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HELICOPTER PERFORMANCE COMPUTER PROGRAMS FOR HP-41  
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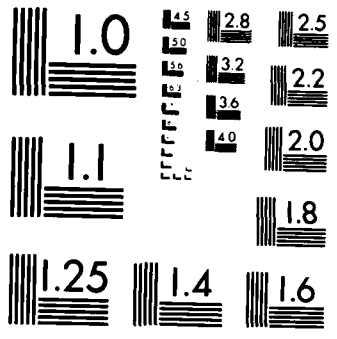
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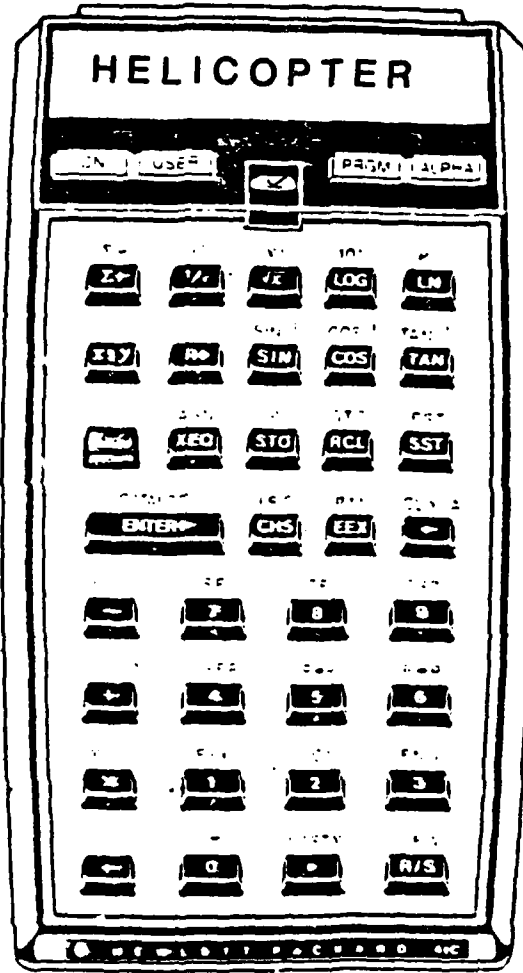
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HP-41

Helicopter Programs

Prof D.M.Layton

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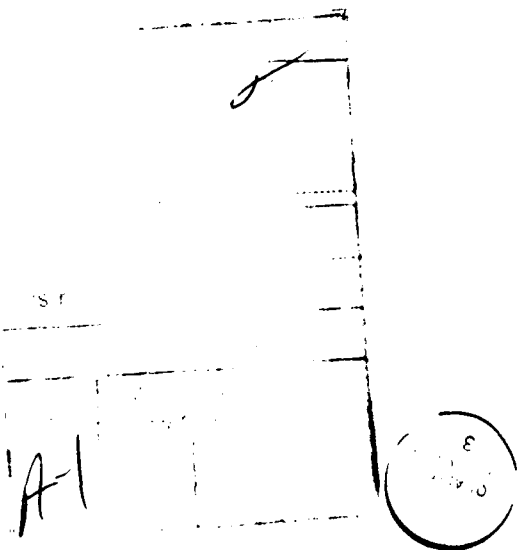
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HELICOPTER PERFORMANCE  
COMPUTER PROGRAMS  
for  
HP-41 Hand-held Computer

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## INTRODUCTION

These programs present the user of the HP-41 hand-held, programmable calculator with a series of self-prompting, alphanumeric programs that can be used with acceptable results to compute and evaluate helicopter performance. Most of the programs are structured so as to be more expedient when doing preliminary helicopter design where intermediate values are of less a concern than would be the case when studying detailed performance.

By presenting only the principal, 'bottom line', values, the programs are shorter than if all of the intermediate values were displayed. However, with the establishment of a standard storage register routine (see Tables I and II), any intermediate value may be readily located and displayed by using the RCL routine.

The standard storage registers also permit direct loading of data from a mass storage unit such as the HP 82161A Digital Cassette Drive.

The basic equations and assumptions inherent in these programs are from "Helicopter Performance" (reference 1) and "Helicopter Design Manual" (reference 2), both by Professor Donald M. Layton. These materials are used regularly in helicopter performance and design courses at the Naval Postgraduate School, Monterey, California.

The programs have been written in a consolidated manner, thus reducing the need to load numerous individual subroutines in order to run a single program. Because of this, many of the programs are quite large and use a considerable amount of the available space in the resident memory of the HP-41CV. If a HP-41C is to be used a Quad Memory Module is required. The option to operate a specific subroutine is maintained for most of the programs. For example, if one desired to ascertain the induced velocity of the main rotor, once data parameters are loaded, that information could be gained by executing that subroutine, e.g., XEQ VI.

Table III is a matrix of program input parameters and programs. Until the user of these programs becomes quite conversant with the programs inputs, it would be wise to check Table III prior to executing a program. For example, the POWER program requires an input of Equivalent Flat Plate Area, and if the drag information is available only in the form of Equivalent Flat Plate Loading, the data must be converted prior inputting FF.

In order to facilitate partial changes of data input sets, most data parameters recall the existing data value prior to asking the prompt question. This permits the maintenance of the same data value by either re-entering the value or pressing R/S.

Each program is documented in essentially the same manner. Listed alphabetically, each program documentation begins with the name of the program (as it appears in the execute statement) and a short phrase that describes the program. This is followed by the introduction which states the purpose of the program, explains the applicability of the program, and describes any assumptions inherent in the program.

For a program which requires the loading of additional programs for execution, an entry following the introduction indicates the required programs. This is, in turn, followed by a listing of the equations used in the program, together with the source of each equation.

An example problem, executed with detailed step-by-step instructions, is furnished with each program. These instructions indicate the inputs required to be made by the user, functions that the user must execute and displays as they would appear on the HP-41. For those program where multiple internal branching occurs, either a representative branch is shown or all branches are demonstrated. For the latter case, indices, such as A or B, follow the appropriate step number.

Within the detailed instructions, the user will be prompted for two types of inputs. The first, and more predominant type, occurs when a numerical input is required by the program. This type of prompt will have the data variable followed by an equality sign and a question mark, e.g.  $VF=?$ . The other type of prompt occurs at branch points where a question is asked, the answer to which is either Yes or No. These prompts consist of a symbol, word or short phrase followed only by a question mark, e.g.,  $NEED\ DATA?$ . If the answer to this type of prompt is Yes, enter 1, and if the answer is No, enter 0.

The last documentation of each program is a complete listing of the program. This permits the user to see how and why the program arrives at its solutions. It also allows for editing, should adjustments be desired. Although the programs have been written in a straight-forward manner, some combination of constants have been used. While this shortens the program, it does add confusion to any editing of the program.

