HEWLETT-PACKARD

HP-41C

AVIATION PAC

NOTICE

INTRODUCTION

The programs in the Aviation Pac were selected by several professional and private pilots. This is the collection of programs that those people felt would be most useful to the majority of pilots.

Each program in this pac is represented by one program in the Application Module and a section in this manual. The manual provides a description of the program with some equations, a set of instructions for using the program, and one or more example problems each of which includes a list of the keystrokes required for its solution.

Before plugging in your Application Module, **turn your calculator off,** and be sure you understand the section Inserting and Removing Application Modules. Before using a particular program, take a few minutes to read ''Format of User Instructions'' and ''A Word About Program Usage.''

You should first familiarize yourself with a program by running it once or twice while following the complete User Instructions in the manual. Thereafter, the program's prompting should provide the necessary instructions, including which variables are to be input, which keys are to be pressed and which values will be output.

We hope the Aviation Pac will assist you in the solution of numerous problems in your discipline. If you have technical problems with this Pac, refer to your HP-41 owner's handbook for information on Hewlett-Packard Customer Support. To find this information, look in the index under "technical support" or "programming assistance."

> Note: Application modules are designed to be used in all HP-41 model calculators. The term "HP-41C" is used throughout the rest of this manual, unless otherwise specified, to refer to all HP-41 calculators.

CONTENTS

INSERTING AND REMOVING APPLICATION MODULES

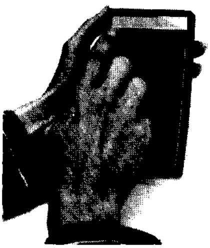
Before you insert an Application Module for the first time, familiarize yourself with the following information.

Up to four Application Modules can be plugged into the ports on the HP-41C. While plugged in, the names of all programs contained in the Module can be displayed by pressing ■ CATALOG 2.

> **CAUTION**
>
> Always turn the HP-41C off before inserting or removing any plug-in extension or accessories. Failure to turn the HP-41C off could damage both the calculator and the accessory.

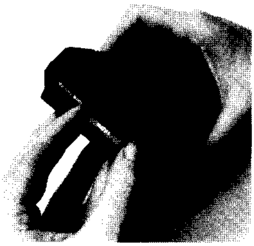
To insert Application Modules:

1. Turn the HP-41C off! Failure to turn the calculator off could damage both the Module and the calculator.



2. Remove the port covers. Remember to save the port covers; they should be inserted into the empty ports when no extensions are inserted.

3. Insert the Application Module with the label facing downward as shown, into any port **after** the last Memory Module. For example, if you have a Memory Module inserted in port 1, you can insert an Application Module in any of ports 2, 3, or 4. (The port numbers are shown on the back of the calculator.) **Never**

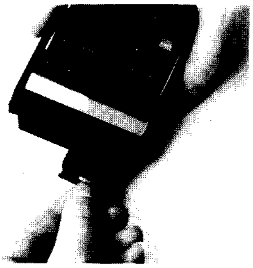


insert an Application Module into a lower numbered port than a Memory Module.

4. If you have additional Application Modules to insert, plug them into any port after the last Memory Module. Be sure to place port covers over unused ports.
5. Turn the calculator on and follow the instructions given in this book for the desired application functions.

To remove Application Modules:

1. Turn the HP-41C off! Failure to do so could damage both the calculator and the Module.
2. Grasp the desired Module handle and pull it out as shown.



3. Place a port cap into the empty ports.

Mixing Memory Modules and Application Modules

Any optional accessories (such as the HP 82104A Card Reader, or the HP 82143A Printer) should be treated in the same manner as Application Modules. That is, they can be plugged into any port after the last Memory Module. Also, the HP-41C should be turned off prior to insertion or removal of these extensions.

The HP-41C allows you to leave gaps in the port sequence when mixing Memory and Application Modules. For example, you can plug a Memory Module into port 1 and an Application Module into port 4, leaving ports 2 and 3 empty.

FORMAT OF USER INSTRUCTIONS

The User Instruction Form—which accompanies each program—is your guide to operating the programs in this Pac.

The form is composed of five labeled columns. Reading from left to right, the first column, labeled STEP, gives the instruction step number.

The INSTRUCTIONS column gives instructions and comments concerning the operations to be performed.

The INPUT column specifies the input data, the units of data if applicable, or the appropriate alpha response to a prompted question. Data input keys consist of 0 to 9 and the decimal point (the numberic keys), [EEX] (enter exponent), and [CHS] (change sign).

The FUNCTION column specifies the keys to be pressed after keying in the corresponding input data.

The DISPLAY column specifies prompts, intermediate and final answers, and their units, where applicable.

Above the DISPLAY column is a box which specifies the minimum number of data storage registers necessary to execute the program. Refer to the Owner's Handbook for information on how the SIZE function affects storage configuration.

The following illustrates the User Instruction Form for In-Flight Winds.

				SIZE: 040
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
	IN-FLIGHT WINDS			
1	To determine In-Flight Winds.		[XEQ] IFW	VAR=(V)?
2	Input variation to obtain winds in true rather than magnetic headings. ([CHS] for westerly variation)	V	([CHS])[R/S]	TAS=(TAS)?
3	Input true air speed	TAS,kts.	[R/S]	MC=(MC)?
4	Input magnetic course	MC	[R/S]	T AT WPT1=?
5	Input time at waypoint one.	H.MMSS*	[R/S]	D TO WPT2=?
6	Input the distance to fly in nautical miles (N.M.) to waypoint 2.	N.M.	[R/S]	T AT WPT2=?
7	Input time at waypoint 2.	H.MMSS	[R/S]	STEERING=?
8	To calculate wind, input the heading the airplane is required to fly to stay on course.	Steer(deg)	[R/S]	WIND=DDD.KKK**
9	For another (IFW) calculation return to step 1.			

