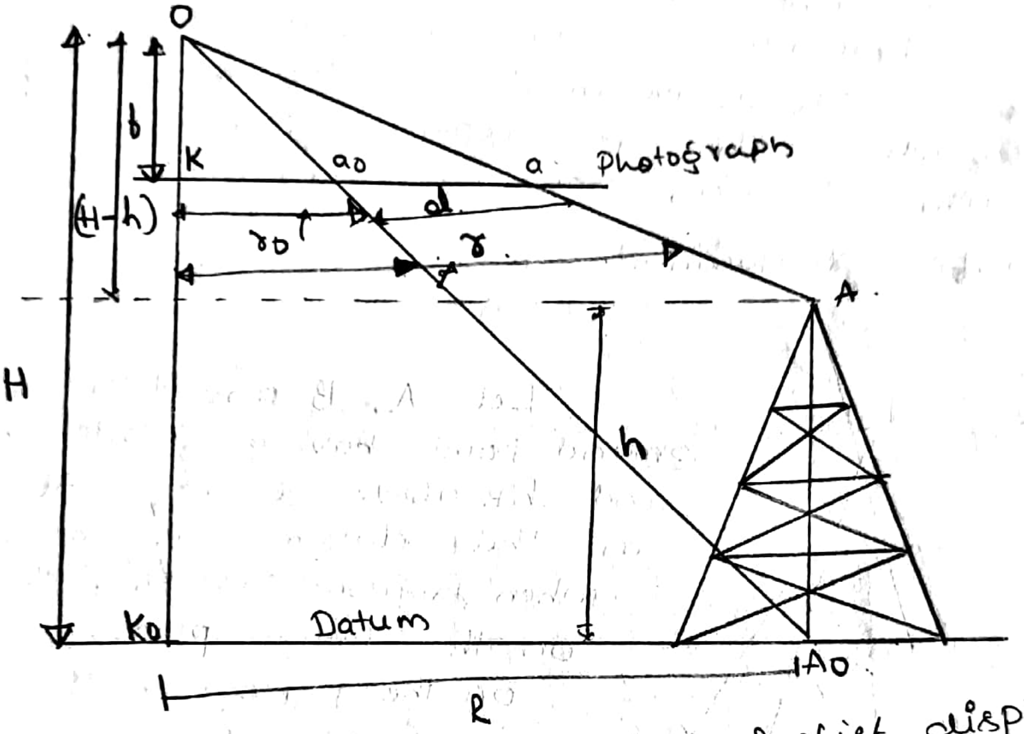
Let A, B and K are three ground points having elevations ha, hb and hK above datum. Ao, Bo, & Ko are their datum positions respectively when projected vertically downwards on the datum plane.

On the photograph their positions are a, b and K respectively. the points K being chosen vertically below the principal point. If the datum points Ao, Bo & Ko are imagined to be photographed along with the ground points, their positions will be ao, bo & K respective-ly. As is clear from the fig. The points a & b are displaced outward from their datum photographic positions. the displacement being along the corresponding radial lines from the principal points.

fig: Relief Displacement on Vertical Photograph.

The radial ~~displacement~~ distance aao is the relief displacement of A while bbo is the relief displacement of B. The Point K is not been displaced since it coincides with the Principal Point of the Photograph.

fig calculation of Relief Displacement.



To calculate the amount of relief displacement fig shows a vertical section through the Photograph of along the line Ka.

fig shows

Let r = radial distance a from K.

r_0 = radial distance of ao from K.

$R = K_oA_o$

Then from similar triangles

$$\frac{f}{H-h} = \frac{r}{R}$$ from which $\boxed{r = \frac{Rf}{H-h}}$ → ①

Also $h=0$

$$\frac{f}{H-h} = \frac{r_0}{R}$$ from which $\boxed{r_0 = \frac{Rf}{H}}$ → ②

Hence the relief displacement [d] is given by

$$d = r - r_0 = \frac{Rf}{H-h} - \frac{Rf}{H}$$

$$\boxed{d = \frac{Rfh}{H(H-h)}} \rightarrow ③$$

But $R = \frac{r(H-h)}{f} = \frac{r_0 H}{f}$ [from eq ① & ②]

Substituting the values of R in eq ③ we get

$$d = \frac{r(H-h)}{f} \cdot \frac{fh}{H(H-h)}$$

$$\boxed{d = \frac{rh}{H}} \longrightarrow \underline{\underline{4a}}$$

$$d = \frac{r_0 H}{f} \cdot \frac{fh}{H(H-h)} = \frac{r_0 h}{H-h}$$

$$\boxed{d = \frac{r_0 h}{H-h}} \rightarrow \text{(4b)}$$

Also from equations ③ & ④ above, we conclude the following

1. The relief displacement increases as the distance from the principal point increases.
2. The relief displacement decreases with the increase in the flying height.
3. For point above datum, the relif displacement is positive being radially outward.
4. For point below datum (h having negative value), relief displacement is negative radially inward.

3. The Relief displacement of the point vertically below the exposure station is zero.

In the above Expressions, H, E h must be measured above the same datum.

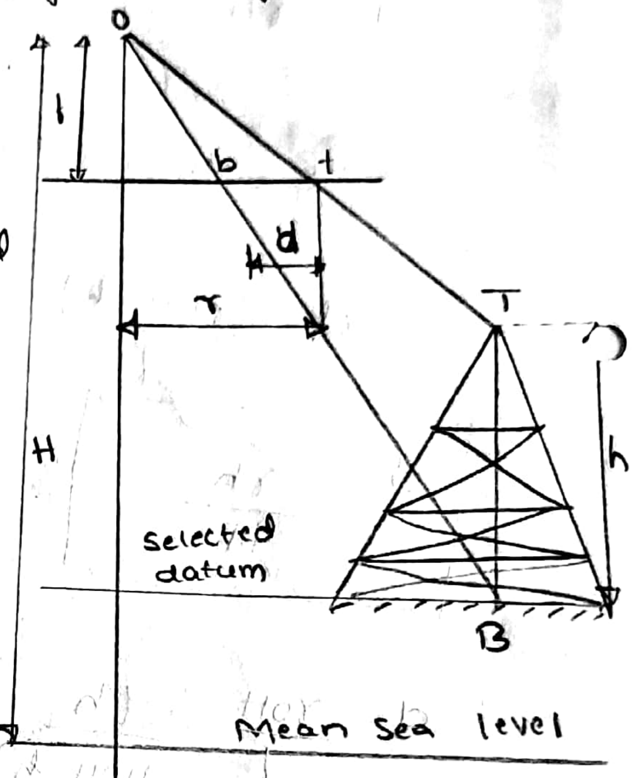
Height of object from Relief displacement.

It can be used to determine the height of any ~~so~~ object, such as a tower TB as shown in fig. Let h = be the height of the tower above its base.

H = be height (unknown) of the Exposure station above the selected datum passing through the base of the tower.

Let t E b be the top E bottom positions of the tower on the photograph.

The radial distance r and the relief displacement can very easily e measured. If the scale S of the hotograph is known. the height can be calculated from the relation.



Height of a Tower from Relief displacement.

$$S = \frac{f}{H} \rightarrow ①$$

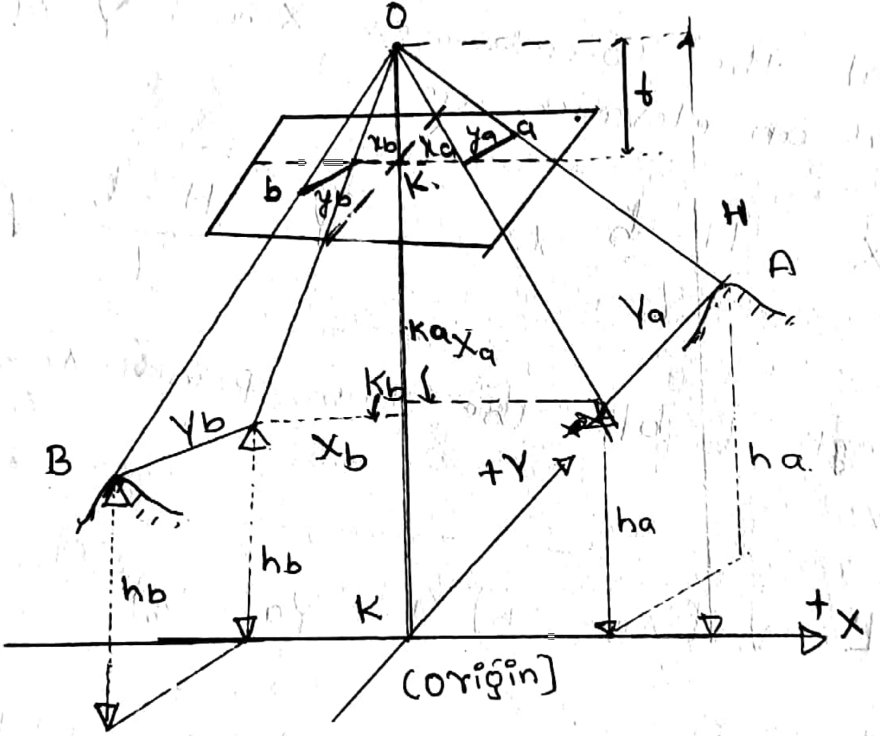
Knowing H and measuring d and r, the height h is calculated from equation (4a) Thus

$$h = \frac{dH}{r}$$

where h is the height of the tower above the selected datum with reference to which H has been computed. If the elevation of the bottom of the tower is known, the height of flight above mean sea level can be known

Computation of length of line b/w points of different Elevations from measurements on a Vertical Photograph.

Let A and B be two ground points having elevations ha and hb above datum and the co-ordinates (Xa, Ya), (Xb. Yb) respectively with respect to the ground co-ordinate ~~coi~~ with the axes which are coincide in the direction with the photographic co-ordinates x and y-axis. The origin of the ground co-ordinates lie vertically beneath the exposure station.



computation of length of a line.

Let a and b be the corresponding points of the Photograph and (xa, ya), (xb, yb) be the corresponding co-ordinates From similar triangles.

$$\frac{OK}{OKa} = \frac{xa}{Xa} = \frac{ya}{Ya} = \frac{f}{H-ha} \rightarrow ①$$

Also

$$\frac{OK}{OKb} = \frac{xb}{Xb} = \frac{yb}{Yb} = \frac{f}{H-hb} \rightarrow ②$$

Hence we have

$$\frac{x_a}{X_a} = \frac{f}{H-h_a} \qquad \frac{y_a}{Y_a} = \frac{f}{H-h_a}$$

$$\boxed{X_a = \frac{H-h_a}{f} \cdot x_a} \quad \boxed{Y_a = \frac{H-h_a}{f} \cdot y_a}$$

$$\frac{x_b}{X_b} = \frac{f}{H-h_b} \qquad \frac{y_b}{Y_b} = \frac{f}{H-h_b}$$

$$\boxed{X_b = \frac{H-h_b}{f} \cdot x_b} \quad \boxed{Y_b = \frac{H-h_b}{f} \cdot y_b}$$

In general the co-ordinates X and Y of any Point at an elevation are

$$\boxed{X = \frac{H-h}{f} \cdot x \qquad Y = \frac{H-h}{f} \cdot y}$$

The length L b/w the two Points A and B is then given by.

$$L = \sqrt{[X_a - X_b]^2 + (Y_a - Y_b)^2}$$

The value of Xa, Xb, Ya and Yb must be substituted with their proper algebraic signs.

Determination of Height [H] of lens for a vertical Photograph.

If the image of two Points A and B having different known elevations and known length b/w them appear on the Photograph, the elevation or height H of the exposure station can be calculated by a reversed Procedure from that of a preceding article

The ground length L is given by

$$L^2 = [X_a - X_b]^2 + [Y_a - Y_b]^2$$

Substituting the values of X_a, X_b, Y_a, & Y_b as obtained in the previous article.

We get

$$L^2 = \left[\frac{H - h_a}{f} \cdot x_a - \frac{H - h_b}{f} \cdot x_b\right]^2 + \left[\frac{H - h_a}{f} \cdot y_a - \frac{H - h_b}{f} y_b\right]^2$$

In the above expression, the ground distance L, and elevations h_a, and h_b are known quantities, The Photographic co-ordinates (x_a, y_a) (x_b, y_b) can be measured. The only unknown is H, collecting the terms for H. The equation takes in quadratic form.

$$pH^2 + qH + r = 0$$

Where P, q & r are the numbers obtained after substituting the values of the known quantities.

The values of H is then obtained by

$$H = \frac{-q + \sqrt{q^2 - 4pr}}{2P}$$

The computations of H by the solution of quadratic equation is rather very tedious and time consuming. Alternately. the value of H can be determined by successive approximations as follows,

Step: 1 The first approximate value of H is obtained from the scale relationship.

$$\frac{f}{H_{approx} - h_{ab}} = \frac{ab}{AB} = \frac{l}{L} \qquad \frac{f}{H_{app} - h_{ab}} = \frac{l}{L}$$

Where
h_{ab}: average elevation of line AB.
$AB = L$ = Known ground distance
$ab = l$ = Measured Photographic distance.
f : focal length of camera

Step: 2 The approximate value of H so obtained is used for calculating the co-ordinates $[X_a, Y_a]$ and $[X_b, Y_b]$ using these co-ordinates, the approximate value of H and the elevations h_a and h_b, the length of the line is computed. Length is then compared with the actual distance to get a more correct value of H.

Thus

$$\frac{H - h_{ab}}{H_{approx} - h_{ab}} = \frac{\text{correct } AB}{\text{computed } AB}$$

Step: 3 With this value of H. step 2 is repeated till the computed length of AB and the corrected length agree within necessary precision, usually 1 in 5000.

June-July - 2017

Problems on ~~vertical~~ Scale of a vertical Photograph

1. A vertical Photograph was taken at an altitude of 1200 m metres above mean sea level. Determine the scale of the Photograph for terrain lying at elevations of 80 metres & 300 metres. if the focal length of the camera is 15cm.

→ Given. H = 1200m, ha = 80m, hb = 300m, f = 15cm

f = 15×10

f = 150mm

$f = \frac{150}{1000}$

f = 0.15m

$S_h = \frac{f}{H-h}$

where h_a = 80mts.

we have

$S_{80} = \frac{f}{H-h_a} = \frac{0.15}{1200-80} = \frac{1}{7466.67}$ (or) $\frac{15cm}{(1200-80)} = \frac{1cm}{74.67m}$

$\boxed{S_{80} = \frac{1}{7466.67}}$ $\boxed{1cm = 74.67m}$

Similarly at h = 300m $S_{300} = \frac{15cm}{1200-300} = \frac{15cm}{900m} = \frac{1cm}{60m}$

$\boxed{1cm = 60m}$

(or) $\frac{0.15}{1200-300} = \frac{1}{6000}$

(02) A camera having focal length of 20cm is used to take a vertical photograph to a terrain having an average elevation of 1500 metres. what is the height above mean sea level at which an air-craft must fly in order to get the scale of 1:8000?

→ ~~The~~ scale ~~Expressed~~ as ~~R.f is given~~ by

Given f = 20cm

f = 200mm = 0.2m

hav = 1500m

Sav = 1:8000

$\cancel{R} = \frac{f}{H-h}$

$S_{av} = \frac{f}{H-h_{av}} = \frac{1}{8000} = \frac{0.2}{H-1500}$

0.2×8000 = H − 1500

1600 = (H − 1500) = H = 1600 + 1500

$\boxed{H = 3100m}$ above the Mean sea level.

3. A line AB, ~~2000m~~ 2000m long, lying at an elevation of 500m measures 8.65cm on a vertical photograph for which focal length is 20cm. Determine the scale of the photograph in an area the average elevation of which is about 800m.

→ Given LAB : 2000m, h=500m, Lab = 8.65cm = 8.65×10 = 86.5mm

f = 20cm = 200mm, = 0.2m   hav = 800m.   Sav = ?

Lab = $\frac{86.5}{1000}$

Lab = 0.0865m

Lab = $\frac{8.65cm}{100}$ = 0.0865m

Scale = $\frac{\text{mape distance}}{\text{Ground distance}} = \frac{f}{H-h}$

$S = \frac{Lab}{LAB}$ $S = \frac{0.0865m}{2000m}$

$S = \frac{86.5mm}{2000m}$ $\frac{1}{0.04325}$ = 23.12mm = 23.12×1000

$S = \frac{1}{23121.3m}$

S : ① in 23121.3m

$\frac{1}{23121.3} = \frac{0.2m}{H-500}$

(H−500) = 0.2×23121.3

(H−500) = 4624.27

H = 4624.27+500

$\boxed{H = 5124.27m}$

$S800 = \frac{~~f~~ f}{H-hav} = \frac{0.2m}{(5124.27-800)m}$

$\boxed{S800 = \frac{1m}{21621.38m}}$

1m : 21621.38m

4. A section line AB appears to be 10.16cm on a photograph for which the focal length is 16cm. The corresponding line measu 2.54cm on a map which is to a scale 1/50,000. The terrain has an average elevation of 200m above mean sea level. Calcul the flying altitude of the air craft, above mean sea level when the photograph was taken.

