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ภาคผนวก

ภาคผนวก ก

โปรแกรมเปลี่ยนระบบแกนพิกัด

```
10 HOME
20 PRINT : PRINT "THIS PROGRAM C
  AN FIT HELIX TRACKS."
30 :PI = 3.141592653
80 GOTO 10070: REM MAIN PROGRAM
90 REM *****
100 REM SUBROUTINE UV TO XY
110 SO = (U + V + W) / 2
120 SW = SO - W
130 SU = SO - U
140 SV = SO - V
150 X = 2 * SO * SV / W - U
160 Y = - 2 * SQR (SO * SU * SV
  * SW) / W
170 RETURN
180 REM END OF UV TO XY
181 REM *****
190 REM CALCULATE ARCTAN(DX/DY)
200 IF DX = 0 THEN TH = PI / 2: GOTO
  230
210 :TH = ATN (DY / DX): IF DX >
  0 THEN 240
220 :TH = TH + PI: GOTO 240
230 IF DY < 0 THEN TH = - PI /
  2
240 RETURN
250 REM END OF ANGLE
255 REM *****
290 REM ROTATE (X1Y1) TO (X2Y2)
300 :X2 = X1 * COS (RA(CN)) - Y1
  * SIN (RA(CN))
310 :Y2 = X1 * SIN (RA(CN)) + Y1
  * COS (RA(CN))
320 RETURN
330 REM END OF ROTATION
340 REM *****
350 REM DETERMINANT 2*2
360 :D0 = A(2,2) - A(1,2)
370 :D1 = A(1,1) * A(2,2) - A(1,2
  ) * A(2,1)
380 :D2 = A(2,1) - A(1,1)
390 RETURN
400 REM END OF DETERMINANT
410 REM *****
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10000 REM *****
10010 REM * *
10020 REM * MAIN PROGRAM *
10030 REM * *
10040 REM *****
10050 REM SET VARIABLES FOR
10060 REM FIDUCIAL POINTS
10070 DIM FX(2,3),FY(2,3),FZ(2)
10080 DIM FU(2,3),FV(2,3)
10090 REM *****
10120 PRINT TAB(15)"FIRST TIME
"
10130 PRINT " THIS PROGRAM WILL
HELP YOU TRANSFORM"
10140 PRINT "MEASURED COORDINATE
(U,V) TO THE"
10150 PRINT "COORDINATE OF FIDUCIAL
MARKS (X,Y). "
10160 PRINT
10170 DIM X1(2,3),Y1(2,3)
10180 DIM X2(2,3),Y2(2,3)
10190 DIM X0(2),Y0(2),Z(2)
10191 REM TRANSLATION VARIABLES
10200 DIM XL(2),YL(2)
10201 REM LENS POSITIONS
10210 DIM RA(2)
10211 REM ROTATION ANGLE
11020 REM FIRST PART TRANSFORM
11030 REM COORDINATE (U,V) FROM
11040 REM PICTURE MEASUREMENT
11050 REM TO COORDINATE OF THE
11060 REM FIDUCIAL POINTS (X,Y)
11070 REM *****
11080 REM INPUT FIDUCIAL POINTS
11090 PRINT TAB(3)"PLANE OF TWO
FIDUCIAL MARKS IS"
11100 INPUT "THE PLANE Z1 = ";FZ
(1)
11110 PRINT
11120 PRINT TAB(3)"PLANE OF ONE
FIDUCIAL MARK IS "
11130 INPUT "THE PLANE Z2 = ";FZ
(2)
11140 : PRINT
11150 PRINT " I HAVE TO KNOW THREE
FIDUCIAL MARKS"
11155 PRINT "FROM EACH VIEW."
11200 : PRINT
11210 : PRINT "FIRST TWO FIDUCIAL
MARKS ARE ON THE"
11215 PRINT "PLANE Z1"
11220 : PRINT "AND THE THIRD MARK
IS ON THE PLANE Z2."
11230 VTAB(24): INVERSE

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11240 PRINT "PRESS ANY KEY TO CO
      NTINUE.";
11250 GET S$: NORMAL
11260 REM *****
11270 REM INPUT FIDUCIAL DATA
11280 FOR CN = 1 TO 2
11290 HOME
11300 PRINT " INPUT DATA OF FID
      UCIAL MARKS."
11310 PRINT "NOW DATA USED IN VI
      EW NUMBER ";; INVERSE : PRINT
      CN: NORMAL
11320 : FOR I = 1 TO 3
11330 : PRINT
11340 : PRINT "FIDUCIAL MARK NUMB
      ER ";I
11350 : INPUT " X = ";FX(CN,I)
11360 : INPUT " Y = ";FY(CN,I)
11370 : INPUT " U = ";FU(CN,I)
11380 : INPUT " V = ";FV(CN,I)
11390 : NEXT I
11400 NEXT CN
11410 REM END OF INPUTTING F.P.
11420 PRINT
11430 PRINT "DISTANCE BETWEEN B1
      AND B2"
11440 INPUT "IS W = ";W
11450 INPUT "POSITION B1 U = ";U
      0
11460 INPUT "POSITION B2 V = ";V
      0
11490 REM *****
11500 HOME : REM CHECKING
11510 PRINT TAB( 18)"NOW,"
11520 PRINT
11530 PRINT "I WILL SHOW YOU EAC
      H VALUE WAS INPUT."
11540 PRINT
11550 : PRINT "IF IT IS THE ";; INVERSE
      : PRINT "RIGHT";: NORMAL : PRINT
      " VALUE, YOU PRESS ";; INVERSE
      : PRINT "R";: NORMAL : PRINT
      ". "
11560 : NORMAL : PRINT : PRINT "I
      F";: PRINT TAB( 14);: INVERSE
      : PRINT "WRONG";: NORMAL : PRINT
      TAB( 31)"PRESS ";; INVERSE
      : PRINT "W";: NORMAL : PRINT
      ". "
11570 PRINT : PRINT "PREPARE DAT
      A FOR CHECKING."

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11580 PRINT : PRINT TAB( 10)"PRESS ANY KEY WHEN READY.": GET
      CH$
11590 HOME
11600 PRINT
11610 INVERSE : HTAB 7: PRINT "R
      ";: HTAB 10: PRINT "=";: HTAB
      13: PRINT "RIGHT";: HTAB 26:
      PRINT "W";: HTAB 29: PRINT
      "=";: HTAB 32: PRINT "WRONG"
      : NORMAL
11620 PRINT
11630 PRINT "FIDUCIAL POINTS DATA"
11640 PRINT : PRINT "FIDUCIAL PLANES"
11650 PRINT "Z1 = "FZ(1);: GET C
      H$: IF CH$ = "W" THEN 61650
11660 HTAB (20): PRINT "Z2 = "FZ
      (2);: GET CH$: IF CH$ = "W" THEN
      61660
11670 FOR CN = 1 TO 2
11680 PRINT : PRINT : PRINT "VIEW
      W "CN
11690 : FOR I = 1 TO 3
11700 : PRINT : PRINT "POINT "I
11710 : PRINT " X = ";FX(CN,I);: GET
      CH$: IF CH$ = "W" THEN 61710

11720 : HTAB (20): PRINT " Y = ";
      FY(CN,I);: GET CH$: IF CH$ =
      "W" THEN 61720
11730 : PRINT : PRINT " U = ";FU(
      CN,I);: GET CH$: IF CH$ = "W
      " THEN 61730
11740 : HTAB (20): PRINT " V = ";
      FV(CN,I);: GET CH$: IF CH$ =
      "W" THEN 61740
11750 : NEXT I
11755 PRINT
11760 NEXT CN
11770 PRINT : PRINT "DISTANCE BETWEEN B1 AND B2 IS W = "W";: GET
      CH$: IF CH$ = "W" THEN 61770
11780 PRINT : PRINT "POSITION OF
      B1 U = ";UO;: GET CH$: IF C
      H$ = "W" THEN 61780
11790 PRINT : PRINT "POSITION OF
      B2 V = ";VO;: GET CH$: IF C
      H$ = "W" THEN 61790
11810 PRINT : PRINT "ALL RIGHT ?
      (Y FOR YES, N FOR NO)";

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11820 GET CH$
11830 IF CH$ = "Y" THEN 11910
11840 IF CH$ = "N" THEN 11590
11850 PRINT " ";: GOTO 11820
11860 REM END OF CHECKING F.P.
11870 REM *****
11880 REM ** TRANSFORMATION **
11890 REM ** (U,V) TO (X,Y) **
11900 REM *****
11910 SPEED= 255
11920 FOR CN = 1 TO 2
11930 FOR I = 1 TO 3
11940 ::FU(CN,I) = FU(CN,I) - U0
11950 ::FV(CN,I) = V0 - FV(CN,I)
11960 ::FU(CN,I) = FU(CN,I) / 40
