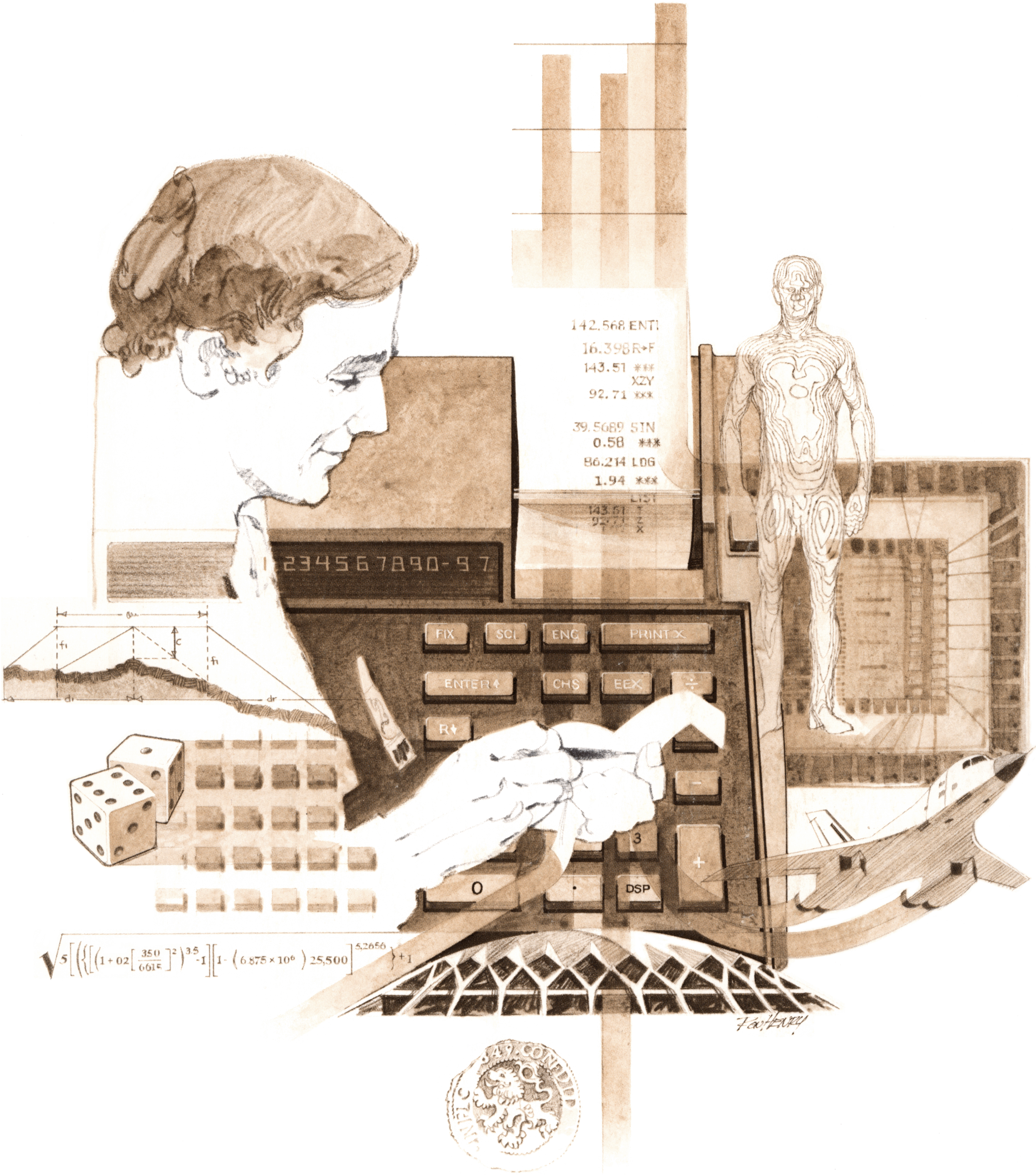
HEWLETT-PACKARD

HP-67/HP-97

Users' Library Solutions

Avigation



INTRODUCTION

In an effort to provide continued value to it's customers, Hewlett-Packard is introducing a unique service for the HP fully programmable calculator user. This service is designed to save you time and programming effort. As users are aware, Programmable Calculators are capable of delivering tremendous problem solving potential in terms of power and flexibility, but the real genie in the bottle is program solutions. HP's introduction of the first handheld programmable calculator in 1974 immediately led to a request for program **solutions** — hence the beginning of the HP-65 Users' Library. In order to save HP calculator customers time, users wrote their own programs and sent them to the Library for the benefit of other program users. In a short period of time over 5,000 programs were accepted and made available. This overwhelming response indicated the value of the program library and a Users' Library was then established for the HP-67/97 users.

To extend the value of the Users' Library, Hewlett-Packard is introducing a unique service—a service designed to save you time and money. The Users' Library has collected the best programs in the most popular categories from the HP-67/97 and HP-65 Libraries. These programs have been packaged into a series of low-cost books, resulting in substantial savings for our valued HP-67/97 users.

We feel this new software service will extend the capabilities of our programmable calculators and provide a great benefit to our HP-67/97 users.

A WORD ABOUT PROGRAM USAGE

Each program contained herein is reproduced on the standard forms used by the Users' Library. Magnetic cards are not included. The Program Description I page gives a basic description of the program. The Program Description II page provides a sample problem and the keystrokes used to solve it. The User Instructions page contains a description of the keystrokes used to solve problems in general and the options which are available to the user. The Program Listing I and Program Listing II pages list the program steps necessary to operate the calculator. The comments, listed next to the steps, describe the reason for a step or group of steps. Other pertinent information about data register contents, uses of labels and flags and the initial calculator status mode is also found on these pages. Following the directions in your HP-67 or HP-97 **Owners' Handbook and Programming Guide,** "Loading a Program" (page 134, HP-67; page 119, HP-97), key in the program from the Program Listing I and Program Listing II pages. A number at the top of the Program Listing indicates on which calculator the program was written (HP-67 or HP-97). If the calculator indicated differs from the calculator you will be using, consult Appendix E of your **Owner's Handbook** for the corresponding keycodes and keystrokes converting HP-67 to HP-97 keycodes and vice versa. No program conversion is necessary. The HP-67 and HP-97 are totally compatible, but some differences do occur in the keycodes used to represent some of the functions.

A program loaded into the HP-67 or HP-97 is not permanent—once the calculator is turned off, the program will not be retained. You can, however, permanently save any program by recording it on a blank magnetic card, several of which were provided in the Standard Pac that was shipped with your calculator. Consult your **Owner's Handbook** for full instructions. A few points to remember:

> The Set Status section indicates the status of flags, angular mode, and display setting. After keying in your program, review the status section and set the conditions as indicated before using or permanently recording the program.
>
> REMEMBER! To save the program permanently, **clip** the corners of the magnetic card once you have recorded the program. This simple step will protect the magnetic card and keep the program from being inadvertently erased.

As a part of HP's continuing effort to provide value to our customers, we hope you will enjoy our newest concept.

TABLE OF CONTENTS

Program Description I

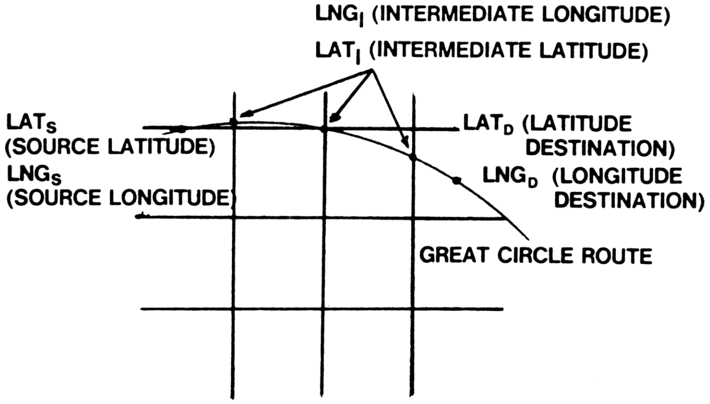
Program Title Great Circle Plotting

Contributor's Name Hewlett-Packard Company, HP-67/97 Users' Library

Address 1000 N. E. Circle Boulevard

City Corvallis **State** OR **Zip Code** 97330

Program Description, Equations, Variables Given the latitude and longitude of two points on the globe and an intermediate longitude, this program calculates the latitude corresponding to the intersection of the great circle route and the intermediate longitude.



$$LAT_I = \tan^{-1}\left[\frac{(A - B)}{\sin(LNG_D - LNG_S)}\right]$$

$$A = (\tan(LAT_D)\ \cos(LNG_S)-\tan(LAT_S)\ \cos(LNG_D))\ \sin(LNG_I)$$

$$B = (\tan(LAT_D)\ \sin(LNG_S)-\tan(LAT_S)\ \sin(LNG_D))\ \cos(LNG_I)$$

Operating Limits and Warnings No leg may pass exactly half way around the earth, and lines of longitude may not be plotted.

Program Description II

Sketch(es)

Sample Problem(s) On a flight from St. Helena to Bermuda, what is the latitude at 35° 17' west longitude?

	LAT	LNG
St. Helena	15° 55' S	5° 44' W
Bermuda	32° 19' N	64° 51' W

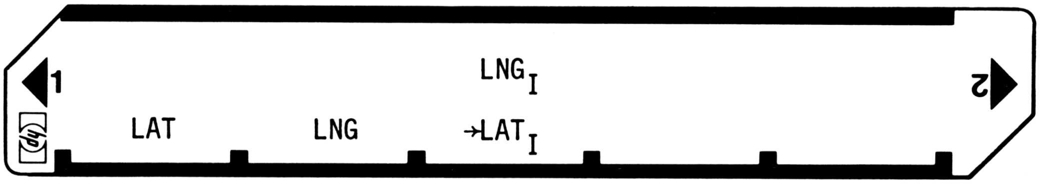
Solution(s) LAT_I = 11° 17' N

Keystrokes:	See Displayed:
15.55 [CHS] [A] 5.44 [B] 32.19 [A]	
64.51 [B] 35.17 [C]	11.17

Reference(s)

This program is a direct translation of a program from the HP-65 <u>Aviation Pac</u>.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input source latitude*	DD.MMSS**	A		degrees
	and longitude	DDD.MMSS	B		degrees
3	Input destination latitude	DD.MMSS	A		degrees
	and longitude	DDD.MMSS	B		degrees
4	Input an intermediate longitude and calculate				
	the corresponding latitude	DDD.MMSS	C		LAT (degrees)
5	For new intermediate point go to step 4, for				
	new case go to step 2.				
	*Southern latitudes and eastern longitudes are				
	expressed as negative values.				
	**DDD.MMSS means degrees, decimal point,				
	minutes and seconds. 120.0713 is 120 degrees,				
	7 minutes and 13 seconds.				

