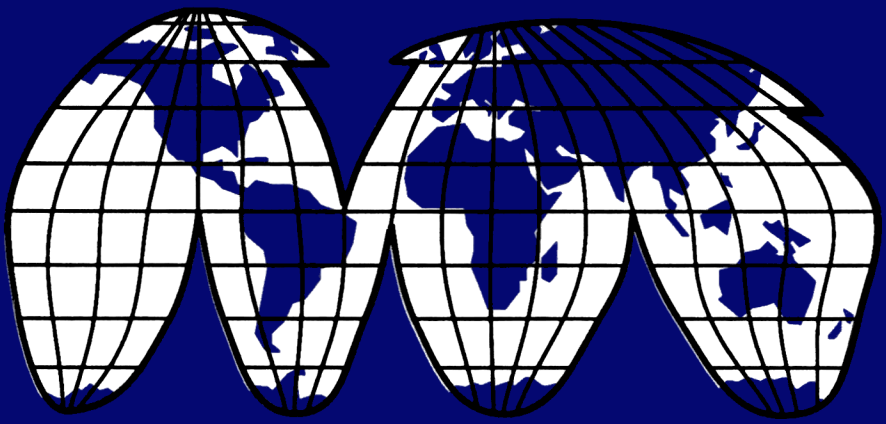
STATE PLANE & UTM

COORDINATE SYSTEM *plus*

GEODETIC FORWARD & INVERSE

48SPC



USER'S MANUAL

CO-OP 48SPC

STATE PLANE

and

UTM

COORDINATE SYSTEMS plus

GEODETIC FORWARD and INVERSE

PROGRAMS

USER'S MANUAL

Surveyors Module Inc.

JAN. 1994

CO-OP 48SPC

STATE PLANE
&
UTM
COORDINATE SYSTEMS plus

GEODETIC FORWARD & INVERSE

PROGRAMS

A SOFTWARE FOR SURVEYORS,
MAPPERS & CIVIL ENGINEERS

made especially for

THE HP 48SX
SCIENTIFIC EXPANDABLE
HANDHELD CALCULATOR/COMPUTER

by

Jose L. Martinez

A DISCLAIMER

We present these products on an "as is" basis. A great deal of time and effort have been reasonably expended into the making and testing of these products before its final release. To our best knowledge and belief, it works and performs according to our expectation.

SMI, Inc. and/or the creator of these products cannot be liable for errors and any incidental or consequential damages that might occur resulting from the use of this manual or software or hardware and other related peripherals.

NOTICE

TABLE OF CONTENTS

PREFACE

This manual and the mathematical equations and formulas used in the creation of the State Plane Coordinate programs are based on the Coast and Geodetic Survey Publication 62-4, "State Plane Coordinates by Automatic Data Processing", by Charles N. Claire and the NOAA Manual Nos. NGS 5, "State Plane Coordinate System of 1983", by James E. Stem. The C & G Survey Publication 62-4 is based on the North America Datum of 1927 (NAD 27) using the Clarke spheroid of 1866. The State Plane Coordinate System of 1983 is based on the North American Datum of 1983 (NAD 83) using the Geodetic Reference System of 1980 ellipsoid (GRS 80).

Similar programs in the Universal Transverse Mercator projection (UTM) are included, using various reference ellipsoids. The UTM Coordinate Transformation Program used the formulas shown on a paper by T. Vincenty entitled, "Transverse Mercator Projection Transformation". The UTM Inverse Program adapted the formulas from the NOAA Manual, Nos. NGS 5.

Two programs in Geodesy are included, not only for their use in surveying, but also in navigation and other purposes. The formulas used in these programs are from a paper by T. Vincenty in the "Survey Review", No. 176, Vol. XXIII.

Some of the formulas adapted from these publications mentioned above were slightly modified to take advantage of the powerful computing capability of the HP48SX for which these programs were designed.

Results obtained from these programs very much agree with the State Plane Coordinate data published by the National Geodetic Survey. All angular quantities are displayed with the "seconds" portion carried to 5 decimal places and the linear quantities up to a maximum of 12 significant digits.

Ellipsoid, map projections, state and state zone constants have been pre-stored in the machine, drastically minimizing the number of input data requirements.

The programs included in this card are designed to facilitate and reduce computing time in the problems relating to State Plane and Universal Transverse Mercator Coordinates, distance, and azimuth computations. The State Plane Coordinate programs covers both the North American Datum of 1927 (NAD 27) and the North American Datum of 1983 (NAD 83), using Clarke's reference ellipsoid of 1866 and the Geodetic Reference System of 1980 (GRS 80), respectively.

The Universal Transverse Mercator Coordinate programs cover eight reference ellipsoids, namely; GRS 80, International, Clarke 1866, WGS 72, Bessel, Everest, Clarke 1880, and NWL 90. The UTM programs included in this card can be made compatible with the Department of Army specifications by selecting the proper reference ellipsoid. Coordinate conversion, distance, and azimuth determination can be obtained in any part of the world (except the 2 polar regions).

The Geodetic Forward and Geodetic Inverse programs are included in this card not only because of their use in mapping and surveying, but also in other purposes, such as, navigation and determination of Geodetic distances and azimuths anywhere on the globe.

Geodetic Coordinates obtained from Global Positioning System (GPS) receivers can be readily converted to either State Plane or UTM Grid Coordinates, and also used as input data for the two Geodetic programs.

The State Plane Coordinate (SPC) programs cover all existing and current map projections and are applicable to all states in the continental U.S., Alaska, Hawaii, Puerto Rico, Virgin Islands, St. Croix, and Guam. Existing and current map projections include the following: Lambert Conformal Conic, Transverse Mercator, Oblique Mercator (used only in Alaska Zone 1) and Approximate Azimuthal Equidistant (used only in Guam under NAD 27).

PROGRAM DESCRIPTION

There are 8 main routines and 3 sub-routines included in this card module. Three pertain to State Plane Coordinate System covering the North American Datum of 1983 (NAD 83) using the Geodetic Reference System of 1980 (GRS 80) and the North American Datum of 1927 (NAD 27) using the Clarke Spheroid of 1866. The other 3 pertain to the Universal Transverse Mercator Coordinate System. The last 2 are programs in Geodesics which can be used anywhere in the globe. The user has the option to select from among the 8 available reference ellipsoids when running either Geodesic or UTM programs. The following is a list of these reference ellipsoids:

1. ***GRS 80***
2. ***International***
3. ***Clarke 1866***
4. ***WGS 72***
5. ***Bessel***
6. ***Everest***
7. ***Clarke 1880.***
8. ***NWL 90***

The following is a list of routines and sub-routine and their descriptions:

State Plane Coordinate System Routines

STATE PLANE COORDINATE SYSTEM ROUTINES

---

(1) **[PRNT]** *- This is a sub-routine whose functions are to SET or CLEAR* **Flag -14**, *which in turn ACTIVATES or DE-ACTIVATES the Automatic Printing Mode. It is also used to force-print an output display present in the stack even if the printing mode was initially de-activated and after the program is run.*

[PRNT] *is a non-prompting routine which means that to run it, you must first enter or place its required argument or input data in the command line (or Screen) BEFORE pressing its softkey. Another way to run it or, for that matter any routine, program, or 48SX's command, is to manually type its input and its NAME on the screen then pressing the* **[ENTER]** *key.*

For example, if you want to automatically print the output display immediately after running any of the main routine, the following must be done:

(a) Turn the printer on and position it in front of the 48SX ready to accept its infrared transmissions.

(b) Enter 1 then press the **[PRNT]** *softkey or, key the following:*

1 **[SPC]** **[α]** **[α]** **[P]** **[R]** **[N]** **[T]** **[ENTER]**

(c) Run your favorite routine or program.

To summarize, the 3 input data required by [PRNT] and their respective functions are as follows:

(1) 1 – Activates auto-printing mode
(2) 0 – De-activates auto-printing mode
(3) 2 – Force prints the output display AFTER a program is run and, even if auto-printing mode was previously de-activated.