11970 ::FV(CN,I) = FV(CN,I) / 40
11980 NEXT I
11990 NEXT CN
12000 HOME
12010 HTAB 10: VTAB 10: PRINT "P
LEASE WAIT FOR 1 MINUTES."
12020 W = W / 40
12050 REM CN = CAMERA:I = POINT
12060 FOR CN = 1 TO 2
12070 : FOR I = 1 TO 3
12080 :U = FU(CN,I):V = FV(CN,I)
12090 : GOSUB 110
12100 :X1(CN,I) = X:Y1(CN,I) = Y
12110 : NEXT I
12120 NEXT CN
12130 FOR I = 1 TO 2
12140 Z(I) = ((X1(I,2) - X1(I,1))
^ 2 + (Y1(I,2) - Y1(I,1)) ^
2) / ((FX(I,2) - FX(I,1)) ^
2 + (FY(I,2) - FY(I,1)) ^ 2)
12150 Z(I) = SQR (Z(I)) * FZ(I)
12160 NEXT I
12180 REM END OF (U,V) TO (X,Y)
12190 REM *****
12195 REM * ROTATION ANGLE *
12196 REM *****
12200 FOR CN = 1 TO 2
12210 :DX = FX(CN,2) - FX(CN,1)
12220 :DY = FY(CN,2) - FY(CN,1)
12230 GOSUB 200: REM * ALPHA *
12240 RA(CN) = TH
12250 :DX = X1(CN,2) - X1(CN,1)
12260 :DY = Y1(CN,2) - Y1(CN,1)
12270 GOSUB 200: REM ** BETA **
12280 RA(CN) = RA(CN) - TH
12290 NEXT CN
12300 FOR CN = 1 TO 2
12310 : FOR I = 1 TO 3
12330 ::X1 = X1(CN,I)

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12340 :::Y1 = Y1(CN,I)
12350 ::: GOSUB 300: REM ROTATE
12360 :::X2(CN,I) = X2
12370 :::Y2(CN,I) = Y2
12380 : NEXT I
12390 NEXT CN
12400 REM END OF ROTATION
12410 REM *****
12411 REM LENS POSTION AND
12412 REM TRANSLATION X AXIS
12413 REM *****
12420 DIM A(2,2)
12430 FOR CN = 1 TO 2
12440 A(1,2) = Z(CN) / FZ(1)
12450 A(1,1) = A(1,2) * FX(CN,1) -
      X2(CN,1)
12460 A(1,2) = A(1,2) - 1
12470 A(2,2) = Z(CN) / FZ(2)
12480 A(2,1) = A(2,2) * FX(CN,3) -
      X2(CN,3)
12490 A(2,2) = A(2,2) - 1
12500 GOSUB 360: REM DETER 2X2
12510 X0(CN) = D1 / D0
12520 XL(CN) = D2 / D0
12529 REM *****
12530 REM *TRANSLATION Y AXIS *
12531 REM *****
12540 A(1,2) = Z(CN) / FZ(1)
12550 A(1,1) = A(1,2) * FY(CN,1) -
      Y2(CN,1)
12560 A(1,2) = A(1,2) - 1
12570 A(2,2) = Z(CN) / FZ(2)
12580 A(2,1) = A(2,2) * FY(CN,3) -
      Y2(CN,3)
12590 A(2,2) = A(2,2) - 1
12600 GOSUB 360: REM DETER 2X2
12610 Y0(CN) = D1 / D0
12620 YL(CN) = D2 / D0
12630 NEXT CN
12640 REM *****
12650 REM END OF TRANSLATION
12689 REM *****
12990 REM * SAVE CONSTANT *
12991 REM *****
13000 HOME
13010 PRINT
13020 PRINT " PLEASE NAME THIS TRACK.";
13022 VTAB 5: HTAB 10: PRINT "PLEASE WAIT !!"
13030 INPUT " ?";NA$
13040 PRINT "OPEN NAME"
13050 PRINT "DELETE NAME"
13060 PRINT "CLOSE NAME"
13070 PRINT "OPEN NAME"

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13080 PRINT "WRITE NAME"
13090 PRINT NA$
13100 PRINT "CLOSE NAME"
13110 PRINT "OPEN";NA$
13120 PRINT "DELETE";NA$
13130 PRINT "OPEN "NA$
13140 PRINT "WRITE "NA$
13150 PRINT W
13153 PRINT UO
13156 PRINT VO
13170 PRINT ""
13180 FOR I = 1 TO 2
13190 PRINT "WRITE "NA$
13200 PRINT RA(I)
13210 PRINT FZ(I)
13220 : PRINT Z(I)
13230 PRINT XL(I)
13240 PRINT YL(I)
13250 PRINT XO(I)
13260 PRINT YO(I)
13270 PRINT ""
13280 NEXT I
13290 PRINT "CLOSE "NA$
13300 PRINT "RUN FITT"
60000 END
61630 REM *****
61640 REM CORRECTING INPUT F.P.
61650 PRINT : PRINT "CORRECT Z1
FROM "FZ(1)" TO BE";: INPUT
FZ(1): GOTO 11590
61660 PRINT : PRINT "CORRECT Z2
FROM "FZ(2)" TO BE";: INPUT
FZ(2): GOTO 11590
61710 PRINT : PRINT "CORRECT X =
"FX(CN,I);: INPUT " TO BE ";
FX(CN,I): GOTO 11590
61720 PRINT : PRINT "CORRECT Y =
"FY(CN,I);: INPUT " TO BE "
;FY(CN,I): GOTO 11590
61730 PRINT : PRINT "CORRECT U =
"FU(CN,I);: INPUT " TO BE "
;FU(CN,I): GOTO 11590
61740 PRINT : PRINT "CORRECT V =
"FV(CN,I);: INPUT " TO BE "
;FV(CN,I): GOTO 11590
61770 PRINT : PRINT "CORRECT W =
"W;: INPUT " TO BE ";W: GOTO
11590
61780 PRINT : PRINT "CORRECT UO
= ";UO;: INPUT " TO BE ";UO:
GOTO 11590
61790 PRINT : PRINT "CORRECT VO
= ";VO;: INPUT " TO BE ";VO:
GOTO 11590
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## ภาคผนวก ข

## โปรแกรมวิเคราะห์ทางเดินขนาดใน 3 มิติ

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10  REM GOTO MAIN PROGRAM
20  GOTO 20010
90  REM *****
99  REM (U,V) TO (X,Y)
100 SO = (U + V + W) / 2
110 SU = SO - U
120 SV = SO - V
130 SW = SO - W
140 X = 2 * SO * SV / W - U
150 Y = - 2 * SQR (SO * SU * SV
      * SW) / W
160  RETURN
170  REM *****
190  REM ROTATE AXIS
200 XR = XX * COS (AL) - YY * SIN
      (AL)
210 YR = XX * SIN (AL) + YY * COS
      (AL)
220  RETURN
19999 REM *****
20000 REM  READ TEXT FILE
20001 REM *****
20010 DIM Z(2),FZ(2),RA(2)
20020 DIM X0(2),Y0(2)
20030 DIM XL(2),YL(2)
20050 PRINT "OPEN NAME"
20060 PRINT "READ NAME"
20070 INPUT NA$
20080 PRINT "CLOSE NAME"
20090 PRINT "OPEN "NA$
20100 PRINT "READ "NA$
20110 INPUT W
20113 INPUT B1
20116 INPUT B2
20130 PRINT ""
20140 FOR I = 1 TO 2
20150 PRINT "READ "NA$
20160 INPUT RA(I)
20170 INPUT FZ(I)
20180 : INPUT Z(I)
20190 INPUT XL(I)
20200 INPUT YL(I)
20210 INPUT X0(I)
20220 INPUT Y0(I)
20230 PRINT ""
20240 NEXT I
20250 PRINT "CLOSE "NA$

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20255 GOTO 20601
20260 REM END OF TEXT FILE
20270 REM *****
20300 REM INPUT FROM KEYBOARD
20301 REM *****
20310 HOME
20320 PRINT : PRINT : PRINT "PLEASE KEY DATA OF STUDYING TRACK."
20340 PRINT : PRINT "I CAN FIT CURVE FROM VIEW1 BY POLYNOMIAL REGRESSION."
20350 PRINT "AND CREATE CONICAL SURFACE BY LENS POSITION AS THE VERTEX."
20360 PRINT "THEN DRAW STRIGHT LINES PASS POSITIONS ON TRACK IN VIEW2 AND LENS POSITION CUT THE SURFACE GENERATED BY VIEW1."
20370 PRINT "FINALLY I CAN MAKE A HELIX FIT FROM THE INTERSECTIONS."
20380 PRINT : PRINT "BE CAREFUL INPUTTING DATA MUST RESPECTIVE THE DATA OF FIDUCIAL POINTS."
20390 PRINT : PRINT "FROM EACH VIEW, YOU MUST READ OUT SEVEN POINTS ALONG THE TRACK IN (U,V) COORDINATE."
20400 PRINT : PRINT "PRESS ANY KEY WHEN READY.";
20410 GET A$: PRINT
20411 REM *****
20420 REM INPUT DATA BY K.B.
20430 REM READING FROM TRACK