97 Program Listing I

STEP KEY ENTRY KEY CODE COMMENTS

```
001
    001  *LBLA    21 11
    002   HMS→    16 36
    003   RCL1    36 01
    004   STO2    35 02
    005    X⇄Y      -41
    006   STO1    35 01
    007    RTN       24
    008  *LBLB    21 12
    009   HMS→    16 36
    010   RCL3    36 03
    011   STO4    35 04
    012    X⇄Y      -41
    013   STO3    35 03
    014    RTN       24
    015  *LBLC    21 13
    016   HMS→    16 36
    017   STO7    35 07
    018   RCL4    36 04
    019   RCL1    36 01
    020   GSBE    23 15
    021   RCL7    36 07
    022   RCL3    36 03
    023   RCL2    36 02
    024   GSBE    23 15
    025     -       -45
    026   RCL4    36 04
    027   RCL7    36 07
    028   RCL1    36 01
    029   GSBE    23 15
    030     -       -45
    031   RCL3    36 03
    032   RCL7    36 07
    033   RCL2    36 02
    034   GSBE    23 15
    035     +       -55
    036   RCL3    36 03
    037   RCL4    36 04
    038     -       -45
    039    SIN       41
    040     ÷       -24
    041   TAN⁻¹   16 43
    042   STO8    35 08
    043   →HMS    16 35
    044    RTN       24
    045  *LBLE    21 15
    046    TAN       43
    047    X⇄Y      -41
    048    COS       42
    049     x       -35
    050    X⇄Y      -41
    051    SIN       41
    052     x       -35
    053    RTN       24
```

STEP KEY ENTRY KEY CODE COMMENTS

060

070

080

090

100

FLAGS	SET STATUS		
0	FLAGS	TRIG	DISP
1	ON OFF 0 ☐ ☒ 1 ☐ ☒ 2 ☐ ☒ 3 ☐ ☒	DEG ☒ GRAD ☐ RAD ☐	FIX ☒ SCI ☐ ENG ☐ n 2
2			
3			

LABELS

A LAT	B LNG	C →LAT LNG	D	E
a	b	c	d	e
0	1	2	3	4
5	6	7	8	9

REGISTERS

0	1 LAT_D	2 LAT_S	3 LNG_D	4 LNG_S	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Rhumb Line Navigation

Contributor's Name Hewlett-Packard Company, HP-67/97 Users' Library

Address 1000 N. E. Circle Boulevard

City Corvallis **State** OR **Zip Code** 97330

Program Description, Equations, Variables This program accepts the coordinates of two points on the globe and calculates the rhumb line heading (HDG) and distance (DIST) between them. The program inputs are latitude and longitude of the source (LAT_S, LNG_S) and latitude and longitude of the destination (LAT_D, LNG_D) in degrees, minutes, and seconds. The program outputs are heading in degrees and distance in nautical miles.

Since the rhumb line is the constant heading path between points on the globe, it forms the basis of short distance navigation. In low and mid latitudes the rhumb line is sufficient for virtually all course and distance calculations which private pilots encounter. However, as distance increases or at high latitudes, the rhumb line ceases to be an efficient flight path since it is not the shortest distance between points.

The shortest distance between points is the great circle. However, in order to fly great circles, an infinite number of heading changes are necessary. Since it is impractical to calculate an infinite number of headings at an infinite number of points, several rhumb lines may be used to approximate a great circle. The more rhumblines that are used the closer to the great circle distance the sum of the rhumb-line distances will be. Great Circle Plotting, may be used may be used to calculate intermediate heading change points which can be linked by rhumb lines.

Operating Limits and Warnings

Program Description I

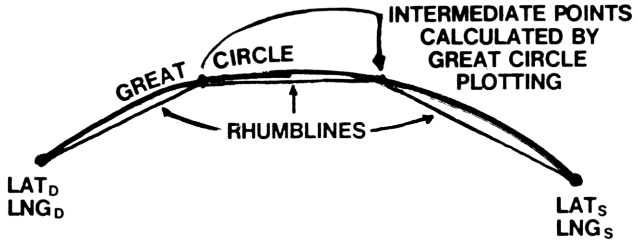
Program Title Rhumb Line Navigation

Contributor's Name Hewlett-Packard Company, HP-67/97 Users' Library

Address 1000 N. E. Circle Boulevard

City Corvallis **State** OR **Zip Code** 97330

Program Description, Equations, Variables



$$HDG = \tan^{-1}\left[\frac{\pi (LNG_S - LNG_D)}{180(\ln \tan(45 + 1/2LAT_D)-\ln \tan(45 + 1/2LAT_S))}\right]$$

$$DIST = 60\ (LAT_D - LAT_S)/\cos\ (HDG)$$

or, if cos (HDG) = 0

$$DIST = 60\ (LNG_D - LNG_S)\ \cos\ (LAT)$$

Operating Limits and Warnings No course should pass through either the south or north pole. Errors in distance calculations may be encountered as the cos (HDG) approaches zero.

Accuracy deteriorates for legs shorter than two or three miles.

Program Description II

Sketch(es)

Sample Problem(s) Find the leg lengths and headings for a flight from St. Helena to Bermuda using the intermediate point calculated in Great Circle Plotting, as an intermediate point of heading change.

	LAT	LNG
St. Helena	15° 55' S	5° 44' W
Intermediate Point	11° 17' N	35° 17' W
Bermuda	32° 19' N	64° 51' W

Solution

	DIST	HDG
LEG 1	2396.39 n.m.	312.92 Degrees
LEG 2	2065.29 n.m.	307.67 Degrees

Solution(s)

Keystrokes:	See Displayed:
15.55 [CHS] [A] 5.44 [B] 11.17 [A]	
35.17 [B] [C]	2396.39
[D]	312.92
32.19 [A] 64.51 [B] [C]	2065.29
[D]	307.67

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Input source latitude*	DD.MMSS**	A	degrees
	and source longitude	DDD.MMSS	B	degrees
3	Input destination latitude	DD.MMSS	A	degrees
	and destination longitude	DDD.MMSS	B	degrees
4	Calculate distance		C	DIST(n.m.)
	and/or heading		D	HDG(deg)
5	If next leg starts at end of last leg go to			
	step 3			
6	For an entirely new case go to step 2			
	*Southern latitudes and eastern longitudes			
	are expressed as negative values.			
	**DDD.MMSS means degrees, decimal point,			
	minutes and seconds. 120.0713 is 120			
	degrees, 7 minutes and 13 seconds.			

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLA	21 11	
002	HMS→	16 36	
003	RCL1	36 01	
004	STO2	35 02	
005	X⇄Y	-41	
006	STO1	35 01	
007	2	02	
008	÷	-24	
009	4	04	
010	5	05	
011	+	-55	
012	TAN	43	
013	LN	32	
014	RCL5	36 05	
015	STO6	35 06	
016	X⇄Y	-41	
017	STO5	35 05	
018	RCL1	36 01	
019	RTN	24	
020	*LBLB	21 12	
021	HMS→	16 36	
022	RCL3	36 03	
023	STO4	35 04	
024	X⇄Y	-41	
025	STO3	35 03	
026	RTN	24	
027	*LBLD	21 14	
028	RCL4	36 04	
029	RCL3	36 03	
030	-	-45	
031	STO7	35 07	
032	2	02	
033	÷	-24	
034	SIN	41	
035	SIN^{-1}	16 41	
036	9	09	
037	0	00	
038	÷	-24	
039	Pi	16-24	
040	×	-35	
041	RCL5	36 05	
042	RCL6	36 06	
043	-	-45	
044	→P	34	
045	R↓	-31	
046	STO8	35 08	
047	RCL7	36 07	
048	SIN	41	
049	SIN^{-1}	16 41	
050	0	00	
051	X>Y?	16-34	
052	GSBd	23 16 14	
053	RCL8	36 08	
054	ABS	16 31	
055	-	-45	
056	ABS	16 31	
057	RTN	24	
058	*LBLC	21 13	
059	GSBD	23 14	
060	RCL7	36 07	
061	RCL1	36 01	
062	COS	42	
063	×	-35	
064	RCL1	36 01	
065	RCL2	36 02	
066	-	-45	
067	RCL8	36 08	
068	COS	42	
069	0	00	
070	X≠Y?	16-32	
071	GSBc	23 16 13	
072	X=Y?	16-33	
073	R↑	16-31	
074	6	06	
075	0	00	
076	×	-35	
077	ABS	16 31	
078	RTN	24	
079	*LBLc	21 16 13	
080	R↓	-31	
081	÷	-24	
082	RTN	24	
083	*LBLd	21 16 14	
084	3	03	
085	6	06	
086	0	00	
087	RTN	24	

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	LAT_D	LAT_S	LNG_D	LNG_S	USED	USED	$LNG_S - LNG_D$	HDG	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Great Circle Navigation

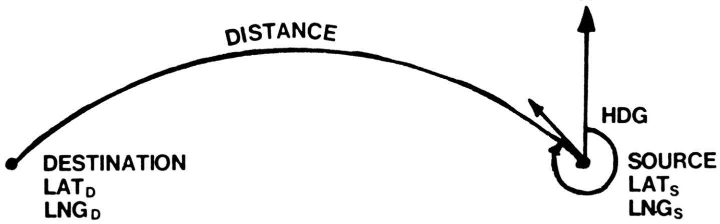
Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Eq

This program computes the great circle distance between two points and computes the initial heading from the first point. Coordinates are input in degrees, minutes and seconds north or south of the equator and east or west of the prime meridian. Outputs are distances in nautical miles and headings in degrees and decimal fractions of a degree.