NOTE: (1) PRNT must be executed ahead of the Main Routines when auto-printing of output display is desired.
(2) To avoid unnecessary drain in the 48SX's batteries when auto-printing is NOT INTENDED or when the printer is not configured to accept printing; ENTER 0 then press [PRNT] BEFORE running any of the Main Routine.

---

(2) [SETUP] - This is the first routine to be executed when accessing this card for the first time or when changing to another state, zone, and datum system. As its name suggests, its function is to prompt and set up the State Code input to be used by the remaining 2 SPC Routines. Once a State Code is entered, these 2 routines can be executed repeatedly under that same State Code and, the Setup Routine may not have to be used again until a new state and zone number is desired. There are 2 types of State Codes corresponding to the 2 datum systems. All State Codes under the NAD 83 System end with a number 3, and those under the NAD 27 end with a number 7. The user's choice of either datum is satisfied by his or her selection of a State Code ending with either number 3 or 7. Map projection types such as Lambert, Transverse Mercator, Oblique Mercator, and others need not be specified by the user since they have been pre-determined and sorted together in the program structure.

A State Code typically consists of the state's 2-letter abbreviation, zone direction or number, and either a 3 or 7 at the end. For example, VAN3 & VAN7 are State Codes for Virginia North Zone in the NAD 83 & NAD 27, respectively.

A complete listing of all State Codes and related information can be found in Appendix "A" of this manual.

---

(3) G→←P - Stands for Geodetic to Plane & Plane to Geodetic Conversion. This is a general routine for direct or inverse coordinate transformation in the NAD 83 & NAD 27 System. When this routine is executed,it will prompt the user for either Geodetic or State Plane Coordinates; in which case, if one type is entered, the other type is produced. All the state, zone, and map projection constants are pre-stored in the program structure to minimize input data requirements. The user need not identify the coordinate type being entered, nor specify the type of map projection such as Lambert, Transverse Mercator, and others.

Latitude and Longitude (ϕ and λ) are entered in degrees, minutes, seconds format (DD.MMSS).

For example:

54° 8' 17.94783"
is entered thus:
54.081794783

State Plane Coordinates under NAD 83 are in meters, while NAD 27 are in feet. Convergence or mapping angle (γ) and grid scale factor (S.F.) are included in the output display.

---

(4) DZ2P - Stands for Distance and Azimuth between 2 points. This routine covers both the NAD 83 and NAD 27 and is used for computing geodetic and grid distances and azimuths between 2 given points. In addition, it automatically converts say, a given Geodetic Coordinates to SP Coordinates and vice versa. When this routine is executed, it will prompt the user for either geodetic or SP Coordinates of the 1st point, then the 2nd point. The user has the option to use one coordinate type or a combination of the two for the Ist and 2nd point. For instance, one point may be in Geodetic Coordinates and the other in SP Coordinates. As always, latitudes and longitudes are entered in degrees, minutes, seconds format (DD.MMSS). NAD 83 SP Coordinates are in meters, and NAD 27 SP Coordinates are in feet. Geodetic and grid azimuths in the NAD 83 system are referenced clockwise from the North Meridian while those in the NAD 27 are referenced clockwise from the South Meridian.

Distance corrections are automatically applied including the arc to chord grid to geodetic azimuth correction for long lines. Grid scale factor for a given line is applied by getting the mean scale factors at both ends.

UNIVERSAL TRANSVERSE MERCATOR (UTM)

---

(5) **SETEZ** *- Stands for Setting Ellipsoid and Zone No. This is the first routine that must be executed before running the other two UTM Routines. Its function is to prompt for two input data. First, a 1 digit code number corresponding to the eight ellipsoid types; second, the area location, designated by a UTM zone number or the value of the zone's Central Meridian (C.M.). Zone numbers range from 1 to 60 and must be appended by any 1 letter of the alphabet. Thus 36R, 36Z, 8K are examples of valid zone number entries. The zone's Central Meridian can be entered in lieu of the its zone number. Central Meridians in the Western Hemisphere (area west of Greenwich) must be preceded by a minus (–) sign, those in the Eastern Hemisphere (area east of Greenwich) need not have any sign. For instance, a C.M. of 75° west is entered thus: –75* **ENTER**. *Both western and eastern central meridians start from 3 then increments by 6; the next and succeeding C.M. being 9, 15, 21, and so on up to and including 177. Other C.M. inputs aside from those pre-determined numbers will not be accepted by this routine.*

The relationship between C.M. and zone no. according to NGS formula is C.M. = 6Z – 183. Where Z is the zone number. A negative value of C.M. denotes that it is in the Western Hemisphere.

In addition, this routine is also used for setting a reference ellipsoid for the [G.FOR] and [G.INV] programs. Since these 2 programs need only an ellipsoid input, the second prompt (for a zone no. or C.M.) will simply be ignored by stroking the following keys:

[ON] [↱] [CLR]

NOTE: This routine may not have to be used every time a program is run as long as the user stays on the same Reference Ellipsoid and/or Central Meridian that he or she had previously selected.

The following are the 8 ellipsoid types and their corresponding input code numbers:

GRS 80	*1*
INTERNATIONAL	*2*
CLARKE 1866	*3*
WGS 72	*4*
BESSEL	*5*
EVEREST	*6*
CLARKE 1880	*7*
NWL 90	*8*

NOTES:

(1) For lack of window space, only the first 4 ellipsoid types are prompted and shown in the [SETEZ] *Routine; however, the other 4 types are, of course, available if needed.*

(2) UTM Grid Coordinates for the Southern Hemisphere (area south of the equator) can be obtained by setting **Flag -13** *before executing any of the UTM Routine. Normally,* **Flag -13** *is* **CLEAR** *when operating in the Northern Hemisphere.*

(3) Keystroke sequence for setting and clearing say, **Flag -13** .

13 [+/-] [SPC] [α] [α] SF [ENTER]

13 [+/-] [SPC] [α] [α] CF [ENTER]

---

(6) [G→←G] *- Stands for Geodetic to Grid and Grid to Geodetic. This routine is used to transform Geodetic Coordinates (latitude & longitude) to UTM Grid Coordinates (north & east) and vice versa. It is also used to indirectly convert State Plane Coordinates (NAD 83 or NAD 27) to UTM Grid Coordinates and vice versa. SPC must first be transformed to Geodetic Coordinates using the* [G→←P] *Routine then the same Geodetic Coordinates are inputted in this routine to obtain UTM Grid Coordinates. The process is reversed when converting UTM Grid Coordinates to SPC.*

Input data for this routine can either be Geodetic or UTM Grid Coordinates, in which case if one is input, the other is output.

Latitude and longitude (ϕ and λ) are entered in degrees, minutes, seconds format (DD.MMSS).

For example:

116° 25' 7.8549"
is entered thus:
116.25078549

UTM Grid Coordinates are in meters. Convergence or mapping angle (γ) and grid scale factor (S.F.) are included in the stack display.

The **G→←G** *Routine normally applies to the Northern Hemisphere. However, if the Southern Hemisphere is desired* **Flag -13** *must be SET. Once this Flag is SET, all subsequent runs apply to the Southern Hemisphere until* **Flag -13** *is CLEARED; in which case, the routine reverts back to the Northern Hemisphere.*

(7) **DZUT** *- Stands for Distance and Azimuth for UTM. This routine is used to compute geodetic and grid distances and azimuths. Appropriate corrections are applied to distances and azimuths and given coordinates are automatically converted. Either coordinate types or a combination of both can be used as input. For example, the first point can be Grid Coordinates and the second point can be Geodetic Coordinates and still be acceptable input values. As always, latitudes and longitudes are entered in degrees minutes seconds format (DD.MMSS). UTM Grid Coordinates are in meters. Azimuths are referenced clockwise from the North Meridian.*

Geodetic Forward (G.FOR)
and
Geodetic Inverse (G.INV)

FOREWORD

GEODETIC FORWARD (G.FOR) and GEODETIC INVERSE (G.INV) PROGRAMS

These 2 programs are used for computing Geodetic Coordinates, ellipsoidal arc distance, and azimuths between any 2 points from a few centimeters to nearly 20,000 kilometers apart. The user has the option to choose from among 8 available reference ellipsoids. Geodetic Coordinates converted and obtained from State Plane and UTM Conversion Routines can be used in these programs. Geodetic Coordinates obtained from GPS receivers, astronomic observations, and other methods can also be used in these programs. Modifications in the input format made it possible for these programs to be compatible with the UTM Grid and U.S. Military Grid Systems.