→ Given Lab = 10.16cm = $\frac{10.16cm}{100}$ = 0.1016m

f = 16cm = $\frac{16}{100}$ = 0.16m

Lab = 2.54cm : 0.0254m. $s = \frac{1}{50,000}$

Lab = $\frac{2.54cm}{100}$

0.0254m hav = 200m

$$S = \frac{Lab}{LAB} = \frac{\text{Map Distance}}{\text{Ground Distance}}$$

$$\frac{1}{50,000} = \frac{0.0254}{LAB}$$

$$LAB = 0.0254 \times 50,000$$

$$\boxed{LAB = 1270m}$$

$$S = \frac{Lab}{LAB} = \frac{0.1016m}{1270m} \overset{8 \times 10^{-05}}{=} \frac{1}{12,500}.$$

$$S = \frac{\text{photo distance}}{\text{ground distance}}$$

$$S = \frac{f}{H - hav} = \frac{1}{12,500} = \frac{0.16}{H - 200}$$

$$H - 200 = 0.16 \times 12,500$$

$$H - 200 = 2000$$

$$H = 2000 + 200$$

$$\boxed{H = 2200m}$$

(05) Two Points A and B having elevations of 500m and 3 respectively above datum appear on the vertical photograph having focal length of 20cm and flying altitude of 2500m above datum, Their corrected Photographic co-ordinate are as follows.

Point	Photographic co-ordinates	
	x (cm)	y (cm)
a	+2.65	+ 1.36
b	− 1.92	+ 3.65

Determine the length of the ground line AB.

→ **Given** $h_a = 500m$, $h_b = 300m$

$b = 20cm$

$b = 200mm$, $H = 2500m$

$= 200 \times 10^{-3}m$

$\underline{\underline{b = 0.2m}}$

$x_a = 26.5mm = 26.5 \times 10^{-3}m$

$x_b = -19.2mm = -19.2 \times 10^{-3}m$

$y_a = 13.6mm = 13.6 \times 10^{-3}m$

$y_b = 36.5mm = 36.5 \times 10^{-3}m$

The Ground co-ordinates ar given by

$$X_a = \frac{H - h_a}{b} \cdot x_a = \quad X_a = \frac{(2500 - 500)}{200 \times 10^{-3}} \times 26.5 \times 10^{-3}$$

$X_a = +265m$

$$Y_a = \frac{H - h_a}{b} \cdot y_a = \quad Y_a = \frac{(2500 - 500)}{200 \times 10^{-3}} \times 13.6 \times 10^{-3}$$

$Y_a = +136m$

$$X_b = \frac{H - h_b}{b} \cdot x_b = \quad X_b = \frac{[2500 - 300]}{200 \times 10^{-3}} \times -19.2 \times 10^{-3}$$

$X_b = -211.2m$

$$Y_b = \frac{H - h_b}{b} \cdot y_b = \quad Y_b = \frac{[2500 - 300]}{200 \times 10^{-3}} \times 36.5 \times 10^{-3}$$

$Y_b = +401.5m$

$$AB = \sqrt{(X_a - X_b)^2 + [Y_a - Y_b)^2}$$

$$(X_a - X_b)^2 = (265 - (-211.2))^2 = 22.67 \times 10^4 \ m^2$$

$$(Y_a - Y_b)^2 = [\overset{136}{\cancel{13.6}} \overset{-}{\cancel{+}} 401.5]^2 = 7.049 \times 10^4 \ m^2$$

$$AB = \sqrt{22.67 \times 10^6 + 7.049 \times 10^4}$$

$$\boxed{AB = 545m}$$

(Q6a) The ground length of a line AB is known to be 545m and the elevations of A and B are respectively 500m and 300m above MSL. On a vertical photograph taken with a camera having focal length of 20cm include the images a and b of these points and their photographic co-ordinates.

(x_a = +2.65cm, y_a = + ~~1.3~~ 1.36cm), (x_b = −1.92cm, ~~y_b~~

y_b = +3.65cm)

The distance ab scaled directly from the photograph is 5.112cm. Compute the flying height above the mean sea level.

⇒ From the scale relationship, the approximate height can be calculated from

$$\frac{f}{H_{approx} - h_{average}} = \frac{ab}{AB}$$

$$h_{average} = \frac{1}{2}(h_a + h_b)$$

$$= \frac{1}{2}[500+300]$$

$$h_{average} = 400m$$

$$\frac{0.2}{(H_{approx} - 400)} = \frac{0.05112}{545}$$

$$H_{approx} - 400 = \frac{0.2 \times 545}{0.05112}$$

$$H_{approx} = 2132.23 + 400$$

$$\boxed{H_{approx} = 2532.23m}$$

Given Data

L_{AB} = 545m

h_a = 500m

h_b = 300m

L_{ab} = $\frac{5.112cm}{100}$ = 0.05112m

L_{ab} = 51.12mm = 0.05112m

H = ?

f = 20cm = 0.2m

x_a = 0.0265m

x_b = 0.0136m

y_a = 0.0192

y_b = 0.0365m

Using this approximate height, the ground co-ordinates of A and B are calculated from

$$X_a = \frac{H - h_a}{f} \cdot x_a = \frac{2532.2 - 500}{\cancel{20}0.2} \times \overset{0.0265}{\cancel{2.65}} = +269.3m$$

$$Y_a = \frac{H - h_a}{f} \cdot y_a = \frac{2532.2 - 500}{\cancel{20}0.2} \times \overset{0.0136}{\cancel{1.36}} = +138.189m$$

$$X_b = \frac{H - h_b}{f} \cdot x_b = \frac{2532.2 - 300}{\cancel{20}0.2} \times [-\overset{(-0.0192)}{\cancel{1.92}}] = -214.29m$$

$$Y_b = \frac{H - h_b}{f} \cdot y_b = \frac{2532.2 - 300}{\cancel{20}0.2} \times 0.0365 = +407.3m$$

The ground length based on the approximate height is given by

$$L = \sqrt{(269.3+214.3)^2 + [138.2 - 407.3)^2}$$

$$\boxed{L = 553.4m}$$

The actual ground length is 545m.
The second approximate height is calculated as follows

$$\frac{H - h_{ab}}{H_{approx} - h_{ab}} = \frac{\text{corrected } AB}{\text{computed } AB}$$

$$\frac{H - 400}{2532.2 - 400} = \frac{545}{553.4}$$

$$(H - 400) \cancel{553.4} = \frac{545[2532.2 - 400]}{553.4}$$

$$H - 400 = 2099.83$$

$$H = 2499.8$$

$$\boxed{H = 2500m}$$

using this value of H to calculate the co-ordinates we

$$X_a = \frac{(2500 - 500)}{\cancel{20}0.2} \times 0.0265 = +265$$

$b = \frac{2500 - 300}{0.2} \times (-0.0192) = -211.2m.$

$Y_a = \frac{2500 - 500}{0.2} \times 0.0136 = +136m$

$Y_b = \frac{2500 - 300}{0.2} \times 0.0365 = +401.5m.$

$L = \sqrt{(265 + 211.2)^2 + (136 - 401.5)^2}$

$\boxed{L = 545m}$

This agrees with the measured length.
Hence height of lens = 2500m.

(27) The distance from the principal point to an image on a photograph is 6.44cm & the elevation of the object above the datum ~~xx~~ [sea level] is 250m. what is the relief displacement of the point. if the datum scale is 1/10,000 and the focal length of the camera is 20cm?

→ given

$r = 6.44$

$r = \frac{6.44}{100} = 0.064m$

$f = \frac{20cm}{100} = 0.20m$

$r = 6.44cm = 64.4mm = 0.644m$

$h = 250m$

$d = ?$

$Sd = \frac{1}{10,000}$

20cm = 200m

$f = 0.2m$

$Sd = \frac{f}{H}$

$\frac{1}{10,000} \times \frac{0.2}{H}$

$H = 0.2 \times 10,000$

$\boxed{H = 2000m.}$

$d = \frac{rh}{H}$

$d = \frac{0.644 \times 250}{2000} = 0.0805 m$

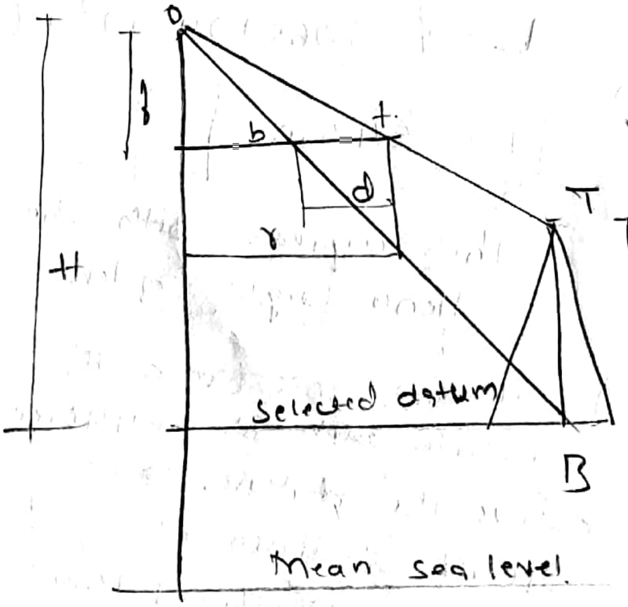
$\boxed{d = 8.05mm}$

(08) A vertical photograph of a flat area having an average elevation of 250metres above mean sea level was taken with a camera having a focal length of 20cm. A section line AB, 250 m long in the area, measure 8.50cm on the photograph. A tower TB in the area also appears on the photograph. The distance b/w the images of top and bottom of the tower measures 0.46cm on the photograph. The distance of the image of the top of the tower is 6.46cm. Determine the height of the tower.

~> Scale $= \frac{\text{Map distance}}{\text{Ground distance}} = \frac{f}{H}$

H = height of camera above the selected datum.

Let the average ground be the selected datum



~~8.50~~ (map distance)

$$\frac{0.085}{250.0} = \frac{0.2}{H}$$

$$H = \frac{0.2 \times 250}{0.085}$$

$$\boxed{H = 588.23m}$$

Again, the height of the tower above its base is given by

$$h = \frac{dH}{r} = \frac{~~0.46~~\ 4.6 \times 10^{-3} \times 588.23}{0.0646}$$

$$\boxed{h = 41.88m}$$

h.av = 250.m

f = 20cm $\frac{20}{100}$

$\boxed{f = 0.2m}$

LAB = 250m

~~LAB~~

lab = 8.50cm

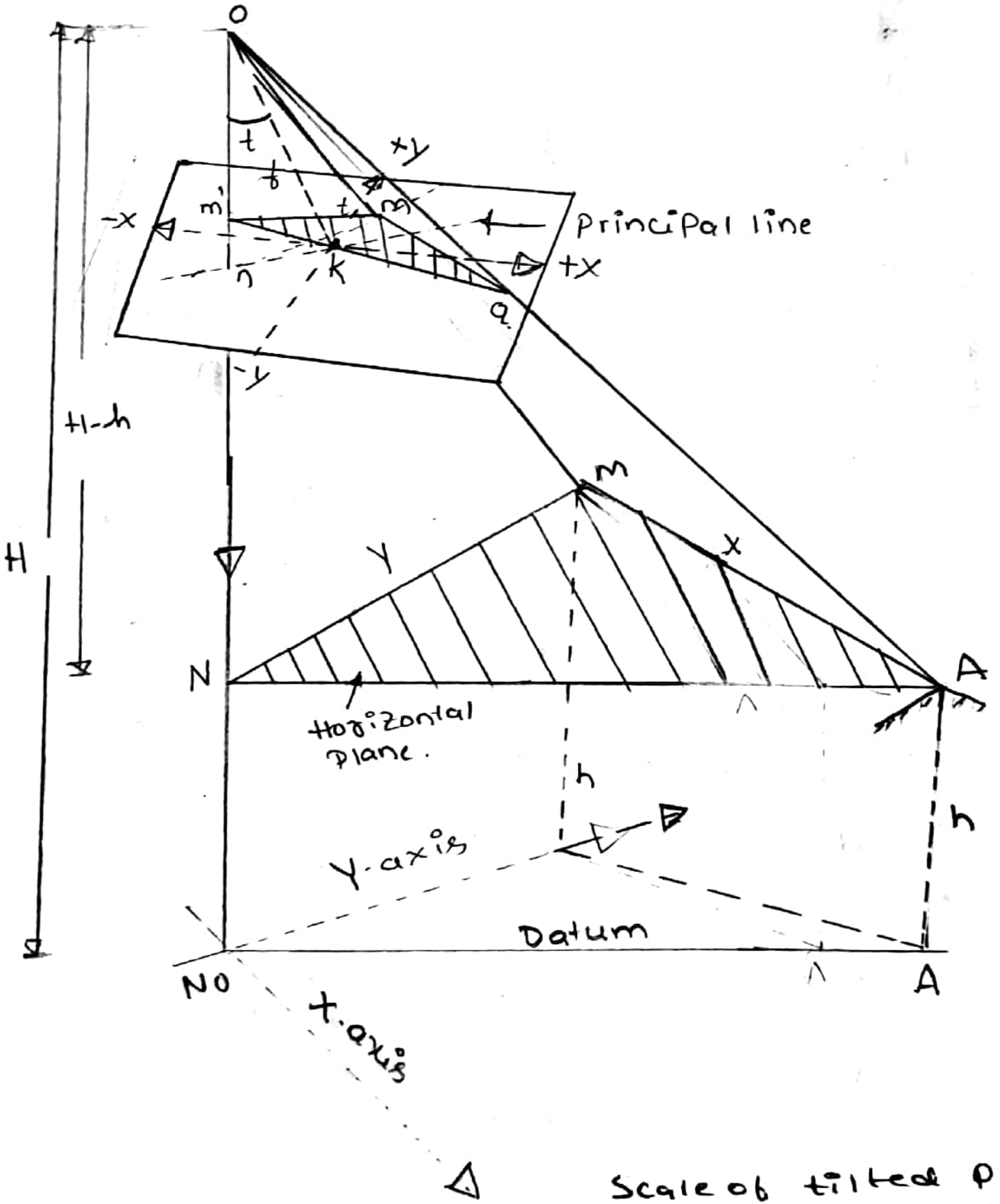
= 0.850m

$\boxed{d = b~~b~~ = 0.46 \times 10^{-3}m}$

r = 0.0646m

Scale of a tilted Photograph :-

In Case of vertical Photograph the scale is uniform, from point to point, only if the ground is flat and has uniform elevation throughout. If the elevations of the point vary, the scale also varies. If a tilted Photograph [or near vertical photograph) is taken over an area having no relief, the scale will not be uniform. The downward half of the Photograph will have a larger scale than the upward half.



Scale of tilted Photograph

The problem becomes still more complicated if a tilted Photograph is taken over an area with relief. ~~The Position of the~~ To determine the scale of the Photograph from point to point in such a case, the position of the points must be known with respect to the principal line. also determine the tilt, swing, flying height, focal length and & the elevation of the point must be also known.