A WORD ABOUT PROGRAM USAGE

Catalog

When an Application Module is plugged into a port of the HP-41C, the contents of the Module can be reviewed by pressing ■ [CATALOG] 2 (the Extension Catalog). Executing the [CATALOG] function lists the name of each program or function in the Module, as well as functions of any other extensions which might be plugged in.

ALPHA and USER Mode Notation

This manual uses a special notation to signify ALPHA mode. Whenever a statement on the User Instruction Form is printed in gold, the [ALPHA] key must be pressed before the statement can be keyed in. After the statement is input, press [ALPHA] again to return the calculator to its normal operating mode, or to begin program execution. For example, [XEQ] PLAN means press the following keys: [XEQ] [ALPHA] PLAN [ALPHA] .

When the calculator is in USER mode, this manual will use the symbols [A] - [J] and ■ [A] - ■ [E] to refer to the reassigned keys in the top two rows. These key designations will appear on the User Instruction Form and in the keystroke solutions to sample problems.

Optional HP 82143A Printer

When the optional printer is plugged into the HP-41C along with the Aviation Application Module, all results will be printed automatically. You may also want to keep a permanent record of the values input to a certain program. A convenient way to do this is to set the Print Mode switch to NORMAL before running the program. In this mode, all input values and the corresponding keystrokes will be listed on the printer, thus providing a record of the entire operation of the program.

Downloading Module Programs

If you wish to trace execution, to modify, or to record on magnetic cards a program in this Application Module, it must first be copied into the HP-41C's program memory. For information concerning the HP-41C's COPY function, see the Owner's Handbook. It is not necessary to copy a program in order to run it.

Program Interruption

These programs have been designed to operate properly when run from beginning to end, without turning the calculator off (remember, the calculator might turn itself off). If the HP-41C is turned off, it may be necessary to set flag 21 (SF 21) to continue proper execution.

Size

Most users will want to SIZE their calculator to 063 to use the flight planning program. SIZE 051 is sufficient for the other programs.

Use of Labels

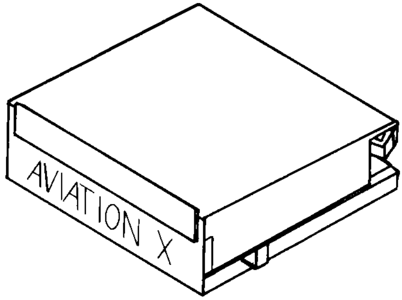
You should generally avoid writing programs into the calculator memory that use program labels identical to those in your Application Module. In case of a label conflict, the label within program memory has priority over the label within the Application Pac program.

Assigning Program Names

Key assignments to keys [A] - [J] and ■[A] - ■[E] take priority over the automatic assignments of local labels in the Application Module. Be sure to clear previously assigned functions before executing a Module program.

Incompatible Application Module

This Pac contains a type X Application Module. Type X Modules have incompatible XROM instructions. You should never plug two type X Application Modules into your HP-41C at the same time. Type X Modules may be identified by an "X" on the Application Module label.



FLIGHT MANAGEMENT

This program provides an interchangeable solution for both the speed-time-distance and the fuel flow-time-fuel consumption problems. The program is organized so that the five keys, A-E, in the top row of the HP-41C correspond to the five variables D, S, T, FF, and F.

Any two knowns from the set D, S, T or the set F, FF, T may be input and the third calculated. Inputs are made by keying in the known values and pressing the corresponding keys. Pressing one of the keys without having keyed in a number results in an attempt to calculate that value.

To gain an understanding of how this program can help you, it is helpful to study all the possible arrangements of the input values.

$D = S \times T$	$F = FF \times T$
$S = D \div T$	$FF = F \div T$
$T = D \div S$	$T = F \div FF$
$D = S \times F \div FF$	$F = FF \times D \div S$
$S = D \div (F \div FF)$	$FF = F \div (D \div S)$

SIZE: 006

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Select the Flight Management program.		[XEQ] FM	D S T FF F
2	Input values for any two of:			
	Distance in some length unit	D	[A]	DIST=(D)
	Speed in the same length unit per hour	S	[B]	SPEED=(S)
	Time in hours, minutes, seconds	T, H.MS	[C]	TIME=(T)
	or,			
	Fuel in some volume or weight unit	F	[E]	FUEL=(F)
	Fuel flow in the same unit per hour	FF	[D]	F FLOW=(FF)
	Time in hours, minutes, and seconds	T, H.MS	[C]	TIME=(T)
3	Compute the remaining variable(s):			
	Distance		[A]	DIST=(D)
	Speed		[B]	SPEED=(S)
	Time		[C]	TIME=(T)
	Fuel Flow		[D]	F FLOW=(FF)
	Fuel		[E]	FUEL=(F)
4	To redisplay the D S T FF F prompt		[R/S]	D S T FF F
	NOTE: You can also input D and S and either FF or F and then solve for F or FF without computing T as an intermediate step.			

Example 1:

An aircraft consumes 10.7 gallons of fuel per hour. How far can it fly at 105 knots with 29.8 gallons of fuel? How long will it take?

Keystrokes	Display	Comments
[XEQ] [ALPHA] FM [ALPHA]	*D S T FF F*	Associate these names with the top-row keys. Notice that the program sets USER mode.
10.7 [D]	*F FLOW=10.70*	
29.8 [E]	*FUEL=29.80*	
105 [B]	*SPEED=105.00*	
[A]	*DIST=292.43*	
[C]	*TIME=2:47:06*	

Example 2:

A jet aircraft used 2150 pounds of fuel during a 10-minute climb. What was its average fuel flow while climbing?

Keystrokes	Display	Comments
2150 [E]	*FUEL=2150.00*	
.10 [C]	*TIME=0:10:00*	
[D]	*F FLOW=12900.00*	

GENERAL AIRCRAFT WEIGHT AND BALANCE

This program organizes and simplifies weight and balance calculations for most private aircraft. It works for an airplane having forward and rear baggage compartments, two rows of passengers in addition to the pilot's row, and fuel. Any of these can be ignored by using a negative value for the weight.