The great circle distance in nautical miles between two points is given by

$$\text{DIST} = 60 \cos^{-1} \left[\sin \text{LAT}_S \sin \text{LAT}_D + \cos \text{LAT}_S \cos \text{LAT}_D \cos(\text{LNG}_D - \text{LNG}_S)\right]$$

Where

LAT$_S$ and LAT$_D$ are the source and destination latitudes and LNG$_S$ and LNG$_D$ are the source and destination longitudes.

Correspondingly, the initial heading from the source to destination is

$$\text{HDG} = \cos^{-1} \left[\frac{\sin \text{LAT}_D - \sin \text{LAT}_S \cos(\text{DIST}/60)}{\sin(\text{DIST}/60) \cos \text{LAT}_S}\right]$$

NOTE: If $\sin(\text{LNG}_S - \text{LNG}_D) < 0$ then HDG = 360 – HDG

Operating Limits and W

Limits and Warnings

Truncation and round off errors occur when the source and destination are very close together (1 mile or less). Input data is in degrees, minutes and seconds, not degrees, minutes and tenths of minutes. North latitudes and west longitudes are positive numbers, south latitudes and east longitudes are negative numbers.

Do not use coordinates located at diametrically opposite sides of the earth. Do not use latitudes at +90° or –90° (i.e., North and South Poles).

This program may give flashing zeros when trying to compute headings along lines of longitude.

Program Description II

Sketch(es)

Sample Problem(s)

Find the great circle distance from St. Helena to Bermuda.

	LAT	LNG
St. Helena	15° 55' S	5° 44' W
Bermuda	32° 19' N	64° 51' W

Solution(s)

4458.19 n.m. (note that this is only slightly shorter than the sum of the rhumb lines in Rhumb Line Navigation).

Keystrokes	See Display
[f] [A] 15.55 [CHS] [A] 5.44 [B] 32.19 [A] 64.51 [B] [C]	4458.19
[D]	311.12

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	
3.	Input source latitude*	DD.MMSS**	A		LAT_S(deg)
	and source longitude	DDD.MMSS	B		LNG_S(deg)
4.	Input destination latitude	DDD.MMSS	A		LAT_D(deg)
	and destination lognitude	DDD.MMSS	B		LNG_D(deg)
5.	Calculate leg distance		C		DIST(n.m.)
	and initial heading		D		HDG (deg)
6.	If next leg starts at last leg end point go to step 4.				
7.	To restart for an entirely new leg go to step 2.				
*	Positive numbers indicate north latitude and west longitudes. Negative numbers indicate south latitudes and east longitudes.				
**	DDD.MMSS means degrees, decimal point, minutes and seconds. 120.0713 is 120 degrees, 7 minutes and 13 seconds.				

97 Program Listing I

```
STEP  KEY ENTRY  KEY CODE     COMMENTS
001   *LBLa      21 16 11
002     CF2      16 22 02
003    CLRG         16-53
004     DEG         16-21
005     CLX           -51
006     RTN            24
007   *LBLA         21 11
008    HMS→         16 36
009    RCL1         36 01
010    STO2         35 02
011     X⇄Y           -41
012    STO1         35 01
013     RTN            24
014   *LBLB         21 12
015    HMS→         16 36
016    RCL3         36 03
017    STO4         35 04
018     X⇄Y           -41
019    STO3         35 03
020     RTN            24
021   *LBLC         21 13
022    RCL4         36 04
023    RCL3         36 03
024       -           -45
025    ENT↑           -21
026     SIN            41
027       0            00
028    X>Y?         16-34
029     SF2      16 21 02
030       +           -55
031     CLX           -51
032       +           -55
033     COS            42
034    RCL2         36 02
035     COS            42
036    STO6         35 06
037       x           -35
038    RCL1         36 01
039     COS            42
040       x           -35
041    RCL1         36 01
042     SIN            41
043    STO7         35 07
044    RCL2         36 02
045     SIN            41
046    STO8         35 08
047       x           -35
048       +           -55
049    COS⁻¹        16 42
050    ENT↑           -21
051    ENT↑           -21
052       6            06
053       0            00
054       x           -35
055     RTN            24
056   *LBLD         21 14
057       3            03
058       6            06
059       0            00
060    GSBC         23 13
061      R↓           -31
062    ENT↑           -21
063     COS            42
064    RCL8         36 08
065       x           -35
066    RCL7         36 07
067     X⇄Y           -41
068       -           -45
069     X⇄Y           -41
070     SIN            41
071       ÷           -24
072    RCL6         36 06
073       ÷           -24
074    COS⁻¹        16 42
075     F2?      16 23 02
076       -           -45
077     RTN            24
```

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	LAT_D	LAT_S	LNG_D	LNG_S		USED	USED	USED	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Position Given Heading, Speed, and Time

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description

Given the starting position (LAT_S, LNG_S), the heading, the speed and the time of travel, the destination position (LAT_D, LNG_D) is calculated by a rhumbline.

$$LAT_D = \left(\frac{\text{Time} \times \text{Speed} \times \cos \text{HDG}}{60}\right) + LAT_S$$

$$LNG_D = LNG_S - \frac{180}{\pi} \left[(\tan \text{HDG}) \times (\ln \tan(45 + \tfrac{1}{2} LAT_D) - \ln \tan (45 + \tfrac{1}{2} LAT_S))\right]$$

If HDG = 90° or 270° then

$$LNG_D = \frac{\text{DIST}}{60 \cos \text{LAT}} + LNG_S$$

HDG = Heading

Speed = Speed in knots

Time = Time in hours

DIST = Speed x Time

Operating Limits and Warnings

Limits and Warnings

The path of flight may not cross a pole.

Program Description II

Sketch(es)

Sample Problem(s)

Sample Problem

Starting at 30° N, 140° W, flying at 500 knots with a heading of 237 degrees what is the position after two hours?

Solution(s)

Solution

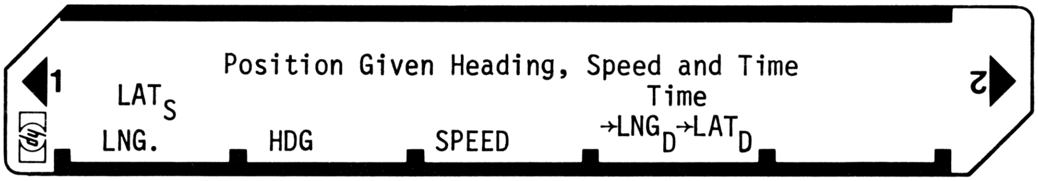
20° 55′ N, 155° 30′ W

Keystrokes	See Displayed
30 A 140 A 237 B 500 C 2 D	155.30
D	20.55

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Input latitude of starting point then	DD.MMSS	A		LAT_S
	longitude of starting point*	DDD.MMSS	A		LNG_S
3.	Input both of the following: true heading,	HDG(deg)	B		HDG
	speed	speed(knots)	C		Speed
4.	Input time at speed and heading and				
	calculate final longitude and	H.MMSS**	D		LNG_D
	latitude (both in degrees, minutes, seconds)		D		LAT_D
5.	For new time go to step 4, for new heading				
	or speed go to step 3, for new starting				
	position go to step 2.				
*	Southern latitudes and eastern longitudes are				
	expressed as negative values.				
**	H.MMSS means hours, decimal point, minutes,				
	seconds. 2.0355 is 2 hours minutes and 55 seconds.				

97 Program Listing I

```
STEP  KEY ENTRY  KEY CODE          STEP  KEY ENTRY  KEY CODE
001   *LBLA      21 11             057   +          -55
002   HMS→       16 36             058   1          01
003   RCL4       36 04             059   →R         44
004   STO2       35 02             060   →P         34
005   X⇌Y        -41               061   R↓         -31
006   STO4       35 04             062   STO3       35 03
007   RTN        24                063   →HMS       16 35
008   *LBLB      21 12             064   RTN        24
009   STO5       35 05             065   *LBLD      21 14
010   RTN        24                066   RCL1       36 01
011   *LBLC      21 13             067   →HMS       16 35
012   STO6       35 06             068   RTN        24
013   RTN        24                069   *LBLE      21 15
014   *LBLD      21 14             070   2          02
015   HMS→       16 36             071   ÷          -24
016   RCL6       36 06             072   4          04
017   x          -35               073   5          05
018   STO7       35 07             074   +          -55
019   RCL5       36 05             075   TAN        43
020   COS        42                076   LN         32
021   x          -35               077   RTN        24
022   6          06
023   0          00                080
024   ÷          -24
025   RCL2       36 02
026   +          -55
027   SIN        41
028   SIN⁻¹      16 41
029   STO1       35 01
030   GSBE       23 15
031   RCL2       36 02
032   GSBE       23 15             090
033   X=Y?       16-33
034   GTO1       22 01
035   -          -45
036   RCL5       36 05
037   TAN        43
038   x          -35
039   Pi         16-24
040   ÷          -24
041   1          01
042   8          08
043   0          00                100
044   x          -35
045   GTO2       22 02
046   *LBL1      21 01
047   RCL7       36 07
048   RCL2       36 02
049   COS        42
050   ÷          -24
051   6          06
052   0          00
053   ÷          -24               110
054   *LBL2      21 02
055   CHS        -22
056   RCL4       36 04
```

FLAGS
0
1
2
3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n 2	

REGISTERS

0	1 LAT D	2 LAT S	3 LNG D	4 LNG S	5 HDG	6 SPEED	7 DIST	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Line of Sight Distance

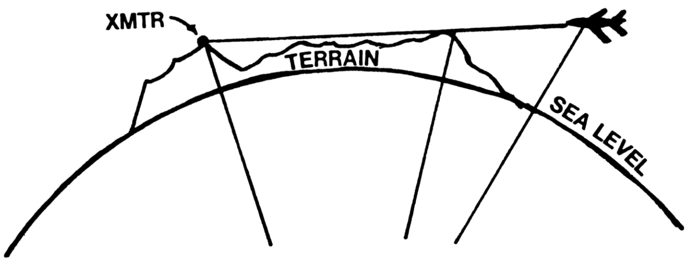
Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description

This program calculates either the aircraft altitude or the line-of-sight distance from an aircraft to a transmitting station. The inputs are the transmitter height (MSL), terrain height (MSL), and either the line-of-sight distance (n.m.) or the aircraft altitude in feet above MSL.