20440 DIM TU(2,6),TV(2,6)
20500 FOR CN = 1 TO 2
20510 PRINT : PRINT "DATA FROM VIEW NUMBER ";: FLASH : PRINT CN: NORMAL
20520 PRINT
20530 : FOR I = 0 TO 6
20540 : PRINT "POSITION NUMBER "; I + 1
20550 : INPUT " U = ";TU(CN,I)
20560 : INPUT " V = ";TV(CN,I)
20570 : NEXT I
20580 NEXT CN
20590 REM END TRACK READING

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20591 REM *****
20600 GOSUB 60000: REM CHECKING
20601 TR$ = "T" + NA$
20602 PRINT "OPEN"TR$
20603 FOR CN = 1 TO 2: FOR I = 0
      TO 6
20604 PRINT "READ "TR$
20605 INPUT TU(CN,I): INPUT TV(C
      N,I): PRINT "": NEXT I,CN
20610 REM BEFORE ANYTHING!
20611 REM CHANGE (U,V) TO (X,Y)
20620 DIM TX(2,6),TY(2,6)
20630 FOR CN = 1 TO 2
20640 : FOR I = 0 TO 6
20650 ::U = (TU(CN,I) - B1) / 40
20655 ::V = (B2 - TV(CN,I)) / 40
20660 : GOSUB 100
20670 ::TX(CN,I) = X
20675 ::TY(CN,I) = Y
20680 : NEXT I
20690 NEXT CN
20691 REM *****
20692 PRINT "ROTATE TO PARALLEL
"

20693 REM *****
20700 DIM RX(2,6),RY(2,6)
20710 FOR CN = 1 TO 2
20720 :AL = RA(CN)
20730 : FOR I = 0 TO 6
20740 ::XX = TX(CN,I)
20745 ::YY = TY(CN,I)
20750 : GOSUB 200
20760 ::RX(CN,I) = XR
20765 ::RY(CN,I) = YR
20770 : NEXT I
20780 NEXT CN
20790 PRINT "SET THE SAME ORIGIN
"

20800 DIM MX(2,6),MY(2,6)
20810 FOR CN = 1 TO 2
20820 : FOR I = 0 TO 6
20830 ::MX(CN,I) = RX(CN,I) + XO(
      CN)
20840 ::MY(CN,I) = RY(CN,I) + YO(
      CN)
20850 : NEXT I
20860 NEXT CN
20890 REM *****
20900 PRINT "ROTATE FOR REGRESSI
      ON"
20902 PRINT "SOLVE FOR ANGLE"
20910 DX = MX(1,6) - MX(1,0)
20920 DY = MY(1,6) - MY(1,0)
20930 PI = 3.141592653

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20940 IF DX = 0 THEN BE = PI / 2
      : GOTO 20970
20950 BE = ATN (DY / DX): IF DX >
      0 THEN 20980
20960 BE = BE + PI: GOTO 20980
20970 IF DY < 0 THEN BE = - PI /
      2
20980 AL = - BE
20990 PRINT "ROTATING"
21000 DIM XR(2,6),YR(2,6)
21010 FOR CN = 1 TO 2
21020 : FOR I = 0 TO 6
21030 ::XX = MX(CN,I)
21040 ::YY = MY(CN,I)
21050 : GOSUB 200
21060 ::XR(CN,I) = XR
21070 ::YR(CN,I) = YR
21080 : NEXT I
21090 NEXT CN
21091 DIM LX(2),LY(2)
21092 FOR CN = 1 TO 2
21093 ::XX = XL(CN):YY = YL(CN)
21094 : GOSUB 200
21095 ::LX(CN) = XR:LY(CN) = YR
21096 NEXT CN
21100 REM *****
21101 FOR CN = 1 TO 2: FOR I = 0
      TO 6: PRINT XR(CN,I),YR(CN,
      I): NEXT I,CN
21110 REM POLYNOMIAL REGRESSION
21120 DIM A(5,5),B(5),X(10)
21121 : REM SET LINEAR EQUATION
21130 : FOR R = 0 TO 5
21140 :: FOR I = 0 TO 6
21150 :::B(R) = B(R) + (XR(1,I) /
      100) ^ R * (YR(1,I) / 100)
21160 :: NEXT I
21170 : NEXT R
21180 ::X(0) = 7
21190 : FOR I = 1 TO 10
21200 :: FOR J = 0 TO 6
21210 :::X(I) = X(I) + (XR(1,J) /
      100) ^ I
21220 :: NEXT J
21230 : NEXT I
21232 : REM SET MATRIX ELEMENT
21240 : FOR R = 0 TO 5
21250 :: FOR C = 0 TO 5
21260 :::A(R,C) = X(R + C)
21270 :: NEXT C
21280 : NEXT R

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21300 REM SOLVE LINEAR EQUATION
21310 : FOR D = 0 TO 5
21320 :: IF A(D,D) = 0 THEN GOSUB
        62000
21330 :: FOR R = D TO 5
21340 ::: IF A(R,D) = 0 THEN 2144
        0
21360 ::::B(R) = B(R) / A(R,D)
21370 ::: IF R = D THEN 21390
21380 ::::B(R) = B(R) - B(D)
21390 ::: FOR C = 5 TO D + 1 STEP
        - 1
21400 ::::A(R,C) = A(R,C) / A(R,D
        )
21410 ::: IF R = D THEN 21430
21420 ::::A(R,C) = A(R,C) - A(D,C
        )
21430 ::: NEXT C
21440 :: NEXT R
21450 : NEXT D
21490 REM FINISH UPPER
21500 REM TRIANGULAR MATRIX
21510 : FOR R = 4 TO 0 STEP - 1
21520 :: FOR C = R + 1 TO 5
21530 ::::B(R) = B(R) - A(R,C) * B
        (C)
21540 :: NEXT C
21550 : NEXT R
21600 : FOR I = 0 TO 5
21610 ::B(I) = 100 * B(I) / 100 ^
        I
21620 : NEXT I
21630 REM *****
21640 REM FINISH REGRESSION
22000 REM *****
22010 REM * START ITERATION *
22020 REM *****
22022 REM * ESTIMATE POINT 0 *
22024 REM *****
22030 DIM DL(2),RL(2,6)
22031 REM *****
22032 REM * SET TWO LINES *
22034 REM *****
22040 :DL(1) = (LX(2) - LX(1)) *
        Z(1)
22050 :DL(2) = (LY(2) - LY(1)) *
        Z(1)
22060 :DD = DL(2) / DL(1)
22070 :RZ = Z(1) / Z(2)
22080 FOR I = 0 TO 6
22090 ::RL(1,I) = (XR(2,I) - LX(2
        )) * RZ + LX(1)
22100 ::RL(2,I) = (YR(2,I) - LY(2
        )) * RZ + LY(1)
22110 NEXT I

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22120 DIM IT(5,6)
22121 REM *****
22122 REM ITERATIVE FUNCTION
22123 REM *****
22130 FOR I = 0 TO 6
22140 : FOR J = 0 TO 5
22150 :::IT(0,I) = IT(0,I) + B(J)
      * RL(1,I) ^ J
22160 : NEXT J
22170 :::IT(0,I) = IT(0,I) - RL(2,
      I)
22180 : FOR J = 1 TO 5
22190 :::IT(1,I) = IT(1,I) + J *
      B(J) * RL(1,I) ^ (J - 1)
22200 : NEXT J
22210 :::IT(1,I) = IT(1,I) - DD
22220 : FOR J = 2 TO 5
22230 :::IT(2,I) = IT(2,I) + J *
      (J - 1) / 2 * B(J) * RL(1,I)
      ^ (J - 2)
22240 : NEXT J
22250 :::IT(3,I) = B(3) + 4 * B(4)
      * RL(1,I) + 10 * B(5) * RL(
      1,I) ^ 2
22260 :::IT(4,I) = B(4) + 5 * B(5)
      * RL(1,I)
22270 :::IT(5,I) = B(5)
22275 NEXT I
22400 DEF FN F0(B) = IT(0,P) +
      IT(1,P) * B + IT(2,P) * B ^
      2 + IT(3,P) * B ^ 3 + IT(4,P
      ) * B ^ 4 + IT(5,P) * B ^ 5
22410 DEF FN F1(B) = IT(1,P) +
      2 * IT(2,P) * B + 3 * IT(3,P
      ) * B ^ 2 + 4 * IT(4,P) * B ^
      3 + 5 * IT(5,P) * B ^ 4
22420 DEF FN F2(B) = 2 * IT(2,P
      ) + 6 * IT(3,P) * B + 12 * I
      T(4,P) * B ^ 2 + 20 * IT(5,P
      ) * B ^ 3
22490 REM *****
22491 REM * INTERSECTION OR *
22492 REM * THE CLOESEST POINT*
22493 REM *****
22500 DIM DI(2,3),CO(2,3)
22510 FOR I = 1 TO 2
22520 :::DI(I,1) = XR(I,0) - LX(I)
22530 :::DI(I,2) = YR(I,0) - LY(I)
22540 :::DI(I,3) = Z(I)
22550 :::CO(I,1) = LX(I)
22560 :::CO(I,2) = LY(I)
22570 :::CO(I,3) = 0
22580 NEXT I