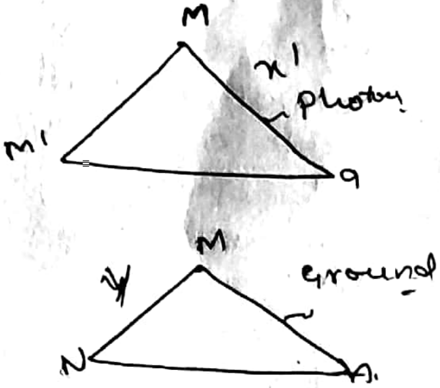
as M'ma & NMA are in horizontal planes,

~~[illegible]~~

We have

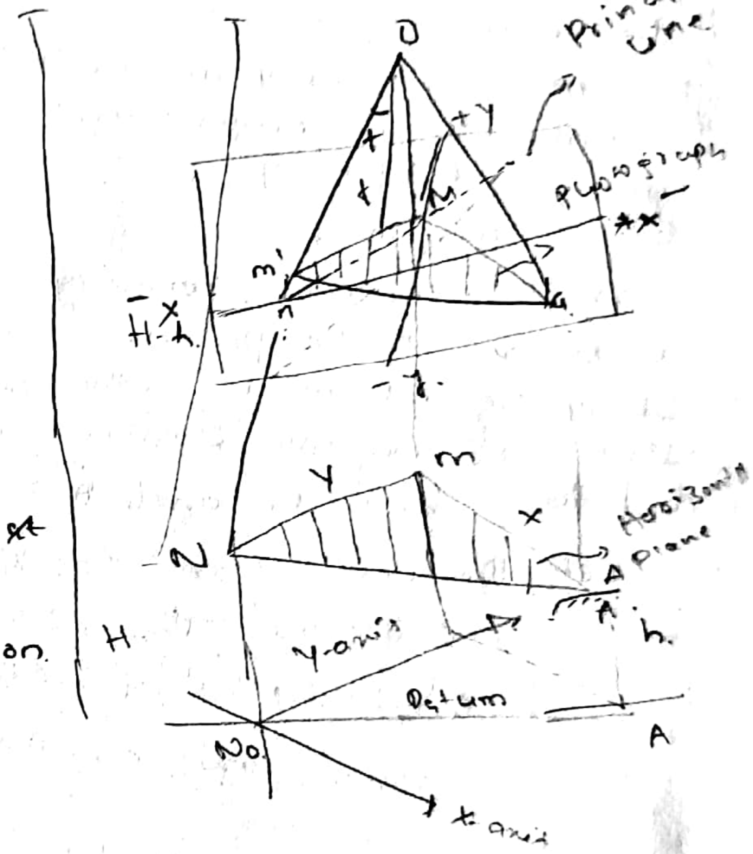
Sh =

$\text{cost} = \frac{M'm}{\;}$



Let N and M be the points on on and om extended, at heights of h above datum. Thus N, M and A have the same elevation. The triangle NMA is in a horizontal plane.

From the similar △les om'a and ONA, we get.



$$\frac{m'a}{NA} = \frac{om'}{ON} \rightarrow eq ①$$

$$om' = on - m'n$$

$$= f\sec t - mn\sin t.$$

$$ON = ONo - NNo$$

$$= H - h.$$

$$\frac{m'a}{NA} = \frac{\text{map distance}}{\text{ground distance}} = \text{scale at}$$

scale at a point whose elevation is $h = S_1$

Substituting the values in eq ①
we get

$$\boxed{S_h = \frac{f\sec t - mn\sin t}{H-h}} \rightarrow ②$$

In the above expression mn is the distance along the principal line, b/w the photo nadir and the foot of the perpendicular from the point under consideration. To find its value. Let us consider the system of co-ordinates axes illustrated in this

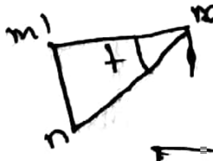
$on = \frac{f}{\cos t}$

$on = f\cdot\sec t$

$\cos t = \frac{ok}{on} = \frac{f}{on}$

$\sec t = \frac{on}{f}$

$$\boxed{on = f\cdot\sec t}$$

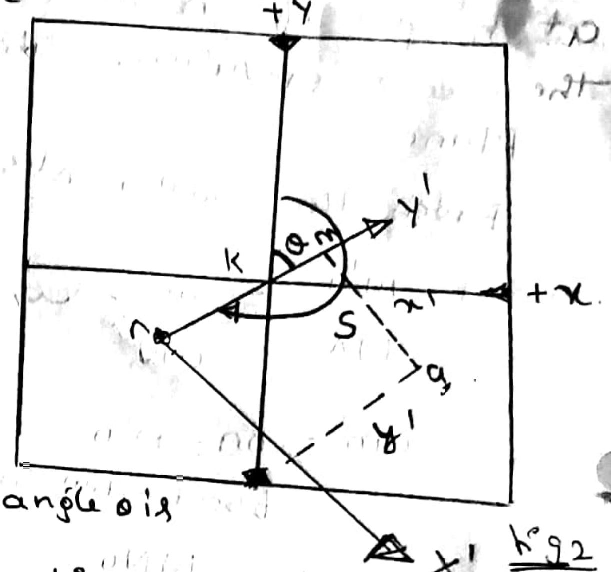


$\sin t = \frac{m'n}{mn}$

$$\boxed{m'n = mn\sin t}$$

Let the Photographic co-ordinates of the image a be x and y.

Let s be the angle of swing and θ be the angle b/w the y-axis and the Principal line.



If the y-axis be rotated to the Position of the Principal line, The new axis (or y' axis) will be Inclined to the original axis by an angle θ given by

$$\theta = 180 - s$$

As in analytic geometry, the angle θ is considered to be positive when the rotation is in the counter-clockwise direction. & Negative when it is in the clockwise direction. Thus the angle θ in fig. is negative.

fig: Co-ordinate Axes Through Plumb Point.

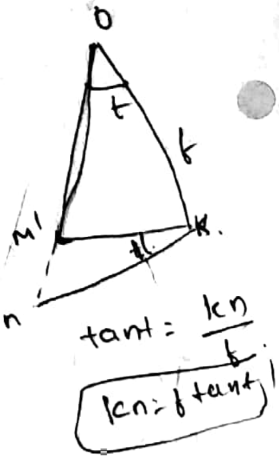
Let the new x-axis (or x'-axis) be selected through the nadir point n.. The distance kn is equal to f tant. The co-ordinates (x', y') of the Point a with reference to the x' and y' axis are given by.

$$x' = x\cos\theta + y\sin\theta. \rightarrow ①$$

$$y' = -x\sin\theta + y\cos\theta + f\tan t. \rightarrow ②$$

The distance nm is therefore equal to y'.

Substituting this in eq ②.

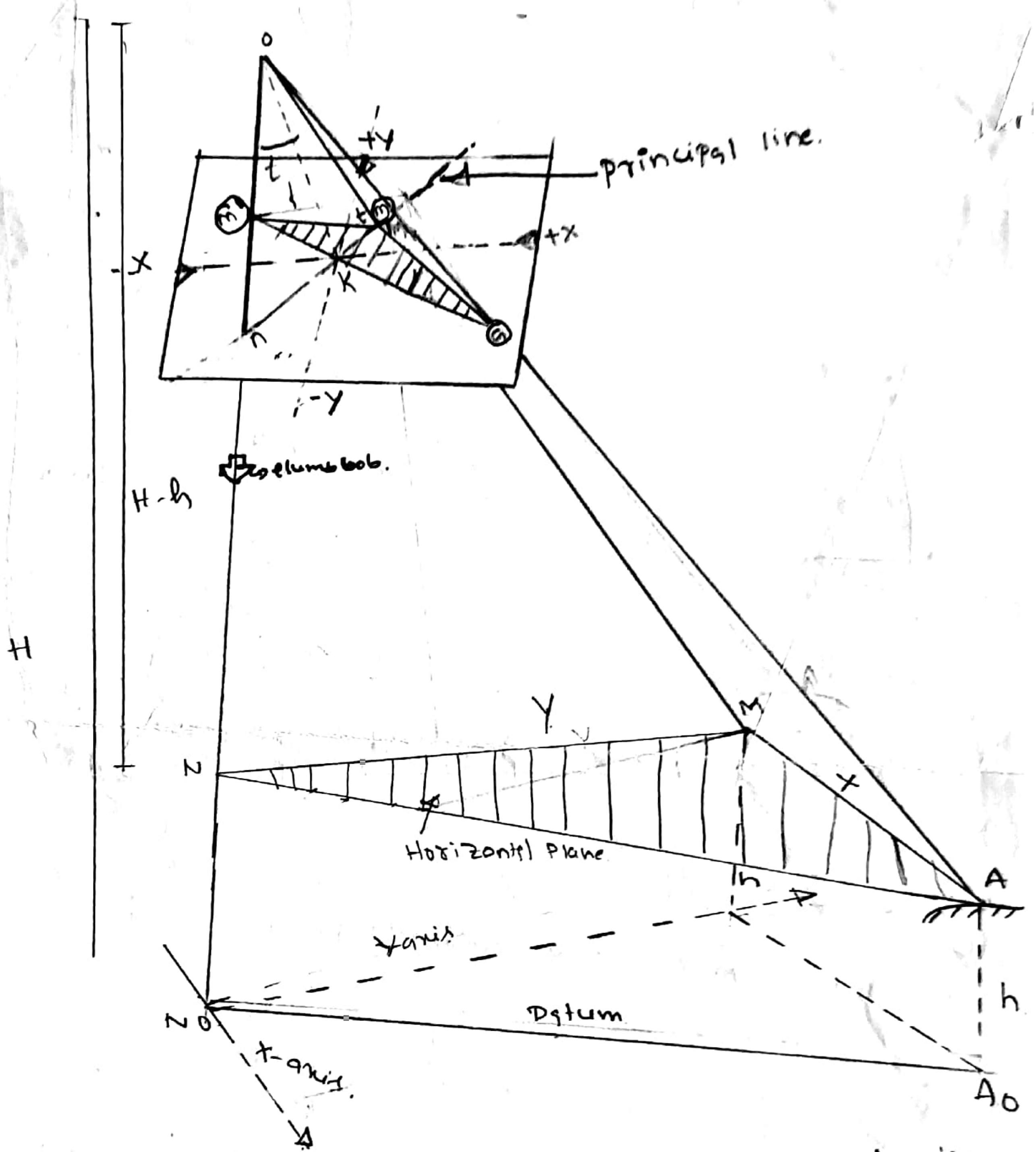


$$\boxed{S_h = \frac{f\sec t - y'\sin t}{H - h}} \rightarrow ③$$

Where y' is the local y co-ordinate.

Since y' is the same for the points on the line ma. Hence the scale, which is the linear function of y is constant for all the points on a line Perpendicular to the Principal line.

Scale of a Tilted Photograph:



Let M & N be the Points on on & om extended, at heights of h above datum, Then N, M, & A have the same elevations. The Δ. NMA is in a horizontal plane. From the similar Δs om'a & ONA we set

$$\frac{m'a}{NA} = \frac{om'}{ON} = \frac{\text{Map distance}}{\text{Ground distance}}$$ = Scale of the point on tilted photograph.

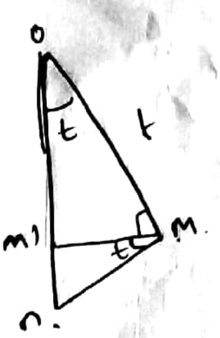
$om' = on - m'n = f\sec t - mn\sin t$

$ON = ON_0 - NN_0$

$= H - h.$

$$\boxed{s = \frac{f\sec t - mn\sin t}{H-h}}$$

$$\boxed{S_h = \frac{f\sec t - mn\sin t}{H-h}}$$



$\frac{1}{\sin\theta} = \sec t.$

$\sec t = \frac{on}{f}.$

$\boxed{on = f\cdot\sec\cdot t}$

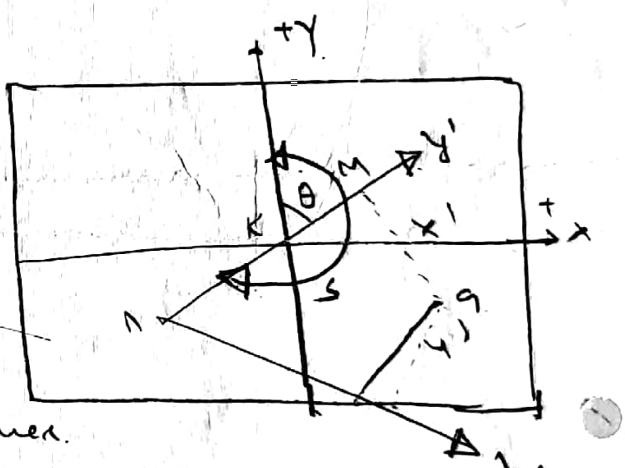
$\sin t = \frac{m'm}{mn.}$

$\boxed{m'n = \sin t \cdot mn}$

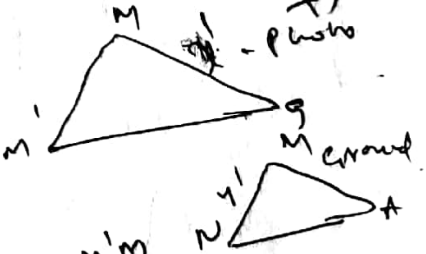
$\cos t = \frac{m'm}{mn}$

~~kn~~ $= \tan t = \frac{kn}{f}$

$\boxed{kn = f\tan t}$



Ⓛ as. m'ms & NMA are in horizontal plane.



$S_h = \frac{am}{AM}$

$am = x'$ $\quad AM = X$ $\quad S_h = \frac{f\sec t - y'\sin t}{H-h}$

$\frac{f\sec t - y'\sin t}{H-h} = \frac{x'}{X.}$

$$\boxed{AM = X = \frac{(H-h)x'}{f\sec t - y'\sin t}}$$

iily

$S_h = \frac{m'm}{NM.}$

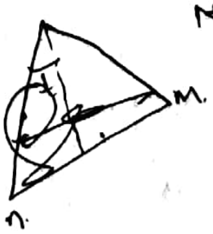
~~NM~~ $= y'.$

$\cos t = \frac{m'm}{mn.}$

$m'm = mn\cos t.$

$m'm = y'\cos t.$

$Nm = Y.$



$S_h = \frac{f\sec t - y'\sin t.}{H-h.}$

$NM = Y = \frac{H-h.}{f\sec t - y'\sin t}\, y'\cos t.$

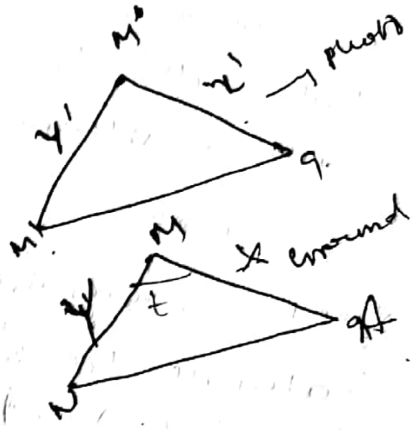
Scanned by CamScanner

Computation of length ob line b/w points of different elevations from measurements on a tilted photograph.

In fig ① triangles m'ma and ~~[illegible]~~ NMA are in horizontal planes. From the scale relationship we have (fig 2).

$$S_h = \frac{am}{Am}$$

But $am = x'$ [from fig ② $Am = X$.



$$S_h : \frac{b\sec t - y'\sin t}{H-h}$$

substituting the value, we get

$$Am = X = \frac{H-h}{b\sec t - y'\sin t} \times x'$$

$$\boxed{X_a = \frac{H-h}{b\sec t - y'\sin t} \; x_a' \qquad X_b = \frac{H-h}{b\sec t - y'\sin t} \; x_b'}$$

similarly from scale relationship we have $S_h = \frac{m'm}{Nm}$.

But $m'm = mm' \cos t$ $\cos t = y'\cos t$, $NM = Y$.

$$S_h = \frac{b\sec t - y'\sin t}{H-h}$$

cos

substituting the value we get

$$NM = Y = \frac{H-h}{b\sec t - y'\sin t} \cdot y'\cos t$$

$$\boxed{Y_a = \frac{H-h}{f\sec t - y'\sin t} \cdot y'\cos t \qquad Y_b = \frac{H-h}{f\sec t - y'\sin t} \; y'\cos t}$$

Thus the ground co-ordinates (x, y) of any point are known.

If ~~there~~ there are two points A and B, their ground co-ordinates (X_a, Y_a) & (X_b, Y_b) can be calculated & the length of L of the line AB computed from the expression.

$$L = \sqrt{(X_a - X_b)^2 + (Y_a - Y_b)^2}$$

$$\frac{am}{AM} = \frac{f\sec t - y'\sin t}{H-h}$$

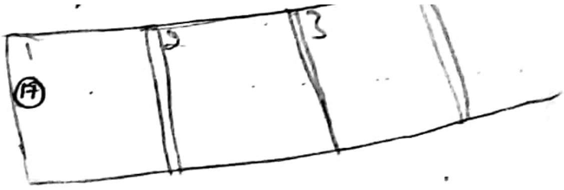
$(H-h)\, x'$ $=$ $Am = X$

Determination of flying height for a tilted Photograph

If the images of two points A and B having different known elevations and known length b/w them appear on a tilted Photograph, the elevation (or) height H of the exposure station can be determined exactly in the same way as discussed in

The method is outlined in the following steps.