The backbone of these programs for performance determination is the program POWER. In many instances, this program is required to be loaded and run in conjunction with another program. For example, the highspeed effects program, HSE, makes power corrections to the basic POWER program.

A program. FLITE, that is somewhat similar to POWER is also included for two reasons. First of all, there are provisions in this program for non-rectangular rotor blades. This capability was not incorporated in POWER due to the size of the program. Secondly, FLITE can be used for partial, en-route solutions such as main rotor only, tail rotor only, or individual subroutines.

These programs are all written in British Units. If it is desired to convert to SI Units it is only necessary to modify the aerodynamic parameters (such as density) and to make the proper conversion for power. For example, if the density for Profile Power is input as  $\text{kg-sec}^2/\text{m}^4$  and all of the measurements are in meters, to obtain horsepower from  $\text{kg-m/sec}$ , divide by 76, vice 550 as with British units. The author has available a set of these programs in SI Units.

These programs have been prepared, revised, modified and edited over a several years with the assistance of students in the Aeronautics Programs at the Naval Postgraduate School. Although their contributions are deeply appreciated, the list of these students has now grown so long as to make a complete acknowledgement impractical.



TABLE I  
STANDARD STORAGE REGISTER UTILIZATION

Storage Register	Stored Quantity
00	R - Main rotor radius (ft)
01	c - Main rotor equivalent chord (ft)
02	RV - Main rotor rotational velocity (Rad/sec)
03	$C_{d_o}$ - Main rotor profile drag coefficient
04	b - Number of main rotor blades
05	R<TR> - Tail rotor radius (ft)
06	c<TR> - Tail rotor equivalent chord (ft)
07	RV<TR> - Tail rotor rotational velocity (rad/sec)
08	$C_{d_o}$ <TR> - Tail rotor profile drag coefficient
09	b<TR> - Number of tail rotor blades
10	L - Length of tail boom (ft)
11	W - Gross weight (lbs)
12	FF - For. flight Equivalent Flat Plate Area (ft <sup>2</sup> )
13	FV - Vert. Equivalent Flat Plate Area (ft <sup>2</sup> )
14	RTR HT - Main rotor height above skid/wheel (ft)
15	$c_o$ - Root chord of main rotor (ft)
16	$c_l$ - Tip chord of main rotor (ft)
17	a CHORD - Main rotor span fraction (for taper)
18	VF - Forward velocity of aircraft (ft/sec) (Entered in kts, stored in ft/sec)
19	VV(FPM) - Vertical velocity of aircraft (ft/sec) (Entered in ft/min, stored in ft/sec)
20	PA/DA - Pressure or Density Altitude (ft)

21 TEMP<F> - Temperature in  $^{\circ}$ Rankine  
(Entered in  $^{\circ}$ F, stored in  $^{\circ}$ R))

22 Density ( $\rho$ ) - Ambient density (slugs/ft<sup>3</sup>)

23 Area - Main rotor disc area (ft<sup>2</sup>)

24 Area<TR> - Tail rotor disc area (ft<sup>2</sup>)

25 SKID HT - Height of skids (wheels) above the  
ground (ft)

26 h/D ratio - Ratio of rotor height to diameter

27  $V_T$  - Main rotor tip velocity (ft/sec)

28  $T_T$ <TR> - Tail rotor tip velocity (ft/sec)

29  $C_T$  - Main rotor coefficient of thrust

30  $C_{T}$ <TR> - Tail rotor coefficient of thrust

31 VI - Main rotor induced velocity (ft/sec)

32 VI<TR> - Tail rotor induced velocity (ft/sec)

33 B - Main rotor tip loss factor

34 B<TR> - Tail rotor tip loss factor

35 PI - Main rotor induced power (includes tip loss  
and ground effect) (SHP)

36 PO - Main rotor profile power (SHP)

37 PP - Main rotor parasite power

38 PC - Main rotor climb power (SHP)

39 PT<MR> - Main rotor total power (SHP)

40 T<TR> - Tail rotor thrust (lbs)

41 PI<TR> - Tail rotor induced power (includes tip  
loss) (SHP)

42 PO<TR> - Tail rotor profile power (SHP)

43 PT<TR> - Tail rotor total power (SHP)

44 PT<AC> - Aircraft total power required (SHP)

45  $PI/PI_{OGE}$  - Ground effect induced power ratio

TABLE II  
STANDARD STORAGE REGISTER UTILIZATION

Stored Quantity	Storage Register
a CHORD - Main rotor span fraction	17
Area - Main rotor disc area (ft <sup>2</sup> )	23
Area<TR> - Tail rotor disc area (ft <sup>2</sup> )	24
b - Number of main rotor blades	04
b<TR> - Number of tail rotor blades	09
B - Main rotor tip loss factor	33
B<TR> - Tail rotor tip loss factor	34
c - Main rotor equivalent chord (ft)	01
c<TR> - Tail rotor chord (ft)	06
C <sub>d<sub>o</sub></sub> - Main rotor average profile drag coefficient	03
C <sub>d<sub>o</sub></sub> <TR> - Tail rotor profile drag coefficient	08
c <sub>0</sub> - Main rotor root chord (ft)	15
c <sub>1</sub> - Main rotor tip chord (ft)	16
CT - Main rotor coefficient of thrust	29
CT<TR> - Tail rotor coefficient of thrust	30
Density (ρ) - Ambient density (slugs/ft <sup>3</sup> )	22
FF - For. Flight Equivalent Flat Plate Area (ft <sup>2</sup> )	12
FV - Vert. Equivalent Flat Plate Area (ft <sup>2</sup> )	13
h/D - Rotor height to rotor diameter ratio	26
L - Tail boom length (ft)	10
PA/DA - Pressure or density altitude (ft)	20
PC - Main rotor climb power (SHP)	38

PI - Main rotor induced power (includes tip loss and ground effect) (SHP)	35
PI<TR> - Tail rotor induced power (includes tip loss)(SHP)	41
PI/PI <sub>OGE</sub> - Induced power ground effect ratio	45
PO - Main rotor profile power (SHP)	36
PO<TR> - Tail rotor profile power (SHP)	42
PP - Main rotor parasite power (SHP)	36
PT<AC> - Total aircraft power required (SHP)	44
PT<MR> - Main rotor total power required (SHP)	39
PT<TR> - Tail rotor total power required (SHP)	42
R - Main rotor radius (ft)	00
R<TR> - Tail rotor radius (ft)	05
RTR HT - Main rotor height above skids/wheels (ft)	14
RV - Main rotor rotational velocity (rad/sec)	02
RV<TR> - Tail rotor rotational velocity (rad/sec)	07
SKID HT - Height of skids/wheels above ground (ft)	25
T<TR> - Tail rotor thrust (lbs)	40
TEMP<F> - Temperature (entered in °F, stored in °R)	21
V <sub>T</sub> - Main rotor tip velocity (ft/sec)	27
V <sub>T</sub> <TR> - Tail rotor tip velocity (ft/sec)	28
VF - Forward velocity (enter in kts, stored in ft/sec)	18
VI - Main rotor induced velocity (ft/sec)	31
VI<TR> - Tail rotor induced power (ft/sec)	32
VV<FPM> - Vertical velocity (Enter in ft/min, stored in ft/sec)	19
W - Gross weight (lbs)	11