```





```

22590 FOR I = 1 TO 3
22600 ::CO(0,I) = CO(1,I) - CO(2,
I)
22610 NEXT I
22620 ::DD = 0:D1 = 0:D2 = 0:DC =
0:CD = 0
22630 FOR I = 1 TO 3
22640 ::DD = DD + DI(1,I) * DI(2,
I)
22650 ::D1 = D1 + DI(1,I) * DI(1,
I)
22660 ::D2 = D2 + DI(2,I) * DI(2,
I)
22670 ::DC = DC + DI(1,I) * CO(0,
I)
22680 ::CD = CD + DI(2,I) * CO(0,
I)
22690 NEXT I
22700 DIM T(2)
22710 ::T(0) = D1 * D2 - DD * DD
22720 ::T(1) = CD * DD - DC * D2
22730 ::T(2) = CD * D1 - DC * DD
22740 ::T(1) = T(1) / T(0)
22750 ::T(2) = T(2) / T(0)
22760 DIM L0(3),L1(3),L2(3)
22770 FOR I = 1 TO 3
22780 ::L1(I) = DI(1,I) * T(1) +
CO(1,I)
22790 ::L2(I) = DI(2,I) * T(2) +
CO(2,I)
22800 ::L0(I) = L1(I) / 2 + L2(I)
/ 2
22810 NEXT I
22820 DIM ZZ(6)
22830 REM *****
22840 REM * START ITERATION *
22850 REM *****
22890 P0 = DL(1) / L0(3)
22900 FOR P = 0 TO 6
22910 ::IT = 0
22920 ::F0 = FN F0(P0)
22930 :: IF F0 = 0 THEN 23020
22940 ::F1 = FN F1(P0)
22950 ::F2 = FN F2(P0)
22960 ::P1 = P0 - F0 * F1 / (F1 *
F1 - F0 * F2)
22970 :: IF ABS ((P1 - P0) / P1)
< 1E - 9 THEN 23020
22980 ::P0 = P1
22990 ::IT = IT + 1
23000 :: IF IT > 50 THEN PRINT "
NO SOLUTION": END
23010 :: GOTO 22920