Step 1: From the photographic co-ordinates (x_a, y_a), (x_b, y_b), calculate the Photographic length ab (or scale it directly from the Photograph. From the existing maps, (or) another sources the ground length of AB is known. calculate



Overlaps:-

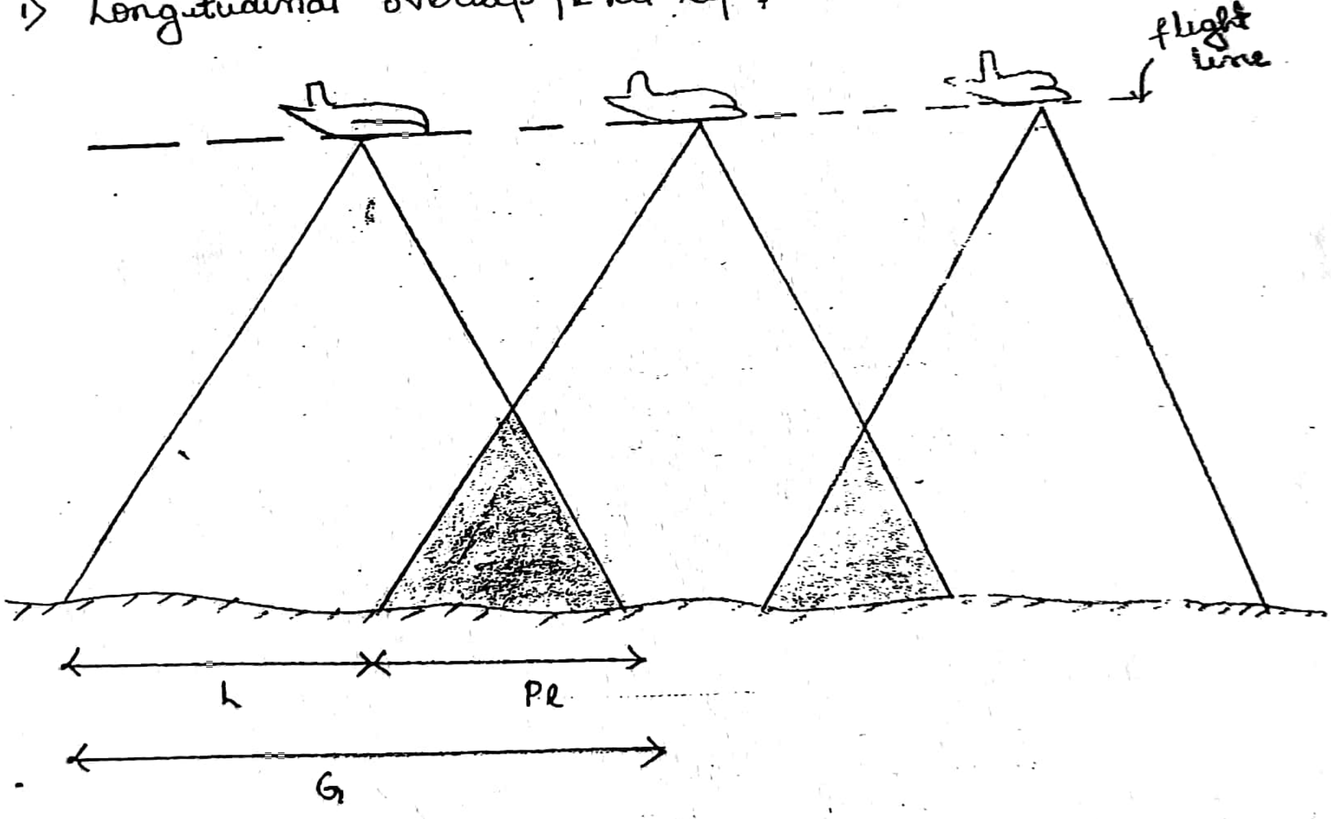
Vertical aerial photography is usually done along flight strips g suitable width, having some common overlapping in a successive photographs.

There are two types of photographic overlaps

1> Longitudinal overlap | End lap | Forward overlap.

2> Lateral overlap | side lap.

1> Longitudinal overlap | End lap:



" The common coverage (or) overlapping in the photographs in the direction of flight (or) photo strip is called the end lap (or) longitudinal overlap.

The end lap is usually kept 55 to 65% with the average of 60% of the total area covered by a photograph. And it is denoted by Pl. It is expressed in percentage (%).

Let G → Longitudinal length on the ground covered by a single photograph <flight direction>.

Pl → Longitudinal overlap in percentage

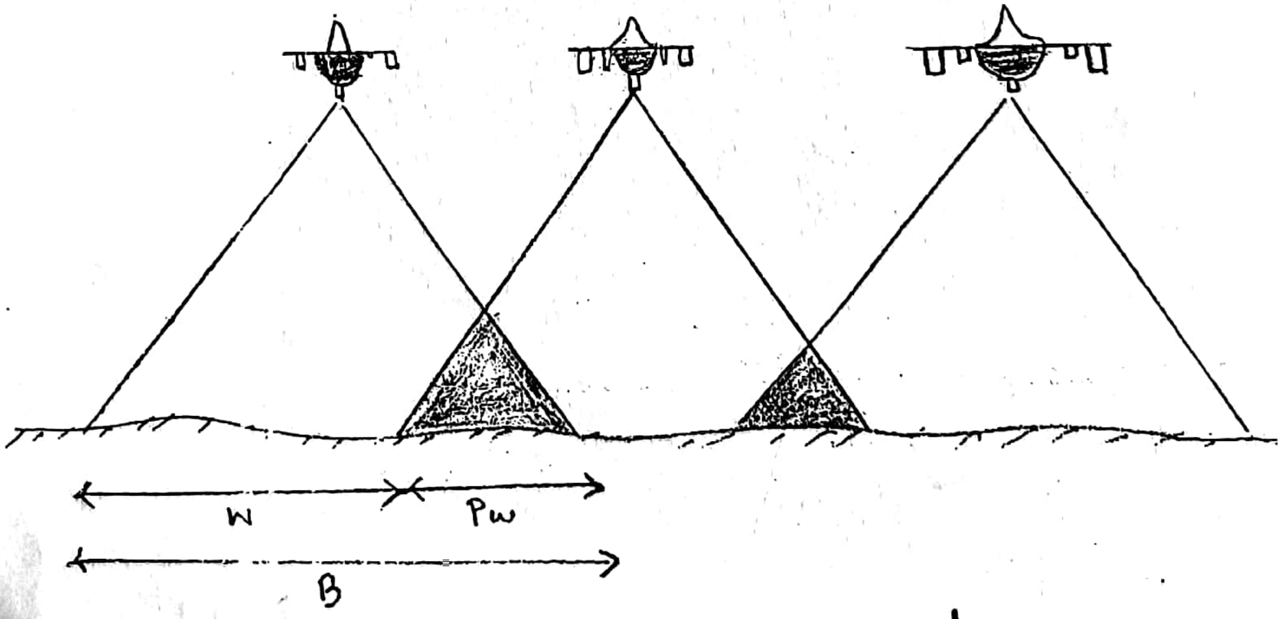
l → length of the photograph in the direction of flight.

L → Net longitudinal length on the ground covered by a single photograph in the direction of the flight.

S → scale of the photograph.

$$\therefore \boxed{G = \frac{l}{S}} \qquad \boxed{L = (1 - P_L) \cdot \frac{l}{S}}$$

2) Lateral overlap | side Lap



" The common coverage (or) overlapping b/w the photographs of two adjacent flight (or) photo strips is called the side lap (or) lateral overlap".

The side lap is usually kept 25 to 35% with an average of 30% of the total area covered by a photograph. It is denoted by Pw & expressed as in terms of percentage (%).

Let, B → width of the ground covered by a single photograph

w → width of the photograph normal to the direction of flight.

W → The net width on the ground covered by a single photograph normal to the direction of flight.

$\boxed{B = \frac{w.}{S}}$; $\boxed{W = (1 - P_w)\frac{l}{s}}$

Pw = % overlap in side [width.

The area on the ground covered by a single photograph is

S = scale of photograph

$\boxed{\cancel{A}^{a} = L \times W}$ (Km²).

Mosaic :-

→ An assembly of individual aerial photograph is known as mosaic.

→ It may be defined as placing the overlapping aerial photographs, all on approximately the same scale, adjusting one another along the edges by cutting the overlapped portion & then pasting them together to form a single composite air photograph, a bird's eye view of the area photographed.

→ In some cases, it may prove to be more useful than plans since a mosaic ~~the~~ shows the actual ground conditions and many details which cannot be shown on plans.

→ For example, for obtaining preliminary information for projects such as possible routes for railways and highways and pipelines etc., river improvements, in estimating timber, in traffic studies etc, the mosaic is often preferable to a map.

Advantage:-

→ Mosaic are low cost, rapid reproduction, completeness, and better portrayal of details.

→ It can be ease of understanding even by a non-technical man.

Disadvantage:-

→ Mosaic do not show elevations & horizontal scale measurement b/w any two points on mosaic are limited in accuracy, primarily due to relief displacement.

Stereoscopes:-

→ An aerial photograph when viewed by an unaided eye shows the surface of a terrain as if it were in horizontal plane.

→ In order to bring out the difference in elevation, a stereoscope is used so that the photograph stands out in relief.

→ Thus, the primary function of a stereoscope is to accommodate the wide separation of the individual photograph of stereopair, to the fixed length of the eye base.

→ The simple stereoscope instrument enables the surveyor to observe a pair of nearly identical photographs, one with each eye, in such a manner that both the photographs appear to fuse into 3 Dimensional picture.

→ Following are types of stereoscopes used generally.

1) Lens stereoscope 2) Mirror stereoscope

3) Scanning mirror stereoscope 4) Zoom stereoscope.

Lens stereoscope - It consist of one magnifying lens for each eye.

→ The two lenses are mounted on an assembly such that seperation b/w them is equal to the average eye base (or) interpupillary distance of human eye.

→ provision is made for minor adjustments of this seperation to user.

→ A typical phenomenon associated with the lens stereoscope is the greatly exaggerated height of building etc.

2) Mirror stereoscope:

→ It consist of an arrangement of four mirrors, each of which is oriented at angle 45° with plane of photographs.

→ the photograph to be viewed stereoscopically are placed at a certain distance from the wing mirrors & the light reaches the eyes exactly as it would come from actual terrain.

→ In both lens & mirror types of stereoscopes, the photographs to be viewed under the stereoscope are first base lined. the line joining the principal points of the photographs represents the direction of flight line. this line is then ~~to~~ aligned parallel to eye base & on viewing through a stereoscope, a spatial view is observed.

Determination of Number of Photographs required for a Photogrammetry project

The plan used for this project is called flight plan.

For a flight plan, the following factors are required.

1. Focal length
2. Extent of area
3. Scale of photograph.
4. Flying height
5. overlaps
6. Exposure interval
7. No of photographs are required.

Case-1: when area to be covered by aerial photography is given

Let A → area to be covered by aerial photography (km^2)

a → area to be covered by one photograph (km^2)

N → no of photograps required.

$$\boxed{N = \frac{A}{a}}$$

Problems:-

1. The Scale of an aerial Photograph is 1cm = 100m. Size of photograph is 20cm x 20cm. Determine the number of photograph required to cover

②T

an area 100 km^2. Longitudinal overlap is 60% & side lap is 30%.

⇒ Given

$S = \frac{1}{10{,}000}$

$A = 100 km^2$

$P_L = 60\% = 0.6$

$P_w = 30\% = 0.3$

$l = 20cm = 0.2m$ $\quad$ $l \times w$ $(20cm \times 20cm)$

$w = 20cm = 0.2m$

$L = (1 - P_L) \times \frac{l}{S}$

$L = (1 - 0.6) \times \frac{0.2}{1/10{,}000} = 800m$

$\boxed{\therefore L = 0.8 Km}$

$W = (1 - P_w) \times \frac{w}{S}$

$W = (1 - 0.3) \times \frac{0.2 \times 1}{\frac{1}{10{,}000}} = (1 - 0.3) \times 0.2 \times 10{,}000$

$W = 1400 m = 1.4 Km$

$\therefore \quad a = L \times W = 0.8 \times 1.4 = 1.12 Km^2$

$N = \frac{A}{a}$

$N = \frac{100 Km^2}{1.12 Km^2}$

$\boxed{N = 89.29 \simeq 90}$

Case-2:- when the dimensions of the area are given:-

Let, N → no of photographs required

N₁ → no of photographs required in one strip.

N₂ → no of flight strips required.

L₁ → length of the area to be covered (km).

W₁ → width of the area to be covered (km).

$$\boxed{N_1 = \frac{L_1}{L} + 1} \quad \& \quad \boxed{N_2 = \frac{W_1}{W} + 1}$$

$$\therefore \boxed{N = N_1 \times N_2}$$

$$\boxed{N = \left[\frac{L_1}{L} + 1\right] \times \left[\frac{W_1}{W} + 1\right]}$$

problems:-

1) A scale of photograph 1cm = 100m, photograph size is 20cm x 20cm, longitudinal overlap is 60%, side overlap is 30%, area covered by 10 km in N-S direction & 10 km in E-W direction. Determine number of photograph required.

given:-

$S = 1cm : 100m$

$$S = \frac{1}{10,000}$$

$P_L = 60\% = 0.6$

②②

$l = 20cm = 0.2m$

$w = 20cm = 0.2m$

$P_L = 60\% = 0.6$

$P_w = 30\% = 0.3$

$L_1 = 10\ km$

$W_1 = 10\ km$

$$L = (1 - P_L)\frac{l}{s}$$

$$= (1 - 0.6) \times \frac{0.2}{\frac{1}{10,000}}$$

$L = 800m = 0.8Km$

$$W = (1 - P_w) \times \frac{w}{s}$$

$$= (1 - 0.3) \times \frac{0.2}{\frac{1}{10,000}}$$

$= 1400m$

$W = 1.4km$

then $N_1 = \frac{L_1}{L} + 1 = \frac{10}{0.8} + 1 = 13.5$

$N_1 \simeq 14$

$N_2 = \frac{W_1}{W} + 1 = \frac{10}{1.4} + 1 = 8.14 \simeq 9$

$N = N_1 \times N_2 = 14 \times 9 = 126.$

Exposure Sinterval (I) :-

$$T = \frac{3600 \times L}{V}$$

where L → ground length covered by one photograph in km

V → speed of aircraft in km/hr.

problems :-

1. An area 40 km in N-S direction & 36 km in E-W direction is to be photographed, with the following data :-

- photograph size = 20cm × 20cm
- Average elevation of the terrain = 450 m
- End lap = 60%
- side lap = 30%
- speed of aircraft = 220 km/hr.
- focal length of the lens = 300 mm
- Average scale of photograph = 1:15,000

Calculate 1) flying height, 2) total number of photographs required.

and 3) exposure intervals.

→ Given

$L_1 = 40\text{km}$

$W_1 = 36\text{Km}$

$l = 20\text{cm} = 0.2\text{m}$

$w = 20\text{cm} = 0.2\text{m}$

$P_L = 60\% = 0.6$

$P_W = 30\% = 0.3$

$S_{av} = 1:15{,}000 = \frac{1}{15{,}000}$

$h_{av} = 450m$

$V = 220\ km/hr$

$f = 300mm = 0.3m$

i) $S_{av} = \frac{f}{H - h_{av}}$

$$\frac{1}{15{,}000} = \frac{0.3}{H - 450}$$

$$\boxed{H = 4950m}$$

ii) $L = (1 - P_L) \times \frac{l}{S} = (1 - 0.6) \times \frac{0.2}{\frac{1}{15{,}000}} = 1200m$

$L = 1.2km.$

$W = (1 - P_W) \times \frac{l}{S} = (1 - 0.3) \times \frac{0.2}{\frac{1}{15{,}000}} = 2100m = 2.1km$

$N_1 = \frac{L_1}{L} + 1 = \frac{40}{1.2} + 1 = 34.33 \simeq 35$

$N_2 = \frac{W_1}{W} + 1 = \frac{36}{2.1} + 1 = 18.14 \simeq 19$

$\therefore\ N = N_1 \times N_2 = 35 \times 19 = 665$

Say

iii) $T = \frac{3600 \times L \rightarrow km}{V \rightarrow km/hr}$ where L in km, V in km/hr

$T = \frac{3600 \times 1.2}{220}$

$T = \boxed{19.64 \text{ sec}}$

Numbers of photographs required to cover the area

Number of photograph = $\frac{\text{Total area to be photographed}}{\text{Net ground area covered by each photo.}}$

Number of photograph $= \frac{A}{a}$

The size of each photograph = l×w (net area of photograph)

The size of each photograph $= [1 - P_1) \times (1 - P_w) w$

The size of each photographs

ground area covered by each photographs

$= S[1 - P_1) l \times S(1 - P_w)w$

A = Total area area to be photographed

l = length of photo in direction of flight

w = width of photo normal to direction

S = scale of photograph f/H

L = net ground distance ~~correction~~ corresponding to l

W = net ground ~~area~~ width corresponding to w.

a = net ground area covered by each photo.