If

$R_p = R + ALT$
$R_g = R + TER$
$R_t = R + XTMR$

where

R = earth's radius = 3440 n.m.
ALT = aircraft altitude
TER = terrain altitude
XMTR = transmitter altitude

Operating Limits and Warnings

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

Since R_g is perpendicular to the line-of-sight

$$DIST = \sqrt{R_p{}^2 - R_g{}^2} + \sqrt{R_t{}^2 - R_g{}^2}$$

and

$$ALT = \sqrt{R_g{}^2 + (D - \sqrt{R_t{}^2 - R_g{}^2})^2}$$

Operating Limits and Warnings Terrain input must not exceed either transmitter height or aircraft altitude. Any attempts to do so will result in an "error" display. This program does not account for refraction of radio waves.

The terrain input yields a worst case answer. If the terrain is close to either the station or the aircraft, the program will calculate a shorter distance or higher altitude than is actually necessary.

Program Description II

Sketch(es)

Sample Problem(s)

An omnidirectional antenna is 2000 feet high. The surrounding terrain is 1000 feet high. How high must you be to receive the transmission from a distance of 100 n.m?

Solution(s)

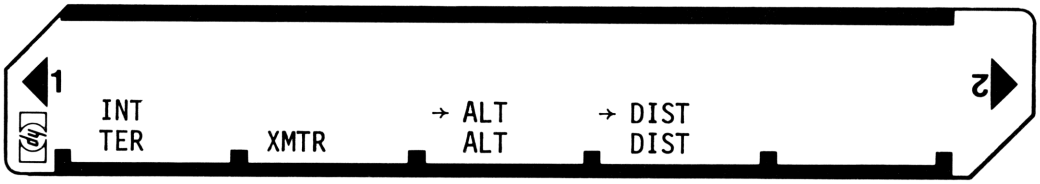
ALT = 4887.18 feet

Keystrokes	See Display
[f] [A] 1000 [A] 2000 [B] 100 [D] [f] [C]	4887.18

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	1.00
3.	Input the following:				
	height of terrain between aircraft and transmitter	TER(feet)	A		TER
	and transmitter height	XMTR(feet)	B		XMTR
	and either airplane altitude	ALT(feet)	C		$R_p{}^2$(feet^2)
	or line of sight distance	DIST(n.m)	D		DIST(feet)
4.	Calculate either aircraft altitude		f	C	ALT (feet)
	or line of sight distance		f	D	DIST(n.m.)
5.	To change inputs go to step 3 and change desired values. For a new case go to step 2.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	CLRG	16-53	
003	6	06	
004	0	00	
005	7	07	
006	6	06	
007	STO6	35 06	
008	3	03	
009	4	04	
010	4	04	
011	0	00	
012	×	-35	
013	STO7	35 07	
014	1	01	
015	RTN	24	
016	*LBLA	21 11	
017	STO1	35 01	
018	RCL7	36 07	
019	+	-55	
020	X²	53	
021	STO8	35 08	
022	RCL1	36 01	
023	RTN	24	
024	*LBLB	21 12	
025	STO2	35 02	
026	RCL7	36 07	
027	+	-55	
028	X²	53	
029	STO4	35 04	
030	RCL2	36 02	
031	RTN	24	
032	*LBLC	21 13	
033	RCL7	36 07	
034	+	-55	
035	X²	53	
036	STO3	35 03	
037	RTN	24	
038	*LBLc	21 16 13	
039	RCL4	36 04	
040	RCL8	36 08	
041	-	-45	
042	√X	54	
043	RCL5	36 05	
044	-	-45	
045	RCL8	36 08	
046	√X	54	
047	→P	34	
048	RCL7	36 07	
049	-	-45	
050	RTN	24	
051	*LBLD	21 14	
052	RCL6	36 06	
053	×	-35	
054	STO5	35 05	
055	RTN	24	
056	*LBLd	21 16 14	
057	RCL4	36 04	
058	RCL8	36 08	
059	-	-45	
060	√X	54	
061	RCL3	36 03	
062	RCL8	36 08	
063	-	-45	
064	√X	54	
065	+	-55	
066	RCL6	36 06	
067	÷	-24	
068	RTN	24	
070			
080			
090			
100			
110			

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	TER	XTMR	$(ALT+R)^2$	$(XMTR+R)^2$	DIST (ft)	6076	R=20901440	$(TER+R)^2$	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

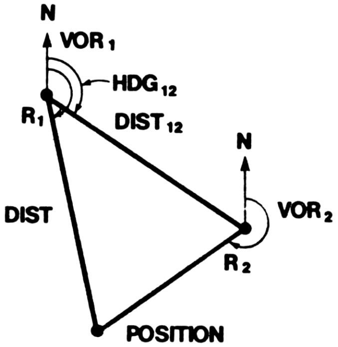
Program Title Position and/or Navigation by Two VOR's

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables This program finds the distance from one of two VOR's to an aircraft and may be used to navigate between any two points, provided signals can be received from two VOR stations.



$$\mathrm{DIST} = \left| \frac{\mathrm{DIST}_{12} \sin(R_2 - \mathrm{HDG}_{12})}{\sin(R_2 - R_1)} \right|$$

where

R_1 = Radial from VOR_1
R_2 = Radial from VOR_2
HDG_{12} = Heading between VORs
DIST_{12} = Distance between VORs
DIST = Distance from VOR_1 to aircraft

Operating Limits and Warnings

Program Description I

Program Title Navigation by Two VORs

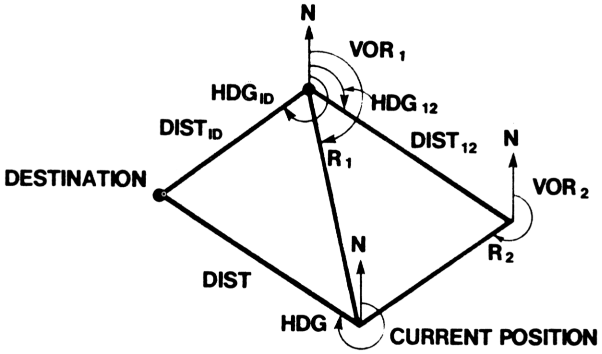
Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

This program may be used to navigate between any two points provided signals can be received from two VOR stations.



$$D_1 = \left| \frac{DIST_{12} \sin(R_2 - HDG_{12})}{\sin(R_2 - R_1)} \right|$$

$$\overrightarrow{DIST} = \vec{D}_1 + \overrightarrow{DIST_{1D}}$$

where

$DIST_{12}$ = Distance between VORs
HDG_{12} = Heading between VORs
R_1 = Radial from VOR_1
R_2 = Radial from VOR_2
D_1 = Distance from VOR_1 to aircraft
$\vec{D}_1$ = Aircraft position vector with respect to VOR_1
$\overrightarrow{DIST_{1D}}$ = Destination position vector with respect to VOR_1
$\overrightarrow{DIST}$ = Required flight vector to destination

Operating Limits and Warnings

The VORs must not be in a straight line from the aircraft.

Program Description II

Sketch(es)

Sample Problem(s)

1. Sample Problem

R_1 = 170 degrees
R_2 = 240 degrees
$DIST_{12}$ = 27 n.m.
HDG_{12} = 125 degrees

What is the distance from VOR_1?

2. Sample Problem

R_1 = 170 degrees
R_2 = 250 degrees
$DIST_{12}$ = 13 n.m.
HDG_{12} = 145 degrees
HDG_{1D} = 255 degrees
$DIST_{1D}$ = 20 n.m.

Find the heading and distance to the destination.

Solution(s)

1. Solution

DIST = 26 n.m.

2. Solution

HDG = 289
DIST = 23 n.m.

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

Program Description II

Sketch(es)

Sample Problem(s)

Solution(s)

Keystrokes	See Displayed
1. [f] [A] 170 [A] 240 [A] 27 [B] 125 [C] [f] [C]	26
2. [f] [A] 170 [A] 250 [A] 13 [B] 145 [C] 255 [D]	
20 [D] [E]	289
[E]	23

Reference(s)

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	
3.	Input all of the following:				
	Present position radial from				
	VOR_1	R_1 (DEG)	A		R_1
	Present position radial from VOR_2	R_2 (DEG)	A		R_2
	Distance between VORS	DIST 12	B		DIST 2
	Heading of VOR_2 from VOR_1	HDG_{12} (DEG)	C		HDG_{12}
4.	Calculate distance from VOR_1 or continue		f	C	DIST
	inputs				
	Heading from VOR_1 to destination	HDG_{1D} (DEG)	D		HDG_{1D}
	Distance from VOR_1 to destination	$DIST_{1D}$	D		$DIST_{1D}$
5.	Calculate magnetic heading		E		HDG
6.	Calculate distance to destination		E		DIST
	For new case return to steps 3 and 4 and				
	change appropriate inputs.				