```



```

23020 :ZZ(P) = P1
23030 P0 = P1
23040 NEXT P
23050 REM *****
23060 REM * END OF ITERATION *
23070 REM *****
23100 REM
23200 REM *****
23210 REM * POSITION ON TRACK *
23220 REM * IN THREE DIMENSION*
23230 REM *****
23240 DIM ZT(6),YT(6),XT(6)
23250 FOR I = 0 TO 6
23260 ::ZT(I) = DL(1) / ZZ(I)
23270 ::XT(I) = LX(2) + ZT(I) / Z
      (2) * (XR(2,I) - LX(2))
23280 ::YT(I) = LY(2) + ZT(I) / Z
      (2) * (YR(2,I) - LY(2))
23290 NEXT I
23299 REM *****
23300 REM TURN TO FID. SYS.
23301 ::AL = - AL
23302 FOR I = 0 TO 6
23303 ::XX = XT(I):YY = YT(I)
23304 : GOSUB 200
23305 ::XT(I) = XR:YT(I) = YR
23306 ::ZT(I) = FZ(1) - ZT(I)
23307 NEXT I
23309 DIM RO(5),X0(5),Y0(5)
23310 REM *****
23320 REM * SERCHING CENTER *
23330 REM *****
23340 FOR J = 1 TO 5
23350 I = J - 1
23360 K = J + 1
23370 A = XT(J) - XT(I)
23380 B = YT(J) - YT(I)
23390 C = XT(K) - XT(J)
23400 D = YT(K) - YT(J)
23410 E = (XT(J) ^ 2 + YT(J) ^ 2 -
      XT(I) ^ 2 - YT(I) ^ 2) / 2
23420 F = (XT(K) ^ 2 + YT(K) ^ 2 -
      XT(J) ^ 2 - YT(J) ^ 2) / 2
23430 DE = (A * D - C * B)
23440 X0 = (E * D - F * B) / DE
23450 Y0 = (A * F - C * E) / DE
23460 R0 = SQR ((XT(J) - X0) ^ 2
      + (YT(J) - Y0) ^ 2)
23470 RO(J) = R0
23480 XO(J) = X0
23490 YO(J) = Y0
23500 NEXT J
23530 R0 = RO(1)
23540 X0 = XO(1)
23550 Y0 = YO(1)

