Computer Solution of Curve Data

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Surveying and Civil engineering office and field personnel frequently are called upon to calculate curve data. Software supplied by manufacturers of calculators and minicomputers includes preprogrammed strips or tapes for calculating curve data. These programs require that one component other than arc length or tangent length be known. However, the plans and plots provided are often reproductions on which the part of the original containing the complete curve data is not included. Consequently, personnel sometimes find that the only data on hand are the arc length and the tangent length. There is no mathematical relationship that provides a direct trigonometric approach for calculating the other curve components from arc and tangent only. A short program in the BASIC computer language will do this for any curve having a central angle less than 180°.

A ten step program containing one loop is adequate for calculating an approximate central angle. In order to obtain the accuracy required for most work a computer will use excessive time in running this ten step program. Additional loops of eight steps can be added to increase the degree of accuracy without involving too much running time. A program with three loops will compute the central angle within a maximum error of 04″ in a few seconds of time.

Trigonometric functions are commonly included as built-in library functions available in a BASIC system. TAN (X) is such a system-furnished function, the value of which the BASIC system is already programmed to compute. In the following argument and program radian measurement of angles is used. Line 270 (Figure 3) converts radians to degrees as well as doubling β (Figure 1) for the final answer printed by line 280.

Tangent length (T) and arc length (L) are sufficient to determine the circle. The argument will establish β (one-half delta) from which the radius (R) and the central angle are calculated (Figure 1). $\tan\beta = T/R$ or $R = T/\tan\beta$. Also, $\beta = L/2R$ radians or $R = L/2\beta$. Thus, $T/\tan = L/2\beta$ or $\tan\beta = 2T\beta/L$. The root of this equation is the intersection of the graphs of the two functions (Figure 2).

With input values for T and L the program will have the computer find the value of B where the two functions are approximately equal (Figure 3). This is accomplished by assigning an initial value to B (line 20), computing F1 as 2TB/L (lines 30 and 40) and F2 as tanB (line 50), and then repetitively testing for F1>F2 at the desired increments of B until F2>F1 is reached.

Figure 3 illustrates a run of the program for a curve with tangent length of 104.79 feet and arc length of 200.02 feet. In the computer program β is symbolized by the variable B, delta is symbolized by the variable D, and the two functions of β are F1 and F2. Note from Figure 2 that F1 is initially greater than F2 except for $\beta = 0$. Line 20 must start with a small positive value of B (not 0). Otherwise F1 will equal F2 (both 0 from lines 40 and 50) and lines 60 and 70 will direct the computer into the next loop without looking for a positive value of F1 which is less than or equal to F2. Then B will receive a negative value in line 100 and, needless to say, the computer will not report a correct answer. This bug is eliminated by letting B=0.000001 in line 20.

Loop 40 through 90 tests the functions at intervals of 0.01 radian until a value of F1 less than or equal to the value of F2 is found. Then line 100 reduces the value of B by 0.01 radian so that F1 is once again greater than F2. Loop 120 through 170 proceeds at 0.0001 radian increments to find a value of F1 that is less than or equal to the value of F2. Then, as previously, line 180 returns F1 to a value greater than F2 by reducing B 0.0001 radian. In a like manner loop 200 through 250 refines the value of B by testing the functions at an increment of 0.00001 radian. Lines 260