97 Program Listing I

```
STEP   KEY ENTRY   KEY CODE     COMMENTS
 001     *LBLa    21 16 11
 002      DSP0      -63 00
 003       CLX         -51
 004       RTN          24
 005     *LBLA       21 11
 006      STO1       35 01
 007       RTN          24
 008     *LBLA       21 11
 009      STO2       35 02
 010       RTN          24
 011     *LBLB       21 12
 012      STO3       35 03
 013       RTN          24
 014     *LBLC       21 13
 015      STO4       35 04
 016       RTN          24
 017     *LBLc    21 16 13
 018      RCL2       36 02
 019      RCL4       36 04
 020         -         -45
 021       SIN          41
 022      RCL3       36 03
 023         x         -35
 024      RCL2       36 02
 025      RCL1       36 01
 026         -         -45
 027       SIN          41
 028         ÷         -24
 029       ABS       16 31
 030       RTN          24
 031     *LBLD       21 14
 032      STO5       35 05
 033       RTN          24
 034     *LBLD       21 14
 035      STO6       35 06
 036       RTN          24
 037     *LBLE       21 15
 038      RCL3       36 03
 039      RCL1       36 01
 040      RCL2       36 02
 041         -         -45
 042       SIN          41
 043         ÷         -24
 044      RCL2       36 02
 045      RCL4       36 04
 046         -         -45
 047       SIN          41
 048         x         -35
 049       ABS       16 31
 050         2          02
 051         7          07
 052         0          00
 053      RCL1       36 01
 054         -         -45
 055       X⇄Y         -41
 056        →R          44
```

```
STEP   KEY ENTRY   KEY CODE     COMMENTS
 057      STO7       35 07
 058       X⇄Y         -41
 059      STO8       35 08
 060         9          09
 061         0          00
 062      RCL5       36 05
 063         -         -45
 064      RCL6       36 06
 065        →R          44
 066      ST+7    35-55 07
 067       X⇄Y         -41
 068      ST+8    35-55 08
 069      RCL8       36 08
 070      RCL7       36 07
 071        →P          34
 072       X⇄Y         -41
 073         9          09
 074         0          00
 075       X⇄Y         -41
 076         -         -45
 077         0          00
 078       X⇄Y         -41
 079      X≤Y?       16-35
 080      GSBe    23 16 15
 081      STO7       35 07
 082        R↓         -31
 083        R↓         -31
 084      STO8       35 08
 085      RCL7       36 07
 086       RTN          24
 087     *LBLE       21 15
 088      RCL8       36 08
 089       RTN          24
 090     *LBLe    21 16 15
 091         3          03
 092         6          06
 093         0          00
 094         +         -55
 095       RTN          24
```

FLAGS
0
1
2
3

SET STATUS

FLAGS			TRIG		DISP	
	ON	OFF				
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	0

REGISTERS

0	1 R_1	2 R_2	3 $DIST_{12}$	4 HDG_{12}	5 HDG_{1D}	6 $DIST_{1D}$	7 USED	8 USED	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Position by One Vor

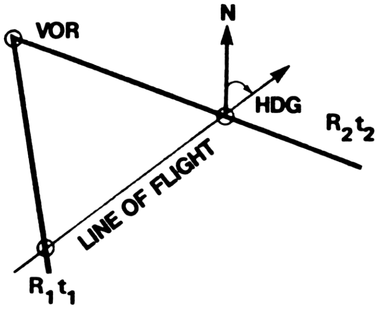
Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

This program computes the distance from a VOR station to an aircraft. The distance is found in a manner similar to the classical situation where one flies at right angles to the VOR radial and computes the time to the VOR from the time between bearings and the degrees of bearing change. This program offers a more complete solution in that it is unnecessary to fly at right angles to the VOR station and it includes the effect of winds.



The distance from the VOR station to the airplane is given by

$$S = \frac{(GS \times \Delta t) \sin(C - R_1)}{\sin(R_1 - R_2)} \qquad (1)$$

where
GS = ground speed of aircraft
Δt = time between readings = $t_2 - t_1$
C = magnetic course of aircraft
R_1 = first radial to the VOR
R_2 = second radial to the VOR
t_1 = time of the first VOR radial intercept.
t_2 = time of the second VOR radial intercept.

Operating Limits and Warnings

Program Description I

Program Title Position by One VOR

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 973330

Program Description, Equations, Variables

Ground speed and course are found from the polar representation:

$$\frac{GS}{60} \angle C = TAS \angle HDG - W \angle D - V \qquad (2)$$

where
V = magnetic variation
TAS = true airspeed
HDG = aircraft heading
W = wind velocity
D = wind direction (true)
∠ should be read as "at angle".

Although the ground speed vector is the true airspeed vector *plus* the wind vector, equation (2) is correct because the wind direction D indicates the direction the wind is coming from, not the direction it is blowing toward.

Operating Limits and Warnings

Limits and Warnings

Overall accuracy is limited by VOR receiver resolution. The difference in VOR readings should be at least 5° and preferably 10° to obtain accurate results. Times must be input to the nearest second.

Program Description II

Sketch(es)

Sample Problem(s)

An airplane is flying at a heading of 35°. Its true airspeed is 150 knots. The reported winds are 240° at 19 knots. Magnetic variation is 15° west. At 3:22:10 the OMNI indicates a heading of 330° to the station. At 3:34:30 the VOR reads 240° to the station. What is the distance to the station at the time of the second reading?

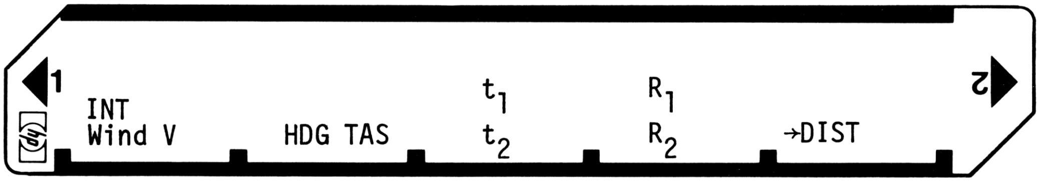
Solution(s) 31.72 nautical miles

Keystrokes	See Display
[f] [A] 240.19 [A] 15 [CHS] [A] 35 [B] 150 [B]	
3.2210 [C] 330 [D] 3.3430 [C] 240 [D] [E]	31.72

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	0.00
3.	Optional: Input wind vector then	DDD.KK	A		DDD.KK
	magnetic variation (+E,-W)	V(Deg)	A		V
4.	Input all of the following:				
	Aircraft heading	HDG(Deg)	B		HDG
	then true airspeed	TAS(n.m.)	B		TAS
	Intersection time of first radial	t_1(H.MMSS)*	C		t_1
	first radial heading to the VOR	R_1(Deg)	D		R_1
5.	Input intersection time of second VOR radial	t_2(H.MMSS)	C		t_2
	and second radial heading to the VOR	R_2(deg)	D		R_2
6.	Calculate distance to VOR		E		DIST(n.m.)
7.	For a second fix using the same station go				
	to step 5. For a new case go to step 3.				
*	H.MMSS means hours, decimal point, minutes,				
	seconds. 2.0355 is 2 hours 3 minutes and 55 seconds.				

97 Program Listing I

```
STEP  KEY ENTRY   KEY CODE      COMMENTS
001   *LBLa     21 16 11
002     CLX          -51
003    STO1        35 01
004    STO2        35 02
005     DEG        16-21
006     RTN           24
007   *LBLA        21 11
008    STO2        35 02
009     RTN           24
010   *LBLA        21 11
011    STO1        35 01
012     RTN           24
013   *LBLB        21 12
014    STO4        35 04
015     RTN           24
016   *LBLB        21 12
017    STO3        35 03
018     RTN           24
019   *LBLC        21 13
020    RCL6        36 06
021    STO5        35 05
022     X⇄Y          -41
023    STO6        35 06
024     RTN           24
025   *LBLD        21 14
026    RCL8        36 08
027    STO7        35 07
028     X⇄Y          -41
029    STO8        35 08
030     RTN           24
031   *LBLE        21 15
032    RCL2        36 02
033     INT        16 34
034    RCL1        36 01
035       -          -45
036    RCL2        36 02
037     FRC        16 44
038     EEX          -23
039       2           02
040       x          -35
041     CHS          -22
042      →R           44
043    RCL4        36 04
044    RCL3        36 03
045      →R           44
046     X⇄Y          -41
047      R↑        16-31
048       +          -55
049      R↓          -31
050       +          -55
051      R↑        16-31
052     X⇄Y          -41
053      →P           34
054    RCL6        36 06
055    RCL5        36 05
056     CHS          -22
057    HMS+        16-55
058    HMS→        16 36
059    ENT↑          -21
060     CLX          -51
061    X>Y?        16-34
062    GSBe     23 16 15
063       +          -55
064       x          -35
065     X⇄Y          -41
066    RCL7        36 07
067       -          -45
068     SIN           41
069       x          -35
070    RCL7        36 07
071    RCL8        36 08
072       -          -45
073     SIN           41
074       ÷          -24
075     RTN           24
076   *LBLe     21 16 15
077     CLX          -51
078       2           02
079       4           04
080     RTN           24
090
100
110
```

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	2

REGISTERS

0	1	2	3	4	5	6	7	8	9
	V(DEG)	DDD.KK	TAS	HDG	T_1	T_2	R_1	R_2	
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title D M E Speed Correction

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equ

The program calculates ground speed from the DME speed indicator when the airplane course is not directly to or from a DME station.

The DME speed indicator reads the component of velocity that is on a line between the plane and the DME station. The component V_1 is given by:

$$V_1 = GS \times |\cos(D - C)|$$

where

GS = The aircraft speed
D = Direction to (or from) the DME station
C = Aircraft ground course

solving for GS

$$GS = \frac{V_1}{|\cos(D-C)|}$$

The program will also correct for aircraft altitude

$$GS' = \frac{GS\sqrt{\Delta h^2 + DIST^2}}{DIST}$$

where

GS′ = Aircraft ground speed corrected for heading and elevation
Δh = Difference between aircraft and DME altitude.
DIST = Distance to DME

Operating Limits and Warnings

Limits and Warnings

The accuracy of the DME and the limits of measuring D and C cause errors when angles to DME radials approach 90 degrees. To obtain accurate values, you should only use data obtained when crossing DME radials at an angle less than 60°.

The program uses ground course as an input, not aircraft heading. Aircraft headings must be corrected by the wind correction angle to obtain ground course.

Program Description II

Sketch(es)

Sample Problem(s)

An airplane flying a course of 265° intercepts the 220° TO radial of a DME station. . The indicated DME speed is 123 knots. What is the ground speed.

If you are 10,000 feet above the DME station and 7 n.m. away what is your ground speed?

Solution(s)

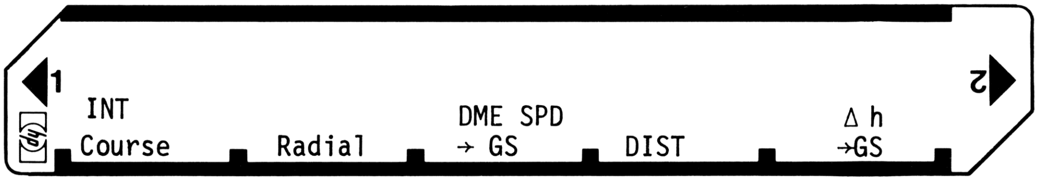
GS = 174 knots
GS'= 179 knots

Keystrokes	See Display
[f] [A] 265 [A] 220 [B] 123 [C]	174
7 [D] 10000 [E]	179

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	
3.	Input course (degrees)	course	A		course
	and radial (degrees)	radial	B		radial
4.	Input DME speed and calculate ground speed	V_1(knots)	C		GS(knots)
5.	Optional:* Input distance to DME	DIST(n.m.)	D		DIST
	Input altitude above DME and calculate GS	Δ h(ft)	E		GS(knots)
6.	For new case with same course and radial go to				
	step 4. Go to step 3 for new case.				
*	Step 5 corrects for elevation effects and is				
	not necessary unless the aircraft is very high				
	or very close to the DME station.				

