AL-BAHA UNIVERSITY
FACULTY OF ENGINEERING
CIVIL ENGINEEING DEPARTMENT

SURVEYING LABORATORY MANUAL

CIVIL ENGINEERING DEPARTMENT
2024

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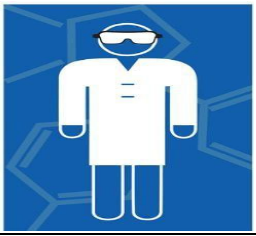
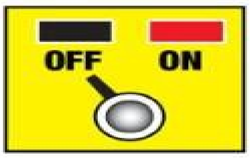
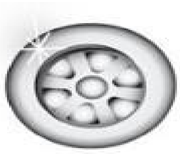
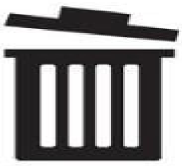
General Safety Guidelines:

Rule	Guideline/Prohibition	Rationale
1	No Eating, Drinking, or Chewing Gum	To maintain a sterile and safe environment. 
2	No Smoking in the Laboratory Area	To safeguard the laboratory and its occupants. 
3	Dress Appropriately	Appropriate attire for personal safety and experiment integrity. 
4	Conduct Yourself Responsibly	Maintain a focused and serious atmosphere. 
5	Hazard Symbols Awareness	Identify potential dangers in the laboratory. 
6	Equipment Shutdown	Conserve energy and prevent equipment damage. 
7	Equipment Cleaning	Promote equipment longevity and prevent cross-contamination. 
8	Maintain Cleanliness	Ensure a safe, efficient, and well-maintained laboratory. 

SAFETY FIRST

(General Administration of Safety and Risks)

الإدارة العامة للسلامة والمخاطر

Phone: 0177257700 - 15424

Email: safety@bu.edu.sa

(Important Phone Number)

ارقام مهمة

رقم التلفون	الجهة	رقم التلفون	الجهة
933	طوارئ الكهرباء Electricity Emergency	999	الشرطة Police
939	طوارئ المياه Water Emergency	998	الدفاع المدني Fire Department
937	استشارة طبية Medical advice	997	الاسعاف Red Crescent
911	الدوريات الأمنية Emergency Number	996	امن الطرق Roads Security
980	مكافحة الفساد Corruption (Nazaha)	993	المرور Traffic

Surveying Laboratory

- **Introduction**

Traditionally, surveying concerned with making some sort of measurement to determine the location of points to produce maps, or layout such point, surveying can be related to all civil engineering branches such as building, road engineering, water resources, irrigation, drainage engineering … etc. in all steps of data acquisition and planning, designing, execution, and monitoring. Laboratory component of surveying engineering courses represents an integral part of the theoretical component. It relates theory with practice. It gives the students a valuable chance to do a real job. Moreover, it gives the students the self-confidence to work in the field. In addition to that, it assists students to improve their skills in teamwork and leadership skills.

- **Objectives**

1. Develop practical surveying skills: The lab emphasizes hands-on experience, allowing students to learn and practice various surveying techniques beyond theory. This includes using equipment, conducting measurements, and applying learned concepts in real-world scenarios.
2. Reinforce theoretical understanding: By actively engaging in practical exercises, students gain a deeper understanding of surveying principles and how they translate into actual fieldwork. This reinforces classroom learning and strengthens their grasp of key concepts.
3. Prepare for diverse civil engineering applications: Surveying plays a crucial role across various civil engineering branches. The lab exposes students to how these skills are applied in different contexts, like building construction, road design, water resource management, and irrigation projects. This broadens their perspective and prepares them for future specialization.
4. Cultivate essential professional skills: Beyond technical knowledge, the lab fosters soft skills like teamwork and leadership. Working together on Surveying projects and taking initiative in different aspects contribute to their professional development and prepare them for collaborative work environments.

- **Report Writing**

Use the report template provided in Appendix (A) as a guide.

- **Lab. Instruments**

  Recently, new surveying instruments have been added to the surveying lab. Now, the surveying Lab consists of all necessary instruments required to achieve surveying course experiments including tapes, poles, compasses, theodolites, levels, and handheld GPS. In addition to other accessories. Table Below represents classification of surveying lab instruments.