TABLE III  
PROGRAM INPUT REQUIREMENTS

	AUTO	CLG	FLITE	FUEL	HSE	POWER	RC	VE	VMR	WT	
a CHORD			x								ft
ALPHA HAT				x							
b		x		x			x			x	
b<TR>		x		x							
BETA HAT				x							
c		x		x						x	ft
CARGO										x	lbs
CL <RAD>					x						
c<TR>			x			x					ft
$C_{d_o}$			x			x					
$C_{d_o}$ <TR>			x			x					
$c_o$			x								ft
$c_l$			x								ft
ENG WT										x	lbs
FF			x		x	x					ft <sup>2</sup>
FUEL WT										x	lbs
FV			x		x	x					ft <sup>2</sup>
INCR (Velocity)								x	x		kts (ft/sec)*
L			x			x					ft
NENG				x							
PA/DA			x			x					ft

\* Stored Quantity

	AUTO	CLG	FLITE	FUEL	HSE	POWER	RC	VE	VMR	WT	
PEOPLE										x	
PERSON WT										x	lb
PSHP									x		shp
PT<AC>										x	shp
RSHP<SSL>		x					x				shp
R	x		x		x	x				x	ft
R<TR>			x	x							ft
RTR<HT>			x			x					ft
RV	x		x		x	x				x	rad/sec
RV<TR>			x			x					rad/sec
SKID HT			x			x					ft
T<TR>											lbsf
TEMP<F>			x	x							$^{\circ}\text{F}$ ( $^{\circ}\text{R}$ )*
TRAN WT											lbs
TWIST					x						deg
VF	x		x	x	x	x	x				kts (ft/sec)*
V-START								x	x		kts (ft/sec)*
V-STOP								x	x		kts (ft/sec)*
VV			x			x					ft/min (ft/sec)*
W	x		x		x	x				x	lbs

\* Stored Quantity

# AUTO

## (Autorotation)

Introduction: This program computes approximations for both minimum rate of descent vertical autorotation and minimum descent rate forward autorotation. It uses the standard input registers, and if data is required, all parameters are requested, even though only a few are needed.

ADDITIONAL PROGRAMS REQUIRED: None

### Equations

$$\bar{C}_L = (3K_2/K_1)^{1/2} \quad \text{Ref 1, Eqn 6-14}$$

$$\bar{C}_d = K_1 \bar{C}_L^2 + K_2 \quad \text{Ref 1, Eqn 6-15}$$

$$\bar{F} = \frac{(C_L^3/C_d^2) \cdot \sigma}{4} \quad \text{Ref 1, Eqn 6-8}$$

$$V_v = \left[ \frac{W}{2 \cdot \rho \cdot A_D \cdot \bar{F}} \right]^{1/2} \quad \text{Ref 1, Eqn 6-11}$$

$$\bar{F} = \frac{\bar{F}}{(1 + \bar{F})^2} \quad (0 < \bar{F} < 1) \quad \text{Ref 1, Eqn 6-9}$$

$$\bar{F} = \frac{(2\bar{F} - \sqrt{3\bar{F}})}{(4\bar{F} - 3)} \quad (\bar{F} > 1) \quad \text{Ref 1, Eqn 6-10}$$

$$V_{f(\text{min ROD})} = 0.00867 \cdot R \cdot \text{RPM} \quad \text{Ref 1, Eqn 6-17}$$

$$V_{v(\text{min ROD})} = 0.251 \cdot R \cdot \text{RPM} \quad \text{Ref 1, Eqn 6-18}$$

$$d_{(\text{hor glide})} = \frac{h}{\tan \gamma} \quad \text{Ref 1, Eqn 6-19}$$

$$\gamma = \arcsin \frac{V_v}{V_f} = 16.6^\circ \quad \text{Ref 1, Eqn 6-20}$$

where

$\bar{C}_L$  is the average coefficient of lift

$\bar{C}_d$  is the average coefficient of drag

$K_1$  is a real number coefficient called the lift coefficient multiplier in drag coefficient terms

$K_2$  is a real number coefficient equal to  $C_{d_0}$

$V_v$  is the vertical velocity in a vertical autorotation (ft/min)

$A_D$  is the area of the rotor disc (ft<sup>2</sup>)

$\sigma$  is the solidity of the main rotor system

$\rho$  is the density of the air  $\left[ \frac{\text{lb-sec}^2}{\text{ft}^3} \right]$

$h$  is the height of the rotor system above the ground (ft)

RPM is the rotational velocity of the main rotor system in revolutions/minute

$\bar{F}$  is a non-dimensional coefficient

$\bar{F}$  is a non-dimensional coefficient

$W$  is the weight of the helicopter (lbs)

$R$  is the radius of the rotor system (ft)

$\gamma$  is the descent angle for minimum descent rate (degrees)



=

VV= vertical velocity in a vertical autorotation (ft/min)

VF(MIN.R.O.D.)= forward autorotative flight velocity for minimum autorotative rate of descent (kts)

VV(MIN.R.O.D.)= vertical autorotative velocity (ft/min) at the forward autorotative flight velocity for minimum autorotative rate of descent

d(HOR.GLIDE)= horizontal distance travelled on the ground at the forward autorotative flight velocity for minimum rate of descent (ft)

AUTO

			SIZE 060
INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1. Initialize the program		XEQ AUTO	NEED DATA?
2. Answer 1 for yes, 0 for no	1	R/S	W=?
3. Input weight (lbs)	20000	R/S	RV=?
4. Input main rotor rotational velocity (rad/sec)	27	R/S	b=?
5. Input number of main rotor blades	4	R/S	c=?
6. Input main rotor chord (ft)	1.75	R/S	CdO=?
7. Input main rotor drag coefficient	.008	R/S	R=?
8. Input main rotor radius (ft)	26.8	R/S	FF=?
9. Input forward flat plate area (sq ft)	25.7	R/S	FV=?
10. Input vertical flat plate area (sq ft)	30.8	R/S	RV(TR)=?
11. Input tail rotor rotational velocity (rad/sec)	124.6	R/S	b(TR)=?
12. Input number of tail rotor blades	4	R/S	c(TR)=?
13. Input tail rotor chord (ft)	.81	R/S	CdO(TR)=?
14. Input tail rotor chord (ft)	.008	R/S	R(TR)=?
15. Input tail rotor radius (ft)	5.5	R/S	L(TAIL)=?