97 Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	*LBLa	21 16 11	
002	DSP0	-63 00	
003	CLX	-51	
004	RTN	24	
005	*LBLA	21 11	
006	STO1	35 01	
007	RTN	24	
008	*LBLB	21 12	
009	STO2	35 02	
010	RTN	24	
011	*LBLC	21 13	
012	RCL2	36 02	
013	RCL1	36 01	
014	-	-45	
015	COS	42	
016	÷	-24	
017	ABS	16 31	
018	STO3	35 03	
019	RTN	24	
020	*LBLD	21 14	
021	STO4	35 04	
022	RTN	24	
023	*LBLE	21 15	
024	ENT↑	-21	
025	6	06	
026	0	00	
027	7	07	
028	6	06	
029	÷	-24	
030	X^2	53	
031	RCL4	36 04	
032	X^2	53	
033	+	-55	
034	√X	54	
035	RCL4	36 04	
036	÷	-24	
037	RCL3	36 03	
038	x	-35	
039	RTN	24	
050			
060			
070			
080			
090			
100			
110			

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	0

REGISTERS

0	1	2	3	4	5	6	7	8	9
	COURSE	TO RADIAL	GS	DIST					
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Average Wind Vector

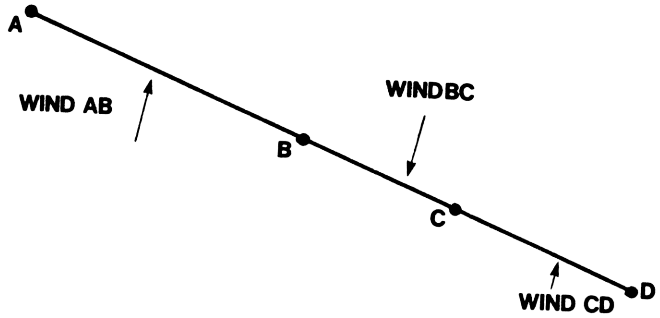
Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

When planning a flight it may be helpful to reduce several reported wind vectors along the flight path to one average wind. By weighting each wind vector along the flight path according to the distance it acts, an approximate average wind vector can be found. For a flight from A to D with forecast winds as shown:



$$\overrightarrow{\text{Wind Ave}} = \frac{1}{\text{Dist}_{AD}}\Big[(\text{Dist}_{AB})(\overrightarrow{\text{Wind}}_{AB}) + (\text{Dist}_{BC})(\overrightarrow{\text{Wind}}_{BC}) + (\text{Dist}_{CD})(\overrightarrow{\text{Wind}}_{CD})\Big]$$

Operating Limits and Warnings

Limits and Warnings

The greater the aircraft velocity as compared to that of the wind, the closer the approximation is to the actual case.

The velocity of input winds must be less than 100.

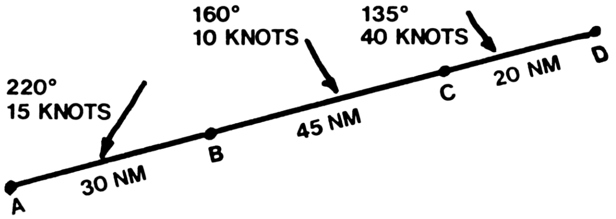
Program Description II

Sketch(es)

Sample Problem(s)

Sample Problem

Suppose a pilot wants to fly from A to D given the following wind pattern along his flight path. What is the approximate average wind?



Solution(s)

Solution

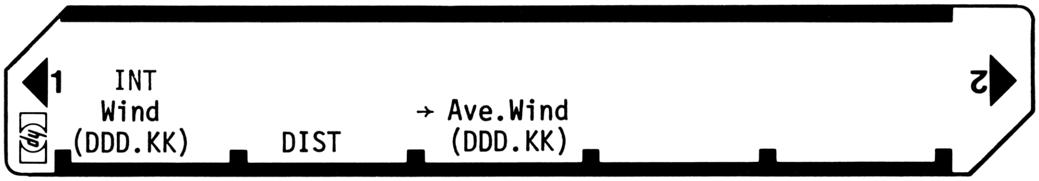
$\overrightarrow{\text{Wind Ave}}$ = 162.15 or a 15 knot wind at 162 degrees

Keystrokes	**See Displayed**
[f][A] 220.15 A 30 B 160.10 A 45 B	
135.40 A 20 B C	162.15

Reference(s)

This program is a direct translation of a program from the HP-65 <u>Aviation Pac</u>.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Enter program			
2.	Initialize		f A	0.00
3.	Input wind vector for a particular flight			
	segment and input distance along segment	DDD.KK*	A	DDD.KK
	over which wind vector acts	DIST	B	DIST
4.	Repeat step 3 for each segment			
5.	Calculate average wind		C	DDD.KK
6.	For new case go to step 2			
*	DDD.KK means direction, decimal point, wind			
	speed. 325.08 means a direction of 325			
	degrees and a speed of 8 knots.			

97 Program Listing I

```
STEP  KEY ENTRY  KEY CODE      COMMENTS
 001   *LBLa   21 16 11
 002    DSP2     -63 02
 003    CLRG      16-53
 004     CLX        -51
 005     RTN         24
 006   *LBLA      21 11
 007    STO7      35 07
 008    ENT↑        -21
 009     FRC      16 44
 010    STO2      35 02
 011       -        -45
 012    STO3      35 03
 013    RCL7      36 07
 014     RTN         24
 015   *LBLB      21 12
 016    STO7      35 07
 017    ST+1   35-55 01
 018    RCL2      36 02
 019       x        -35
 020    RCL3      36 03
 021     X⇄Y        -41
 022      →R         44
 023    ST+4   35-55 04
 024     X⇄Y        -41
 025    ST+5   35-55 05
 026    RCL7      36 07
 027     RTN         24
 028   *LBLC      21 13
 029    RCL5      36 05
 030    RCL1      36 01
 031       ÷        -24
 032    RCL4      36 04
 033    RCL1      36 01
 034       ÷        -24
 035      →P         34
 036    STO6      35 06
 037      R↓        -31
 038    STO7      35 07
 039    ENT↑        -21
 040     CLX        -51
 041    X>Y?      16-34
 042    GSBc   23 16 13
 043       +        -55
 044       .        -62
 045       5         05
 046       +        -55
 047     INT      16 34
 048    RCL6      36 06
 049       +        -55
 050     RTN         24
 051   *LBLc   21 16 13
 052     CLX        -51
 053       3         03
 054       6         06
 055       0         00
 056     RTN         24
```

FLAGS	
0	
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	2

REGISTERS

0	1 Sum D	2 V/100	3 WIND°	4 E_x	5 E_y	6 AVE V/100	7 USED	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Course Correction

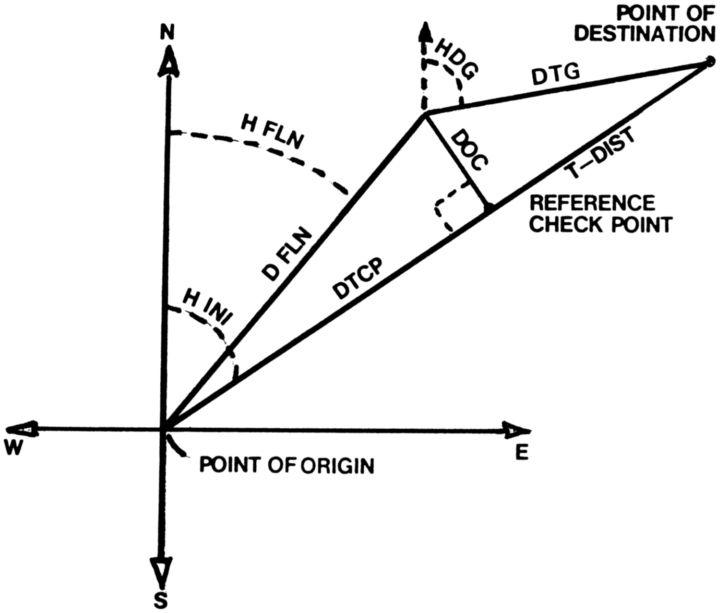
Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

The program calculates the new corrected heading and the distance to destination for an aircraft which has strayed a known distance off course.



Operating Limits and Warnings

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

The following inputs are used in calculations.

DOC = Distance off course (this is input as a positive quantity if you are left of course and as a negative quantity if you are to the right of course);

T DIST = Total distance from the point of origin to the point of destination;

DTCP = Distance to checkpoint from point of origin;

D FLN = Distance actually flown from origin to point of course correction calculation. This value may be used instead of DTCP. When it is used it is input as a negative quantity;

H INI = The initial heading that should have been flown to arrive at the point of destination;

H FLN = The heading actually flown to arrive at the point of calculation for course correction. It may be used instead of H INI. If it is, it is input as a negative value;

The outputs of calculation are:

HDG = The new heading to be flown to arrive at the point of destination;

Operating Limits and Warnings

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

DTG = The distance to go from the point of calculation;

$$DTCP = \sqrt{(-DF)^2 - (DOC)^2}$$

$$DTG = \sqrt{(DTCP - T\ DIST)^2 + (DOC)^2}$$

$$HDG = \sin^{-1}\left[\frac{DOC}{DTG}\right] + H\ INI$$

Operating Limits and Warnings

Limits and Warnings

This program assumes a flat earth. Large distances or calculations near the poles will yield inaccurate results.

Program Description II

Sketch(es)

Sample Problem(s)

Sample Problem

Suppose:

DOC = 15.6 (left)
T DIST = 180
H INI = 85.5 degrees
D FLN = 104 (input as – 104)

Find the heading which must be flown to reach the destination and the distance to destination.