No.	Instrument	Description	Quantity
1	Theodolite	Digital Theodolite	2
2	Level	Automatic Level	3
3	Levelling Rod	Aluminum Grad Rod	4
4	Tripod	Surveying Tripod	4
5	Tape	Fiberglass Tape (LAND 50m LD-159)	4
6	Reflector	Single Prizm Reflector (GPH1)	1
7	Compass	Prismatic Compass	2
8	handheld GPS	Garmin	1
9	Measuring wheel	-	1
10	Distometer	-	1

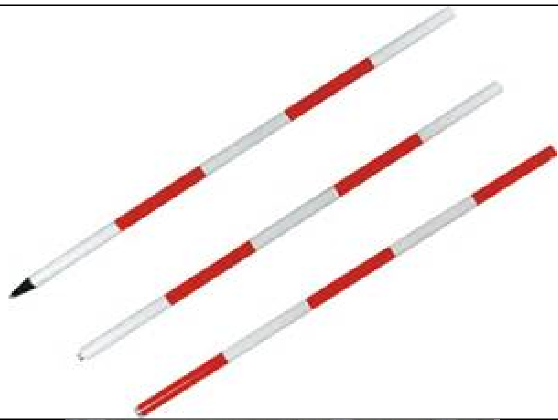
- **Lab. Experiments**

  Throughout this semester, students had a chance to do the following eight experiments:

1. Temporary adjustment of the level including Levelling and Parallax elimination.
2. Differential levelling and series levelling.
3. Applying the Stadia system as a sample of O.D.M.
4. Taking linear measurements using tape.
5. Theodolite temporary adjustment, including Centering, Levelling, and Parallax elimination.
6. Measuring horizontal angles.
7. Measuring vertical angles.
8. Setting out circular curves using tape.

MORE DETAILS IN APPENDIX (B)

- **Surveying Instruments:**

Item	Instrument	Figure
1	Steel Tape	
2	Ranging Rods	
3	Compass	
4	Optical Level	

Item	Instrument	Figure
5	Digital Theodolite	
6	Distometer	
7	Handheld GPS	
8	Measuring Wheel	

Appendixes

A.Writing lab Report Template

Albaha University

Faculty of Engineering

Civil Engineering Department

Course # (……..)

Course Title: ……………………….

Semester: (…………………)

Instructor: …………………………….

Group ….

Experiment No. …….

Title of Experiment: …………………….

Names	ID.s
1.	

Date of Experiment: …………………

Time of Experiment……………………………

Table of contents

Team meeting (Optional)

Introduction

Experimental design

Data

Calculations

Figures & Graphs

Results & Discussion

References

(Optional)

Meeting Minutes

Meeting#... of Report#...

Time: ....

Date: ....

Venue: ....

Attendants:

1) ....
2) ....
3) ....
4) ....

Agenda

Writing tasks that are taken before and during the meeting.

Discussion Taken

Writing down all objectives you will discuss in the meeting.

Actions Person Responsible

Writing the distribution of tasks between team members.

Introduction:

Usually, the Introduction is one paragraph that **explains the objectives or purpose of the lab**. In one sentence, state the hypothesis. Sometimes an introduction may contain background information, briefly **summarize how the experiment was performed**, state the findings of the experiment, and list the conclusions of the investigation. Even if you don't write a whole introduction, you need to state the purpose of the experiment, or why you did it. This would be where you state your hypothesis.

Experimental design

a) Materials
List everything needed to complete your experiment.

b) Equipment:
List everything needed to complete your experiment.

c) Methods
Describe the steps you took during your investigation. This is your procedure. Be sufficiently detailed that anyone could read this section and duplicate your experiment. Write it as if you were giving directions for someone else to do the lab. It may be helpful to provide a Figure to diagram your experimental setup.

Data:

Numerical data obtained from your procedure usually is presented as a table. Data encompasses what you recorded when you conducted the experiment. It's just the facts, not any interpretation of what they mean.

Calculations:

The Analysis section contains **any calculations you made based on those numbers**. This is where you interpret the data and determine whether a hypothesis was accepted.

Figures & Graphs

Graphs and figures must both be labeled with a descriptive title. Label the axes on a graph, being sure to include units of measurement.

Results & Discussion

Describe in words what the data means. Sometimes the Results section is combined with the Discussion (Results & Discussion).