AUTO

INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
16. Input length of tail (ft)	31.5	R/S	RTR HT=?
17. Input rotor height above skids (ft)	10	R/S	SKID HT=?
18. Input skid height above ground (ft)	4000	R/S	LCM=?
19. Input lift coefficient multiplier (K1)	.004	R/S	VV=
20. Outputs vertical velocity in vertical autorotative (ft/min)	0	R/S	VF(MIN ROD)=
21. Outputs flight velocity for minimum rate of descent (kts)	59.9	R/S	VV(MIN ROD)=
22. Outputs vertical velocity at minimum rate of descent (ft/min)	1816.3	R/S	d(HOR GLIDE)=
23. Outputs horizontal distance at minimum rate of descent (ft)	6092.7		

# AUTO

01+LBL "AUTO"	51 STO 06	101 PI	151 *
02 FIX 1	52 RCL 08	102 /	152 1/X
03 CF 02	53 "C<D>(TR)=?"	103 4	153 RCL 11
04 "NEED DATA?"	54 PROMPT	104 /	154 *
05 PROMPT	55 8	105 STO 48	155 SQR
06 X=0?	56 RCL 05	106 X<0?	156 60
07 GTO "PGM"	57 "R<TR>=?"	107 GTO 01	157 *
08 RCL 11	58 PROMPT	108 1	158 "VV="
09 "W=?"	59 STO 05	109 -	159 PROMPT
10 PROMPT	60 RCL 10	110 "X>0?"	160 VIEW X
11 STO 11	61 "L<TAIL>=?"	111 GTO 02	161 STOP
12 RCL 02	62 PROMPT	112 2	162 RCL 02
13 "RV=?"	63 STO 10	113 +	163 RCL 00
14 PROMPT	64 RCL 14	114 X↑2	164 *
15 STO 02	65 "RTR HT=?"	115 1/X	165 .002798
16 RCL 04	66 PROMPT	116 RCL 48	166 *
17 "b=?"	67 STO 14	117 *	167 "VF<MIN,R.O.D>="
18 PROMPT	68 "SKID HT=?"	118 GTO 03	168 PROMPT
19 STO 04	69 PROMPT	119+LBL 02	169 VIEW X
20 RCL 01	70 STO 25	120 RCL 48	170 STOP
21 "c=?"	71+LBL "PGM"	121 3	171 30.3158
22 PROMPT	72 "LCM=?"	122 *	172 *
23 STO 01	73 PROMPT	123 SQR	173 "VV<MIN,R.O.D>="
24 RCL 03	74 STO 46	124 CHS	174 PROMPT
25 "C<D>=?"	75+LBL "A1"	125 RCL 48	175 VIEW X
26 PROMPT	76 RCL 46	126 2	176 STOP
27 STO 03	77 1/X	127 *	177 "ALT<FT>=?"
28 RCL 00	78 3	128 +	178 STO 25
29 "R=?"	79 *	129 RCL 48	179 .29811
30 PROMPT	80 RCL 03	130 4	180 /
31 STO 00	81 *	131 *	181 "d<HOR.GLIDE>="
32 RCL 12	82 SQR	132 3	182 PROMPT
33 "FF=?"	83 STO 47	133 -	183 VIEW X
34 PROMPT	84 X↑2	134 /	184 STOP
35 STO 12	85 RCL 46	135 RCL 48	185 GTO 04
36 RCL 13	86 *	136 6.875 E-6	186+LBL 01
37 "FV=?"	87 RCL 03	137 *	187 "F="
38 PROMPT	88 +	138 1	188 ARCL X
39 STO 13	89 X↑2	139 +	189 AVIEW
40 RCL 07	90 1/X	140 4.2561	190+LBL 04
41 "RV<TR>=?"	91 RCL 47	141 Y↑X	191 END
42 PROMPT	92 3	142 .0023769	
43 STO 07	93 Y↑X	143 *	
44 RCL 09	94 *	144 *	
45 "b<TR>=?"	95 RCL 04	145 RCL 00	
46 PROMPT	96 *	146 X↑2	
47 STO 09	97 RCL 01	147 *	
48 RCL 06	98 *	148 PI	
49 "c<TR>=?"	99 RCL 00	149 *	
50 PROMPT	100 /	150 2	

## CLG

### Helicopter Hover, Service and Combat Ceilings

Introduction: This program will determine the hover, service and combat ceilings for a helicopter. It is run in conjunction with POWER (which must be loaded up through and including step 19 of the step-by-step instructions). For the three different ceilings, rates of climb of 0, 100, and 500 feet per minute are imposed upon the aircraft. The power is computed for the selected airspeed (0 for hover) and compared with the maximum rotor shaft horsepower available. There are no new equations utilized. CLG utilizes the same storage registers as POWER and additionally those listed below.

Additional Programs Required: POWER

Additional Storage Registers:

Storage Registers	Quantity Stored
48	scratch
58	RSHP(SSL) - maximum rotor shaft horsepower available at standard sea level conditions (SHP)

CLG

			SIZE 060
INSTRUCTION	INPUT	FUNCTION	DISPLAY
1. Initialize program			XEQ CLG
2. Reminder flashes			*LOAD POWER*
3. Reminder flashes			HOVER CLG?
4. Do you want hover ceiling? Input 1 for Yes	1	R/S	RSHP(SSL)=?
5. Input SSL rotor shaft horsepower available (SHP)	2500	R/S	HOVER CLG= 3,770
6. Output hover ceiling (feet)			

- or to get service ceiling -

2. Do you want hover ceiling? Input 0 for No	0	R/S	SERVICE CLG?
3. Do you want service ceiling? Input 1 for yes	1	R/S	VF=?
4. Input forward velocity (kts)	90	R/S	RSHP(SSL)=?
5. Input SSL rotor shaft horsepower available (SHP)	2500	R/S	SERVICE CLG= 17543
6. Output service ceiling (feet)			

CLG

- Or to get combat ceiling

INS'TRUCION	INPUT	FUNCTION	DISPLAY
3. Do you want service ceiling? Input 0 for No	0	R/S	COMBAT CLG?
4. Do you want combat ceiling? Input 1 for Yes	1	R/S	VF=?
5. Input forward velocity (kts)	90	R/S	RSHP(SSL)=?
6. Input SSL rotor shaft horsepower available (SHP)	2500	R/S	COMBAT CLG= 15758
7. Ouput combat ceiling (feet)			