Pl = % overlap in direction of flight

Pw = % overlap in side (width)

Procedure of aerial survey :-

The general procedure of an aerial survey consist of establishing ground control, flight planning & photography, photo interpretation & stereoscopy & the construction of map & cartography.

1) ground control

- → To obtain results with sufficient accuracy, a certain amount of ground control is essential.
- → It consist in establishing a frame work of points of known relative positions around which the details in the photograph are plotted & through which the photographic data is correlated with the terrain surveyed.
- → These points are known as control stations (or) control points.

2) Flight planning :-

- → The information required to plan a flight mission consist of the area to be surveyed, focal length of the camera, scale of the photograph, longitudinal and side overlap & the approximate ground speed of the aircraft in still air.
- → This information is used to compute the altitude of the aircraft above datum, area covered by each potograph, time interval b/w exposures,

number of strips & number of photographs.

3) photo-interpretation:-

→ photo-interpretation means identifying & recognising objects in the aerial photograph & then judging their significance in the photograph.

→ The main application of this technique for civil engineering project are identification of land forms & consequently site considerations, areas of wet (or) unstable ground, density & type of vegetation etc.

~~The~~ following characteristics of the photo images should be studied.

1) Shape : Shape relates to the general form, configuration (or) outline of an object. It is most important factors for recognising object.

2) Size:- Size of an object on the photograph is helpful for interpretation

3) pattern:- It means the spatial arrangement of the objects photographed.

4) Shadow : The outline of a shadow gives the profile of an object, which aids in interpolation

5) Texture:- Texture is the frequency of the change in tone in the photographic image. Texture is produced by an aggregate of unit features, which individually may be too small to be discerned on photograph.

4) Stereoscopic photo-interpretation is carried out with the help of magnifiers. The instrument used is known as stereoscope. It enables the observer to see the spatial model of the area photographed.

→ It provides a means of measuring parallax, 3 dimensional study of photographs and drawing planimetric (or) topographic map if sufficient ground control, length of lines & elevations are available.

5) Photographic maps:

→ Photo-maps are mosaic on which certain details have been accentuated by drawing & the result reproduced in the sheets of a map series as a combination of drawn detail & a background of photographic details.

→ The photographs are arranged under a transparent celluloid control sheet & then the details are transferred on it from the photographs which result in a map.

→ Depending upon the purpose and method of the plotting, the photographic maps are classified as Index map, planimetric map, topographic map & stereotopographic map.

Applications of photography (uses)

1> Topographic mapping

2> planimetric mapping

3> viewing photographs stereoscopically

4> Digital elevation model.

5> Measurement of parallax

6> photomaps & mosaics.

MODULE - 05

Advanced Surveying - 15CV46

Modern Surveying Instruments.

Introduction: there are three methods of measuring distance between any two given points:

1. Direct distance measurement [DDM], such as the one by chaining or tapping.
2. Optical distance measurement [ODM], such as the one by tacheometry, horizontal subtense method or telemetric method using optical wedge attachments.
3. Electromagnetic distance measurement [EDM] such as the one by geodimeter, tellurometer or distomat etc.

EDM is a general term embracing the measurement of distance using electronic methods. In electromagnetic [or Electronic] method, distances are measured with instruments that rely on propagation, reflection and subsequent reception of either radio, visible light or infrared waves. EDM enables the accuracies upto 1 in 10^5, over ranges upto 100km.

Types of EDM Instruments

Depending upon the type of carrier wave employed, EDM instruments can be classified under the following three heads.

a. Microwave instruments
b. Visible light instruments
c. Infrared instruments.

It is seen that all the above three categories of EDM instruments use short wavelengths and hence higher frequencies.

1. Microwave instruments: These instruments come under the category of long range instruments, where in the carrier frequencies of the range of 3 to 30GHz [1 GHz = 10^9] enable distance measurements upto 100 km range. Tellurometer come under this category.

Phase Comparison technique is used for distance measurement. Remote instrument which is identical to the master instrument placed at the measuring end. the remote instruments receives the transmitted signal, amplie it and transmits it back to the master in exactly the phase at which it was received. This means that microwave EDM instruments require two instruments and two operators.

Frequency modulation is used in most of the microwave instruments The method of varying the measuring wavelength in multiplies of 10 is used to obtain an unambiguous measurement of distance. The microwave signals are radiated from small aerials [called dipoles] mounted in front of each instrument, producing directional signal with a beam of width varying from 2° to 20°. Hence the alignment of master & remote units is not critical. Typical maximum ranges for microwave instruments are from 30 to 80 km, with an accuracy of ±15 mm to ±5 mm/km.

2. Visible light instruments: These instruments use visible light as carrier wave, with a higher frequency, of the order of 5×10^{14} Hz. Since the transmitting power of carrier wave of such high frequency falls off rapidly with the distance, the range of such EDM instruments is lesser than those of microwave units. A geodimeter comes under this category of EDM instruments. The carrier, transmitted as light beam, is concentrated on a signal using lens or mirror system, so that signal loss does

The advantage of visible light EDM instruments, over the microwave EDM instruments is that only one instrument is required, which work in conjunction with the inExpensive corner cube reflector. Amplitude modulation is employed, using a form of electro-optical shutter. The line is measured using three different wavelengths, using the Same Carrier in Each Case. The EDM instrument in this category have a range of 25 Km, with an accuracy of ±10mm to ±2 mm/km. The recent instruments use pulsed light Sources and highly Specialised modulation and phase Comparison techniques, and produce a Very high degree of accuracy of ±0.2mm to ±1 mm/km with a range of 2 to 3km.

3 Infrared instruments: The EDM instruments in this group use near infrared radiation band of wavelength about 0.9μm as Carrier wave which is Easily obtained from gallium arsenide [Ga As] infrared emitting diode. These diodes Can be Very Easily directly amplitude modulated at high frequencies. Thus, modulated carrier wave is obtained by an inExpensive method. Due to this reason, there is predominance of infrared instruments in EDM.

The power output of the diodes is low. Hence the range of these instruments is limited to 2to5 km. However, this range is quite Sufficient for most of the civil Engineering works. The EDM instruments of this category are Very light and Compact, and these Can be theodolite mounted. This enables angles and distances to be measured Simultaneously at the Site. A typical combination is wild DI 1000 infrared EDM with wild T 1000 Electronic theodolite [Theomat]. The accuracy obtainable is of the Order of ±10mm, irrespective of the distance in most Cases.

Electronic tacheometer, Such as wild TC 2000 'Tachymat' is a further development of the infrared [& laser] distance measurer, which combines theodolite and EDM Units. Microprocessor Controlled angle measurement give Very high degree of accuracy, enabling horizontal & Vertical angles, & the distance [horizontal, Vertical, inclined] to be automatically displayed & recorded.

Total station:

A total station is a combination of an electronic theodolite and an electronic distance meter [EDM]. This combination makes it possible to determine the coordinates of a reflector by aligning the instruments cross-hairs on the reflector and simultaneously measuring the vertical and horizontal angles and slope distances. A microprocessor in the instrument takes care of recording, readings and the necessary computations. The data is easily transferred to a computer where it can be used to generate a map. Wild, 'Tachymat' TC 2000 is one such total station manufactured by M/s Wild Heerbrugg.

Fundametal measurements: When aimed at an appropriate target, a total station measures three parameters:

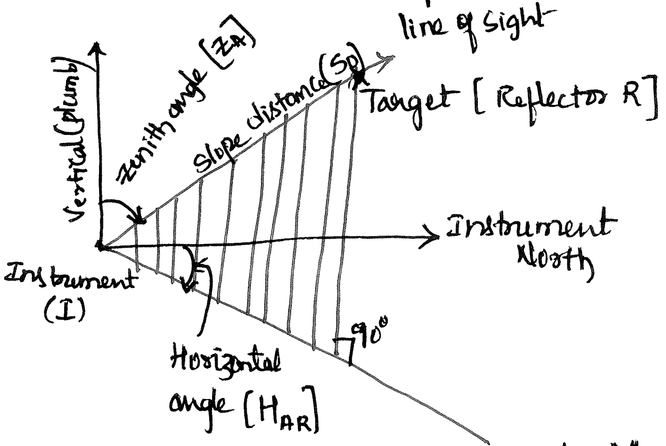


Fig: Fundamental Measurements Made by a total Station

1. The rotation of the instrument's optical axis from the instrument north in a horizontal plane: i.e., horizontal angle
2. The inclination of the optical axis from the local vertical i.e., Vertical angle.
3. The distance between the instrument and the target i.e., Slope distance.

All the numbers that may be provided by the total station are derived from these three fundamental measurements.

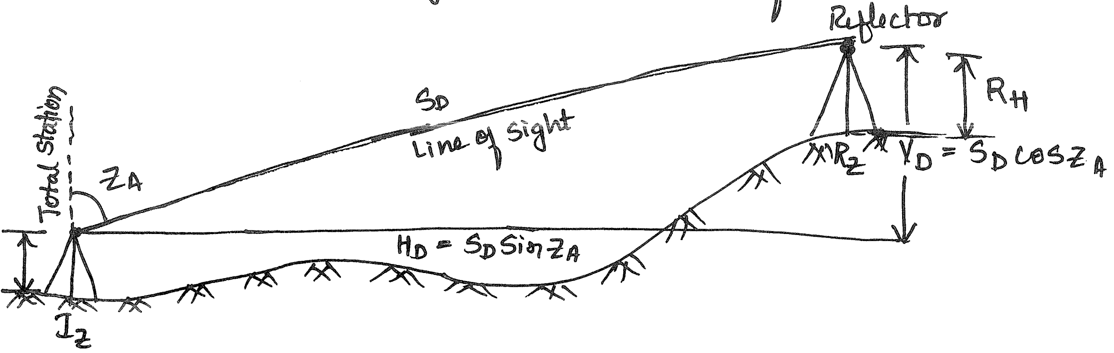
1. **Horizontal Angle:** The horizontal angle is measured from the zero direction on the horizontal scale [or horizontal circle].

- When the user first sets up the instrument the choice of the zero direction is made – this is Instrument North.
- The user may decide to set zero (North) in the direction of the long axis of the map area, or choose to orient the instrument approximately to True, Magnetic or Grid North.
- The zero direction should be set so that it can be recovered if the instrument was set up at the same location at some later date. This is usually done by sighting to another benchmark, or to a distance recognizable object
- Using a magnetic compass to determine the orientation of the instrument is not recommended and can be very inaccurate. ~~Most~~ +
- Most total stations can measure angle to at least 5 seconds, or 0.0013888°. The best procedure when using a total station is to set a convenient "north" & carry this through the survey by using backsights when the instrument is moved.

2. **Vertical Angle:** The vertical angle is measured relative to the local vertical (plumb) direction.

- The vertical angle is usually measured as a zenith angle [0° is vertically up, 90° is horizontal, and 180° is verticaly down], although one is also given the option of making 0° horizontal.
- The zenith angle is generally easier to work with.
- The telescope will be pointing downward for zenith angles greater than 90° & upward for angles less than 90°
- Measuring vertical angles requires the the instrument be exactly vertical. It is very difficult to level an instrument to the degree of accuracy of the instrument.
- Total stations contain an internal sensor [the vertical compensator] that can detect small deviations of the instrument from vertical.

- The Electronics in the instrument then adjust the horizontal & Vertical angles accordingly. The Compensator can only make small adjustments, so the instrument till has to be well leveled. If it is too far out of level, the instrument will give some kind of "tilt" error message.



I = Instrument, R = Reflector, S_D = Slope distance, V_D = Vertical distance between telescope & reflector, H_D = Horizontal distance, Z_A = Zenith angle, I_H = Instrument height, R_H = Reflector height, I_Z = Ground elevation of total station; R_Z = ground elevation of Reflector.

Fig: Geometry of the Instrument [Total Station] & Reflector.

- Because of the compensator, the instrument has to be pointing Exactly at the target in order to make an accurate vertical angle measurement. If the instrument is not perfectly leveled then as you turn the instrument about the Vertical axis [i.e., change the horizontal angle] the Vertical angle displayed will also change.

3. Slope Distance: ~~Because of the compensator, the instrument has~~ The instrument to reflector distance is measured using an Electronic Distance Meter [EDM]. Most EDM's use a Gallium Arsenide Diode to emit an infrared light beam. This beam is usually modulated to two or more different frequencies. The infrared beam is emitted from the total station, reflected by the reflector and received & amplified by the total station. The received signal is then compared with a reference signal generated by the instrument [the Same Signal generator that transmits the microwave pulse] and the phase-shift

is determined. This phase shift is a measure of the travel time and thus the ~~phase~~ - distance between the total station and the reflector.

This method of distance measurements is not sensitive to phase shift larger than one wavelength, so it cannot detect instrument - reflector distances greater than 1/2 the wavelength [The instruments measures the two-way travel distance].

Since measurement to the nearest millimeter would require very precise measurements of the phase difference, EDM's send out two [or more] wavelengths of light. One wavelength may be 4000m & the other 20m. The longer wavelength can read distance from 1m to 2000m to the nearest metre, and then the second wavelength can be ~~read distances from~~ used to measure distances of 1mm to 9.999m. combing the two results gives a distance accurate to millimeters. Since there is overlap in readings, the metre value from each reading can be used as a check.

Basic Calculations:

Total station only measure three parameters: Horizontal Angle, Vertical Angle. & Slope distance. All of these measurements have some error associ-ated with them, however for demonstrating the geometric calculations, we will assume the readings are without error.

Horizontal Distance:

From Fig, the horizontal distance (H_D) is

$$H_D = S_D \cos(90^\circ - Z_A) = S_D \sin Z_A$$

where S_D is the slope distance and Z_A is the zenith angle. The horizontal distance will be used in the coordinate calculation.

Vertical Distance;

Elevation difference dz between the two points on the ground.

$$dz = V_D + [J_H - R_H]$$

The quantities I_H & R_H are measured and recorded in the field.

The Vertical difference V_D is calculated ~~p~~ as

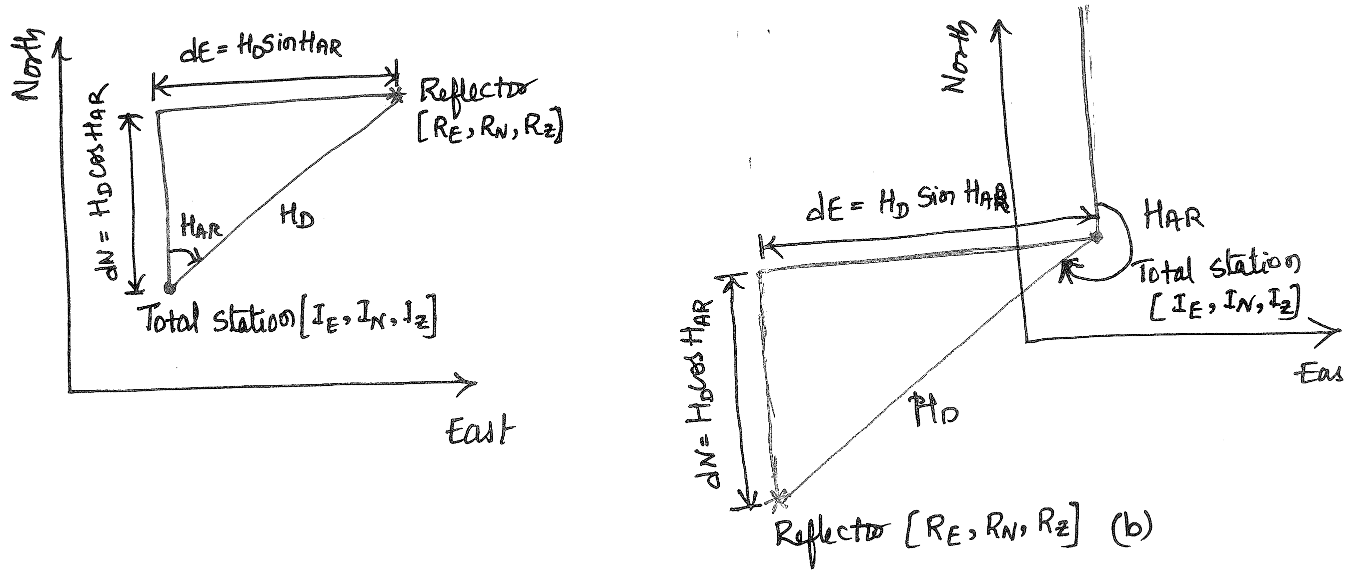
$$V_D = S_D \sin[90 - Z_A] = S_D \cos Z_A$$

$$\therefore \; dZ = S_D \cos Z_A + [I_H - R_H]$$

If the instrument is at a known elevation, I_Z, then the elevation of the ground beneath the reflector, R_Z is

$$R_Z = I_Z + S_D \cos Z_A + (I_H - R_H).$$

Coordinate Calculation:



(b)

(a)

Fig: Computation of East & North Coordinates of the Reflector.