The program prompts you for weights which must be integers and moment arms which must be positive. Moment arms and aircraft weight and moment are stored so that once they have been input, you will not be prompted further for them. You will not be prompted again for weights which you entered as negative values, either.

The register containing fuel is used by the Flight Plan program to compute landing center of gravity. Fuel is stored in pounds, but you may elect to input it in gallons (assuming a density of 6.0).

				SIZE:021
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	To deliberately clear the WB registers:		[XEQ] CLWB	FUEL IN GAL or FUEL IN LBS
	(to change the fuel units)		[R/S]	FUEL IN LBS or FUEL IN GAL
2	Begin the program.		[XEQ] WB	FWD BAG=0.?
3a	Input weight in forward baggage compartment.	W_{FB},lb.	[R/S]	MOM ARM=?
3b	Input moment arm for this compartment.	MOM_{FB},in	[R/S]	PILOTS=0.?
4a	Input weight of pilot and "co-pilot".	W_{P},lb.	[R/S]	MOM ARM=?
4b	Input moment arm for pilot seats.	MOM_{P},in.	[R/S]	ROW1=0.?
5a	Input weight of passengers in row 1.	W_{1},lb.	[R/S]	MOM ARM=?
5b	Input moment arm for row 1.	MOM_{1},in.	[R/S]	ROW2=0.?
6a	Input weight of passengers in row 2.	W_{2},lb.	[R/S]	MOM ARM=?
6b	Input moment arm for row 2.	MOM_{2},in.	[R/S]	REAR BAG=0.?
7a	Input weight in rear baggage compartment.	W_{RB},lb.	[R/S]	MOM ARM=?
7b	Input moment arm for this compartment.	MOM_{RB},in	[R/S]	FUEL=0.?
8a	Input fuel quantity	W_{F},lb or gal	[R/S]	MOM ARM=?
8b	Input moment arm for fuel.	MOM_{F},in.	[R/S]	EMPTY WT=?

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
9a	Input weight of empty aircraft.	W_A,lb.	[R/S]	MOM ARM=?
9b	Input moment arm of empty aircraft.	MOM_A,in.	[R/S]	GROSSWT=(GW)
10	Display outputs, one at a time.		[R/S] [R/S] [R/S]	NET WT=(NW) MOM=(M) CG=(CG)*
11	You may review the weights, changing any you desire by returning to step 2. Weights input as negative numbers will be skipped. Moment arms are stored until cleared.			

*If you wish to see a more precise CG, press ■[FIX] 2[RDN].

Example 1:

A Piper Cherokee Turbo Arrow III has an empty weight of 1833 pounds and a moment arm of 85.16 inches. A 200-pound pilot and 150-pound passenger occupy the pilot's row which has an 80.5-inch moment arm. There is only one row of seats at 118.1 inches which are empty. The rear baggage compartment (arm = 142.8 in.) contains two 50-pound suitcases. There is no front baggage compartment. If 50 gallons of fuel are aboard (arm = 95 in.), what is the position of the center of gravity?

Keystrokes	Display	Comments
[XEQ] [ALPHA] CLWB [ALPHA]	*FUEL IN LBS*	
[R/S]	*FUEL IN GAL*	Press [R/S] until FUEL IN GAL appears.
[XEQ] [ALPHA] WB [ALPHA]	*FWD BAG=0.?*	
1 [CHS] [R/S]	*PILOTS=0.?*	
350 [R/S]	*MOM ARM=?*	
80.5 [R/S]	*ROW1=0.?*	
[R/S]	*MOM ARM=?*	
118.1 [R/S]	*ROW2=0.?*	
1 [CHS] [R/S]	*REAR BAG=0.?*	
100 [R/S]	*MOM ARM=?*	
142.8 [R/S]	*FUEL=0. GAL?*	
50 [R/S]	*MOM ARM=?*	
95 [R/S]	*EMPTY WT=?*	
1833 [R/S]	*MOM ARM=?*	
85.16 [R/S]	*GROSSWT=2,583.*	
[R/S]	*NET WT=750.*	
[R/S]	*MOM=227,053.*	
[R/S]	*CG=88.*	

Example 2:

What is the center of gravity of the airplane in example 1 if passengers weighing 375 pounds are added?

Keystrokes	Display	Comments
[XEQ] [ALPHA] WB [ALPHA]	*PILOTS=350?*	You could have continued the program using [R/S], but this method will always work.
[R/S]	*ROW1=0.?*	
375 [R/S]	*REAR BAG=100.?*	
[R/S]	*FUEL=50.GAL?*	
[R/S]	*GROSSWT=2,958.*	
[R/S]	*NET WT=1,125.*	
[R/S]	*MOM=271,341.*	
[R/S]	*CG=92.*	The aft limit on this aircraft is 90 inches.

Example 3:

Try moving the suitcases forward, one to the front seat, and one to the rear seats.

[XEQ] [ALPHA] WB [ALPHA]	*PILOTS=350.?*	
400 [R/S]	*ROW1=375.?*	
425 [R/S]	*REAR BAG=100.?*	
0 [R/S]	*FUEL=50.GAL?*	
[R/S]	*GROSSWT=2,958.*	
[R/S]	*NET WT=1,125.*	
[R/S]	*MOM=266,991.*	
[R/S]	*CG=90.*	OK, but a bit uncomfortable.

FLIGHT PLAN

This program is used when making a flight plan. It includes winds, top-of-climb calculations, ETE (estimated time enroute), ETA (estimated time of arrival), fuel consumption, and landing weight and balance. It solves the wind triangle, giving correct values for magnetic heading (MH) and ground speed (GS). It works for up to six legs (more with additional memory), storing desired course, direction, and flight level for each leg.