Some minor modifications to the original formulas were made by this author so that computed forward and reverse azimuths are always positive and referenced clockwise from North. Since the formulas involve iterative solution, program execution will be delayed. Execution times for [G.FOR] and [G.INV] are 8 and 32 seconds, respectively.

Program application aside from surveying and mapping might include navigation, determination of direction, and distance between any 2 cities or airports, etc.

---

(8) **G.FOR** *- Stands for Geodetic Forward. This program is used to compute Geodetic Coordinates (latitude and longitude) of another point and the reverse azimuth given the Geodetic Coordinates of a starting point, the forward azimuth, and the ellipsoidal distance. A forward azimuth can be entered with a* ***NEGATIVE SIGN*** *(an azimuth counterclockwise from North) or with* ***NO SIGN*** *(an azimuth clockwise from North). This program is applicable to any of the 8 available reference ellipsoids.*

---

(9) **G.INV** *- Stands for Geodetic Inverse. This program is used to compute ellipsoidal arc distance, forward azimuth, and reverse azimuth given the Geodetic Coordinates of any 2 points on the surface of a given reference ellipsoid.*

NOTE: Results obtained from running either the **G.FOR** *or the* **G.INV** *Routine will be duplicated by the other if output values from one are inputted to the other without rounding. However, there are certain limitations in which these 2 routines will duplicate each other's results. It must be noted that the Inverse Routine* **G.INV** *computes the NEAREST distance between any 2 points. This nearest distance sometimes would mean going over the polar region,*

and not along the EAST-WEST line. In the Forward Routine [G.FOR] *you can compute the Geodetic Coordinates of another point using an azimuth and "any" distance; however, when you inverse between the 2 points, the result will not duplicate the values obtained from the* [G.FOR] *Routine because the nearest distance could be over the polar region.*

NOTES ON OPERATIONAL CHARACTERISTICS AND INPUT DATA SPECIFICATIONS FOR [G.FOR] AND [G.INV] PROGRAMS.

1. *Maximum longitude difference or separation between 2 points not to exceed 180°.*
2. *Input formats for latitude, longitude, and azimuth must be in degrees, minutes, seconds, plus fractional seconds (if needed) or DD.MMSSSS.*
3. *Latitudes in the Southern Hemisphere when used as input must be entered NEGATIVE; no sign for latitudes in the Northern Hemisphere.*
4. *Longitudes in the Eastern Hemisphere when used as input must be entered NEGATIVE; no sign for longitudes in the Western Hemisphere.*
5. *Ellipsoidal arc distances are in meters.*
6. *Azimuths are referenced clockwise from North.*

---

(10) [DCFS] *- Stands for Display Current Flag Settings. It is a sub-routine used for listing all the current settings in the systems flag and user's flag. DCFS does not require any input. Simply press its assigned softkey to run it, or stroke the following keys:*

[α] [α] [D] [C] [F] [S] [ENTER]

---

(11) [STAT] *- Stands for Status of Current Settings. This routine does not require an input and is executed similarly as the DCFS Routine. Its output display lasts for 13 seconds, showing the current settings created by the different programs in this card. Output display include the following:*

(a) Current State Code
(b) Name of Reference Ellipsoid
(c) UTM Zone Number
(d) UTM Central Meridian (EAST or WEST)

ACCESSING AND RUNNING THE 48SPC PROGRAMS

Before the user can access and execute the 48SPC programs, the following must be done:

1. The 48SPC card or any other card containing the same is in-placed in one of the HP48SX card ports.

> ***CAUTION: The calculator must be OFF when inserting or removing a card. Please refer to Chapter 34, Page 636, Volume II of the Owner's Manual for details.***

2. Having inserted the card and the calculator turned on, press the left (orange) [SHIFT] key, the [LIBRARY] key, and the [SPC48] key, thus:

[↰] [LIBRARY] [SPC48]

The screen will show the names of the first 6 Routines in the Softkeys shown thus:

[PRNT] [SETUP] [G→←P]

[DZ2P] [SETEZ] [G→←G]

NOTE: To view or access the other routines stroke the [NXT] key.

3. The user is now ready to run the program by selecting and pressing the (white) Softkey directly below each name. All main routines will prompt the user for the required input data. For the 3 sub-routines, only [PRNT] *requires an input before stroking its softkey; however,* [DCFS] *and* [STAT] *do not. Multiple data entries must be separated by the space* [SPC] *key in the same order as these prompts appear on the screen. The* [ENTER] *key is pressed to terminate data entry.*

NOTE: The [SETUP] *and the* [SETEZ] *Routines when executed, automatically turn the alpha mode on to enable the user to directly type in the alpha-numeric input without pressing the alpha* [α] *key.*

GENERAL NOTES AND REMINDERS

1. Angular quantities such as latitudes, longitudes, azimuths and convergence angles are expressed in degrees, minutes, seconds, and decimals of a second.

2. Linear quantities such as distances, northings, and eastings are expressed in meters in the NAD 83 system while the same are expressed in feet in the NAD 27 system.

3. Automatic printing of the output stack display is accomplished by pre-setting **Flag -14** *and a compatible printer such as the HP82240B is available. Printing is suppressed if* **Flag -14** *is CLEARED.*

4. UTM Routines normally apply to areas or zones in the Northern Hemisphere. If the Southern Hemisphere is desired, **Flag -13** *must be SET prior to running those routines..*

5. Multiple input data when required by a particular routine must be entered in the same sequence as they appear from left to right in the prompt display; and each individual data must be separated by a space [SPC] *key or by a comma (,). The* [ENTER] *is stroked to signal the end of data entry.*

6. There are two definitions of a foot and its equivalence to a meter:

(a) 1200/3937 m. = 1 U.S. survey foot
(b) 0.3048 m. exactly = 1 international foot. As of 8/1/88, states that have enacted legislation selecting the international foot when converting from meters are as follows: Michigan, Montana, Oregon, South Carolina, and Utah.

7. To get familiar with the execution of these routines, it is suggested that the user go through the illustrated example problems.

I. NAD 27

(1) Grid Coordinates are in feet

(2) Azimuths are referenced clockwise from SOUTH

II. NAD 83

(1) Grid Coordinates are in meters

(2) Azimuths are referenced clockwise from NORTH

III. UTM

(1) Grid Coordinates are in meters

(2) Azimuths are referenced clockwise from NORTH

(3) A Central Meridian when chosen as an input:

(a) must be preceded by a minus (–) sign for Central Meridians in the WESTERN HEMISPHERE

(b) must not have any sign in the EASTERN HEMISPHERE

IV. GEODETIC FORWARD and INVERSE PROGRAM

When inputting Geodetic Coordinates:

(1) Latitudes in the SOUTHERN HEMISPHERE must be preceded by a minus (–) sign; No sign (or positive) in the NORTHERN HEMISPHERE

(2) Longitudes in the EASTERN HEMISPHERE must be preceded by a minus (–) sign; No sign (or positive) in the WESTERN HEMISPHERE.

PRINTING THE OUTPUT DISPLAY

All output stack and screen displays can be printed automatically if a compatible printer such as the HP82240B is ON and configured to accept infrared transmission from the 48SX.

A routine called [PRNT] can be found in one of the softkeys for this purpose. "PRNT" is a non-prompting routine in that it needs an INPUT before it is run or executed.

NOTE: You must first execute [PRNT] before running a particular program in order to ACTIVATE or DE-ACTIVATE automatic printing of output display.

The following are 3 ways to use the "PRNT" Routine:

(A) ENTER 1 then press or execute [PRNT] to Activate automatic printing. Manually setting Flag -14 will also serve the same function.