- The Zero direction Set on the instrument is instrument North. This may not have any relation on the ground to true, magnetic or grid north.
- Fig shows the geometry for two different cases, one where the horizontal angle is less than 180° and the other where the horizontal angle is greater than 180°.
- Let R_E & R_N be the Easting, & northing of the reflector and I_E & I_N be the Easting and northing of the instrument [i.e. total station].

From fig. the coordinates of the reflector relative to the total station are

$$dE = \text{change in Easting} = H_D \sin H_{AR}$$

$$dN = \text{change in Northing} = H_D \cos H_{AR}$$

where H_D is the horizontal distance & H_{AR} is the horizontal angle measured in a clockwise sense from instrument north. In terms of fundamental measurements,

$$dE = S_D \sin Z_A \sin H_{AR}$$

$$dN = S_D \cos [90° - Z_A] \cos H_{AR} = S_D \sin Z_A \cos H_{AR}$$

The co-ordinates of the ground under the reflector,

$$R_E = I_E + S_D \sin Z_A \sin H_{AR}$$

$$R_N = I_N + S_D \sin Z_A \cos H_{AR}$$

$$R_Z = I_Z + S_D \cos Z_A + [I_H - R_H]$$

All of these calculations can be made within a total station, or in an attached electronic notebook. Although it is tempting to let the total station do all the calculations, it is wise to record the three fundamental measurements. This allows calculations to be checked and provides the basic data that is needed for a more sophisticated error analysis.

Lidar Scanner for topographical Survey:

Survey methods using Light Detection and Ranging [LiDAR] have become more common for both terrestrial and hydrographic Surveys. This rapid Survey method provides unprecedented detail over large, Even regional areas, and has demonstrated great potential for a Variety of uses by Coastal Engineers and Scientists.

LiDAR Systems employ an aircraft mounted laser System that measures the reflection of laser pulses emanating in a swath over the ground or Sea floor. Advances in laser technology facilitate Extraordinarily detailed Survey data at amazing Speeds of up to 100,000 pulses per sec for terrestrial systems. This System can Survey over 20 square miles per hour.

Once collected, processed, and cleaned of errors, the terrestrial LiDAR data arrive to the end user as first return which includes the elevation of structures and vegetation or bare Earth. The Survey data typically appear as XYZ coordinate point data in ASCII text files in the horizontal and Vertical reference of choice. Due to the high density of these Surveys, the files commonly contain tens of millions of data points, Consume gigabytes of storage, & can present challeges for the end user wishing to visualize and analyse the data.

Typically, the point data is converted into a Surface, or Digital Elevation Model [DEM]. Having flexibility for the end user to create DEM's of Various Scales is beneficial. Once a Surface is Created, analysis can be performed including cross Sections, contour analysis & Volume Calculations. If there are data collected over the same area at different times, the surfaces can be Compared and change analysis can be performed.

Advantages of LiDAR in Topographic Mapping.

In the past decade, because of the advantages of LiDAR, it has largely displaced photogrammetry as the process for development of large ~~deve~~lo Scale topographic ~~Surveying~~ maps. the LiDAR advantages in topographic Surveying may be as found below

- LiDAR sensors can be operated in any weather
- LiDAR Sensors are not affected by low Sun angles - which would prevent useful photos
- LiDAR can actually operate at night
- LiDAR offers greater efficiency, faster results & can cover more ground than photogrammetry.
- Rural and remote areas are Easier and quicker to Survey with LiDAR because each point has geo-referenced location & Elevation - no orthorectification of image - no network of photo Panels required
- photogrammetry needs to be able to See the ground to Create contours
- LiDAR returns come from Every object illuminated - the lowest being the ground - wherever the Sunlight hits LiDAR will return XYZ
- LiDAR creates a 3D model directly from the returns
- photogrammetry requires the incremental comparison of a Pair of Stereoscopic photographs - indirect & much more labor intensive
- photogrammetry requires contrast to see ground Surfaces. desert, wetlands, beaches, coasts are difficult or impossible.

REMOTE SENSING AND GIS - [15CV563]

MODULE - 1

REMOTE SENSING

BASIC CONCEPT OF REMOTE SENSING:

Generally, remote Sensing refers to the activities of recording/ observing/ Perceiving [sensing] objects or Events at far way [remote] places. In remote Sensing, the Sensors are not in direct contact with the objects or Events being observed,. The information needs a physical Carrier to travel from the objects/ Events to the Sensors through an intervening medium. The Electromagnetic radiation is normally used as an information Carrier in remote Sensing.

As you View the Screen of your Computer monitor, you are actively engaged in remote Sensing. A physical quantity [light] emenates from that Screen, which is a Source of radiation. The radiated light passes over a distance, and thus is "remote" to some extent, untill it encounters and is Captured by a Sensor [your eyes]. Each eye Sends a Signal to a processor [your brain] which records the data and interprets this information.

DEFINITION:

Remote Sensing is the Science and art of obtaining information about an object, area or phenomena, through the analysis of data, acquired by a device, that is not in contact with the object, area or phenomena under investigation.

ELEMENTS OF REMOTE SENSING or Remote Sensing Process.

1. Energy Sources or Illumination [1]

The first requirement for remote sensing is to have an Energy Source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere [2]

As the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the target [3]

Once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4.

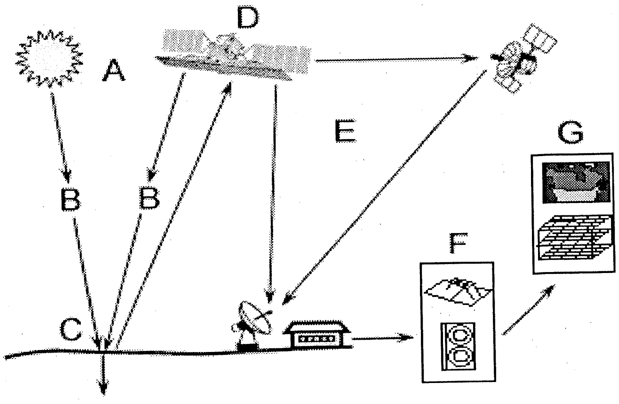


Fig: Pinciples of Remote Sensing

4. Recording of Energy by the Sensor [4]

After the Energy has been Scattered by, or emitted from the target, we require a Sensor [remote - not in contact with the target] to collect and record the electromagnetic radiation.

5. Transmission, Reception, and processing [5]

The Energy recorded by the Sensor has to be transmitted, often in Electronic form, to a receiving and processing Station where the data are processed into an image [hardcopy/or digital]

6. Interpretation and Analysis [6]

The processed image is interpreted, visually and/or digitally or Electronically, to Extract information about the target which was illuminated.

7. Applications [7]

The final Element of the remote Sensing process is achieved when we apply the information we have been able to Extract from the imagery about the target in order to better understand it, reveal Some new information, or assist in solving a particular problem.

These Seven Elements Comprise the remote Sensing process from begining to end.

TYPES OF REMOTE SENSING

With respect to the type of resources, remote sensing is classified as:

1. Passive remote sensing: It make use of sensors that detect the reflected or emitted electro-magnetic radiation from natural sources. They depend on solar radiation to illuminate the target.

2. Active remote sensing: It make use of sensors that detect reflected responses from objects that are irradiated from artificially generated energy sources, such as radar.

It generates and uses its own energy to illuminate the target and records the reflected energy.

General process involved in Electromagnetic Remote Sensing.

The two main processes involved in passive or electro-magnetic remote sensing.

1) Data acquisition:

It comprises distinctive elements namely.

a) Energy sources
b) Propagation of energy through the atmosphere
c) Energy interactions with the Earths surface features.
d) Air borne, space borne, sensors to record the reflected energy.
e) Generation of sensor data as pictorial or digital information.

2) Data Analysis:

Data analysis can be broadly classified as

a) Visual image interpretation:

This involves the Examination of data with various viewing instrument to analyse pictoral data.

b) Digital image processing:

when computers are used to analyze digital data then the process is called digital image processing.

REMOTE SENSING ADVANTAGES AND DISADVANTAGES:

ADVANTAGES

1. Satellite images are permanent records, providing useful information in various wavebands
2. Large area coverage enables regional surveys on a variety of themes and identification of large features.
3. Repetitive coverage allows monitoring of dynamic themes like water, agriculture etc.
4. Easy data acquisition at different scales and resolutions.
5. A single remotely sensed image can be analysed and interpreted for different purpose and applications.
6. Amenability of remotely sensed data for fast processing using a computer
7. The images are analysed in the laboratory thus reducing the amount of field work, the analysis from remote sensing data therefore is cost effective.
8. Map revision at medium to small scales is Economical and faster.

9. Colour composite can be produced from three individual band images, which provide better details of the area than a single band image or aerial photograph.

10. Stereo Satellite data may be used for three dimensional Studies

DISADVANTAGES:

1. Expensive for small areas, particularly for one time analysis.
2. Requires specialized training for analysis of images
3. Large Scale Engineering maps cannot be prepared from Satellite.
4. Needs cross verification with ground survey data [Field data]
5. Distortions may occur in an image due to the relative motion of sensor & sources.

ELECTROMAGNETIC RADIATION:

Electromagnetic waves are energy transported through space in the form of periodic disturbances of electric and magnetic fields. All electromagnetic waves travel through space at the same speed, $C = 2.99792458 \times 10^8$ m/s, commonly known as the speed of light. An electromagnetic wave is characterized by a frequency and a wavelength.

The wavelength is the length of one wave cycle, which can be measured as the distance between successive wave crests. Wavelength is usually represented by the Greek letter lambda (λ). The wavelength is measured in meters (m) or some factors of meters such as nanometers [nm, 10^{-9} m], micrometers [μm, 10^{-6} m] or centimeters [cm, 10^{-2} m].

Frequency refers to the number of cycles of a wave passing a fixed point per unit of time. Frequency is normally measured in hertz [Hz], equivalent to one cycle per second, and various multiples of hertz.

Wavelength and frequency are related by the following formula:

$$C = (\lambda)n$$

where (λ) = wavelength (m)
n = Frequency [cycle per sec, Hz]
c = Speed of light [3×10^8 m/s]

The frequency [& hence, the wavelength] of an Electromagnetic wave depends on its source. There is a wide range of frequence encountered in our physical world, ranging from the low frequency of the Electoic waves generated by the power transmission lines to the very high frequency of the gama rays originating from the atomic nuclei. This wide frequency range of Electromagnetic wave consitute the Electromagnetic Spectrum.

A Black Body transforms heat energy in to radiant Energy at the maximum possible rate. This radiation thus evolved is known as Black Body Radiation. For Examples, if the Sun ~~is known~~ were to be a perfect emitter, it would be an ideal black body. A black body is hypothetical~~ly~~, ideal radiator that absorbs and reemits all Energy incident on it.

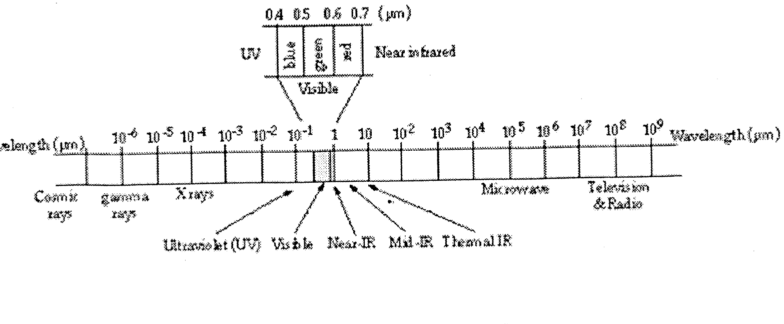
Emission of electromagnetic radiation from gases is due to atoms and molecules in the gas. Atoms consists of a positively charged nucleus surrounded by orbiting Electrons, which have discrete energy states.

Transition of electrons from one energy to the other leads to emission of radiation at discrete wavelengths. The resulting spectrum is called line spectrum. Molecules posses rotational and vibrational energy states, transition between which leads to emission of radiation in a band spectrum. The wavelengths, which are emitted by atmos/molecules, are also the one, which are absorbed by them. Emission from solids and liquids occurs when they are heated and results in a continuous spectrum. This is called Thermal emission and it is an important source of EMR from the viewpoint of remote sensing.

BANDS USED IN REMOTE SENSING

The Electro-Magnetic Radiation [EMR], which is reflected or emitted from an object, is the usual source of remote sensing data. However, any medium, such as gravity or magnetic fields, can be used in remote sensing. Remote sensing technology makes use of the wide range Electro-Magnetic Spectrum [EMS] from a very short wave "Gamma Ray" to a very long "Radio wave".

Wavelength regions of electro-magnetic radiation have different names ranging from Gamma Ray, X-ray, Ultraviolet (UV), visible light, Infrared [IR] to Radio wave, in order from the short wavelengths. Fig. below shows the Electromagnetic spectrum used in remote sensing.



The optical wavelength region, an important region for remote Sensing applications, is further Subdivided as shown in Table1below. Microwave region [1mm to 1m] is another portion of EM spectrum that is frequently used to gather valuable remote Sensing information. Table.2. shows the major regions of EMS used in Remote Sensing.

Table 1. Optical wavelength region.

Region	Wavelength (μm)
Optical wavelength	0·30 - 15·0
Reflective portion	0·38 - 3·00
• Visible	0·38 - 0·72
• Near IR	0·72 - 1·30
• Middle IR	1·30 - 3·00
Far IR [Thermal, Emissive]	7·00 - 15·0

Extra

PASSIVE AND ACTIVE REMOTE SENSING:

Remote Sensing which measure Energy that is naturally available are called passive Sensors. Passive Sensors can only be used to detect Energy when the naturally occurring Energy is available. For all reflected Energy, this can only take place during the time when the Sun is illuminating the Earth. There is no reflected Energy available from the Sun at night. Energy that is naturally Emitted [Such as thermal infrared] can be day or night, as long as the amount of Energy is large Enough to be recorded.

Table: MAJOR REGIONS OF EMS USED IN REMOTE SENSING

Region Name	Wavelength	Comments
Gamma Ray	< 0.03 nanometers	Entirely absorbed by the Earth's atmosphere and not available for remote sensing.
X-ray	0.03 to 30 nanometers	Entirely absorbed by the Earth's atmosphere and not available for remote sensing.
Ultraviolet	0.03to 0.4 micrometers	Wavelengths from 0.03 to 0.3 micrometers absorbed by ozone in the Earth's atmosphere.
Photographic Ultraviolet	0.3 to 0.4 micrometers	Available for remote sensing the Earth. Can be imaged with photographic film.
Visible	0.4 to 0.7 micrometers	Available for remote sensing the Earth. Can be imaged with photographic film.
Infrared	0.7 to 100 micrometers	Available for remote sensing the Earth. Can be imaged with photographic film.
Reflected Infrared	0.7 to 3.0 micrometers	Available for remote sensing the Earth. Near Infrared 0.7 to 0.9 micrometers. Can be imaged with photographic film.
Thermal Infrared	3.0 to 14 micrometers	Available for remote sensing the Earth. This wavelength cannot be captured with photographic film. Instead, mechanical sensors are used to image this wavelength band.
Microwave or Radar	0.1 to 100 centimeters	Longer wavelengths of this band can pass through clouds, fog, and rain. Images using this band can be made with sensors that actively emit microwaves.
Radio	>100 centimeters	Not normally used for remote sensing the Earth.

Active Sensors, on the other hand, provide their own energy source for illumination. The Sensor Emits radiation which is directed toward the target to be investigated. The radiation reflected from the target is detected and measured by the Sensor. Advantages for active Sensors include the ability to obtain measurements anytime, regardless of the time of day or Season. Active Sensors can be used for Examining wavelengths that are not Sufficiently provided by the Sun, Such as microwaves, or to better control the way a target is illuminated. However, active Systems require the generation of a fairly large amount of energy to adequately illuminate targets. Some Examples of active sensors are a laser fluorosensor and a Synthetic aperture radar [SAR].