Inputs are magnetic variation, number of legs, magnetic course, distance, and flight level for each leg, starting and ending altitudes, winds aloft, rates of climb and descent, and TAS and fuel flow for climb, cruise, and descent. Outputs for each leg are magnetic heading, ground speed, fuel used, fuel remaining, leg time, and accumulated time. If there is a change of altitude between consecutive legs, it is assumed to occur at the beginning of that leg. Climb and descent phases of each leg are output separately as if they were separate legs.

The descent point is calculated based on the specified rate of descent. It will normally occur in the last or next-to-last leg, but may occur anywhere. The program will get erroneous results if the descent point occurs before top-of-climb is reached (i.e.: garbage in yields garbage out).

				SIZE: 063
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	First run WB.		[XEQ] WB	
2	Then begin your flight plan.		[XEQ] PLAN	VAR=0.?
3	Input magnetic variation (+E, −W).†	VAR	([CHS]) [R/S]	LEGS=0?
4	Input number of legs.	LEGS	[R/S]	L(n)CRS=000?
5	Input for each leg: course – (magnetic) distance flight level	 CRS DIST FL	 [R/S] [R/S] [R/S] [R/S]	 L(n)DIST=0.? FL(n)=0.? L(+1)... START ALT= 0.?
6	Input altitudes of starting point and destination.	START ALT DEST ALT	[R/S] [R/S]	DEST ALT=0.00? WA(i)=000.000?
	†People who are accustomed to using the correction for variation, in which the signs for east and west are reversed, must be careful to input the **magnetic variation** correctly.			

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
7	Input winds aloft as required by flight levels. (i=3,6,9,12,18,24)	DDD.KKK	[R/S]	CLIMB FUEL FLOW =0.0?
8	Input aircraft performance:			
	climb fuel flow	FF_{CL}	[R/S]	CLIMB TAS=0.0?
	climb TAS	TAS_{CL}	[R/S]	ROC=0.0?
	rate of climb	ROC	[R/S]	CRUISE FUEL FLOW=0.0?
	cruise fuel flow	FF_{CR}	[R/S]	CRUISE TAS= 0.0?
	cruise TAS	TAS_{CR}	[R/S]	DESCENT FUEL FLOW=0.0?
	descent fuel flow	FF_{D}	[R/S]	DESCENT TAS= 0.0?
	descent TAS	TAS_{D}	[R/S]	ROD=0.0?
	rate of descent	ROD	[R/S]	T.O. TIME=?
9	Input takeoff time and compute outputs for each leg (or portion thereof if there is an altitude change).	T_0	[R/S]	LEG(n) CLIMB, DESCENT, OR LEVEL
	Magnetic heading			HDG=(MH)
	ground speed		[R/S] *	GS=(GS)
	fuel used this leg		[R/S] *	FUEL=(F)
	remaining fuel		[R/S] *	REM FUEL= (FUEL)
	leg time		[R/S] *	LEG TIME= (ΔT)
	total time		[R/S] *	T/TIME=(ΣT)
10	After the last leg, landing weight and GG are output.		[R/S] * [R/S] *	GROSSWT=(WT) CG=(CG)
11	You can return to various steps to correct input errors:			
	Step 2		[XEQ] PLAN	
	Step 6		[XEQ] WA	
	Step 8		[XEQ] PERF	
	Step 9		[XEQ] FLY	
12	To try a different flight plan, start over at step 1, changing appropriate items.			
*	These [R/S]'s are not necessary if you are using a printer.			

Example 1:

A four-leg flight is planned from Corvallis, Oregon, to Astoria, Oregon, via TICKY, Newport, and GANGS. The aircraft is the same one used in the Weight and Balance example, except that only a 100-pound passenger is carried in row 1 and no baggage is carried.

We wish to fly these legs:

	Course	Distance	Altitude
Leg 1	214°	17 n. mi.	8000 ft.
Leg 2	286°	24 n. mi.	8000 ft.
Leg 3	344°	50 n. mi.	6000 ft.
Leg 4	343°	46 n. mi.	6000 ft.

There are winds as follows:

3000 ft.	270 deg at 15 kts
6000 ft.	275 deg at 25 kts
9000 ft	280 deg at 30 kts

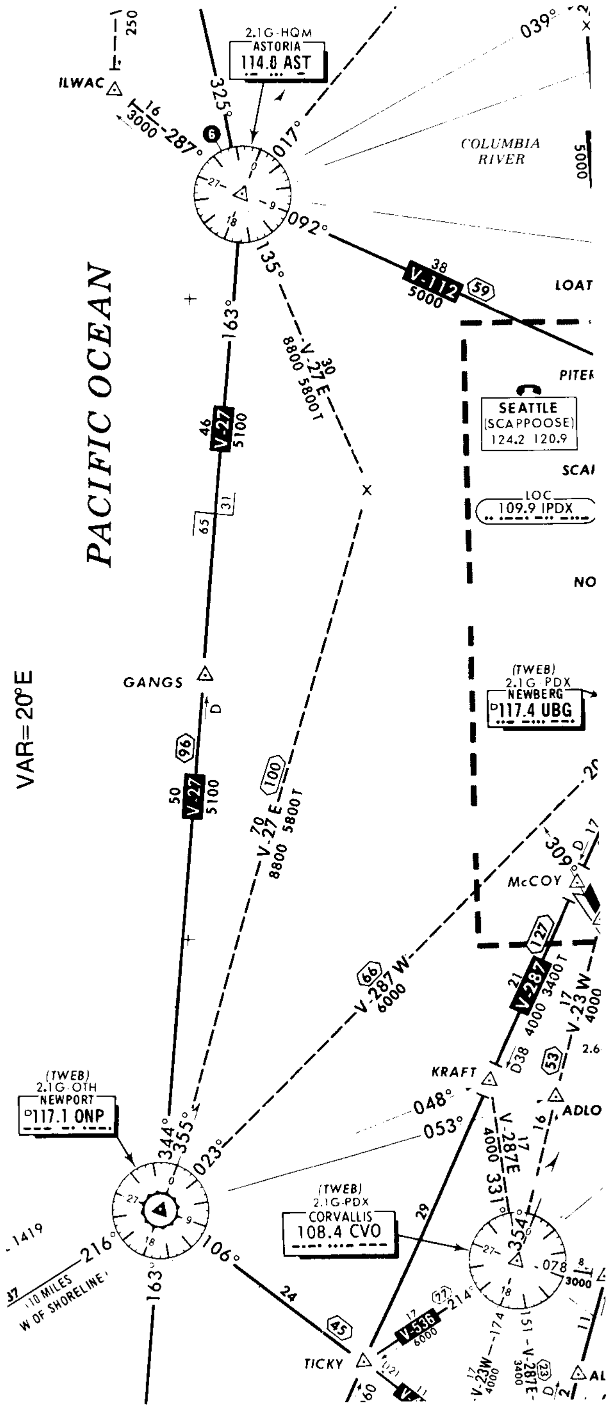
The aircraft will be operated as shown here:

Climb	FF	18	gph
	TAS	96	kts
	ROC	700	fpm
Cruise	FF	12	gph
	TAS	150	kts
Descent	FF	9	gph
	TAS	165	kts
	ROD	500	fpm

If we take off at 1:05, when will we arrive in Astoria? How much fuel will we use?

Keystrokes	Display	Comments
[XEQ] [ALPHA] WB [ALPHA]	*PILOTS=400.?*	
350 [R/S]	*ROW1=425.?*	
100 [R/S]	*REAR BAG=0.?*	
[R/S]	*FUEL=50.GAL?*	
[R/S]	*GROSSWT=2,583.*	
[R/S]	*NET WT=750.*	
[R/S]	*MOM=224,583.*	
[R/S]	*CG=87.*	
[XEQ] [ALPHA] PLAN [ALPHA]	*VAR=0.?*	
20 [R/S]	*LEGS=0?*	
4 [R/S]	*L1 CRS=000?*	- Mag. Course
214 [R/S]	*L1 DIST=0.?*	

Keystrokes	Display	Comments
17 [R/S]	*FL1=0.?*	
8000 [R/S]	*L2 CRS=000?*	
286 [R/S]	*L2 DIST=0.?*	
24 [R/S]	*FL2=8,000.?*	
[R/S]	*L3 CRS=000?*	
344 [R/S]	*L3 DIST=0.?*	
50 [R/S]	*FL3=8,000.?*	
6000 [R/S]	*L4 CRS=000?*	
343 [R/S]	*L4 DIST=0.?*	
46 [R/S]	*FL4=6,000.?*	
[R/S]	*START ALT=0.?*	
246 [R/S]	*DEST ALT=0.?*	
11 [R/S]	*WA3=000,000?*	
270.015 [R/S]	*WA6=000.000?*	
275.025 [R/S]	*WA9=000.000?*	
280.030 [R/S]	*CLIMB FUEL FLOW=0.0?*	
18 [R/S]	*CLIMB TAS=0.0?*	
96 [R/S]	*ROC=0.0?*	
700 [R/S]	*CRUISE FUEL FLOW=0.0?*	
12 [R/S]	*CRUISE TAS=0.0?*	
150 [R/S]	*DESCENT FUEL FLOW=0.0?*	
9 [R/S]	*DESCENT TAS=0.0?*	
165 [R/S]	*ROD=0.0?*	
500 [R/S]	*T.O. TIME=?*	
1.05 [R/S]		


PACIFIC OCEAN
VAR=20°E
COLUMBIA RIVER
ASTORIA
114.0 AST
2.1G-HQM
ILWAC
GANGS
V-27
5100
V-27 E
8800 5800T
V-112
5000
LOAT
PITER
SEATTLE
(SCAPPOOSE)
124.2 120.9
LOC
109.9 IPDX
(TWEB)
2.1G-PDX
NEWBERG
117.4 UBG
McCOY
V-287
4000 3400T
V-287 W
6000
V-23 W
KRAFT
ADLO
(TWEB)
2.1G-OTH
NEWPORT
117.1 ONP
(TWEB)
2.1G-PDX
CORVALLIS
108.4 CVO
TICKY
V-536
6000
V-287E
10 MILES W OF SHORELINE
325°
017°
287°
092°
135°
163°
344°
355°
023°
048°
053°
216°
106°
331°
354°
078

LEG1
MC=214 D=17

CLIMB 246.-8,000.
HDG=221
GS=80.3
FUEL=3.3
REM FUEL=46.7GAL
LEG TIME=0:11:05
T/TIME=1:16:05

LEVEL AT 8,000.
HDG=222
GS=128.3
FUEL=0.2
REM FUEL=46.5GAL
LEG TIME=0:01:01
T/TIME=1:17:06

LEG2
MC=286 D=24

LEVEL AT 8,000.
HDG=281
GS=124.4
FUEL=2.3
REM FUEL=44.2GAL
LEG TIME=0:11:35
T/TIME=1:28:40

LEG3
MC=344 D=50

DESCENT 8,000.-6,000.
HDG=335
GS=161.4
FUEL=0.6
REM FUEL=43.6GAL
LEG TIME=0:04:00
T/TIME=1:32:40

LEVEL AT 6,000.
HDG=334
GS=147.5
FUEL=3.2
REM FUEL=40.4GAL
LEG TIME=0:15:58
T/TIME=1:48:38

LEG4
MC=343 D=46

LEVEL AT 6,000.
HDG=333
GS=147.0
FUEL=1.1
REM FUEL=39.3GAL
LEG TIME=0:05:20
T/TIME=1:53:58

DESCENT 6,000.-11.
HDG=338
GS=165.0
FUEL=1.8
REM FUEL=37.5GAL
LEG TIME=0:11:59
T/TIME=2:05:57

LANDING WT,CG
GROSSWT=2,508.
CG=87.