(B) ENTER 0 then press or execute [PRNT] will DE-ACTIVATE auto printing. Clearing Flag -14 will also serve the same function.

(C) ENTER 2 then press or execute [PRNT] to force the output display present in the stack to be printed AFTER the program has finished running and, even if printing was previously DE-ACTIVATED.

NOTE: To press or execute a program means that if its name appears on a softkey, simply press that softkey to run it. Another way to run a program is to spell out its name on the screen, then press the ENTER key.

Notes on

Flag Settings

NOTES ON FLAG SETTINGS

(1) *When* **Flag -13** *is SET –*

UTM Coordinate Conversion & Inverse Routines will be in the Southern Hemisphere datum.

(2) *When* **Flag -13** *is CLEARED –*

UTM Conversion & Inverse Routines are in the Northern Hemisphere datum.

(3) *When* **Flag -14** *is SET –*

Output displays of all primary routines are automatically printed if a compatible printer such as the HP 82240B is available. Use the **PRNT** *Routine to set auto printing (Set* **Flag -14** *).*

(4) *When* **Flag -14** *is cleared – Printing is OFF.*

(5) *Systems Flag -1 thru -8 are used to designate Reference Ellipsoid types in the UTM and Geodetic Routines.*

(6) *User's Flag 1 thru 60 are used to designate UTM Zone numbers.*

(7) *The* **SETEZ** *Routine is used to set the Flags in (5) and (6) above.*

(8) *The* **SETEZ** *Routine must be executed prior to running the UTM and Geodetic Routines in order to clear certain flags that might affect the execution of these routines.*

(9) *When* **Flag -37** *is SET double-space printing is active; when cleared, single-space printing is active.*

(10) *A built-in routine called* **DCFS** *(Display Current Flag Settings) when executed through its softkey or manually, will display all users and systems flags in the stack. The following is the keystroke sequence to execute* **DCFS**.

α α DCFS ENTER

PROGRAM EXECUTION

NAD 83
Coordinate Conversion

Using The [G→←P] *Routine*

Example Problem No. 1

GIVEN:

(1) Datum = NAD 83
(2) Name of State = Alaska
(3) Zone No. or Location = 1
(4) State Code = AK13
(5) Latitude = 57° 42' 07.42539"
(6) Longitude = 133° 25' 52.88352"

REQUIRED: State Plane Coordinates

(1) N = ?
(2) E = ?

STEPS:

1. Press the [SETUP] *Softkey*

(SCREEN DISPLAY)

State Code = ?

2. *Type in the following:*

   AK13 [ENTER]

   (SCREEN DISPLAY)

   None

3. *Press* [G→←P] *Softkey*

   (SCREEN DISPLAY)

   Lat. = ? & Long. = ?
   or
   North = ? & East = ?

4. *Type in the following:*

   57.420742539 [SPC]

   133.255288352 [ENTER]

(SCREEN DISPLAY)	*(REMARKS ONLY)*
8: "NAD 83"	*Name of Datum*
7: State Code: AK13	*NAD 83 Alaska Zone 1*
6: ¢: 57° 42' 7.42539"	*Given Latitude*
5: λ: 133° 25'52.88352"	*Given Longitude*
4: N: 653301. 358460	*Northing in Meters*
3: E: 832704. 785610	*Easting in Meters*
2: γ: 0° 12' 1.24020"	*Convergence Angle*
1: S.F.: 0.9999414	*Grid Scale Factor*

END OF RUN

NOTES: If the N and E were given instead of the Geodetic Coordinates, the output screen display will be:

8: "NAD 83"
7: State Code: AK13
6: N: 653301.358460
5: E: 832704.785610
4: ¢: 57° 42' 7.42539"
3: λ: 133° 25' 52.88352"
2: γ: 0° 12' 1.24020
1: S.F.: 0.9999414

NOTES:

Use the Scroll Keys [△] [▽] *to view the rest of the stack display.*

Press the [ON] *key to quit scrolling.*

NAD 83

Inverse Between 2 Points

DZ2P Routine

PROGRAM EXECUTION

NAD 83
Inverse Between 2 Points

Using the DZ2P Routine

Example Problem No. 2

GIVEN:

(1) Datum = NAD 83
(2) Name of State = New Jersey
(3) Zone no. or Location = None
(4) State Code = NJ3
(5) Geodetic Coordinates of the first point
Latitude = 38° 56' 52.1108"
Longitude = 74° 53' 08.75309"
(6) Geodetic Coordinates of the second point
Latitude = 38° 56' 12.23766"
Longitude = 74° 51' 55.66190"

REQUIRED:

(1) Geodetic azimuth and distance between the first and second point
(2) Grid azimuth and distance between the first and second point
(3) Convert the given Geodetic Coordinates to State Plane Coordinate

STEPS:

1. *Press the* [SETUP] *Softkey*

   (SCREEN DISPLAY)

   State Code = ?

2. *Type in the following:*

   NJ3 [ENTER]

   (SCREEN DISPLAY)
   None

3. *Press* [DZ2P] *Softkey*

   (SCREEN DISPLAY) *(Remarks Only)*

   Lat. = ? & Long. ? *The user has the option to*
   or *enter either Geodetic or*
   N = ? & E = ? (1st Pt.) *State Plane Coordinates*

4. *Type in the following:*

   38.56521108 [SPC] *74.530875309* [ENTER]

   (SCREEN DISPLAY)

   Lat. = ? & Long. = ?
   or
   N = ? & E = ? (2nd pt.)

5. Type in the following:

38.561223766 [SPC] *74.51556619* [ENTER]

(SCREEN DISPLAY) (REMARKS ONLY)

14: "NAD 83"	*Datum*
13: State Code: NJ3	*NAD 83 NEW JERSEY*
12: ϕ_1: 38°56'52.11080	*Given Latitude of 1st Pt.*
11: λ_1: 74° 53'8.75309	*Given Longitude of 1st Pt.*
10: ϕ_2: 38° 56' 12.23766"	*Given Latitude of 2nd Pt.*
9: λ_2: 74° 51' 55.66190"	*Given Longitude of 2nd Pt.*
8: N_1: 12777.77489	*Northing of 1st Pt.*
7: E_1: 116561.34216	*Easting of 1st Pt.*
6: N_2: 11541.05879	*Northing of 2nd Pt.*
5: E_2: 118316.32156	*Easting of 2nd Pt.*
4: Gr. D: 2146.95585	*Grid Distance in Meters*
3: Gr.AZ:125°10'19.06664"	*Grid Azimuth (Clockwise fr. North)*
2: Geo. D: 2147.14263	*Geodetic Distance in Meters*
1: Geo.AZ 124°55'46.17470"	*Geodetic Azimuth (Clockwise fr. North)*

END OF RUN

NOTES:

(1) If double space is desired in printing the output display, Set Flag -37 before running the routine.

(2) [DZ2P] *Routine provides some flexibility in inputting coordinate data. For example, N & E coordinates are also valid input data for both points in Example No. 2. Some combination of Geodetic Coordinates and State Plane Coordinates for either point are also acceptable. In any case, output display will be similar to the previous screen display.*

NAD 27

Coordinate Conversion

G→←P Routine

PROGRAM EXECUTION

NAD 27
Coordinate Conversion

Using the G→←P *Routine*

Example Problem No. 3

GIVEN:

(1) DATUM - NAD 27
(2) Name of State = IDAHO
(3) Zone No. or Location = West
(4) State Code = IDW7
(5) Y = 2,350,849.562 feet
(6) X = 348,773.301 feet

REQUIRED:

(1) Latitude = ?
(2) Longitude = ?

STEPS:

1. Press the SETUP ***Softkey***

(SCREEN DISPLAY)

State Code = ?

2. *Type in the following:*

   IDW7 [ENTER]

   (SCREEN DISPLAY)

   None

3. *Press* [G→←P] *Softkey*

   (SCREEN DISPLAY)

   Lat. = ? & Long. = ?
   or
   Y = ? & X = ?