With respect to wavelength regions remote Sensing is classified as

i Vissible and Reflected Infrared Remote Sensing

ii Thermal Infrared Remote Sensing

iii Microwave Remote Sensing.

ENERGY INTERACTION WITH THE ATMOSPHERE

Before radiation reaches the Earth's surface it has to travel through atmosphere. Particles and gases in the atmosphere can affect the incoming light and radiation. These effects are caused by the mechanisms of Scattering and absorption.

SCATTERING occurs when particles or large gas molecules present in the atmosphere interact with and cause the Electromagnetic radiation to be redirected ~~from~~ its original path. How much Scattering takes place depends on several factors including the wavelength of the radiation, the abundance of ~~particular~~ particles or gases, and the distance the radiation travels through the atmosphere. There are three types of Scattering which takes place: Rayleigh Scattering, Mie Scattering and Non Selective Scattering.

~~Rayleigh Scattering~~

It is defined as the unpredictable diffusion of radiation by the particles in the atmosphere. This diffusion or redirection of the Electromagnetic Energy is done by the particles suspended in the atmosphere or by the molecules of atmospheric gases. The two main classes of Scattering are Selective and non-Selective Scattering.

The ~~three~~ different types of Selective Scattering are

Rayleigh Scattering :

It occurs when particles are very Small compared to the wavelength of the radiation. These could be particles Such as

Small specks of dust or nitrogen and oxygen molecules. Rayleigh Scattering causes shorter wavelengths of Energy to be Scattered much more than longer wavelengths. Rayleigh Scattering is the dominant Scattering mechanism in the upper atmosphere.

The fact that the Sky appears "blue" during the day is because of this phenomenon. As Sunlight passes through the atmosphere, the Shorter wavelengths [i.e blue] of the visible Spectrum are Scattered more than the other [longer] visible wavelengths. At sunrise and Sunset the light has to travel farther through the atmosphere than at midday and the Scattering of the Shorter wavelengths is more complete, this leaves a greater proportion of the longer wavelengths to penetrate the atmosphere.

$$\text{Rayleigh Scatter} \propto \frac{1}{\lambda^4}$$

Blue light is Scattered four times than of red light. UV light is Scattered 16 times than that of red light.

Mie Scattering:

It happens when the atmospheric particles diameter are of Same size as that of the wavelength of radiations being sensed. Spherical particles of water Vapour, pollen grains and dust cause Mie's Scattering, mainly in the lower parts of the atmosphere, i.e., from 0 to 5 km. It affects longer wavelengths and EMR in the visible region.

Raman's Scattering:

Raman's scattering is caused by atmospheric Particles, which are larger, smaller or equal to that of the wavelengths of the radiations being sensed.

~~The atmospheric particles may be gaseous molecules, water droplets, fumes or dust. These portions have an elastic collision with the atmospheric particles which result in either loss or gain of energy and thus an increase or decrease in wavelength.~~

Non-Selecti~~ng~~ve Scattering:

This occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of Scattering. Non-Selective Scattering decreases the contrast of the image

Non Selective Scattering gets its name ~~from~~ the fact that all wavelengths are scattered about equally. This type of scattering causes fog & clouds to appears white to our eyes because blue, green, & red light are all Scattered in approximately equal quantities [blue + green + red light = white light]

ATMOSPHERIC TRANSMISSION WINDOWS

Some types of Electromagnetic radiation easily pass through the atmosphere, while other types do not. The ability of the atmosphere to allow radiation to pass through it is referred to as its Transmissivity, and varies with the wavelength or type of the radiation. The gases that Compose our atmosphere absorb radiation in ~~Sa~~ Certain wavelength while allowing radiation with differing wavelengths to pass through. The areas of the EM spectrum that are~~a~~ absorbed by atmospheric gases such as water vapour, carbon dioxide, & ozone are known as Absorption Bands.

In contrast to the absorption bands, there are areas of the electromagnetic spectrum where the atmosphere is transparent [little or no absorption of radiation] to specific wavelengths. These wavelength bands are known as Atmospheric windows, since they allow the radiation to easily pass through the atmosphere to Earth surface. Fig shows the atmospheric window.

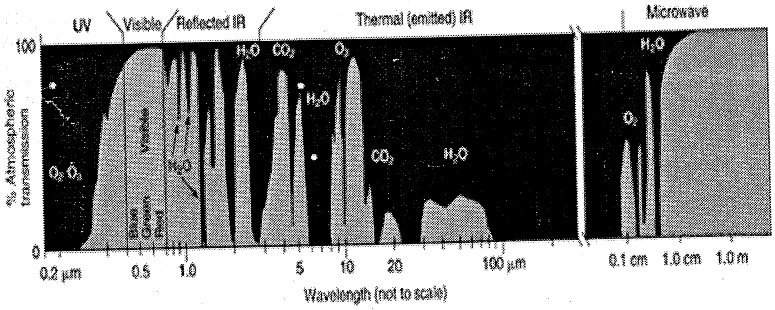


Fig: ATMOSPHERIC TRANSMISSION WINDOWS

Most remote instruments on aircraft are spaced based platforms operate in one or more of these windows by making by making their measurements with detectors tunned to specific frequencies [wavelength] that pass through the atmosphere.

SPECTRAL REFLECTANCE SIGNATURE

For any given material, the amount of solar radiation that reflects, absorbs, or transmits varies with wavelength. This important property of matter makes it possible to identify different substances or classes and separate them by their spectral signatures [spectral curves], ~~as shown in the fig~~.

Any set of observable characteristics that directly or indirectly lead to the identification of an object and/or its condition is termed as signature. Spectral, spatial, temporal and polarisation variations are four major characteristics of the targets, which help in discrimination.

Spectral variations are the changes in the reflectance or emittance of objects as a function of wavelength. Spatial arrangements of terrain features providing attributes such as shape, size and texture of objects, which lead to their identification are termed as spatial variations. Temporal variations refers to changes of reflectivity or emissivity of a feature over a time. This particularly helps to distinguish crops, which may have similar spectral reflectance but different growing cycles. Polarisation variations relate to the changes in the polarisation of radiation reflected or emitted by an object & hence help in distinguishing the object. This observation is particularly useful in microwave region. Signatures are not completely deterministic. They are statistical in nature with a certain mean value and dispersion around it.

Reflectance is defined as the ratio of incident flux on the surface to the reflected flux from the surface. Reflectance with respect to the wavelength is called spectral reflectance. Spectral reflectance is assumed to be unique for each and every object.

$$\rho_\lambda = \frac{E_R[\lambda]}{E_I[\lambda]}$$

ρ_λ is expressed in %

$E_R[\lambda]$ = Energy of the wavelength λ reflected from the object

$E_I[\lambda]$ = energy of the wavelength λ incident on the object.

Spectral Signature of Earth Surface features:

Fig shows the spectral reflectance of different Earth surface features.

VEGETATION: plant pigments, leaf structures and total water content are three important factors, which influence the spectrum in the visible, near infrared and middle infrared wavelength regions regions respectively. In the visible region of the spectrum, chlorophyll in the plant levels strongly absorbs energy with the blue and red wavelength bands, centered at about 0.45 μm & 0.65 μm and the high reflection of the green energy waves. In the near infrared portion of the spectrum i.e., in the range of 0.7 μm to 1.3 μm wavelength reflectance in the order of 40% to 50%. This reflectance is primarily due to the internal structure of the leaves. This helps to discriminate plant species, and also used to detect Vegetation Stress. Beyond 1.3 μm, reflectance in the wavelength 1.4 μm, 1.9 μm & 2.7 μm is less, mainly due to absorption of energy by water present in the leaves.

SOIL: Soil reflectance curve shows generally an increasing trend with wavelength in the visible and near infrared regions. The parameters that influence the soil reflectance are the moisture content, the amount of organic matter, iron oxide, relative percent of clay, silt and sand and the roughness of soil surface. Increase in the moisture content decreases reflectance in the optical and IR bands. In thermal IR regions most soils look darker compared to dry soils. In microwave region, it is possible to quantify soil moisture due to the large differences in di-electric constant of water & soil.

WATER: Water absorbs most of the radiation in the near IR & middle IR regions. This helps is easy identification of even small water bodies. Turbid water increases reflectance and the peak reflectance shifts towards longer wavelength. Dissolved gases and inorganic salt do not change reflectance.

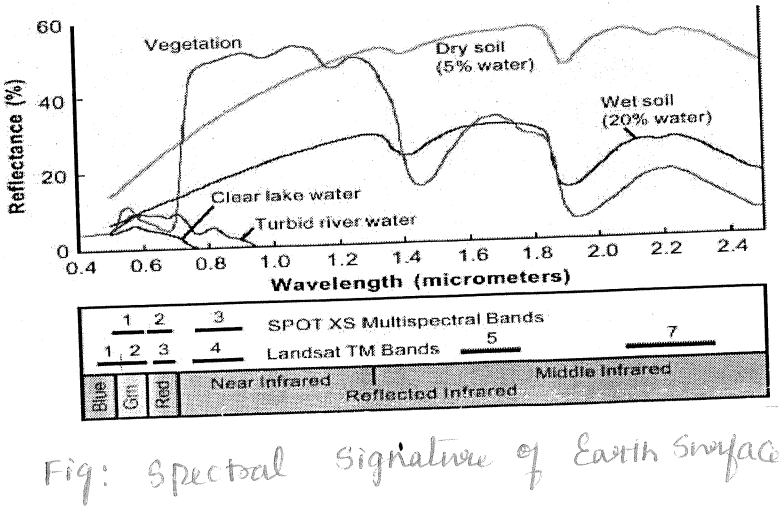
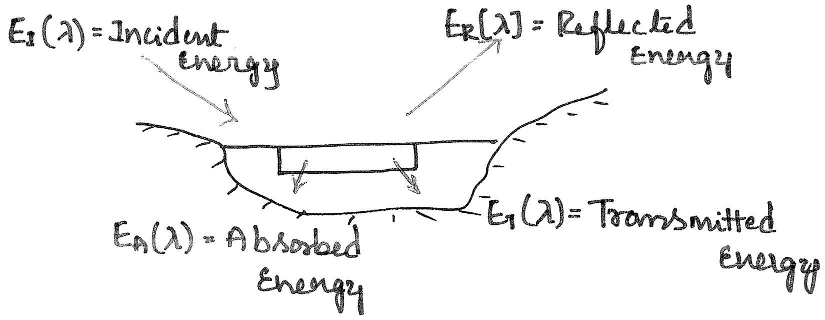


Fig: Spectral signature of Earth Surface feature.

ENERGY INTERACTION WITH THE EARTH SURFACE FEATURE

When Electro-magnetic Energy is incident on any Earth surface feature, three fundamental Energy interactions with the feature are possible as shown in the fig below.



$$E_I(\lambda) = E_R(\lambda) + E_A(\lambda) + E_T(\lambda)$$

Fig. Basic interactions between Electromagnetic Energy and an Earth surface feature

The above Equation is the energy balance Equation Expressing the interrelationship among the mechanism of reflection, absorption, & transmission. Two points about the above given relationship [Expressed in the form of Equation] should be noted.

1) The proportions of Energy reflected, absorbed and transmitted will vary for different Earth features, depending upon their material type and conditions. These differences permit us to distinguish different features on an image.

2) The wavelength dependency means that, even within a given feature type, the proportion of reflected, absorbed & transmitted Energy will vary at different wavelengths.

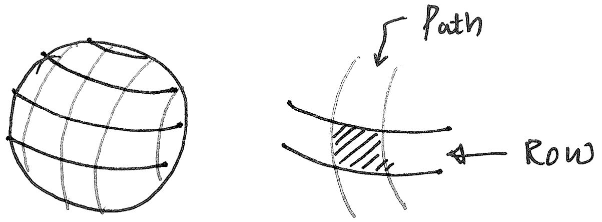
Thus, two features may be distinguishable in one spectral range & be vary different on another wavelength band.

within the visible portion of the spectrum, these spectral variations result in the visual effect called "colour". For Example, we call blue objects "blue" when they reflect highly in the "green" spectral region, & so on. Thus, the eye uses spectral variations in the magnitude of reflected energy to discriminate between various objects. The colour discrimination based on wavelengths of spectral reflectance is given the Table.

Table colour discrimination based on wavelengths of spectral reflectance [IRS - 1A/1B LISS I & LISSII]

Band	Wavelength µm	Principle
1	0.45-0.52	Sensitive to sedimentation, deciduous/coniferous forest cover discrimination, Soil vegetation differentiation
2	0.52-0.59	green reflectance by healthy vegetation, vegetation vigor, rock-soil discrimination, turbidity & bathymetry in shallow waters.
3	0.62-0.68	Sensitive to chlorophyll absorption, plant species discrimination, differentiation of soil & geological boundary
4.	0.77-0.86	Sensitive to green biomass & moisture in vegetation, land & water contrast, land form/geomorphic studies.

INTERPRETATION : Identification of different objects in the Scene is called interpretation.



The area acquired by row & path is Scene.

1. Visual interpretation
2. Digital interpretation.

Visual interpretation does not allow for full Exploration of data provided. Human can Visually interpret 3 layers of Remotely Sensed information at a time.

Digital interpretation allows for quantative analysis of all spectral bands in imagery & is able to detect differences that cannot be detected by human eyes.

Visual interpretation is the act of or process of Examining images[satellite imageries] for the purpose of identifying Objects and assessing their Significance. Visual image interpretation involves detection, recognition, identification, classification and delineation of Objects in an aerial or a Satellite image.

ELEMENTS OF VISUAL INTERPRETATION:

The Elements to be considered during interpretation of Satellite images are

1. Tone It refers to the relative brightness or colour of objects in an image. It is the fundamental Element for distinguishing targets or features in an image.

2. Shape: It refers to the general form, structure or outline of the individual object for Example, straight Edge shapes represent urban or agricultural field, forests may be represented by irregular Shapes.

3. Size: It is a function of Scale. It is important to assess the Size of a target relative to other objects in the Scene and also the absolute Size to aid in interpretation.

4. Pattern: It refers to the spatial arrangement of visible discernable objects. A unique Ordely repitition of Similar tones and textures will produce a distinctive and recognizable pattern Example, Orchards with Evenly spaced trees etc.

5. Texture: It refers to the arrangement & frequency of tonal Variation in particular areas of an image. Rough texture would consist of grey levels changing abruptly in a Small area where as smooth has Very little tonal Variations, Example, Smooth texture - grass lands, rough texture - forest Canopy.

6. Shadow: It provides an idea of the profile and relative height of a target which makes identification Easier. Targets within shadows are much less discernible from their surrounding.

7. Association: It takes into account the relationship between other recognizable objects or features in proximity to the target of interest for Example, commercial properties may be associated with proximity to major transportation route etc.

8. Site: Location of an objects in relation to its Environment. Identification of features based on the land use characteristics of a region, such as a citrus grove being placed on a ridge to prevent damage from mountain breezes or a vineyard occurring on the south facing slope to take advantage of the mountain breezes to prevent frost.

9. Resolution: More than most other picture characteristics, resolution depends on aspects of the remote sensing system including its nature, design and performance.

DIGITAL IMAGE

A digital remotely sensed images is typically composed of picture elements [pixels] located at the intersection of each row i and column j in each K bands of imagery. Associated with each pixel is a number known as Digital Number [DN] or Brightness Value [BV], that depicts the average radiance of a relatively small area within a scene [Fig.1]. A smaller number indicates low average radiance from the area and the high number is an indicator of high radiant properties of the area. The size of this area effects the reproduction of details within the scene. As pixel size is reduced more scene detail is presented in digital representation.