Reference:

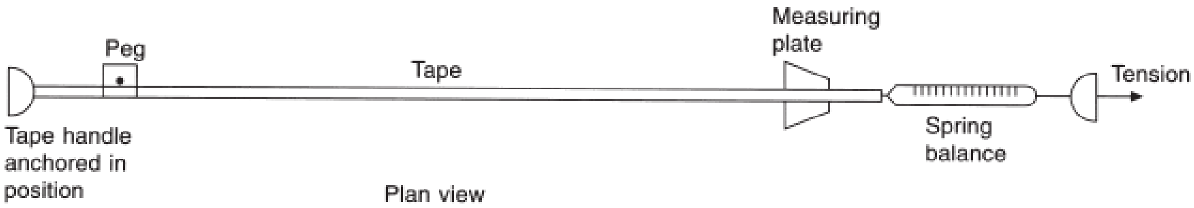
If your research was based on someone else's work or if you cited facts that require documentation, then you should list these references.

B. Experiments described as per Al-Baha University Curriculum for Surveying laboratory.

Measuring along the ground

The most accurate way to measure distance with a steel band is to measure the distance between pre-set measuring marks, rather than attempt to mark the end of each tape length. The procedure is as follows:

1. The Surveying points to be measured are defined by nails in pegs and should be set flush with the ground surface. Ranging rods are then set behind each peg, in the line of measurement.



2. Using a linen tape, arrows are aligned between the two points at intervals less than a tape length. Measuring plates are then set firmly in the ground at these points, with their measuring edge normal to the direction of taping.
3. The steel band is then carefully laid out, in a straight line between the Surveying point and the first plate. One end of the tape is firmly anchored, whilst tension is slowly applied at the other end. At the exact instant of standard tension, both ends of the tape are read simultaneously against the Surveying station point and the measuring plate edge respectively, on command from the person applying the tension. The tension is eased and the whole process repeated at least four times or until a good set of results is obtained.
4. When reading the tape, the meters, decimeters, and centimeters should be noted as the tension is being applied; thus, on the command ‘to read’, only the millimeters are required.
5. The readings are noted by the booker and quickly subtracted from each other to give the length of the measured bay.
6. In addition to ‘rear’ and ‘fore’ readings, the tape temperature is recorded, the value of the applied tension, which may in some instances be greater than standard, and the slope or difference in level of the tape ends are also recorded.
7. This method requires a Surveying party of five; one to anchor the tape end, one to apply tension, two observers to read the tape and one booker.
8. The process is repeated for each bay of the line being measured, care being taken not to move the first measuring plate, which is the start of the second bay, and so on.
9. The data may be booked as follows:

Line	Fore-distance	Back-distance	Mean	Remarks
AB				
BC				
CD				
DA				
AC				
BD				

10. Plot measurements using suitable scale.

Measuring Linear Distance Using Laser Distometer

1. Make the required reconnaissance,
2. Set up the instrument:
    a. The required units
    b. The required values such as Lengths, Areas, or Volumes etc.
    c. Repeat.

Theodolite Temporary Adjustment

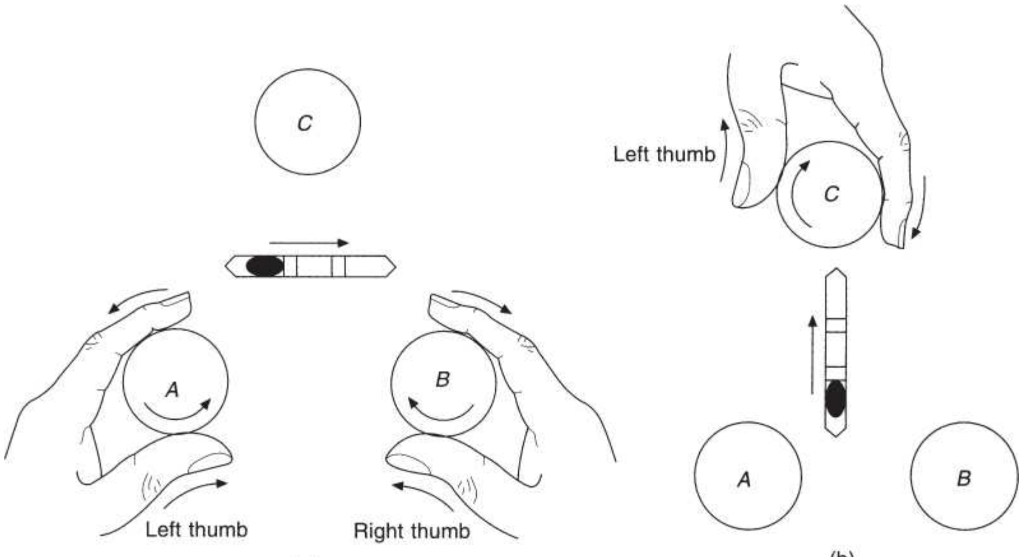
The methods of setting up the theodolite and observing angles will now be dealt with. It should be emphasized, however, that these instructions are no substitute for practical experience.