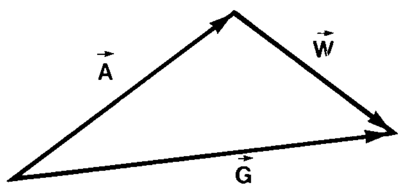
WINDS

This program is actually in two parts: one to determine in-flight winds, and the other to resolve a wind into its headwind or tailwind and right or left crosswind components.

Determining In-Flight Winds

This program computes the winds at altitude from TAS, course of aircraft, ground speed and heading. Ground speed is automatically calculated from time-distance inputs. Winds can be computed as either magnetic or true. The latter must be used when verifying wind forecasts by the weather bureau. The program allows continuous updating of winds.

This program solves the wind triangle shown below.



$$\vec{A} + \vec{W} = \vec{G} \quad \text{OR} \quad \vec{W} = \vec{G} - \vec{A}$$

W, **A** and **G** are all vector quantities representing wind direction and speed; TAS and heading; and ground speed and course respectively.

Since both **A** and **G** use magnetic directions, **W** is computed as a magnetic direction. It must be corrected to true heading by adding the variation V.

True wind direction = magnetic wind direction + magnetic variation

Headwinds and Crosswinds

Also, this program calculates both the head wind and cross wind components from the aircraft heading and reported winds. The program works both at altitude, where magnetic variation must be considered, and at landing and takeoff, where winds are reported in magnetic directions rather than true directions.

The head wind (HW) and right cross wind (RCW) components are computed from

$$HW = K \cos (D - HDG - V)$$

$$RCW = K \sin (D - HDG - V)$$

where

K = the reported wind velocity

D = the reported wind direction

HDG = the aircraft heading

V = the magnetic variation (− west, + east)

Operating Limits and Warnings

Wind directions reported by the control tower are magnetic and the variation need not be input when using the program for takeoff and landings. Other wind directions are reported in true directions and variation must be included to find the wind components.

				SIZE: 040
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	IN-FLIGHT WINDS			
1	To determine In-Flight Winds.		[XEQ] IFW	VAR=(V)?
2	Input variation to obtain winds in true rather than magnetic headings. ([CHS] for westerly variation)	V	([CHS])[R/S]	TAS=(TAS)?
3	Input true air speed	TAS,kts.	[R/S]	MC=(MC)?
4	Input magnetic course	MC	[R/S]	T AT WPT1=?
5	Input time at waypoint one.	H.MMSS*	[R/S]	D TO WPT2=?
6	Input the distance to fly in nautical miles (N.M.) to waypoint 2.	N.M.	[R/S]	T AT WPT2=?
7	Input time at waypoint 2.	H.MMSS	[R/S]	STEERING=?
8	To calculate wind, input the heading the airplane is required to fly to stay on course.	Steer(deg)	[R/S]	WIND=DDD.KKK**
9	For another (IFW) calculation return to step 1.			
	HEADWINDS AND CROSSWINDS			
1	To determine crosswind and headwind components.		[XEQ] HCW	VAR=(V)?
2	Enter magnetic variation if at altitude. Input 0 if surface winds.		[R/S]	HDG=?
3	Input Heading.		[R/S]	WIND=DDD.KKK?
4	Input Wind and resolve into components HW=Head Wind RCW=RightCross Wind TW=Tail Wind LCW=Left Cross Wind	DDD.KKK**	[R/S]	HW=(HW) RCW=(RCW)
5	For another HCW calculation return to step 1.			
	*H.MMSS means Hours, decimal point, minutes, seconds.			
	**DDD.KKK means direction, decimal point, wind speed. 325.008 means a direction of 325 degrees and a speed of 8 knots.			

Example 1:

After passing over a checkpoint at 3:05:20 a pilot flying a magnetic course of 150° finds that he must apply 15° right correction, i.e., steer 165° to maintain his ground course. He passes over his next checkpoint at 70 n.m. away at 3:40:20. The TAS of his airplane is 110 knots and the variation is 7.5° east. If the local FSS asked him to report the winds, what would he tell them?

Keystrokes	Display	Comments
[XEQ] [ALPHA] IFW [ALPHA]	***VAR=0?***	Values shown depend upon previous program execution.
7.5 [R/S]	***TAS=0?***	
110 [R/S]	***MC=000?***	
150 [R/S]	***T AT WP1=?***	
3.0520 [R/S]	***D TO WP2=?***	
70 [R/S]	***T AT WP2=?***	
3.4020 [R/S]	***STEERING=?***	
165 [R/S]	***WIND=273.032***	Wind is 273° at 32 kts.

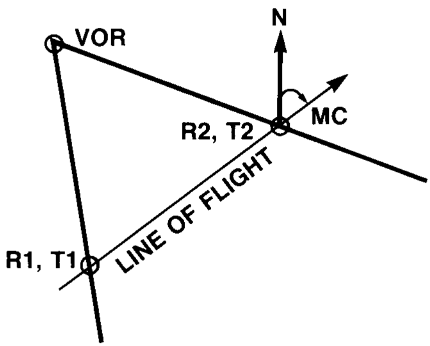
Example 2:

At takeoff on runway 28 the winds are reported as 240° at 25 knots. What are the head wind and cross wind components?

Keystrokes	Display	Comments
[XEQ] [ALPHA] HCW [ALPHA]	***VAR=8?***	Use VAR=0 for surface winds.
0 [R/S]	***HDG=?***	
280 [R/S]	***WIND=273.032***	
240.025 [R/S]	***HW=19 LCW=16***	

POSITION AND NAVIGATION BY ONE OR TWO VOR'S

If one VOR is available, this program computes the distance from the VOR to the aircraft (Fig. 1). If two VOR's are available, this program finds the distance from one of the VOR's to the aircraft and may be used to navigate between any two points (Fig. 2).