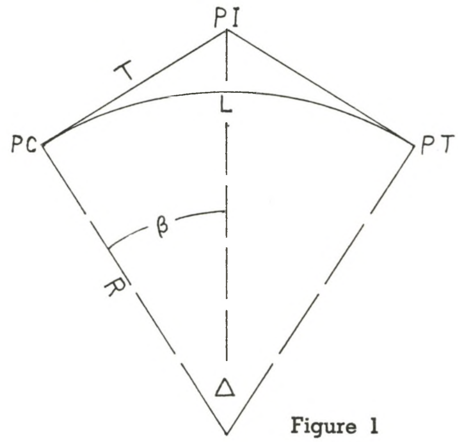

Figure 1

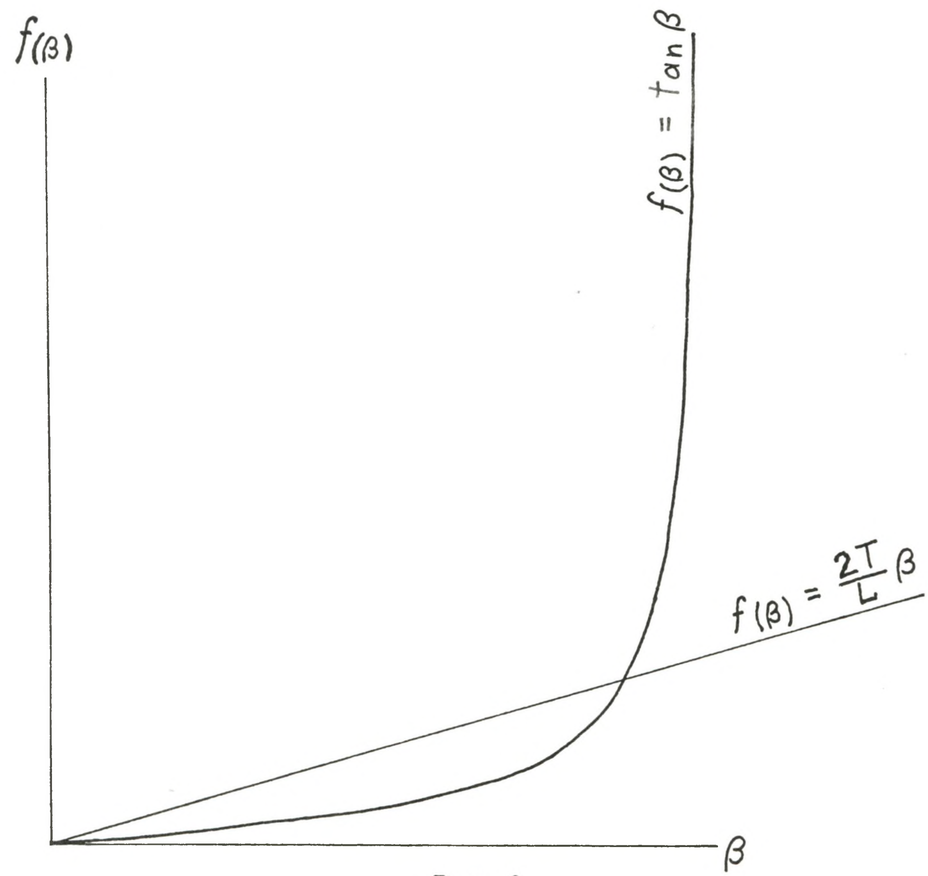

Figure 2

and 270 calculate the radius and central angle from the final value of B. Lines 110 and 190 are unnecessary and redundant but were included in the program to supply continuity to the reader and emphasize the repetitive character of the three loops.

Since 0.00001 radian equals 02″, the final loop will locate B with an accuracy of +02″ (line 240). D=2B and the factor of 2 is included in the radian to degree conversion of line 270. Thus the maximum error in computing D, the central angle, is +04″.

A T/L ratio greater than 400.42 will not be solved by this program. Obviously this situation would not arise in standard surveying and engineering practice. At tangent length 400.42 and arc length 1.00 the central angle is 179.91° and B is approximately 1.57 radians. At a T/L ratio of 400.43 the graphs of the functions will have crossed. To look for an F1 less than or equal to F2, the first loop will increase the 1.57 radians by the 0.01 increment to 1.58 radians which is greater than 90°. The computer will not report an answer because at 1.58 radians and from there on at 0.01 radian intervals an F1 less than or equal to F2 will not be found.

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LIST
CURVE     10:09 AM     15-Sep-81
 10 INPUT T,L
 20 LET B=0.000001
 30 LET C=2*T/L
 40 LET F1=B*C
 50 LET F2=TAN(B)
 60 IF F1>F2 THEN 80
 70 GO TO 100
 80 LET B=B+0.01
 90 GO TO 40
100 LET B=B-0.01
110 LET C=2*T/L
120 LET F1=B*C
130 LET F2=TAN(B)
140 IF F1>F2 THEN 160
150 GO TO 180
160 LET B=B+0.0001
170 GO TO 120
180 LET B=B-0.0001
190 LET C=2*T/L
200 LET F1=B*C
210 LET F2=TAN(B)
220 IF F1>F2 THEN 240
230 GO TO 260
240 LET B=B+0.00001
250 GO TO 200
260 LET R=T/F2
270 LET D=360*B/3.14159
280 PRINT "THE RADIUS IS" R "AND THE CENTRAL ANGLE, DELTA, IS" D "DEGREES"
290 END
Ready
RUN
CURVE     10:10 AM     15-Sep-81
? 104.79.200.02
THE RADIUS IS 271.581 AND THE CENTRAL ANGLE, DELTA, IS 42.1985 DEGREES
Ready
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Figure 3

DISCIPLINE - *cont'd from page 26*

this decision. The total cost for this monitoring is not to exceed $2,000 and will be co-ordinated by the Standards Officer.

(iv) Mr. Mackey will undertake in writing to permit a respected and knowledgeable surveyor named by the Council to attend at Mr. Mackey's office at Mr. Mackey's expense to discuss and advise regarding business and professional matters relating to Mr. Mackey's practice.

(d) That the responsibility of ensuring that the above noted conditions have been fulfilled is the responsibility of the Standards Officer and that the Standards Officer will report forthwith to Council any contravention of the terms of the undertaking made by Mr. Mackey.

(e) That upon compliance with all of the terms of this decision noted above the suspension of Mr. Mackey will be remitted; and

(f) That in the event of a failure to comply with any or all of the above by Mr. Mackey within 60 days, or in the case of 6 (iii), subsequent thereto, the (6) six month suspension will commence forthwith on the 60th day from the service of this decision or forthwith upon non-compliance with section 6 (iii), and compliance will be determined by the Discipline Committee.

Note:

Mr. Mackey complied with the conditions set out above in paragraph C (i), (ii), and (iv) within the 60 day period as required and is presently being monitored as set out in paragraph (iii). ●

NOTICE

ACSTTO Annual Meeting

MAY 14 and 15, 1982

HOLIDAY INN, OAKVILLE

SEMINAR: JOINT AOLS/ACSTTO SEMINAR ON FRIDAY, MAY 14

TOPICS: EVIDENCE - field procedures
what is evidence?
depiction on plans and field notes?

RESPONSIBILITY - of ACSTTO member
to the Association
to the public
to his employer

SOCIALS: Friday evening - get acquainted party
(more information to follow)

Saturday evening - Dinner and Dance

Set these dates aside and plan to attend.

Also encourage your staff to attend