CLG

01+LBL "CLG"	38 STO 18	76 CF 02
02 "+LOAD POWER"	39 FS? 07	77 XEQ "CT"
03 AVIEW	40 100	78 RCL 55
04 PSE	41 FS? 08	79 SORT
05 SF 03	42 500	80 RCL 47
06 CF 06	43 ENTER↑	81 *
07 CF 07	44 60	82 RCL 58
08 CF 08	45 /	83 *
09 FIX 0	46 STO 19	84 RCL 44
10+LBL 00	47+LBL 04	85 XY?
11 "HOVER CLG?"	48 "RSHM<SSL>=?"	86 GTO 05
12 PROMPT	49 PROMPT	87 RCL 48
13 X=0?	50 STO 58	88 ST+ 20
14 GTO 01	51 6561	89 GTO "DEL"
15 SF 06	52 STO 48	90+LBL 05
16 0	53 0	91 RCL 48
17 STO 18	54 STO 20	92 ST- 20
18 STO 19	55+LBL "DEL"	93 J
19 GTO 04	56 RCL 20	94 /
20+LBL 01	57 6.875 E-6	95 STO 48
21 "SERVICE CLG?"	58 *	96 I
22 PROMPT	59 CHS	97 X=Y?
23 X=0?	60 I	98 GTO "ANS"
24 GTO 02	61 +	99 GTO "DEL"
25 SF 07	62 STO 55	100+LBL "ANS"
26 GTO 03	63 5.2561	101 RCL 20
27+LBL 02	64 Y↑X	102 I
28 "COMBAT CLG?"	65 STO 47	103 -
29 PROMPT	66 RCL 55	104 FS? 06
30 X=0?	67 518.68	105 "HOVER CLG="
31 GTO 00	68 *	106 FS? 07
32 SF 08	69 STO 21	107 "SERVICE CLG="
33+LBL 03	70 RCL 47	108 FS? 08
34 "VF=?"	71 RCL 55	109 "COMBAT CLG="
35 PROMPT	72 /	110 ARCL X
36 1.68889	73 .0023769	111 AVIEW
37 *	74 *	112 STOP
	75 STO 22	113 END



FLITE  
Basic Power Requirements

Introduction: The user inputs the basic geometric and flight parameters of the helicopter and the program determines the steady state power requirements to maintain a given flight condition. In the FLITE program, high speed effects are neglected. The program will determine the power required for the main rotor only, or for the main rotor plus the tail rotor. The user must input whether the flight condition is hover only, forward only, vertical only or forward and vertical. FLITE utilizes the Standard Data Set for storage registers 00 through 45, and the non-standard registers listed in Additional Storage Registers.

To execute the program and view only the power results, enter XEQ FLITE. To execute the program and view power and parameter results, enter XEQ FLITE+. This program is also written so that each parameter may be calculated individually, as long as the user executes DATA first (XEQ DATA), or the data is already in the proper storage registers. To execute the individual subroutine, follow the instructions listed in Subroutines to Determine Individual Parameters.

Additional Programs Required: None

Equations

$$A_D = \pi R^2 \quad \text{Ref 1, Eqn 2-36}$$

$$V_T = \Omega R \quad \text{Ref 1, Eqn 2-22}$$

$$\mu = V_f/V_T \quad \text{Ref 1, Page 123}$$

$$C_T = W/(\rho A V_T^2) \quad \text{Ref 1, Eqn 2-23}$$

$$B = 1 - (2C_T)^{.5}/b \quad \text{Ref 1, Eqn 3-1}$$

$$\sigma = bc/\pi R \quad \text{Ref 1, Eqn 2-37}$$

$$c_e = c_l + .25(c_o - c_l)(1 - a^4)/(1 - a) \quad \text{Ref 1, Page 55}$$

$$H = 1 - H_p \cdot 6.875 \cdot 10^{-6})^{.5} \cdot 2561 / ((T^{\circ}F - 32) \cdot .555 + 273.16) \quad \text{Ref 2, Page 55}$$

$$H_p = 1 - (H \cdot 288.16) \cdot 23496 / 6.875 \cdot 10^{-6} \quad \text{Ref 2, Page 55}$$

FLITE

$$\rho = 0.0023769 \cdot (1 - 6.875 \cdot 10^{-6} H_p)^{4.2561} \quad \text{Ref 2, Page 55}$$

$$\begin{aligned} P_{i_{IGE}} / P_{i_{OGE}} &= -.1276(h/D)^4 + .7070(h/D)^3 \quad \text{Ref 1, Eqn 3-8} \\ &\quad - 1.4569(h/D)^2 + 1.3434(h/D) \\ &\quad + 0.5147 \end{aligned}$$

$$v_{i_h} = (W/2\rho A_D)^{.5} \quad \text{Ref 1, Eqn 4-1}$$

$$v_{i_v} = .5(-V_v + (V_v + (4v_{i_h})^{.5}))^{.5} \quad \text{Ref 1, Eqn 4-13}$$

$$v_{i_T} = -V_f^2/2 + ((V_f^2/2)^2 + v_{i_h}^4)^{.5})^{.5} \quad \text{Ref 1, Eqn 4-34}$$

$v_i = v_{i_T}$  or  $v_{i_v}$  or  $v_{i_{Tv}}$  depending on flight condition

$$P_i = (Wv_i)/(550) \quad \text{Ref 1, Eqn 4-2}$$

$$P_{i_{TL}} = (Wv_i)/(550 \cdot B) \quad \text{Ref 1, Eqn 3-6}$$

$$P_{i_{(TL+GE)}} = P_{i_{TL}} \cdot (P_{i_{IGE}} / P_{i_{OGE}}) \quad \text{Ref 1, Eqn 4-3}$$

$$P_o = \sigma C_{d_o} \rho A_D V_T^3 (1 + 4.3\mu^2)/4400 \quad \text{Ref 1, 4-53}$$

$$P_p = .5\rho((V_f^3 F_f) + (V_v^3 F_v))/550 \quad \text{Ref 1, Eqn 4-62}$$

$$P_c = (WV_v)/550 \quad \text{Ref 1, Eqn 4-62}$$

$$P_T = P_{i_{(TL+GE)}} + P_o + P_p + P_c \quad \text{Ref 1, Eqn 4-64}$$

$$C_{T(TR)} = P_{TMR} / \rho A_{DTR} \ell \Omega_{TR} \quad \text{Ref 1, Page 145}$$

$$B_{(TR)} = 1 - (2C_{TTR})^{.5} / b_{TR} \quad \text{Ref 1, Page 146}$$

$$v_{i_h(TR)} = (P_{TMR} / 2\rho A_{DTR} \ell \Omega_{MR})^{.5} \quad \text{Ref 1, Eqn 5-8}$$

$$\begin{aligned} v_{i_T(TR)} &= ((-V_f^2/2 + \\ &\quad ((V_f^2/2)^2 + v_{i_h(TR)}^2))^{.5})^{.5} \quad \text{Ref 1, Eqn 5-9} \end{aligned}$$

$$P_{i_{(TR)}} = P_{TMR} v_{i_T(TR)} / (\ell \Omega_{MR} \cdot 550) \quad \text{Ref 1, Eqn 5-11}$$

$$P_{i_{(TL+GE)}} = P_{i_{TR}} / (B_{TR} \cdot 550) \quad \text{Ref 1, Eqn 5-4}$$