Setting up using a plumb bob

1. Extend the tripod legs to the height required to provide comfortable viewing through the theodolite. It is important to leave at least 100 mm of leg extension to facilitate positioning of the plumb bob.
2. Attach the plumb bob to the tripod head, so that it is hanging freely from the center of the head.
3. Stand the tripod approximately over the surveying station, keeping the head reasonably horizontal.
4. If the tripod has them, tighten the wing units at the top of the tripod legs and move the whole tripod until the plumb bob is over the station.
5. Now tread the tripod feet firmly into the ground.
6. Unclamp a tripod leg and slide it in or out until the plumb bob is exactly over the station. If this cannot be achieved in one movement, then use the slide extension to bring the plumb bob in line with the Surveying point and another tripod leg. Using this latter leg, slide in or out to bring the plumb bob onto the Surveying point.
7. Remove the theodolite from its case and hold it by its standard, attach it to the tripod head.

8. The instrument axis is now set truly vertical using the plate bubble as follows:

    a. Set the plate bubble parallel to two-foot screws A and B and center it by equal amounts of simultaneous contra-rotation of both screws. (The bubble follows the direction of the left thumb.)
    b. Rotate alidade through 90◦ and Centre the bubble using foot screw C only.
    c. Repeat (a) and (b) until bubble remains central in both positions. If there is no bubble error this procedure will suffice. If there is a slight bubble error present, proceed as follows.
    d. From the initial position at B, rotate the alidade through 180◦; if the bubble moves off-center bring it halfway back using the foot screws A and B.
    e. Rotate through a further 90◦, placing the bubble 180◦ different from its position. If the bubble moves off-center, bring it halfway back with foot screw C only.
    f. Although the bubble is off center, the instrument axis will be truly vertical and will remain so as long as the bubble remains the same amount off center.
    g. Test that the instrument has been correctly levelled by turning the instrument to any arbitrary direction. If the instrument is correctly levelled the bubble will remain in the same position within its vial no matter where the instrument is pointed.
9. Check the plumb-bob; if it is off the Surveying point, slacken off the whole theodolite and shift it laterally across the tripod head, taking care not to allow it to rotate until the plumb-bob is exactly over the Surveying point.
10. Repeat (8) and (9) until the instrument is centered and levelled.



(a) (b)

Setting up using the optical plumb-bob

All modern instruments have an optical plummet built into the alidade section of the instrument (Figures (a)and (b)), or into the tribrach. Proceed as follows:

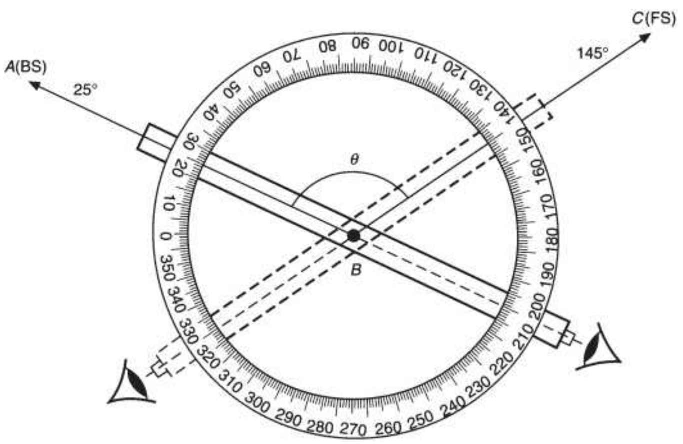
1. Establish the tripod roughly over the Surveying point using a plumb bob as in (1) to (5) above.
2. Depending on the situation of the optical plummet, attach the tribrach only, or the theodolite, to the tripod.
3. Using the foot screws to incline the line of sight through the plummet, center the plummet exactly on the Surveying point.
4. Using the leg extension, slide the legs in or out until the circular bubble of the tribrach/theodolite is exactly Centre. Even though the tripod movement may be excessive, the plummet will still be on the surveying point. Thus, the instrument is now approximately centered and levelled.
5. Precisely level the instrument using the plate bubble, as described in (8) of above. Unclamp and move the whole instrument laterally over the tripod until the plummet crosshair is exactly on the Surveying point.
6. Repeat (5) and (6) until the instrument is exactly centered and levelled.