4. *Type in the following:*

   2350849.562 [SPC] *348773.301* [ENTER]

(SCREEN DISPLAY)	*(REMARKS ONLY)*
8: "NAD 27"	*Name of Datum*
7: State Code: IDW7	*NAD 27 Idaho West Zone*
6: Y: 2350849. 56200	*Y Coordinate in Feet*
5: X: 348773. 30100	*X Coordinate in Feet*
4: ¢: 48°6'47.76945"	*Latitude*
3: λ: 116°22'8.58460"	*Longitude*
2: γ: –0°27'39.13474"	*Convergence or Mapping Angle*
1: S.F.: 0.9999594	*Grid Scale Factor*

END OF RUN

PROGRAM EXECUTION

NAD 27
Inverse Between 2 Points

Using the DZ2P *Routine*

Example Problem No. 4

GIVEN:

(1) Datum = NAD 27
(2) Name of State = Rhode Island
(3) Zone No. or Location = None
(4) State Code = RI7
(5) Geodetic Coordinates of the first point
Latitude = 41° 12' 37.46822"
Longitude = 71° 03' 18.46278"

(6) State Plane Coordinates of the second point

Y = 132714.433
X = 615948.612

REQUIRED:

(1) Geodetic azimuth and distance between the first & second point
(2) Grid azimuth and distance between the first & second point
(3) Convert given coordinates

STEPS:

1. *Press the* **SETUP** *Softkey*

   (SCREEN DISPLAY)

   State Code = ?

2. *Type in the following:*

   RI7 **ENTER**

   (SCREEN DISPLAY)

   None

3. *Press* **DZ2P** *Softkey*

   (SCREEN DISPLAY)

   Lat. = ? & Long. = ?
   or
   Y = ? & X = ? (Ist pt.)

4. *Type in the following:*

   41.123746822 **SPC**

   71.031846278 **ENTER**

(SCREEN DISPLAY)

Lat. = ? & Long. = ?
or
Y = ? & X = ? (2nd pt.)

5. *Type in the following:*

132714.433 [SPC] *615948.612* [ENTER]

(SCREEN DISPLAY)	***(REMARKS ONLY)***
14: "NAD 27"	*Datum*
13: State Code: R17	*NAD 27 Rhode Island*
12: ϕ_1: 41° 12' 37.46822"	*Given Latitude of 1st Point*
11: λ_1: 71° 3' 18.46278"	*Given Longitude of Ist Point*
10: ϕ_2: 41° 26' 48.47080"	*Converted Latitude of 2nd Point*
9: λ_2: 71° 4' 37.51634"	*Converted Longitude of 2nd Point*
8: Y_1: 46612.78793	*Converted Y of 1st Point*
7: X_1: 622410.79916	*Converted X of 1st Point*
*6: Y_2: 132714.43301**	*Given Y of 2nd Point*
*5: X_2: 615948.61212**	*Given X of 2nd Point*
4: Gr. D: 86343.80781	*Grid Distance in Feet*
3: Gr.Az:175°42'28.17653"	*Grid Azimuth (Clockwise fr. South)*
2: Geo. D: 86342.9448	*Geodetic Distance in Feet*
1: Geo.Az:176°0'5.76374"	*Geodetic Azimuth (Clockwise fr. South)*

END OF RUN

* *Small discrepancy from given value due to rounding off of constants in the conversion formula.*

UTM Coordinate Conversion

G→←G Routine

(NORTH HEMISPHERE)

UTM COORDINATE CONVERSION
Using the G→←G Routine

Example Problem No. 5

GIVEN:

(1) Hemisphere = North
(2) Name of State or Location = Algeria
(3) Ellipsoid type = International
(4) Central Meridian/Zone No. = Zone 31
(5) Latitude (ϕ) = 33° 55' 47.642"
(6) Longitude (λ) = 5° 49' 08.855"

NOTE: If Southern Hemisphere is desired, Flag -13 must be set before the routine is executed.

REQUIRED:

(1) UTM Grid Coordinates N & E
(2) Convergence Angle (γ)
(3) Scale Factor (S.F.)

STEPS:

1. Press SETEZ Softkey

(SCREEN DISPLAY)

Select Ellipsoid No.

GRS 80 = 1 INTL. = 2
66 CLARKE = 3 WGS 72 = 4

2. *Type in the following:*

   2 [ENTER]

   (SCREEN DISPLAY)

   ZONE # = ? *(1→60 plus any letter: ex. 36R)*
   or
   (±) CENTRAL M = ?

3. *Type in the following:*

   31Z [ENTER]

   (SCREEN DISPLAY)

   None

4. *Press* [G→←G] *Softkey*

   (SCREEN DISPLAY)

   LAT. = ? & LONG. = ?
   or
   NORTH = ? & EAST = ?

5. *Type in the following:*

   33.5547642 [SPC] *5.4908855* [ENTER]

(SCREEN DISPLAY)	*(REMARKS ONLY)*
10: "UTM - INTL."	*Ellipsoid Type*
9: "North Hemisphere"	*Hemisphere*
8: Zone #: 31	*Zone No.*
7: C.M. (EAST): 3	*Central Meridian*
6: ϕ: 33° 55' 47.64200"	*Given Latitude*
5: λ 5° 49' 8:85500"	*Given Longitude*
4: N: 3758022.11996	*Computed Northing (Meters)*
3: E: 760605.213955	*Computed Easting (Meters)*
2: γ: 1° 34' 28.06237"	*Convergence Angle*
1: S.F.: 1.00043725352	*Grid Scale Factor*

END OF RUN

NOTE: Ellipsoid types and their code numbers not shown (but are accessible if desired) in the prompt display are the following:

BESSEL	*= 5*
EVEREST	*= 6*
CLARKE 1880	*= 7*
NWL 90	*= 8*

UTM Coordinate Conversion

G→←G Routine

(SOUTH HEMISPHERE)

UTM COORDINATE CONVERSION

Using the [G→←G] Routine

Example Problem No. 6

GIVEN:

(1) Hemisphere - South
(2) Name of State or Location: Hypothetical
(3) Ellipsoid type = GRS 80
(4) Central Meridian or Zone No. =
C.M. = 99 (West)
(5) Latitude (ϕ) = 33 ° 45' 28.773"
(6) Longitude (λ) = 100 ° 27 05.619"

NOTES:

(1) Since the area is in the Southern Hemisphere, Flag - 13 must be SET first. To accomplish this, type in the following:

13 [+/-] [SPC] [α] [α] *SF* [ENTER]

(2) All subsequent UTM Coordinate Conversion and Inversing will be in the Southern Hemisphere coordinate datum until Flag -13 is CLEARED in which case, the datum will revert back to the Northern Hemisphere.

STEPS:

1. *Stroke* **SETEZ** *Softkey*

   (SCREEN DISPLAY)

   Select Ellipsoid No.

   GRS 80 = 1
   INTL. = 2
   66 CLARKE = 3
   WGS 72 = 4

2. *Type in the following:*

   1 **ENTER**

   (SCREEN DISPLAY)

   ZONE # = ? *(+ →60 plus any letter: ex. 36R)*
   or
   (±) CENTRAL M = ?

3. *Type in the following:*

   -99 **ENTER**

   (SCREEN DISPLAY)

   None

4. *Stroke* [G→←G] *Softkey*

(SCREEN DISPLAY)

LAT. = ? & LONG. = ?
or
NORTH = ? & EAST = ?