FLITE

$$P_{O(TR)} = \sigma C_{dO} \rho A_D V_T^3 (1 + 4.3\mu^2) / 4400 \quad \text{TR} \quad \text{Ref 1, Eqn 5-12}$$

$$P_{T(TR)} = P_{iTR} + P_{OTR} \quad \text{Ref 1, Eqn 5-14}$$

$$P_{T(AC)} = P_{TMR} + P_{TTR}$$

Additional Storage Registers

Storage Register	Stored Quantity
46	SD - Solidity of Main Rotor
47	SD(TR) - Solidity of Tail Rotor
48	AR - Advance Ratio of Main Rotor
49	AR(TR) Advance Ratio of Tail Rotor
50	PI - Induced Power
51	PT(TL) - Induced power with Tip Loss
52	PI(TR) - Tail Rotor Induced Power

## FLITE

### Subroutines to Determine Individual Parameters:

\*\*\*\*\* To AVIEW the answers for these subroutines,  
set flag 07 (SF 07) \*\*\*\*\*

Input data -- XEQ DATA

Density -- XEQ DATA : XEQ PA

Disk Area (MR) -- XEQ DATA : XEQ AD

Disk Area (TR) -- XEQ DATA : XEQ ADTR

Tip Velocity -- XEQ DATA : XEQ VT

Tip Velocity (TR) -- XEQ DATA : XEQ VTTR

Advance Ratio (MR) -- XEQ DATA : Store VF (ft/sec)  
in Reg 18 : XEQ AR

Advance Ratio (TR) -- XEQ DATA : Store VF (ft/sec)  
in Reg 18 : XEQ ARTR

Solidity (MR) -- XEQ DATA : XEQ SD

Solidity (TR) -- XEQ DATA : XEQ SDTR

Coefficient of Thrust (MR -- XEQ DATA : XEQ CT

Tip Loss (MR) -- XEQ DATA : XEQ CT : XEX TL

Ground Effect -- XEQ DATA : XEQ GE

\*\*\*\* The following parameters can only be determined  
by executing FLITE and then recalling the storage  
register for that parameter \*\*\*\*

Coefficient of Thrust (TR) -- XEQ FLITE : RCL 30

Tip Loss (TR) -- XEQ FLITE : RCL 34

Induced Velocity (MR) -- XEQ FLITE : RCL 31 (value will be  
for chosen flight condition)

Induced Velocity (TR) -- XEQ FLITE : RCL 32 (value will be  
for chosen flight condition)

FLITE

			Size 060
INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1. Initialize program		XEQ FLITE	MR ONLY?
2. You may determine power requirements for main rotor only or main and tail rotor MR ONLY ( 1 ) MR + TR ( 0 )	0	R/S	MR AND TR (pause) NEED DATA?
3. Do you need to input any data? Yes ( 1 ) No ( 0 ) If No, go to Step 21a	1	R/S	REC?
4. Is main rotor blade rectangular?	1	R/S	c0=?
5. Yes - Input value of chord (ft). Go to Step 8	1.75	R/S	R=?
5a. No - Input root chord (ft)	-	-	(Cl=?)
6. No - Input tip chord (ft)	-	-	(a=?)
7. Input fractional distance where taper begins	-	-	ce=
8. Continue from Step 5		R/S	R=?
9. Input MR Radius (ft)	26.8	R/S	RV=?
10. Input MR Rotational velocity (rad/sec)	27.0	R/S	Cdo=?
11. Input MR coefficient of drag	.008	R/S	b=?

FLITE

INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
12. Input number of Main Rotor blades	4	R/S	R(TR)=?
13. Input TR radius (ft)	5.5	R/S	c(TR)=?
14. Input TR chord (ft)	.81	R/S	RV(TR)=?
15. Input TR rotational velocity (rad/sec)	124.6	R/S	Cdo(TR)=?
16. Input TR Coefficient of Drag	.008	R/S	b(TR)=?
17. Input number TR blades	4	R/S	L=?
18. Input tail length (ft)	31.5	R/S	W=?
18a. Continue from Step 12			W=?
19. Input gross weight (lbs)	20000	R/S	RTR HT=?
20. Input height of MR above skid/wheel (ft)	11.2	R/S	SKID HT=?
21. Input height of skids above ground (ft)	2500	R/S	HOVER ONLY?
21a. Continue from Step 3			HOVER ONLY?
22. Is problem for hover flight only? Yes ( 1 ) No ( 0 ) If Yes go to Step 28a	0	R/S	FWD ONLY?
23. Is problem for forward flight only? Yes ( 1 ) No ( 0 ) If Yes go to Step 25	0	R/S	VERT ONLY? VF=? (Yes)
24. Is problem for vertical flight only? Yes ( 1 ) No ( 0 ) If Yes go to Step 27	0	R/S	FWD + VERT (pause) VF=? VV=? (Yes)

FLITE

INSTRUCTION	INPUT	FUNCTION	DISPLAY
25. Input Forward velocity (kts) (Must input each time through program)	50	R/S	FF=?
26. Input forward Equiv. Flat Plate Area (ft <sup>2</sup> ) (Must input each time) If FWD ONLY go to Step 28a.	25.7	R/S	VV=?
27. Input vertical velocity (fpm). (Must input each time)	200	R/S	FV=?
28. Input vert. Equiv. Flat Area (ft <sup>2</sup> ). (Must input each time)	30.8	R/S	PA?
28a. Continue			PA?
29. Are you using Pressure Altitude? Yes ( 1 ) No ( 0 ) If Yes go to Step 30a.	0	R/S	DA=?
29. If you are running FLITE+, you will get output for DEN, AD, VT AR, CT, B, SD and VI			DEN = * * VI=
30. Input density alt. (ft) Go to Step 31	2500	R/S	PI=773.6
30a. Input Temp (°F)		R/S	PI=
31. Output induced power w/o TL or GE (SHP)		R/S	PI(TL)=798
31a. If you are running FLITE+, you will get output for GE.			GE=
32. Output induced power w/TL (SHP)		R/S	PI(TL+GE)= 798.3
33. Output induced power w/(TL+GE) SHP)		R/S	PO=302.0