Horizontal Angle Measurement

Although the theodolite or total station is a very complex instrument the measurement of horizontal and vertical angles is a simple concept. The horizontal and vertical circles of the instrument should be regarded as circular protractors graduated from 0o to 360o in a clockwise manner. Then a simple horizontal angle measurement between three surveying points A, B, and C in the sense of measuring at A clockwise from B to C would be as shown in Figure below.

1. The instrument is set up centered and levelled on Surveying point *B*. Parallax is removed.
2. Commencing on, say, 'face left', the target set at Surveying point *A* is carefully bisected and the horizontal scale reading noted = 25°.
3. The instrument is rotated to Surveying point *C* which is bisected. The horizontal scale reading is noted = 145 °.
4. The horizontal angle is then the difference of the two directions, i.e. Forward Station (C) minus Back Station (A), (FS - BS) = (145° - 25°) = 120°.
5. Change face and observe Surveying point *C* on 'face right' and note the reading = 325°.
6. Swing to point A and note the reading = 205°.
7. The readings or directions must be subtracted in the same order as in (4), i.e. *C — A.*

Thus (325o — 205o) = 120o



8. Note how changing face changes the readings by 180°, thus affording a check on the observations. The mean of the two values would be accepted if they are in good agreement.
9. Try to use the same part of the vertical hair when pointing to the target. If the target appears just above the central cross on FL it should appear just below the central cross on FR. This will minimize the effect of any residual rotation of the crosshairs.

Had the BS to *A* read 350° and the FS to *C* 110°, it can be seen that 10° has been swept out from 350° to 360° and then from 360° or 0° to 110°, would sweep out a further 110°. The total angle is therefore 10° + 110° = 120° or (FS - BS) = [(110° + 360°) - 350°] = 120°.

A further examination of the protractor shows that (BS - FS) = [(25° + 360°) - 145°] = 240°, producing the external angle. It is thus the manner in which the data are reduced that determines whether or not it is the internal or external angle which is obtained.

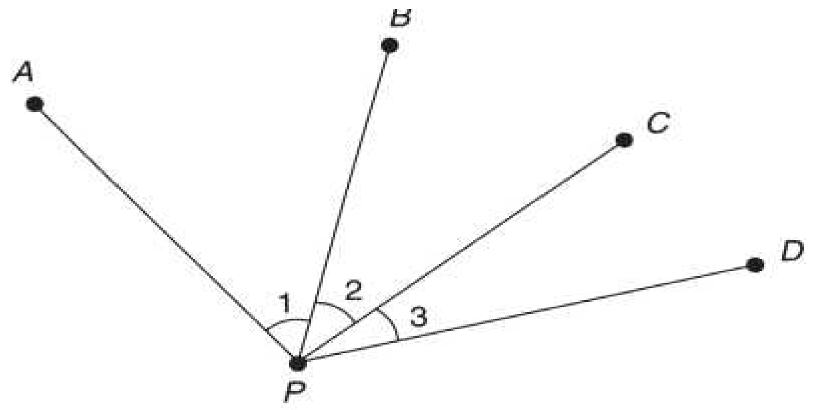
A method of booking the data for an angle measured in this manner is shown in *Table.* This approach constitutes the standard method of measuring single angles in traversing, for instance.

Measurement by directions:

The method of directions is generally used when observing a set of angles as in *Figure.* The angles are observed, commencing from *A* and noting all the readings, as the instrument moves from point to point in a clockwise manner. On completion at *D,* face is changed, and the observations repeated moving from *D* in an anticlockwise manner.

Finally, the mean directions are reduced relative to the starting direction for *PA* by applying the 'orientation correction'. For example, if the mean horizontal circle reading for *PA* is 48° 54' 36" and the known bearing for *PA* is 40° 50' 32", then the orientation correction applied to all the mean bearings is obviously -8° 04' 04''.

The observations as above, carried out on both faces of the instrument, constitute a full set. If measuring *n* sets the reading is altered by 180°/n each time.



Sight to	Face	Reading			Angle		
		d	m	s			
A	L	020	46	28	80	12	06
C	L	100	58	34			
C	R	280	58	32	80	12	08
A	R	200	46	24			
A	R	292	10	21	80	12	07
C	R	012	22	28			
C	L	192	22	23	80	12	04
A	L	112	10	19			
					Mean = 80	12	06

Station	Point	Face	H.C. Reading	Angle	Mean Horizontal Angle	Remarks
A	B	L	30° 30′ 15″	95 05 10	95° 02′ 35″	
	C	L	125 35 25			
	C	R	305 30 25	95 00 00		
	B	R	210 30 20			

Vertical Angle Measurement

In the measurement of horizontal angles, the concept is of a measuring index moving around a protractor. In the case of a vertical angle, the situation is reversed, and the protractor moves relative to a fixed horizontal index.