5. *Type in the following:*

33.4528773 [SPC] *100.2705619* [ENTER]

(SCREEN DISPLAY)

10: "UTM - GRS 80"
9: "South Hemisphere"
8: Zone #: 14
7: C.M. (West): 99
6: ϕ: 33 ° 45 28.77300"
5: λ: 100 ° 27' 5.61900"
4: N: 6263730.40721
3: E: 365567.013275
2: γ: -0 ° 48' 24.23994"
1: S.F.: 999822794087

END OF RUN

UTM Inverse Between 2 Points

DZUT Routine

UTM Inverse Between 2 Points
Using the [DZUT] *Routine*

Example Problem No. 7

GIVEN:

(1) Hemisphere = North
(2) Name of Locality/State = San Luis Obispo (Zone 4) CA
(3) Ellipsoid Type = GRS 80
(4) Central Meridian or Zone No. = Zone #10
(5) Coordinates of 1st point (NGS Control Pt. called "Burnett Peak")

ϕ_1 = 35° 45' 22.80953"
λ_1 = 121° 09' 37.07950"

(6) Coordinates of 2nd point (NGS Control Pt. "Brushy Knob")

ϕ_2 = 35° 42' 01.34933"
λ_2 = 121° 17' 07.62245"

REQUIRED:

(1) Geodetic azimuth and distance
(2) Grid azimuth and distance
(3) Converted coordinates

NOTE: You must clear **Flag -13** *first if you went through Example Problem No. 6.*

Thus: 13 [±] [SPC] [α] [α] *CF* [ENTER]

STEPS:

1. *Press* **SETEZ** *Softkey*

   (SCREEN DISPLAY)

   Select Ellipsoid No.

   GRS 80 = 1
   INTL. = 2
   66 CLARKE = 3
   WGS 72 = 4

2. *Type in the following:*

   1 **ENTER**

   (SCREEN DISPLAY)

   Zone + = ? *(1→60 plus any letter: ex. 36R)*
   or
   (±) Central M. = ?

3. *Type in the following:*

   10Z **ENTER**

   (SCREEN DISPLAY)

   None

4. *Press* [DZUT] *Softkey*

   (SCREEN DISPLAY)

   LAT. = ? LONG. = ?
   or
   N = ? & E = (Ist Pt.)

5. *Type in the following:*

   35.452280953 [SPC] *121.09370795* [ENTER]

   (SCREEN DISPLAY)

   LAT. = ? & LONG. = ?
   or
   N = ? & E = ? (2nd Pt.)

6. *Type in the following:*

   35.420134933 [SPC] *121.170762245* [ENTER]

(SCREEN DISPLAY)

16: "UTM - GRS 80"
15: "North Hemisphere"
14: ZONE # 10
13: C.M. (WEST): 123
12: ϕ_1: 35° 45' 22.80953"
11: λ_1: 121° 09' 37.07950"
10: ϕ_2: 35° 42' 01.34933"
9: λ_2: 121° 17' 07.62245"
8: N_1: 3958483.75262
7: E_1: 666325.499902
6: N_2: 3952071.07233
5: E_2: 655118.120693
4: Gr. D: 12912.3126215
3: Gr. Az: 240° 13' 21.04099"
2: Geo.D: 12913.3624176
1: Geo.Az: 241° 17' 49.31387"

Using the G.INV Routine

Example Problem No. 8

GIVEN:

The same 2 control points in Problem No. 7

(1) Reference ellipsoid = GRS 80
(2) Geodetic Coordinates of the first point ("Burnett Peak")

ϕ = 35° 45' 22.80953"
λ = 121° 09' 37.07950"

(3) Geodetic Coordinates of the 2nd point ("Brushy Knob")

ϕ = 35° 42' 01.34933"
λ = 121° 17' 07.62245"

REQUIRED:

(1) Geodetic distance in meters, kilometers, miles, and nautical miles between the 1st and 2nd point

(2) Geodetic Azimuth (reckoned clockwise from North) of a line from the 1st to the 2nd point (Forward Azimuth)

(3) Geodetic Azimuth (reckoned clockwise from North) of a line from the 2nd to the 1st point (Reverse Azimuth)

STEPS:

NOTE: The first thing to do is to set the GRS 80 reference ellipsoid.

1. *Stroke* [SETEZ] *softkey*

   (SCREEN DISPLAY)
   Select Ellipsoid No.

   GRS 80 = 1
   INTL. = 2
   66 CLARKE = 3
   WGS 72 = 4

2. *Type in the following:*

   1 [ENTER]

   (SCREEN DISPLAY)

   Zone # = ? (1→60 plus any letter: ex. 36R)
   or
   (±) CENTRAL M. = ?

NOTE: Since the above prompt does not apply in this routine, simply clear the screen by using the following keystroke sequence:

[ON] [↱] [CLR]

3. *Press the* [NXT] *key to find the* [G.INV] *Routine, then press its softkey.*

   (SCREEN DISPLAY)

   LAT. = ? LONG. = ?
   of Starting Point

4. *Type in the following: (Enter Latitude and longitude)*

   35.452280953 [SPC] *121.093707950* [ENTER]

   (SCREEN DISPLAY)

   LAT. = ? LONG. = ?
   of ENDING POINT

5. *Type in the following:*

   35.420134933 [SPC] *121.170762245* [ENTER]

***NOTE:** The formulas used in this particular routine involve iterative solution process. It will take approximately 32 seconds to obtain an output display.*

(SCREEN DISPLAY)	*(REMARKS)*
13. "UTM - GRS 80"	*Reference Ellipsoid*
12. "GEODETIC INVERSE"	*Name of Routine*
11. "WEST HEMISPHERE"	*Hemisphere*
10. ϕ_1: 35° 45' 22.80953	*Given Latitude Pt. #1*
9. λ_1 121° 9' 37.07950"	*Given Longitude Pt. #1*
8: ϕ_2: 35° 42' 1.34933"	*Given Latitude Pt. #2*
7: λ_2: 121° 17' 7.62245"	*Given Longitude Pt. #2*
6: α_1: 241° 17' 49.31176"	*Computed Forward Azimuth*
5: α_2: 61° 13' 26.22020"	*Computed Reverse Azimuth*
4: D(m): 12913.365826	
3: D(km): 12.91	
2: D(mi): 8.02	
1: D(nmi): 6.97	

END OF RUN

G.FOR Routine

(SHORT DISTANCE)

Using the G.FOR Routine

Example Problem No. 9

GIVEN:

Data obtained from Example Problem No. 8

(1) Reference ellipsoid = GRS 80
(2) Geodetic Coordinates of 1st point ("Burnett Peak")

ϕ_1 = *35° 45' 22.80953"*
λ_1 = *121° 09' 37.07950"*

(3) Forward azimuth from 1st pt. to 2nd pt. to be computed

Az = 241° 17' 49.31176" (clockwise fr. North)

(4) Geodetic distance from 1st pt. to 2nd pt. to be computed

D = 12913.36583

REQUIRED:
(1) Geodetic Coordinates of 2nd point ("Brushy Knob")
(2) Reverse Azimuth (from 2nd point to 1st point)

STEPS:

NOTE: The first thing to do is to execute SETEZ Routine to set the GRS 80 reference ellipsoid. Since we have already done the above in Example Problem No. 8, we go straight to executing the G.FOR Routine.

1. *Press the* [G.FOR] *Softkey.*

   (SCREEN DISPLAY)

   LAT. = ? LONG. = ?
   of Starting Point

2. *Type in the following:*

   35.452280953 [SPC] *121.093707950* [ENTER]

   (SCREEN DISPLAY)

   (±) AZ. = ? Geod. D = ?

3. *Type in the following:*

   241.174931176 [SPC] *12913.36583* [ENTER]

NOTE: Allow 8 seconds for the output display to appear on the screen.

(SCREEN DISPLAY)	*(REMARKS)*
10: "UTM - GRS 80"	*Reference Ellipsoid*
9: "GEODETIC FORWARD"	*Name of Routine*
8: "WEST HEMISPHERE"	*Hemisphere*
7: ϕ_1: 35° 45' 22.80953"	*Given latitude of Pt.#1*
6: λ_1: 121° 9' 37.07950"	*Given longitude of Pt.#1*
5: α_1: 241° 17' 49.31176"	*Given Forward Azimuth*
4: Geo.D: 12913.36583	*Given Geodetic Distance*
3: ϕ_2: 35° 42' 1.34933"	*Computed latitude of Pt. #2*
2: λ_2: 121° 17' 7.62245"	*Computed longitude of Pt.#2*
1: α_2: 61° 13' 26.22023"	*Computed reverse azimuth*

END OF RUN

NOTE: Results match with data in example problem No. 8.