```



```

23600 REM *****
23610 REM * INCLINATION ANGLE *
23620 REM * OR ZENITH ANGLE *
23630 REM *****
23640 :DX = XT(1) - XT(0)
23650 :DY = YT(1) - YT(0)
23660 :SS = DX ^ 2 + DY ^ 2
23670 ::S = SQR (SS)
23680 :TH = ATN (S / SQR (4 * R
      0 ^ 2 - SS))
23690 :KK = TH / (ZT(1) - ZT(0))
23700 :TZ = 1 / KK / R0
23710 :ZE = PI / 2 - ATN (TZ)
24300 REM *****
24310 PRINT "START TRACK AT (X,Y
      ) = ("XT(0)","YT(0)")"
24320 PRINT "CENTER (X,Y) = (";X
      0;","YO")"
24330 PRINT "ZENITH ANGLE OF TAN
      GENT AT STARTING POINT I
      S "ZE" RADIAN."
24340 :AX = XT(0) - X0:AY = YT(0)
      - Y0
24350 IF AX = 0 THEN AZ = PI / 2
      : GOTO 24400
24360 :AZ = ATN (AY / AX): IF AX
      > 0 THEN 24410
24370 :AZ = AZ + PI: GOTO 24410
24400 IF AY < 0 THEN AZ = - PI /
      2
24410 AZ = AZ + PI / 2
24420 PRINT "AZIMUTH ANGLE OF TA
      NGENT AT STARTING POINT I
      S "AZ" RADIAN."
59990 END
59999 REM *****
60000 HOME : PRINT : PRINT : PRINT
      " THIS IS THE CHECKING PA
      RT."
60010 PRINT : PRINT " I WILL SHO
      W YOU EACH INPUT DATUM."
60020 PRINT : PRINT " IF IT IS
      ";; INVERSE : PRINT "WRONG"
      ;; NORMAL : PRINT " YOU PRES
      S ";; FLASH : PRINT "W";: NORMAL
      : PRINT "."
60030 PRINT " OTHER WISE PRESS A
      NY KEYS."
60040 HOME
60050 FOR CN = 1 TO 2:VT = 12 *
      (CN - 1) + 1
60060 : VTAB VT: HTAB 13
60070 : PRINT " VIEW NUMBER ";; INVERSE : PRINT CN