Figure (a) shows the telescope horizontal and reading 90°; changing face would result in a reading of 270°. In *Figure (b),* the vertical circle index remains horizontal whilst the protractor rotates with the telescope, as the top of the spire is observed. The vertical circle reading of 65° is the zenith angle, equivalent to a vertical angle of (90° — 65°) = +25° = *a*. This illustrates the basic concept of vertical angle measurement.

Sight to	*Face*		*Reading*		*Apply misclosure*			*Mean of FL and FR reduced to FL*		
		o	*t*	*tt*	*o*	*t*	*tt*	*o*	*t*	*tt*
A	*L*	*20*	*26*	*36*	*20*	*26*	*36*	*20*	*26*	*31*
B	*L*	*65*	*37*	*24*	*65*	*37*	*22*	*65*	*37*	*18*
C	*L*	*102*	*45*	*56*	*102*	*45*	*52*	*102*	*45*	*54*
D	*L*	*135*	*12*	*22*	*135*	*12*	*16*	*135*	*12*	*16*
A	*L*	*20*	*26*	*44*	*20*	*26*	*36*	*20*	*26*	*31*
Misclosure				*+8*			*0*			
A	*R*	*200*	*26*	*26*	*200*	*26*	*26*			
D	*R*	*315*	*12*	*14*	*315*	*12*	*15*			
C	*R*	*282*	*45*	*44*	*282*	*45*	*46*			
B	*R*	*245*	*37*	*12*	*245*	*37*	*15*			
A	*R*	*200*	*26*	*22*	*200*	*26*	*26*			
Misclosure				*—4*			*0*			

Station	Point	Face	V.C. Reading	Vertical Angle	Mean Vertical Angle	Remarks
A	B	L	85° 30′ 30″	04 30 30	04° 30′ 25″	
	B	R	274 30 20	04 30 20		

Setting out circular curve using offsets from the tangent length method

Objectives:

Is to set out 10m circular curve with 30 deflection angle using offsets from the tangent length method.

<u>**Instruments Required:**</u>

1. Two measuring tapes
2. Pegs, nails or similar
3. Methodology
4. Compute tangent length Lc.
5. Select suitable range (0.5m)
6. Calculate offsets values Yi and tabulate results.
7. Set out tangent points T, U and intersection point I.
8. Starting from one tangent point set out values of Xi.
9. Using the other tape set out values of Ys analogue to Xs.
10. Repeat steps (e) and (f) above for another tangent.

Computation and Results:

Tangent Length = R tan (Θ/2) = 10 tan (30˚/2) = 2.68m

$$Y = \frac{X^2}{2R}$$

X(m)	0.5	1.0	1.5	2.0	2.5
Y(m)	0.01	0.50	0.11	0.20	0.31

Setting out circular curve using offsets from long chord method

Objectives:

Is to set out 10m circular curve with 30 deflection angle using offsets from long chord method.

Instruments Required

1. Two measuring tapes
2. Pegs, nails or similar

<u>Methodology:</u>

3. Compute long chord TU.
4. Select suitable range X_i (0.5m).
5. Calculate offsets values Y_i and tabulate results.
6. Set out tangent points T and U.
7. Set out mid-point of the long chord X_0.
8. Starting from the mid-point of the long chord measure Y_0 at right angle to X_0 to set out first point on the curve.
9. From the mid-point of the long chord measure X_i towards T using one tape and measure Y_i at right angle to X_i using the other tape.
10. Repeat steps (f) and (g) above towards U to set out the second half of the curve.

Computation and Results:

$\mathbf{Long\ Chord\ (TU)} = 2Rsin\ (\frac{\theta}{2})$=2×10×sin (30 /2)=5.18m

TU/2 = 5.18/2 =2.59 m

$$Y = \sqrt{R^2 - X^2} - \sqrt{R^2 - \left(\frac{Long\ chord}{2}\right)^2}$$

X(m)	0.0	0.5	1.0	1.5	2.0	2.5
Y(m)	0.34	0.33	0.29	0.23	0.14	0.02