Example Problem No. 10

LONG DISTANCE INVERSE OF 2 POINTS IN THE SAME HEMISPHERE

GIVEN:

(1) Reference ellipsoid = GRS 80
(2) Geodetic Coordinates of a point in New York

ϕ_1 = 39° 01' 42" N
λ_1 = 73° 57' 43" W

(3) Geodetic Coordinates of a point in California

ϕ_2 = 36° 02' 18" N
λ_2 = 119° 58' 49" W

REQUIRED:

(1) Geodetic Distance in meters, km, miles, and nautical miles from NY to CA
(2) Forward Azimuth (NY to CA)
(3) Reverse Azimuth (CA to NY)

STEPS:

1. ***Run the [SETEZ] Routine to set the given reference ellipsoid.***

NOTE: Ignore the 2nd prompt in the [SETEZ] Routine by using [ON] [↱] [CLR] keys.

2. Press [G.INV] softkey

(SCREEN DISPLAY)
LAT. = ? LONG. = ?
of Starting Point

3. Type in the following:

39.0142 [SPC] 73.5743 [ENTER]

(SCREEN DISPLAY)

LAT. = ? LONG. = ?
of Ending Point

4. Type in the following:

36.0218 [SPC] 119.5849 [ENTER]

NOTE: Allow approximately 32 seconds for the output display.

(SCREEN DISPLAY)	(REMARKS)
13: "UTM - GRS 80"	Reference ellipsoid
12: "GEODETIC INVERSE"	Name of Routine
11: "WEST HEMISPHERE"	Hemisphere
10: ϕ_1: 39° 01' 42"	Given latitude 1
9: λ_1: 73° 57' 43"	Given longitude 1
8: ϕ_2: 36° 02' 18"	Given latitude 2
7: λ_2: 119° 58' 49"	Given longitude 2
6: α_1: 280° 06' 04.39162"	Forward Azimuth
5: α_2: 71° 04' 37.939878"	Reverse Azimuth
4: D(m): 4037593.97476	
3: D(km): 4037.59	
2: D(mi): 2508.84	
1: D(nmi): 2180.13	

END OF RUN

Using the G.INV Routine

Example Problem No. 11

LONG DISTANCE INVERSE OF 2 POINTS
NOT ON THE SAME HEMISPHERE

GIVEN:

(1) Reference ellipsoid = GRS 80
(2) Geodetic Coordinates of Pt. 1 (in California)

ϕ_1 = 36° 02' 18" N
λ_1 = 119° 58' 49" W

(3) Geodetic Coordinates of Pt. 2 (in island of Guam)

ϕ_2 = 13° 28' 21" N
λ_2 = 144° 44' 56" E

REQUIRED:
(1) Geodetic Distance between Points 1 and 2
(2) Forward Azimuth
(3) Reverse Azimuth

NOTE: Assumed we have already set the given reference ellipsoid using the SETEZ Routine

STEPS:

1. Press G.INV softkey

(SCREEN DISPLAY)
LAT. = ? LONG. = ?
of Starting Point

2. *Type in the following:*

36.0218 [SPC] *119.5849* [ENTER]

(SCREEN DISPLAY)
LAT. = ? LONG. = ?
of Ending Point

NOTE: Since Guam is in the Eastern Hemisphere, its longitude must be entered with a NEGATIVE SIGN.

3. *Type in the following:*

13.2821 [SPC] [−] *144.4456* [ENTER]

NOTE: Wait approximately 32 seconds for the display.

(SCREEN DISPLAY)	*(REMARKS)*
13: "UTM - GRS 80"	*Reference Ellipsoid*
12: "GEODETIC INVERSE"	*Name of Routine*
11: "WEST HEMISPHERE"	*(1st pt. in West Hemisphere)*
10: ϕ_1: 36° 2' 18"	*Given latitude 1*
9: λ_1: 119° 58' 49"	*Given longitude 1*
8: ϕ_2: 13° 28' 21"	*Given latitude 2*
7: λ_2: −144° 44' 56"	*Given longitude 2*
6: α_1: 284° 4' 26.422810"	*Forward Azimuth*
5: α_2: 53° 50' 10.780585	*Reverse Azimuth*
4: D(m): 9606773.94848	
3: D(km): 9606.77	
2: D(mi): 5969.37	
1: D(nmi): 5187.24	

END OF RUN

Using the G.FOR Routine

Example Problem No. 12

DETERMINING THE GEODETIC COORDINATES OF ANOTHER POINT ON THE SAME HEMISPHERE AS THE GIVEN POINT AT LONG DISTANCES

GIVEN:

(1) Reference ellipsoid = GRS 80

The same data given and computed in Example Problem No. 10

(2) Starting Coordinates (a point in New York)

ϕ_1: *39° 01' 42" N*
λ_1: *73° 57' 43" W*

(3) Forward Azimuth = 280° 06' 04.391620"

(4) Geodetic Distance = 4,037,593.97476

REQUIRED:

(1) Coordinates of another point (in California)
(2) Reverse Azimuth

STEPS:

1. *Press* [G.FOR] *softkey*

   (SCREEN DISPLAY)

   LAT. = ? LONG. = ?
   of Starting Point

2. *Type in the following:*

   39.0142 [SPC] *73.5743* [ENTER]

   (SCREEN DISPLAY)

   (±) AZ. = ? GEOD. D = ?

3. *Type in the following:*

   280.0604391620 [SPC] *4037593.97476* [ENTER]

NOTE: Allow approximately 8 seconds for the display to appear.

(SCREEN DISPLAY)	*(REMARKS)*
10: "UTM - GRS 80"	*Reference ellipsoid*
9: "GEODETIC FORWARD"	*Name of Routine*
8: "WEST HEMISPHERE"	*Hemisphere*
7: ϕ_1: 39° 1' 42"	*Given latitude P1*
6: λ_1: 73° 57' 43"	*Given longitude P1*
5: α_1: 280° 6' 4.391620"	*Given forward azimuth*
4: Geo.D: 4037593.97476	*Given Distance*
3: ϕ_2: 36° 2' 17.999996"	*Computed latitude P2*
2: λ_2: 119° 58' 49"	*Computed longitude P2*
1: α_2: 71° 4' 37.939872"	*Computed reverse azimuth*

END OF RUN

Using the G.FOR Routine

Example Problem No. 13

DETERMINING THE GEODETIC COORDINATES OF ANOTHER POINT NOT ON THE SAME HEMISPHERE AS THE GIVEN STARTING POINT. FOR ILLUSTRATION PURPOSES, USE THE SAME DATA GIVEN AND COMPUTED IN EXAMPLE PROBLEM NO. 11

GIVEN:

(1) Reference Ellipsoid - GRS 80
(2) Starting Coordinates (a point in California)

$\phi_1 =$ 36° 02' 18" N
$\lambda_1 =$ 119° 58' 49" W

(3) Forward Azimuth = 284° 04' 26.42281" (Direction from California to Guam)
(4) Geodetic Distance = 9,606,773.94848 meters or 5,969.3726 miles

REQUIRED:

(1) Geodetic Coordinates (a point in Guam)
(2) Reverse Azimuth (Guam to California)

NOTE: Reference ellipsoid is set using the SETEZ Routine

STEPS:

1. *Press* [G.FOR] *softkey*

   (SCREEN DISPLAY)

   LAT. = ? LONG. = ?
   of Starting Point

2. *Type in the following:*

   36.0218 [SPC] *119.5849* [ENTER]

   (SCREEN DISPLAY)

   (±) AZ. = ? GEOD. D = ?

3. *Type in the following:*

   284.042642281 [SPC] *9606773.94848* [ENTER]

NOTE: Allow approximately 8 seconds for the display to appear.