```



```

60080 : HTAB 10: VTAB 3: PRINT "U
      "; HTAB 30: PRINT "V"
60090 : NORMAL
60095 ::VT = VT + 4 / CN
60100 : FOR I = 0 TO 6
60110 : INVERSE
60120 : VTAB VT + I: PRINT I + 1;
      : NORMAL
60130 :: HTAB 4: PRINT TU(CN,I);:
      HTAB 24: PRINT TV(CN,I)
60140 NEXT I,CN
60200 : FOR CN = 1 TO 2
60210 ::VT = 12 * CN - 11 + 4 / C
      N
60220 :: FOR I = 0 TO 6
60230 :: VTAB VT + I: HTAB 4: GET
      CH$
60240 :: IF CH$ = "W" THEN GOSUB
      61240
60250 :: VTAB VT + I: HTAB 24: GET
      CH$
60260 :: IF CH$ = "W" THEN GOSUB
      61260
60270 :: NEXT I
60280 NEXT CN
60285 PRINT
60290 INVERSE : PRINT "ALL RIGH
      T?";: NORMAL : PRINT "YES O
      R NO";: GET CH$
60300 IF CH$ = "N" THEN 60040_
60310 PRINT : RETURN
61240 INPUT "" ;TU(CN,I)
61250 VTAB VT + I: HTAB 24: PRINT
      TV(CN,I): RETURN
61260 INPUT "" ;TV(CN,I): RETURN

61999 REM SET A(C,C) <> 0
62000 ::JJ = D
62010 ::JJ = JJ + 1
62020 : IF JJ > 5 THEN PRINT "NO
      SOLUTION.": END
62030 : IF A(JJ,D) = 0 THEN 62010

62040 : FOR K = D TO 5
62050 ::A(D,K) = A(D,K) + A(JJ,K
      )
62055 ::B(D) = B(D) + B(JJ)
62060 : NEXT K
62070 RETURN : REM TO 21320

```



## ภาคผนวก ค

## ตำแหน่งจุดอ้างอิงระนาบ C

ระนาบ	จุด	X(mm)	Y(mm)
C	41	0.000	0.000
	42	290.195	230.056
	43	290.128	-229.983
	44	639.994	0.002
	45	985.130	195.017
	46	985.095	0.000
	47	985.120	-229.959
	48	1320.019	229.967
	49	1319.942	-230.034

ตำแหน่งจุดอ้างอิงนี้ มีระบบพิกัดต่างจากจุดอ้างอิงบนระนาบ A และจุดอ้างอิงบนระนาบ B โดยมีจุดกำเนิดอยู่ที่จุด 41