FLITE

INSTRUCTION	INPUT	FUNCTION	DISPLAY
34. Output profile power (SHP)		R/S	PP=33.1
35. Output parasite power (SHP)		R/S	PC= 121.2
36. Output climb power (SHP)		R/S	PT(MR)= 1252.6
37. Output total power (SHP)			PI(TR+TL)= 33.6
37a. If you are running FLITE+, you get output for ADTR, VTTR, ARTR SDTR, CTTR, BTR, VITR and PI(TR)			ADTR= * * * PI(TR)=
37b. If MR only, go to Step 42.		R/S	CHANGE?
38. Output induced power (TR) w/TL (SHP)		R/S	PO(TR)=24.5
39. Output profile power (TR) (SHP)		R/S	PT(TR)=58.2
40. Output total power (TR) (SHP)		R/S	PT(AC)= 1310.7
41. Output total power for AC MR + TR (SHP)		R/S	CHANGE?
42. Do you wish to change any Input Data? Yes ( 1 ) No ( 1 ) Yes will restart No will stop program See NOTE	0	R/S	0.0000

Note: To make changes there is no need to input all the data again. Just change those values which require changing. When other values are requested, just press R/S.

\*\*\* THIS DOES NOT APPLY TO VF, VV, FF or FV \*\*\*



FLITE

01*LBL *FLITE*	51*LBL 08	101 XEQ *PT*	151 FS? 01
02 CF 07	52 *VF(VTS)=?*	102 FIX 3	152 GTO 06
03 GTO 10	53 PROMPT	103 FS? 01	153 PCL 05
04*LBL *FLITE+*	54 1.68889	104 GTO 20	154 *P(PT)=?*
05 SF 07	55 *	105 XEQ *TR*	155 PROMPT
06*LBL 10	56 STO 18	106*LBL 20	156 STO 05
07 CF 01	57 *FF=?*	107 *CHANGE ?*	157 RCL 06
08 CF 02	58 PROMPT	108 PROMPT	158 *c(TR)=?*
09 CF 03	59 STO 12	109 X)0?	159 PROMPT
10 CF 04	60 FS? 04	110 GTO 11	160 STO 06
11 CF 05	61 GTO 07	111 GTO 12	161 RCL 07
12 CF 06	62 GTO 09	112*LBL 11	162 *PV(TR)=?*
13 0	63*LBL 0?	113 FS? 07	163 PROMPT
14 STO 12	64 *VV(FPM)=?*	114 XEQ *FLITE+*	164 STO 07
15 STO 13	65 PROMPT	115 XEQ *FLITE*	165 RCL 08
16 STO 18	66 60	116*LBL 12	166 *Cd0(TR)=?*
17 STO 19	67 /	117 STOP	167 PROMPT
18 FIX 3	68 STO 19	118*LBL *DATA*	168 STO 08
19 *MF ONLY ?*	69 *FV=?*	119 *NEED DATA ?*	169 RCL 09
20 PROMPT	70 PROMPT	120 PROMPT	170 *b(TR)=?*
21 X)0?	71 STO 13	121 X=0?	171 PROMPT
22 GTO 01	72*LBL 0?	122 GTO 03	172 STO 09
23 *MF+TP+*	73 XEQ *PA*	123 *PEC ?*	173 RCL 10
24 AVIEW	74 XEQ *AD*	124 PROMPT	174 *L=?*
25 PSE	75 XEQ *VT*	125 X)0?	175 PROMPT
26 GTO 02	76 XEQ *AP*	126 GTO 04	176 STO 10
27*LBL 01	77 XEQ *CT*	127 XEQ *ECHORD*	177*LBL 06
28 SF 01	78 XEQ *TL*	128 GTO 05	178 PCL 11
29*LBL 02	79 XEQ *SD*	129*LBL 04	179 *M=?*
30 XEQ *DATA*	80 XEQ *VIM*	130 PCL 01	180 PROMPT
31 *HAYES ONLY ?*	81 FS? 05	131 *c=?*	181 STO 11
32 PROMPT	82 GTO 13	132 PROMPT	182 RCL 14
33 X)0?	83 XEQ *VIT*	133*LBL 05	183 *PTP HT=?*
34 GTO 07	84 FS? 06	134 STO 01	184 PROMPT
35 SF 04	85 GTO 14	135 RCL 08	185 STO 14
36 *FWD ONLY ?*	86 GTO 15	136 *P=?*	186 RCL 25
37 PROMPT	87*LBL 13	137 PROMPT	187 *SKID HT=?*
38 X)0?	88 XEQ *VIV*	138 STO 00	188 PROMPT
39 GTO 08	89 GTO 15	139 RCL 02	189 STO 25
40 SF 05	90*LBL 14	140 *PV=?*	190*LBL 03
41 *VEPT ONLY ?*	91 XEQ *VITV*	141 PROMPT	191 RTN
42 PROMPT	92*LBL 15	142 STO 02	192*LBL *ECHORD*
43 X)0?	93 *VI=*	143 PCL 03	193 RCL 15
44 GTO 09	94 FS? 07	144 *Cd0=?*	194 *c0=?*
45 *FWD+VERT+*	95 XEQ *S*	145 PROMPT	195 PROMPT
46 AVIEW	96 FIX 1	146 STO 03	196 STO 15
47 PSE	97 XEQ *PI*	147 RCL 04	197 RCL 16
48 SF 06	98 XEQ *PO*	148 *b=?*	198 *cL=?*
49 CF 04	99 XEQ *PP*	149 PROMPT	199 PROMPT
50 CF 05	100 XEQ *PC*	150 STO 04	200 STO 16