(SCREEN DISPLAY)	*(REMARK)*
10: "UTM - GRS 80"	*Reference ellipsoid*
9: "GEODETIC FORWARD"	*Name of Routine*
8: "WEST HEMISPHERE"	*(Starting pt. in West Hemisphere)*
7: ϕ_1: 36° 2' 18"	*Given latitude P1*
6: λ_1: 119° 58' 49"	*Given longitude P1*
5: α_1: 284° 4' 26.422810"	*Given forward azimuth*
4: Geo.D: 9606773.94848	*Given geodetic distance*
3: ϕ_2: 13° 28' 20.999999"	*Computed Latitude*
2: λ_2: -144° 44' 56"	*Computed longitude (minus sign indicates East Hemisphere)*
1: α_2: 53° 50' 10.780585"	*Computed reverse azimuth*

END OF RUN

APPENDIX A

LIST OF STATE CODES

APPENDIX A
List of State Codes

T.M. = Transverse Mercator
O.M. = Oblique Mercator
L.C. = Lambert Conic
A.E. = Azimuthal Equidistant

NO.	STATE	ZONE	STATE CODES NAD 27	STATE CODES NAD 83	TYPE OF PROJ.
1	Alabama	East	ALE7	ALE3	T.M.
2	Alabama	West	ALW7	ALW3	T.M.
3	Alaska	1	AK17	AK13	O.M.
4	"	2	AK27	AK23	T.M.
5	"	3	AK37	AK33	"
6	"	4	AK47	AK43	"
7	"	5	AK57	AK53	"
8	"	6	AK67	AK63	"
9	"	7	AK77	AK73	"
10	"	8	AK87	AK83	"
11	"	9	AK97	AK93	"
12	"	10	AK107	AK103	L.C.
13	Arizona	East	AZE7	AZE3	T.M.
14	"	Central	AZC7	AZC3	"
15	"	West	AZW7	AZW3	"
16	Arkansas	North	ARN7	ARN3	L.C.
17	"	South	ARS7	ARS3	"
18	California	1	CA17	CA13	"
19	"	2	CA27	CA23	"
20	"	3	CA37	CA33	"
21	"	4	CA47	CA43	"
22	"	5	CA57	CA53	"
23	"	6	CA67	CA63	"
24	"	7	CA77	–	"
25	Colorado	North	CON7	CON3	"
26	"	Central	COC7	COC3	"
27	"	South	COS7	COS3	"
28	Connecticut	–	CT7	CT3	"
29	Delaware	–	DE7	DE3	T.M.
30	Florida	East	FLE7	FLE3	"
31	"	West	FLW7	FLW3	"
32	"	North	FLN7	FLN3	L.C.
33	Georgia	East	GAE7	GAE3	T.M.
34	"	West	GAW7	GAW3	"

NO.	STATE	ZONE	STATE CODES NAD 27	STATE CODES NAD 83	TYPE OF PROJ.
35	Hawaii	1	HI17	HI13	"
36	"	2	HI27	HI23	"
37	"	3	HI37	HI33	"
38	"	4	HI47	HI43	"
39	"	5	HI57	HI53	"
40	Idaho	East	IDE7	IDE3	"
41	"	Central	IDC7	IDC3	"
42	"	West	IDW7	IDW3	"
43	Illinois	East	ILE7	ILE3	"
44	"	West	ILW7	ILW3	"
45	Indiana	East	INE7	INE3	"
46	"	West	INW7	INW3	"
47	Iowa	North	IAN7	IAN3	L.C.
48	"	South	IAS7	IAS3	"
49	Kansas	North	KSN7	KSN3	"
50	"	South	KSS7	KSS3	"
51	Kentucky	North	KYN7	KYN3	"
52	"	South	KYS7	KYS3	"
53	Louisiana	North	LAN7	LAN3	"
54	"	South	LAS7	LAS3	"
55	"	Offshore	LA07	LA03	"
56	Maine	East	MEE7	MEE3	T.M.
57	"	West	MEW7	MEW3	"
58	Maryland	–	MD7	MD3	L.C.
59	Massachusetts	Mainland	MAM7	MAM3	"
60	"	Island	MAI7	MAI3	"
61	Michigan	North	MIN7	MIN3	"
62	"	Central	MIC7	MIC3	"
63	"	South	MIS7	MISC	"
64	"	East	MIE7	–	T.M.
65	"	Central	MIC7T	–	"
66	"	West	MIW7	–	"
67	Minnesota	North	MNN7	MNN3	L.C.
68	"	Central	MNC7	MNC3	"
69	"	South	MNS7	MNS3	"
70	Mississippi	East	MSE7	MSE3	T.M.
71	"	West	MSW7	MSW3	"
72	Missouri	East	MOE7	MOE3	"
73	"	Central	MOC7	MOC3	"
74	"	West	MOW7	MOW3	"

NO.	STATE	ZONE	STATE CODES NAD 27	STATE CODES NAD 83	TYPE OF PROJ.
75	Montana	North	MTN7	–	L.C.
76	"	Central	MTC7	–	"
77	"	South	MTS7	–	"
78	"	–	–	MT3	"
79	Nebraska	North	NEN7	–	"
80	"	South	NES7	–	"
81	"	–	–	NE3	"
82	Nevada	East	NVE7	NVE3	T.M.
83	"	Central	NVC7	NVC3	"
84	"	West	NVW7	NVW3	"
85	New Hampshire	–	NH7	NH3	"
86	New Jersey	–	NJ7	NJ3	"
87	New Mexico	East	NME7	NME3	"
88	"	Central	NMC7	NMC3	"
89	"	West	NMW7	NMW3	"
90	New York	East	NYE7	NYE3	"
91	"	Central	NYC7	NYC3	"
92	"	West	NYW7	NYW3	"
93	"	Long Island	NYL7	NYL3	L.C.
94	North Carolina	–	NC7	NC3	"
95	North Dakota	North	NDN7	NDN3	"
96	"	South	NDS7	NDS3	"
97	Ohio	North	OHN7	OHN3	"
98	"	South	OHS7	OHS3	"
99	Oklahoma	North	OKN7	OKN3	"
100	"	South	OKS7	OKS3	"
101	Oregon	North	ORN7	ORN3	"
102	"	South	ORS7	ORS3	"
103	Pennsylvania	North	PAN7	PAN3	"
104	"	South	PAS7	PAS3	"
105	Rhode Island	–	RI7	RI3	T.M.
106	South Carolina	North	SCN7	–	L.C.
107	"	South	SCS7	–	"
108	"	–	–	SC3	"
109	South Dakota	North	SDN7	SDN3	L.C.
110	"	South	SDS7	SDS3	"
111	Tennessee	–	TN7	TN3	"
112	Texas	North	TXN7	TXN3	"
113	"	North Central	TXNC7	TXNC3	"
114	"	Central	TXC7	TXC3	"
115	"	South Central	TXSC7	TXSC3	"
116	"	South	TXS7	TXS3	"

NO.	STATE	ZONE	STATE CODES NAD 27	STATE CODES NAD 83	TYPE OF PROJ.
117	Utah	North	UTN7	UTN3	"
118	"	Central	UTC7	UTC3	"
119	"	South	UTS7	UTS3	"
120	Vermont	–	VT7	VT3	T.M.
121	Virginia	North	VAN7	VAN3	L.C.
122	"	South	VAS7	VAS3	"
123	Washington	North	WAN7	WAN3	"
124	"	South	WAS7	WAS3	"
125	West Virginia	North	WVN7	WVN3	"
126	"	South	WVS7	WVS3	"
127	Wisconsin	North	WIN7	WIN3	"
128	"	Central	WIC7	WIC3	"
129	"	South	WIS7	WIS3	"
130	Wyoming	East	WYE7	WYE3	T.M.
131	"	East Central	WYEC7	WYEC3	"
132	"	West Central	WYWC7	WYWC3	"
133	"	West	WYW7	WYW3	"
134	Puerto Rico & Virgin Islands	–	PR7	PR3	L.C.
135	St. Croix	–	SCX7	–	"
136	Guam	–	GU7	–	A.E.

Other Engineering Cards Available:

48CE: Civil Engineering Card

- Vertical curve & tangent
- Horizontal curve layout — deflection & offset method
- Earthwork — X-sectional area & volume
- Storm & sanitary pipe design — full or partial flow
- Open channel design — trapezoidal, V & rectangular sections
- Multiple pipe culvert design
- Anderson Method — run-off calculation

SMI
Surveyors Module, Inc.
412 Payne Ridge Rd.
Church Hill, TN 37642
1-800-234-0123