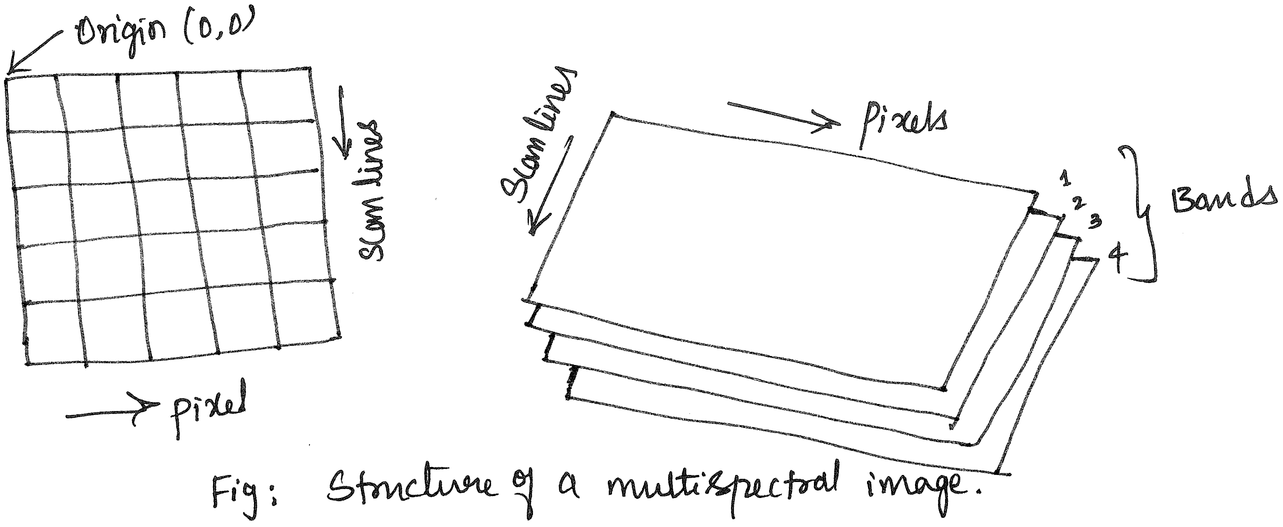


Fig: Structure of a multispectral image.

DIGITAL IMAGE DATA FORMATS

The Image data acquired from Remote Sensing Systems are stored in different types of formats viz (1) band sequential (BSQ), (2) band interleaved by line (BIL), (3) band interleaved by pixel (BIP). It should be noted, however, that each of these formats is usually preceded on the digital tape by "header" and/or "trailer" information, which consists of ancillary data about the date, altitude of the sensor, attitude, sun angle, and so on.

Such information is useful when geometrically or radiometrically correcting the data. The data are normally recorded on nine-track CCTs with data density on the tape of 800, 1600, or 6250 bits per inch (bpi).

Band Sequential Format The band sequential format requires that all data for a single band covering the entire scene be written as one file. Thus if one wanted the area in the centre of a scene in four bands, it would be necessary to read into this location in four separate files to extract the desired information. Many researches like this format because it is not necessary to read "serially" past unwanted information if certain bands are of no value. The number of tapes may be dependent on the number of bands provided for the scene.

Band Interleaved by Line Format:

In this format, the data for the bands are written line by line onto the same tape [i.e. line 1 band 1, line 1 band 2, line 1 band 3, line 1 band 4, etc.]. It is a useful format if all the bands are to be used in the analysis. If some bands are not of interest, the format is inefficient since it is necessary to read serially past all the unwanted data.

Band Interleaved by pixel Format

In this format, the data for the pixel in all bands are written together. Taking the example of LANDSAT - MSS [Four Bands of Image Data every element in the matrix has four pixel values (one from each spectral band) placed one after the other [i.e pixel (1,1) of band 1, pixel (1,1) of band 2, pixel (1,1) of band 3, pixel (1,1) of band 4, and then pixel (1,2) of band 1, pixel (1,2) of band 2 & so no]. Again, this is a practical data format if all bands are to be used, otherwise it would be inefficient. This format is not much popular now, but was used Extensively by EROS Data Centre for Landsat Scene at initial stage.

DIGITAL IMAGE PROCESSING:

Digital Image processing is an Extremely broad Subject and involves procedures which are mathematically complex. The procedure for digital image processing may be categorized into the following types of computer assisted operations.

1. Image Rectification: These operations aim to correct distorted or degraded image data to create a faithful representation of the Original Scene. This typically involves the initial processing of raw image data to correct for Geometric distortion, to calibrate the data radiometrically and to eliminate noise present in the data. Image rectification and restoration procedures are often termed preprocessing operations because they normally precede manipulation and analysis of Image data.

2. Image Enhancement: These procedures are applied to image data in order to effectively display the data for Subsequent Visual interpretation. It involves techniques for increasing the visual distinction between features in a Scene. The objective is to create new images from original data in order to increase the amount of information that can be visually interpreted from the data.

It includes level slicing, contrast stretching, spatial filtering edge enhancement, spectral rationing, principal components and intensity-hue-saturation colour space transformations.

3. Image Classification: The objective of these operations is to replace visual analysis of the image data with quantitative techniques for automating the identification of features in a scene. This involv the analysis of multispectral image data and the application of statically based decision rules for determining the land cover identity of each pixel in an image. The intent of classification process is to categorize all pixels in a digital image into one of several land cover classes or themes. This classified data may be used to produce thematic maps of land cover present in an image.

GEOMETRIC CORRECTIONS: The flux radiance registered by a remote sensing system ideally represents the radiant energy leaving the surface of earth like vegetation, urban land, water bodies etc. Unfortunately, this energy flux is interspersed with errors, both internal & external which exist as noise within the data. the internal errors, also known as systematic errors are sensor created in nature and hence are systematic and quite predictable. The external errors are largely due to perturbations in the platform or atmospheric scene characteristics. Image preprocessing is the technique used to correct this degradation/noise created in the image, thereby to produce a corrected image with replicates the surface characteristics as closely as possible. The transformation of a remotely sensed image, so that it possesses the scale and projection

REMOTE SENSING & GIS

MODULE - 03

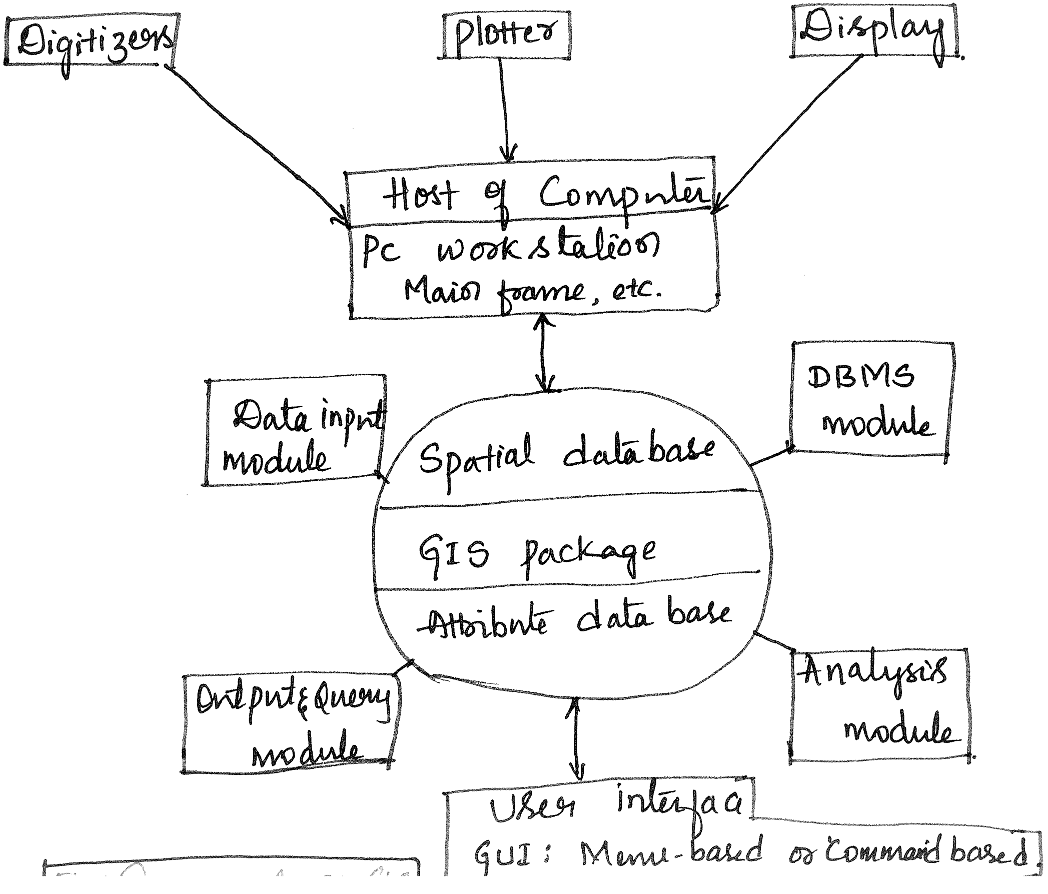
GEOGRAPHIC INFORMATION SYSTEM:

Introduction to GIS:

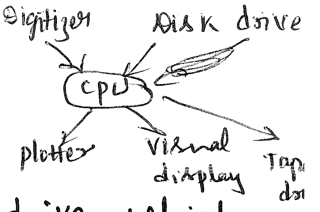
The Association for Geographic Information defines GIS as: A system for capturing, storing, checking, integrating, manipulating, analyzing, and displaying data which are spatially referenced to the Earth.

A simpler working definition is: A computer-based approach to interpreting maps and images and applying them to problem solving.

Components of GIS:



Geographic information systems have three important Components They are
(i) Computer hardware.
(ii) Set of application Software modules
(iii) And a proper Organization Contest.



Hardware Components of a GIS

CPU: Central processing Unit is linked to disk drive, which provides Space for Storing data programs.

Digitizer: It is used to convert data from maps and documents into digital form [Raster ~~to~~ Vector].

Plotter: plotter is used to present the Results of the data Processing on a paper.

Tape drive: It is used to store data or programs on magnetic tape for communicating with other Systems.

Display: It is used to control the computer and the other Peripherals. It is Otherwise known as terminal or workstation.

Software Components of a GIS:

The Software Components of a GIS Consists of five basic modules. These basic modules are Subsystems for

(i) Data input and Verification
(ii) Data Storage and data base management.
(iii) Data output and presentation
(iv) Data transformation
(v) Interaction with the User.

Organizational Context:

Organizational aspect or context is nothing but the way the information flows and the way in which the analysis is done. The Organizational Context involves three Sub Components:

a. **Data:** Data is nothing but information being used for the analysis: The following are the more common data that are encountered

1. Digital Elevation Model [DEM]
2. Triangular Irregular Network [TIN]
3. Digital Line Graph [DLG]

b. **People:** GIS Technology is of limited Value without trained technical experts who manage the System and develop plans for applying it to real-world problems. GIS Users range from technical Specialists who design and maintain the System to those who use it to help them perform their Everyday Work.

c. **Methods:** The methods is nothing but the Steps, procedures which are used for the analysis and in the making of the information System.

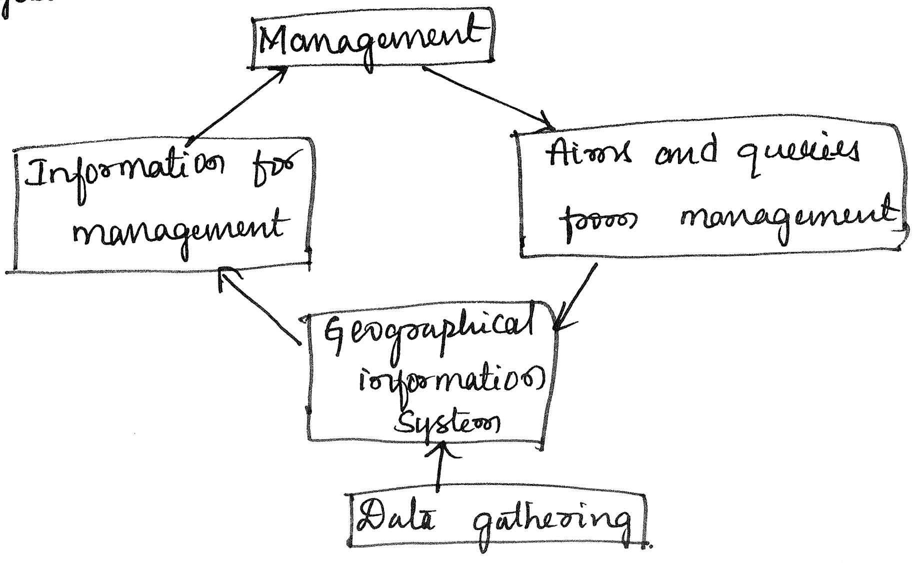


Fig: Organizational aspects of Geographical Information System

Geographically Referenced Data:

Geographic location is the element that distinguishes geographic information from all other types. Geodata describe both the location and the characteristics of spatial features such as households, roads, land parcels and water bodies. Geodata represent real-world objects [also called features] in a digital format.

A Geographically referenced objects has two main components "Spatial data" representing its location, and "Attribute data" representing its characteristics.

Spatial Data: spatial data [mapable data] of geo-referenced data is commonly characterized by the presence of two fundamental components.

1. The physical dimension or class i.e., the phenomena being reported.

   For Example: Height of the forest Canopy, demographic class, rock type, vegetation type details of a city etc.,

2. The spatial location of the phenomena

   For Example: Specified with reference to common coordinate System [latitude and longitude etc.].

Non Spatial / Attribute / Tabular Data: There are usually data tables that contain information about the spatial components of the GIS theme. These can be numeric and/or character data such as timber type, timber volume, road size, well depth etc. ~~the~~

The attributes are related back to the spatial features by use of unique identifiers that are stored both with the attribute tables and the features in each spatial data layer. Attributes can be either qualitative [low, medium, high income] or quantitative [actual measurements]. The database allows us to manipulate information in many ways : from simple listing of attributes, sorting features by some attributes, grouping by attributes, or selecting and singling out groups by attributes.

Joining Spatial and attribute data :

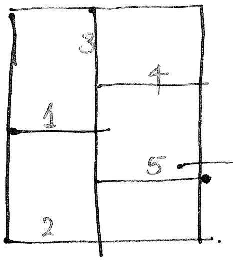
Often, what's most interesting about a map is not the individual layers but the relationships between the features in those layers. For Example, suppose you wanted to tell customers where they can find the nearest branch office of your business, or you want to compare different wildlife species with information about the habitats they live in. These types of queries can be answered with a spatial join

A spatial join joins the attributes of two layers based on the location of the features in the layers. Like joining two tables by matching attribute values in a field, a spatial join appends the attributes of one layer to another

you can then use the additional information to query your data in new ways. while you can also select features in one layer based on their location relative to another layer, a spatial join provides a more permanent association between the two layers because it creates a new layer containing both sets of attributes.

The georelation data model stores attribute data seperately from spatial data in a split system. However the object based data model stores spatial data & attribute data in a single system. This eliminates the complexity of co-ordinating & synchronizing two sets of data files as required in a split system.

Whether spatial & attribute data are stored in a split or single system, the relational database model is the norm for data management in GIS. A relational database is a collection of tables[relations]. The connection between tables is made through a key, a common field whose values can uniquely identify a record in a table. The feature ID serves as the key in the georelational data model to link spatial and attribute data.



Road layer

ID	class	No. of lanes
1	2	4
2	1	2
3	1	2
4	1	2
5	2	2

Road attribute table.

Feature ID

Name	ID	Maintainance Date
Kingsway	1	22-02-2014
University	2	01-01-2014
Avenue	3	13-12-2013
Dundasstreet	4	29-11-2013
St. George Street	5	25-11-2013

longitude and latitude values from one geographic coordinate system to another. Although the migration from NAD27 to NAD83 is still underway, new developments on datums continue in the U.S for local surveys. ~~Conc~~

Concept of datum also applies to measurements of elevations or heights. the National Geodetic Vertical Datum [NGVD] of 1929 was based on observations at tidal stations on the Atlantic, pacific & gulf of mexico. Refinement of 1929 datum has resulted in North American Vertical Datum of 1988 [NAVD 88]. NAVD88 is now the reference vertical datum for elevation readings in North America

GIS operation:

Spatial Data Input: The most expensive part of GIS project is data acquistion [process of collecting or organising the information]. Data can be acquired by using Existing data or by creating new data

New digital data can be created from Satellite images, GPS data, field surveys, street adresses & text files with x, y co-ordinates. But paper maps remains the dominant data source. Manual digitizing scanning can convert paper maps into digital format. A newly digitized map requires Editing & geometric transformation. Editing removes digitizing errors, which may relate to the location of spatial data such as missing polygons distorted lines, unclosed polygons, geometric transformation converts a newly digitized map which has the same physical dimension as its source map. Geometric transformation can also ~~transfers~~ coverts satellite images into projected co-ordinates. Geometric transformation operates on a set of control points. we often have to adjust the control points to reduce the amount of transformation error to an acceptable level.

Attribute data Management:

To complete GIS database, we must Enter & Verify attribute data through digitizing and editing. Attribute data reside as table in a relational database. An attribute table is organized by row and column. Each row represents a spatial features, & Each column or field describes a characteristics. Attribute tables in a database must be designed to facilitate data input, search, retrieval, manipulation & output.

Two basic elements in the design of a relational database are the key & the type of relationship. The key Establishes a connection between corresponding records in two tables, & the type of data relationship dictates how the tables are actually joined or linked. Attribute data management also includes adding or deleting fields or creating new field from Existing fields.