The distance from the VOR station to the aircraft at time T_2 is given by

$$DIST = \frac{(GS \times T) \times \sin(MC - R1)}{\sin(R1 - R2)}$$

where

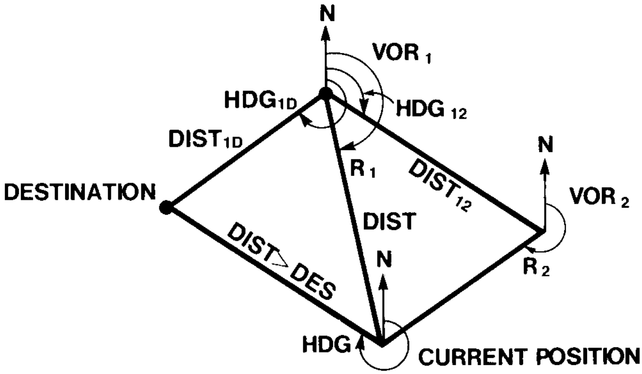
GS = ground speed
T = time between readings = T1 − T2
MC = magnetic course of aircraft
R1 = first radial to VOR
R2 = second radial to VOR
T1 = time of first VOR radial intercept
T2 = time of second VOR radial intercept

Ground speed and magnetic course are found from the polar representation:

$$GS \angle MC = TAS \angle MH - W \angle (D - V)$$

where

V = magnetic variation
TAS = true airspeed
MH = magnetic heading
W = wind velocity
D = wind direction
$\angle$ = should be read as "at angle"



The distance from VOR1 to the aircraft is given by

$$DIST = \left| \frac{(DIST\ VOR12) \times \sin(R2 - HDG(VOR12))}{\sin(R2 - R1)} \right|$$

where

DIST (VOR 12) = Distance between VOR's 1 and 2
R1 = Radial from VOR1
R2 = Radial from VOR2
HDG(VOR12) = Heading between VOR's
DIST = Distance from VOR1 to aircraft

The distance and heading to destination is given by a vector addition of the aircraft position vector with respect to VOR1 and the destination position vector with respect to VOR1.

STEP	INSTRUCTIONS	INPUT	FUNCTION	SIZE: 051 DISPLAY
	ONE VOR			
1	If using one VOR		[XEQ] 1VOR	WIND=(w)?
2	Input wind direction, decimal point and wind speed.	DDD.KKK	[R/S]	VAR=(v)?
3	Input variation. ([CHS] for west)	V	([CHS]) [R/S]	MH=(MH)?
4	Input magnetic heading.	MH	[R/S]	TAS=(TAS)?
5	Input true airspeed.	TAS	[R/S]	T AT R1=?
6	Input intersection time at first VOR radial.	H.MMSS	[R/S]	R1<DEG>=?
7	Input first radial heading to the VOR.	R1(DEG)	[R/S]	R2<DEG>=?
8	Input second radial heading to the VOR.	R2(DEG)	[R/S]	T AT R2=?

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
9	Input time at intersection of second VOR, and calculate distance along second radial from VOR.	H.MMSS	[R/S]	DIST=(D)NM
10	For a second fix using the same VOR press [R/S] and go to step 8; for a new case go to step 1.		[R/S]	R2<DEG>=?
	TWO VOR'S			
1	If using two VOR's		[XEQ] 2VOR	R1<VOR1>=?
2	Input present position radial from VOR1.	R1(DEG)	[R/S]	R2<VOR2>=?
3	Input present position radial from VOR2.	R2(DEG)	[R/S]	DIST VOR 12=?
4	Input distance between VOR1 and VOR2.	NM	[R/S]	BRG VOR 12=?
5	Input bearing of VOR2 from VOR1.	HDG(DEG)	[R/S]	DIST>VOR1=(D)
6	Continue.		[R/S]	B<V1-DES>=?
7	Input bearing from VOR1 to destination.	HDG(DEG)	[R/S]	D<V1-DES>=?
8	Input distance from VOR1 to destination and calculate magnetic heading.	D(V1-DES)	[R/S]	MH=(MH)
9	Calculate distance to destination.		[R/S]	DIST>DES=(D)
10	For new position radials		[R/S]	R1<VOR1>=?
11	Input new radial from VOR1	R1(DEG)	[R/S]	R2<VOR2>=?
12	Input radial from VOR 2	R2(DEG)	[R/S]	MH=(MH)
			[R/S]	DIST>DES=(D)

Example 1:

Two VOR's are available: R1 = 170°, R2 = 250°, DIST VOR12 = 13 naut. mi., BRG(VOR12) = 145°, DIST TO DES from VOR1 = 20 naut. mi., BRG from VOR1 to DES = 255°.

Keystrokes	Display	Comments
[XEQ] [ALPHA] 2VOR [ALPHA]	*R1<VOR1>=?*	
170 [R/S]	*R2<VOR2>=?*	
250 [R/S]	*DIST VOR 12=?*	
13 [R/S]	*BRG VOR 12=?*	
145 [R/S]	*DIST>VOR1=13.*	
[R/S]	*B<V1-DES>=?*	
255 [R/S]	*D<V1-DES>=?*	
20 [R/S]	*MH=289*	
[R/S]	*DIST>DES=23.*	

Example 2:

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?

Keystrokes	Display	Comments
[XEQ] [ALPHA] 1VOR [ALPHA]	*WIND=000.000?*	Values shown depend on previous program execution.
240.019 [R/S]	*VAR=0.?*	
15 [CHS] [R/S]	*MH=289.?*	
35 [R/S]	*TAS=0.?*	
150 [R/S]	*T AT R1=?*	
3.2210 [R/S]	*R1<DEG>=?*	
330 [R/S]	*R2<DEG>=?*	
240 [R/S]	*T AT R2=?*	
3.3430 [R/S]	*DIST=32.NM*	

MACH NUMBER AND TRUE AIRSPEED

This program converts calibrated airspeed (CAS) to mach number (M) and true airspeed (TAS). Inputs required are pressure altitude (PALT), aircraft recovery coefficient (C_T) and indicated air temperature (IAT). Values for recovery coefficient vary from 0.6 to 1.0, but 0.8 is a good value for most aircraft.