Solution(s)

Solution

HDG = 96.93 degrees
DTG = 78.74 miles

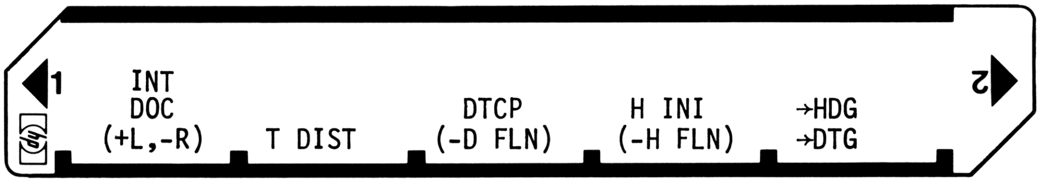
Course Correction

Keystrokes	**See Displayed**
[f][A] 15.6 A 180 B 85.5 D 104 CHS C E	96.93
E	78.74

Reference(s)

This program is a direct translation of a program from the HP-65 <u>Aviation Pac</u>.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Initialize		f	A	0.00
3.	Input distance off course (+left or -right)	DOC	A		DOC
	and total distance	T DIST	B		T DIST
	and distance from origin to checkpoint	DTCP	C		DTCP
	or distance flown (negative)	-D FLN	C		-D FLN
	and initial heading	H INI(Deg)	D		H INI (Deg)
	or heading flown (negative)	-H FLN(Deg)	D		-H FLN(Deg)
4.	Calculate new heading		E		HDG (Deg)
5.	Calculate distance to destination		E		DTG
	(Steps 4 and 5 may be repeated alternately to				
	display HDG and DTG)				
6.	To modify problem go to step 3. For new case				
	go to step 2.				

97 Program Listing I

```
STEP  KEY ENTRY  KEY CODE      COMMENTS

001   *LBLa      21 16 11
002   CLRG          16-53
003   CLX             -51
004   RTN              24
005   *LBLA         21 11
006   STO1          35 01
007   RTN              24
008   *LBLB         21 12
009   STO4          35 04
010   RTN              24
011   *LBLC         21 13
012   STO2          35 02
013   RTN              24
014   *LBLD         21 14
015   STO3          35 03
016   RTN              24
017   *LBLE         21 15
018   RCL2          36 02
019   0                00
020   X≤Y?          16-35
021   GTO3          22 03
022   RCL2          36 02
023   X²               53
024   RCL1          36 01
025   X²               53
026   -               -45
027   √X               54
028   ENT↑            -21
029   *LBL3         21 03
030   R↓              -31
031   STO5          35 05
032   RCL4          36 04
033   -               -45
034   X²               53
035   RCL1          36 01
036   X²               53
037   +               -55
038   √X               54
039   STO6          35 06
040   RCL1          36 01
041   X⇄Y             -41
042   ÷               -24
043   SIN⁻¹         16 41
044   STO7          35 07
045   RCL3          36 03
046   X>0?          16-44
047   GTO1          22 01
048   CHS             -22
049   RCL1          36 01
050   RCL5          36 05
051   ÷               -24
052   TAN⁻¹         16 43
053   +               -55
054   *LBL1         21 01
055   RCL7          36 07
056   +               -55
057   STO8          35 08
058   3                03
059   6                06
060   0                00
061   X≤Y?          16-35
062   GSBe       23 16 15
063   0                00
064   RCL8          36 08
065   X≤Y?          16-35
066   GSBd       23 16 14
067   0                00
068   +               -55
069   STO8          35 08
070   RTN              24
071   *LBLE         21 15
072   RCL6          36 06
073   RTN              24
074   *LBLe      21 16 15
075   -               -45
076   STO8          35 08
077   RTN              24
078   *LBLd      21 16 14
079   3                03
080   6                06
081   0                00
082   +               -55
083   RTN              24
```

FLAGS	SET STATUS		
	FLAGS	TRIG	DISP
0	ON OFF 0 ☐ ☑ 1 ☐ ☑ 2 ☐ ☑ 3 ☐ ☑	DEG ☑ GRAD ☐ RAD ☐	FIX ☑ SCI ☐ ENG ☐ n 2
1			
2			
3			

REGISTERS

0	1 DOC	2 — D FLN OR DTCP	3 — H FLN OR H INC	4 T DIST	5 DTCP	6 DTG	7 CORRECTION	8 HDG	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Description I

Program Title Time of Sunrise and/or Sunset

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

Sunrise is computed from

$$S = [\theta_0 - \cos^{-1}(-\tan\phi_s \tan\phi_0)]/15 - E + 12 \qquad (1)$$

where

θ_0 = observer's longitude
ϕ_0 = observer's latitude
ϕ_s = subsolar latitude (declination of sun)
E = equation of time

ϕ_s and E are approximated by

$$\phi_s \doteq -23.5 \cos(t + 10) \qquad (2)$$

$$E \doteq 0.123 \cos(t + 87) - {}^1/_6 \sin(2t + 20) \qquad (3)$$

$$t \doteq 0.988\,(D - 1 + 30.3\,(m - 1)) \qquad (9)$$

where D and m are day and month respectively.

NOTE: Equation (1) computes the time at which the middle of the sun is on the horizon. Equation (1) does not account for atmopheric refractions. Refraction causes the sun to rise earlier than the value given by equation (1).

Operating Limits and Warnings

Program Description I

Program Title

Contributor's Name

Address

City **State** **Zip Code**

Program Description, Equations, Variables

Sunset is computed from

$$S = [\theta_0 + \cos^{-1}(-\tan\phi_s \tan\phi_0)]/15 - E + 12 \qquad (1)$$

where:

θ_0 = observer's longitude
ϕ_0 = observer's latitude
ϕ_s = subsolar latitude (declination of sun)
E = equation of time

ϕ_s and E are approximated by

$\phi_s \doteq -23.5 \cos(t + 10)$
$E \doteq 0.123 \cos(t + 87) - {}^1/_6 \sin(2t + 20)$
$t \doteq 0.988 (D - 1 + 30.3 (m - 1))$

where D and m are day and month respectively.

NOTE: Equation (1) computes the time at which the middle of the sun is on the horizon. Equation (1) does not account for atmospheric refractions. Refraction causes the sun to set later than the value given by equation (1).

Operating Limits and Warnings

Limits and Warnings

The approximate values of ϕ_s and E cause s to exhibit a maximum error of + 4.7 minutes and −0.6 minutes at 45° north latitude, based on 1973 ephemeris data. Refraction and secular changes in the ephemeris can result in errors as large as +8 minutes from observed data at 45° north. Errors decrease as latitudes approach 0°. Large errors exist above 65°.

Program Description II

Sketch(es)

Sample Problem(s)

Sample Problems

What time does the sun rise in San Francisco (37° 37′ N, 122° 23′ W) on Christmas Day? What time does the sun rise on June 25?

Solution(s)

Solutions

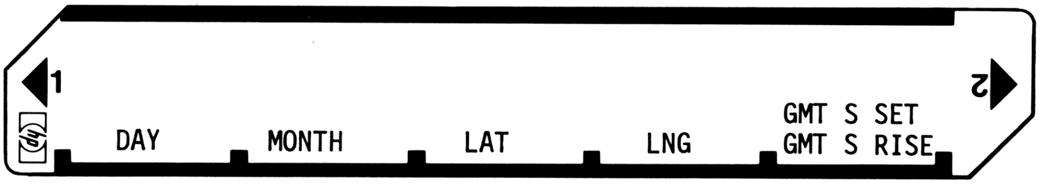
15:27 GMT (07:27 AM Pacific Standard Time)
12:53 GMT (05:53 AM Pacific Daylight Time)

Keystrokes	See Displayed
25 **A** 12 **B** 37.37 **C** 122.23 **D**	
E	15.27
6 **B** **E**	12.53

Reference(s)

This program is a direct translation of a program from the HP-65 <u>Aviation Pac</u>.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Enter all of the following:				
	Day of the month	Day	A		
	Month	Month	B		
	Observer Latitude **	DD.MMSS*	C		
	Observer Longitude	DDD.MMSS	D		
3.	Compute Sunrise		E		HH.MM***
4.	Compute Sunset		f	E	HH.MM
5.	To change any variable, go to Step 2 and change only those affected.				
*	DD.MMSS means degrees, decimal point, minutes and seconds. 120.0713 is 120 degrees, 7 minutes and 13 seconds.				
**	Southern latitudes and eastern longitudes are expressed as negative values.				
***	HH.MM means hours, decimal point, minutes. 2.03 is 2 hours 3 minutes.				

97 Program Listing I

```
STEP  KEY ENTRY  KEY CODE      COMMENTS
 001    *LBLA     21 11
 002    STO1      35 01
 003     RTN         24
 004    *LBLB     21 12
 005    STO2      35 02
 006     RTN         24
 007    *LBLC     21 13
 008    STO3      35 03
 009     RTN         24
 010    *LBLD     21 14
 011    STO4      35 04
 012     RTN         24
 013    *LBLE     21 15
 014       3         03
 015       0         00
 016       .        -62
 017       3         03
 018    RCL2      36 02
 019       1         01
 020       -        -45
 021       x        -35
 022    RCL1      36 01
 023       +        -55
 024       1         01
 025       -        -45
 026       .        -62
 027       9         09
 028       8         08
 029       8         08
 030       x        -35
 031    STO5      35 05
 032       8         08
 033       7         07
 034       +        -55
 035     COS         42
 036       .        -62
 037       1         01
 038       2         02
 039       3         03
 040       x        -35
 041    RCL5      36 05
 042    ENT↑        -21
 043       +        -55
 044       2         02
 045       0         00
 046       +        -55
 047     SIN         41
 048       6         06
 049       ÷        -24
 050       -        -45
 051     CHS        -22
 052    RCL5      36 05
 053       1         01
 054       0         00
 055       +        -55
 056     COS         42
 057       2         02
 058       3         03
 059       .        -62
 060       5         05
 061       x        -35
 062     TAN         43
 063    RCL3      36 03
 064    HMS→      16 36
 065     TAN         43
 066       x        -35
 067    COS⁻¹     16 42
 068     F2?   16 23 02
 069    GTOc   22 16 13
 070     CHS        -22
 071    RCL4      36 04
 072    HMS→      16 36
 073       +        -55
 074       1         01
 075       5         05
 076       ÷        -24
 077       +        -55
 078       1         01
 079       2         02
 080       +        -55
 081    ENT↑        -21
 082     CLX        -51
 083    X>Y?      16-34
 084    GSBa   23 16 11
 085       +        -55
 086    →HMS      16 35
 087     RTN         24
 088   *LBLe   21 16 15
 089     SF2   16 21 02
 090    GTOE      22 15
 091   *LBLc   21 16 13
 092    RCL4      36 04
 093    HMS→      16 36
 094       +        -55
 095       1         01
 096       5         05
 097       ÷        -24
 098       +        -55
 099       1         01
 100       2         02
 101       +        -55
 102       2         02
 103       4         04
 104    X>Y?      16-34
 105    GSBb   23 16 12
 106       -        -45
 107    →HMS      16 35
 108     RTN         24
 109   *LBLa   21 16 11
 110       2         02
 111       4         04
 112     RTN         24
```