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## ภาคผนวก ง

การคำนวณหาจุดใกล้ที่สุดระหว่างเส้นตรงสองเส้นใน 3 มิติ

สมมติว่าสมการเส้นตรงใน 3 มิติ เขียนเป็น

$$\vec{L}_1 = \vec{C}_1 + \vec{D}_1 t_1$$

$$\vec{L}_2 = \vec{C}_2 + \vec{D}_2 t_2$$

(ความหมายของ  $\vec{L}_1$   $\vec{L}_2$   $\vec{C}_1$   $\vec{D}_1$   $\vec{C}_2$   $\vec{D}_2$  ดูเทียบกับสมการ 5.42 และ 5.43)

พารามิเตอร์  $t_1$  และ  $t_2$  ที่ทำให้  $\vec{L}_1$  และ  $\vec{L}_2$  ใกล้กันที่สุดจะหาได้จาก

$$t_1 = \frac{\begin{vmatrix} -(\vec{C}_1 - \vec{C}_2) \cdot \vec{D}_1 & -\vec{D}_1 \cdot \vec{D}_2 \\ (\vec{C}_1 - \vec{C}_2) \cdot \vec{D}_2 & \vec{D}_2 \cdot \vec{D}_2 \end{vmatrix}}{\begin{vmatrix} \vec{D}_1 \cdot \vec{D}_1 & -\vec{D}_1 \cdot \vec{D}_2 \\ -\vec{D}_1 \cdot \vec{D}_2 & \vec{D}_2 \cdot \vec{D}_2 \end{vmatrix}}$$

และ

$$t_2 = \frac{\begin{vmatrix} \vec{D}_1 \cdot \vec{D}_1 & -(\vec{C}_1 - \vec{C}_2) \cdot \vec{D}_1 \\ -\vec{D}_1 \cdot \vec{D}_2 & (\vec{C}_1 - \vec{C}_2) \cdot \vec{D}_2 \end{vmatrix}}{\begin{vmatrix} \vec{D}_1 \cdot \vec{D}_1 & -\vec{D}_1 \cdot \vec{D}_2 \\ -\vec{D}_1 \cdot \vec{D}_2 & \vec{D}_2 \cdot \vec{D}_2 \end{vmatrix}}$$

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## ภาคผนวก จ

การเปลี่ยนสมการ (5.39) เป็นสมการ (5.40)

เพื่อความสะดวก จะกำหนดสัญลักษณ์ใหม่ดังนี้

$$a = (X_1'' - XL_2)ZP_1/ZP_2 + XL_1$$

$$b = (XL_2 - XL_1)ZP_1/Z$$

กระจายข้างขวาของสมการ (5.39) ดังนี้

$$\begin{aligned} \sum_{j=0}^5 A_j (a+b)^j &= \sum_{j=0}^5 A_j a^j + \left[ \sum_{j=1}^5 j A_j a^{j-1} \right] b + \\ &\left[ \sum_{j=2}^5 \frac{j(j-1)}{2} a^{j-2} \right] b^2 + \left[ A_3 + 4 A_4 a + 10 A_5 a^2 \right] b^3 + \\ &\left[ a_4 + 5 A_5 a \right] b^4 + \left[ a_5 \right] b^5 \end{aligned}$$

ดังนั้นจะหาค่า  $b_j$  ตามสมการ (5.40) ได้ดังนี้

$$b_0 = \left[ \sum_{j=0}^5 A_j a^j \right] - \left[ YL_2 - YL_1 \right]$$

$$b_1 = \left[ \sum_{j=1}^5 j A_j a^{j-1} \right] - \left[ YL_2 - YL_1 \right] / \left[ XL_2 - XL_1 \right]$$

$$b_2 = \sum_{j=2}^5 \frac{j(j-1)}{2} A_j a^{j-2}$$

$$b_3 = A_3 + 4 A_4 a + 10 A_5 a^2$$

$$b_4 = A_4 + 5 A_5 a$$

$$b_5 = A_5$$



## ประวัติผู้เขียน

นายนิรันดร์ เจริญกุล เกิดวันที่ 21 กันยายน 2497 เกิดที่กรุงเทพฯ สำเร็จชั้นปริญญา วิทยาศาสตร์บัณฑิต จาก คณะวิทยาศาสตร์จุฬาลงกรณ์มหาวิทยาลัย เมื่อ ปี พ.ศ. 2519 หลังจากนั้นได้รับราชการเป็นอาจารย์สอนวิชาฟิสิกส์ระดับมัธยมศึกษาตอนปลายที่โรงเรียนเตรียมอุดมศึกษา เป็นอาจารย์พิเศษที่โรงเรียนวัฒนาวิทยาลัย ปี 2525-2527 เป็นอาจารย์พิเศษที่โรงเรียนเตรียมอุดมศึกษา ปี 2527 เป็นวิทยากรรับเชิญของสถาบันส่งเสริมการสอนวิทยาศาสตร์และเทคโนโลยี ปี 2523 , เป็นผู้อำนวยการพิเศษของสถาบันส่งเสริมการสอนวิทยาศาสตร์และเทคโนโลยี ปี 2530- , นอกนั้นยังได้แต่งตั้งดำรงและคู่มือการเรียนระดับมัธยมศึกษาตอนปลายไว้หลายเล่ม ปัจจุบันยังคงทำงานเป็นอาจารย์ประจำของ โรงเรียนเตรียมอุดมศึกษา



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