The formulas used are less accurate for mach numbers above 1.0 (i.e., supersonic flight).

$$\text{Pressure ratio}\left(\frac{P}{P_0}\right) = \left[\frac{518.67 - 3.566 \times 10^{-3}\,\text{PALT}}{518.67}\right]^{5.2563}$$

$$M^2 = 5\left[\left(\frac{P_0}{P}\left\{\left[1 + 0.2\left(\frac{\text{CAS}}{661.5}\right)^2\right]^{3.5} - 1\right\} + 1\right)^{0.2857} - 1\right]$$

$$\text{TAS} = 38.96M\sqrt{(\text{IAT} + 273)\left[C_T\left(\frac{1}{(1 + 0.2\,M^2)} - 1\right) + 1\right]}$$

SIZE: 039

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	To compute mach number and true airspeed		[XEQ] TAS	PALT=(ALT)?
2	Input pressure altitude.	PALT, ft.	[R/S]	CAS=(CAS)?
3	Input calibrated airspeed.	CAS, kt.	[R/S]	CT=(CT)?
4	Input aircraft recovery coefficient.	C_T	[R/S]	IAT=(IAT)?
5	Input indicated air temperature.	IAT, °C	[R/S]	MACH M
			[R/S]*	TAS=(TAS)
	*Press [R/S] if you are not using a printer.			

Example:

An aircraft is flying at 8000 ft. If the calibrated airspeed is 120 knots and the indicated air temperature is −5°C, what is the true airspeed? (USE C_T = 0.8)

[XEQ] [ALPHA] TAS [ALPHA]	*PALT=0.?*	Values shown depend on previous program execution.
8000 [R/S]	*CAS=0.?*	
120 [R/S]	*CT=0.0?*	
.8 [R/S]	*IAT=0.?*	
5 [CHS] [R/S]	*MACH 0.21*	Mach number.
[R/S]	*TAS=133.59*	

Appendix A

PROGRAM DATA

Program	# Regs. to Copy	Data Registers	Flags	Subprograms Called
Flight Management FM	46	01 Distance 02 Speed 03 Time 04 Fuel Flow 05 Fuel	05 S: DST, C: FF F T 06 S: Time just calculated 22 Data entry	*T
General Aircraft Weight & Balance WB, CLWB, CG	53	11 F BAG 12 PILOTS 13 ROW 1 14 ROW 2 15 R BAG 16 FUEL in LB 17 ΣWT 18 ΣMOM 19 UNLOADED MOMENT 20 EMPTY WT	00 S: Gal C: Lbs 01 CG only	
Flight Plan PLAN WA PERF FLY	90	00 Scratch 01 Distance 02 Speed 03 Time 04 Fuel Flow 05 Fuel 06 Leg CRS.DIST 07 Wind DIR.SPEED, WD 08 WS 09 not used 10 not used	00 S: Gal, C: Lbs 01 S: Descent C: Climb 05 S: DP = 0 07 S: DP is in Leg 1	*T WALT DP CRUISE CLIMB DISP 360+

Program	# Regs. to Copy	Data Registers	Flags	Subprograms Called
		11-15 used by WB		
		16 FUEL in LB		
		17-20 used by WB		
		21 TAS (effective TAS)		
		22 Descent Time		
		23 Fuel Used		
		24 Total Time		
		25 Descent GS		
		26 Descent HDG	Temporary	
		27 Altitude previous leg		
		28 Time this leg		
		29 VAR		
		30 ROC		
		31 Climb TAS		
		32 Cruise TAS		
		33 Descent TAS		
		34 Climb Fuel Rate		
		35 Cruise Fuel Rate		
		36 Descent Fuel Rate		
		37 Altitude this leg		
		38 COS (climb 2), climb GS		
		39 Climb HDG		
		40 ROD		
		41 FL0 (start alt)		
		41 FL (L + 1) (End alt)		
		43 WA3		

Program	# Regs. to Copy	Data Registers	Flags	Subprograms Called
		44 WA6		
		45 WA9		
		46 WA12		
		47 WA18		
		48 WA24		
		49 # Legs		
		50 Leg pointer 51.(51 + 2L)		
		51 Leg1		
		52 FL1		
		53 Leg2		
		54 FL2		
		55 Leg3		
		56 FL3		
		57 Leg4		
		58 FL4		
		59 Leg5		
		60 FL5		
		61 Leg6		
		62 FL6		
Winds	50	06 MC		
IFW		07 WIND		
HCW		21 TAS		
		22 T at WP1		
		23 D to WP2		
		24 T at WP2		
		25 Temporary		

Program	# Regs. to Copy	Data Registers	Flags	Subprograms Called
		26 Temporary 29 VAR 39 HDG		
Position by One or Two VOR's 1VOR 2VOR	74	00 R1 (DEG) 06 DIST>DES 07 WIND 21 TAS 22 R2(DEG) 23 R1(VOR1) 24 R2(VOR2) 25 DIST VOR 12 26 VRG VOR 12 27 B(V1-DES) 28 D(V1-DES) 29 VAR 38 T at R1 39 MH 50 T at R2		
Mach Number and True Airspeed TAS	28	10 CT 21 TAS 22 CAS 23 P/PO 24 M 37 PALT 38 IAT		

Appendix B

PROGRAM LABELS

Label	Duplicate Label In
CG	Petroleum Fluids Pac
* T	Navigation Pac
1VOR 2VOR 360+ CLIMB CLWB CRUISE DISP DP FLY FM HCW IFW PERF PLAN R2 TAS WA WALT WB	(no Label Conflicts)

The labels in this list are not in the same order as they appear in the catalog listing for the module.

HEWLETT
PACKARD

Portable Computer Division
1000 N.E. Circle Blvd., Corvallis, OR 97330, U.S.A.

European Headquarters
150, Route du Nant-d'Avril
P.O. Box, CH-1217 Meyrin 2
Geneva-Switzerland

HP-United Kingdom
(Pinewood)
Gb-Nine Mile Ride, Wokingham
Berkshire RG11 3LL

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