REGISTERS

0	1	2	3	4	5	6	7	8	9
	DAY	MONTH	LAT	LNG	t				
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

97 Program Listing II

STEP KEY ENTRY KEY CODE COMMENTS

```
113 *LBLb  21 16 12
114  ENT↑       -21
115   -         -45
116  RTN         24
```

LABELS					FLAGS
A DAY	B MONTH	C LAT	D LNG	E SUNRISE	0
a	b	c	d	e SUNSET	1
0	1	2	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS			TRIG		DISP	
	ON	OFF				
0	☐	☑	DEG	☑	FIX	☑
1	☐	☑	GRAD	☐	SCI	☐
2	☐	☑	RAD	☐	ENG	☐
3	☐	☑			n	2

Program Description I

Program Title Azimuth of Sunrise and Sunset

Contributor's Name Hewlett-Packard

Address 1000 N.E. Circle Blvd.

City Corvallis **State** Oregon **Zip Code** 97330

Program Description, Equations, Variables

This program computes the true heading (azimuth) of the sun as it rises or sets. Input data are day of the month, month of the year and latitude.

The azimuth of the sun is given by

$$Az = \cos^{-1} \frac{\sin \phi_s}{\cos \phi_0}$$

ϕ_s is the latitude of the subsolar point
ϕ_0 is the latitude of the observer
ϕ_s is approximated by

$\phi_s = 0.5 - 23.5 \cos(0.986 \text{ day} + 9.66)$ where day is the day of the year.

Operating Limits and Warnings

The approximations used in this program limit the overall accuracy to = 1%. Significant errors can occur at or above the arctic circles and their respective poles during certain times of the year.

Program Description II

Sketch(es)

Sample Problem(s)

Sample Problem

What is the azimuth of sunset on Christmas day for an observer in San Francisco (37° 37′ N)?

Solution(s)

Solution

Answer: 240.51 degrees

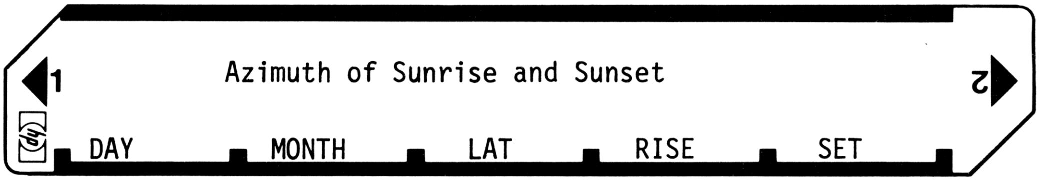
Azimuth of Sunrise and Sunset

Keystrokes	See Displayed
25 A 12 B 37.37 C E	240.51

Reference(s)

This program is a direct translation of a program from the HP-65 Aviation Pac.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Enter program				
2.	Input all of the following				
	Day of the month	Day	A		
	Month (Jan = 1, Dec = 12)	Month	B		
	Observer's latitude	DD.MMSS*	C		
3.	Calculate either or both				
	Azimuth of Sunrise		D		
	Azimuth of Sunset		E		
4.	Go to step three to change any input variable				
	NOTE: Azimuth is given as a true azimuth, not magnetic.				
*	DD.MMSS means degrees, decimal point, minutes and seconds. 20.0713 is 20 degrees, 7 minutes and 13 seconds.				

97 Program Listing I

```
STEP  KEY ENTRY   KEY CODE      COMMENTS
001   *LBLA       21 11
002    STO1       35 01
003     RTN          24
004   *LBLB       21 12
005    STO2       35 02
006     RTN          24
007   *LBLC       21 13
008    STO3       35 03
009     RTN          24
010   *LBLD       21 14
011    RCL2       36 02
012       .         -62
013       4          04
014       x         -35
015       2          02
016       .         -62
017       3          03
018       +         -55
019     INT       16 34
020    STO8       35 08
021       2          02
022    RCL2       36 02
023    X≤Y?       16-35
024    GSBd    23 16 14
025    RCL1       36 01
026    RCL8       36 08
027       -         -45
028    RCL2       36 02
029       1          01
030       -         -45
031       3          03
032       1          01
033       x         -35
034       +         -55
035       .         -62
036       9          09
037       8          08
038       6          06
039       x         -35
040       9          09
041       .         -62
042       6          06
043       6          06
044       +         -55
045     COS          42
046       2          02
047       3          03
048       .         -62
049       5          05
050       x         -35
051     CHS         -22
052       .         -62
053       5          05
054       +         -55
055     SIN          41
056    RCL3       36 03
057    HMS→       16 36
058     COS          42
059       ÷         -24
060    COS⁻¹      16 42
061       3          03
062       6          06
063       0          00
064     X⇄Y         -41
065     F2?    16 23 02
066       -         -45
067     RTN          24
068   *LBLE       21 15
069     SF2    16 21 02
070    GTOD       22 14
071   *LBLd    21 16 14
072     CLX         -51
073    STO8       35 08
074     RTN          24
075     R/S          51
080
090
100
110
```

FLAGS	SET STATUS		
0	FLAGS	TRIG	DISP
1	ON OFF		
2	0 ☐ ☑ 1 ☐ ☑ 2 ☐ ☑ 3 ☐ ☑	DEG ☑ GRAD ☐ RAD ☐	FIX ☑ SCI ☐ ENG ☐ n 2
3			

REGISTERS

0	1 DAY	2 MONTH	3 LAT	4	5	6	7	8 0.4m+2.3	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

NOTES

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EE (Lab)
Industrial Engineering
Aeronautical Engineering
Control Systems
Beams and Columns
High-Level Math
Test Statistics
Geometry
Reliability/QA
Medical Practitioner
Anesthesia
Cardiac
Pulmonary
Chemistry
Optics
Physics
Earth Sciences
Energy Conservation
Space Science
Biology
Games
Games of Chance
Aircraft Operation
Avigation
Calendars
Photo Dark Room
COGO-Surveying
Astrology
Forestry

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RHUMB LINE NAVIGATION
GREAT CIRCLE NAVIGATION
POSITION GIVEN HEADING, SPEED AND TIME
LINE OF SIGHT DISTANCE
POSITION AND/OR NAVIGATION BY TWO VOR'S
POSITION BY ONE VOR
DME SPEED CORRECTION
AVERAGE WIND VECTOR
COURSE CORRECTION
TIME OF SUNRISE AND SUNSET
AZIMUTH OF SUNRISE AND SUNSET

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Program Listing I

S

COMMENTS

STEP KEY ENTRY KEY CODE COMMENTS

```
001  *LBLA     21 11
002   HMS→     16 36
003   RCL4     36 04
004   STO2     35 02
005    X⇄Y       -41
006   STO4     35 04
007    RTN        24
008  *LBLB     21 12
009   STO5     35 05
010    RTN        24
011  *LBLC     21 13
012   STO6     35 06
013    RTN        24
014  *LBLD     21 14
015   HMS→     16 36
016   RCL6     36 06
017      x       -35
018      6        06
019      0        00
020      ÷       -24
021   STO7     35 07
022   RCL5     36 05
023    COS        42
024      x       -35
025   RCL2     36 02
026      +       -55
027   STO1     35 01
028   GSBE     23 15
029   RCL2     36 02
030   GSBE     23 15
031   X=Y?     16-33
032   GTO2     22 02
033      -       -45
034   RCL5     36 05
035    TAN        43
036      x       -35
037     Pi     16-24
038      ÷       -24
039      1        01
040      8        08
041      0        00
042      x       -35
043  *LBL1     21 01
044    CHS       -22
045   RCL4     36 04
046      +       -55
047      1        01
048     →R        44
049     →P        34
050     R↓       -31
051   STO3     35 03
052   RCL1     36 01
053   →HMS     16 35
054    RTN        24
055  *LBL2     21 02
056   RCL7     36 07
057   RCL5     36 05
058    SIN        41
059      x       -35
060   RCL2     36 02
061    COS        42
062      ÷       -24
063   GTO1     22 01
064  *LBLD     21 14
065   RCL3     36 03
066   →HMS     16 35
067    RTN        24
068  *LBLE     21 15
069      2        02
070      ÷       -24
071      4        04
072      5        05
073      +       -55
074    TAN        43
075     LN        32
076    RTN        24
077    R/S        51
```

L1

080

090

100

110

FLAGS	SET STATUS		
	FLAGS	TRIG	DISP
0	ON OFF	DEG ☒	FIX ☒
1	0 ☐ ☒	GRAD ☐	SCI ☐
2	1 ☐ ☒	RAD ☐	ENG ☐
3	2 ☐ ☒ 3 ☐ ☒		n 2

REGISTERS

0	6 D	4 LNGS	5 HDG	6 SPEED	7 DIST	8	9
S0		S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

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Comments:

THERE ARE TWO (2) ERRORS IN THE PROGRAM LISTING.

(a) STEP 107 READS HMS→ 16 36

IT SHOULD READ →HMS 16 35

(b) STEP 111 IN SUBROUTINE "a" SHOUD BE FOLLOWED BY

STEP 112	+	-55	(THIS IS AN EXTRA - AND NECESSARY - STEP)
113	RTN	24	
114	*LBLb	21 16 12	
115	ENT ↑	-21	
116	-	-45	
117	RTN	24	

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