FLITE

201 RCL 17	251 STO 21	301 STO 27	351 XEQ "S"
202 "a=?"	252 /	302 "VT="	352 PTM
203 PROMPT	253 288.16	303 FS? 07	353*LBL "SD"
204 STO 17	254 *	304 XEQ "S"	354 RCL 04
205 4	255 .23496	305 PTM	355 RCL 01
206 YPX	256 YPX	306*LBL "AP"	356 *
207 CHS	257 CHS	307 RCL 18	357 RCL 00
208 1	258 1	308 RCL 27	358 /
209 +	259 +	309 /	359 PI
210 RCL 15	260 6.875 E-06	310 STO 48	360 /
211 RCL 16	261 /	311 "AP="	361 STO 46
212 -	262 STO 20	312 FS? 07	362 "SD="
213 *	263 GTO "DEN"	313 XEQ "S"	363 FS? 07
214 RCL 17	264*LBL "DA"	314 RTN	364 XEQ "S"
215 CHS	265 "DA=?"	315*LBL "CT"	365 RTN
216 1	266 PROMPT	316 RCL 22	366*LBL "GE"
217 +	267 STO 20	317 PI	367 RCL 25
218 /	268*LBL "DEN"	318 *	368 RCL 14
219 4	269 RCL 20	319 RCL 00	369 +
220 /	270 6.875 E-06	320 X+2	370 RCL 00
221 RCL 16	271 *	321 *	371 2
222 +	272 CHS	322 RCL 00	372 *
223 STO 01	273 1	323 PCL 02	373 /
224 "ce="	274 +	324 *	374 STO 26
225 XEQ "S"	275 ENTEPT	325 X+2	375 1.55
226 PTM	276 4.2561	326 *	376 -
227*LBL "PA"	277 YPX	327 1/X	377 X)0?
228 "PA ?"	278 .0023769	328 RCL 11	378 GTO 18
229 PROMPT	279 *	329 *	379 PCL 26
230 Y=0?	280 STO 22	330 STO 29	380 1.3432
231 GTO "DA"	281 FIX 6	331 FIX 6	381 *
232 "PA=?"	282 "DEN="	332 "CT="	382 PCL 26
233 PROMPT	283 FS? 07	333 FS? 07	383 X+2
234 STO 20	284 XEQ "S"	334 XEQ "S"	384 -1.4569
235 6.875 E-06	285 FIX 3	335 FIX 3	385 *
236 *	286 RTN	336 RTN	386 +
237 CHS	287*LBL "AD"	337*LBL "TL"	387 RCL 26
238 1	288 RCL 00	338 FIX 3	388 3
239 +	289 X+2	339 RCL 29	389 YPX
240 5.2561	290 PI	340 2	390 .7080
241 YPX	291 *	341 *	391 *
242 "TEMP(F)=?"	292 STO 23	342 SQRT	392 +
243 PROMPT	293 "AD="	343 PCL 04	393 RCL 26
244 STO 21	294 FS? 07	344 /	394 4
245 32	295 XEQ "S"	345 CHS	395 YPX
246 -	296 RTN	346 1	396 -.1276
247 .5555	297*LBL "VT"	347 +	397 *
248 *	298 RCL 02	348 STO 33	398 +
249 273.16	299 RCL 00	349 "B="	399 .514
250 +	300 *	350 FS? 07	400 +

FLITE

401 GTO 19	451 STO 31	501 *	551 +
402*LEL 18	452 PTN	502 4400	552 STO 39
403 1	453*LBL "VITV"	503 /	553 "PT(MR)=-"
404*LEL 19	454 RCL 19	504 STO 36	554 XEQ "S"
405 STO 45	455 2	505 "PO=-"	555 PTN
406 "GE=-"	456 /	506 XEQ "S"	556*LBL "TP"
407 FS? 07	457 CHS	507 RTN	557 XEQ "ADTR"
408 XEQ "S"	458 RCL 31	508*LBL "PP"	558 XEQ "VTTP"
409 RTN	459 +	509 RCL 18	559 XEQ "APTR"
410*LBL "VIM"	460 STO 31	510 3	560 XEQ "SDTR"
411 RCL 11	461 RTN	511 Y↑X	561 RCL 39
412 2	462*LBL "PI"	512 RCL 12	562 550
413 /	463 RCL 11	513 *	563 *
414 RCL 22	464 RCL 31	514 RCL 19	564 PCL 02
415 /	465 *	515 3	565 /
416 RCL 23	466 550	516 Y↑X	566 RCL 10
417 /	467 /	517 RCL 13	567 /
418 SQRT	468 STO 50	518 *	568 STO 40
419 STO 31	469 "PI=-"	519 +	569 PCL 24
420 RTN	470 XEQ "S"	520 PCL 22	570 /
421*LBL "VIT"	471 RCL 33	521 *	571 RCL 22
422 PCL 18	472 /	522 1100	572 /
423 X↑2	473 STO 51	523 /	573 STO 55
424 2	474 "PI<TL)=-"	524 STO 37	574 PCL 28
425 /	475 XEQ "S"	525 X=0?	575 X↑2
426 STO 53	476 XEQ "GE"	526 GTO 16	576 /
427 X↑2	477 RCL 51	527 "PP=-"	577 STO 30
428 RCL 31	478 *	528 XEQ "S"	578 FIX 6
429 4	479 STO 35	529*LBL 16	579 "CTTP=-"
430 Y↑X	480 "PI<TL+GE)=-"	530 PTN	580 FS? 07
431 +	481 XEQ "S"	531*LBL "PC"	581 XEQ "S"
432 SQRT	482 RTN	532 PCL 11	582 FIX 3
433 RCL 53	483*LBL "PD"	533 RCL 19	583 2
434 -	484 PCL 48	534 *	584 *
435 SQRT	485 X↑2	535 550	585 SQRT
436 STO 31	486 4.3	536 /	586 PCL 09
437 PTN	487 *	537 STO 38	587 /
438*LBL "VIV"	488 1	538 X=0?	588 CHS
439 RCL 31	489 +	539 GTO 17	589 1
440 X↑2	490 RCL 27	540 "PC=-"	590 +
441 4	491 3	541 XEQ "S"	591 STO 34
442 *	492 Y↑X	542*LBL 17	592 "BTP=-"
443 PCL 19	493 *	543 PTN	593 FS? 07
444 X↑2	494 PCL 23	544*LBL "PT"	544 XEQ "S"
445 +	495 *	545 RCL 35	595 RCL 55
446 SQRT	496 RCL 22	546 RCL 36	596 2
447 RCL 19	497 *	547 +	597 /
448 -	498 RCL 03	548 RCL 37	598 X↑2
449 2	499 *	549 +	599 PCL 53
450 /	500 RCL 46	550 RCL 38	600 X↑2

FLITE

601 +	651 *	701 RTN
602 SQRT	652 STO 28	702*LBL "S"
603 RCL 53	653 *VTTR="	703 ARCL X
604 -	654 FS? 07	704 AVIEW
605 SQRT	655 XEQ "S"	705 STOP
606 STO 32	656 PTM	706 RTN
607 *VITP="	657*LBL "ARTR"	707 END
608 FS? 07	658 RCL 18	
609 XEQ "S"	659 RCL 28	
610 RCL 40	660 /	
611 *	661 STO 49	
612 550	662 "ARTR="	
613 /	663 FS? 07	
614 STO 52	664 XEQ "S"	
615 FIX 1	665 RTN	
616 *PI(TR)="	666*LBL "SDTP"	
617 FS? 07	667 RCL 09	
618 XEQ "S"	668 RCL 06	
619 PCL 34	669 *	
620 /	670 RCL 05	
621 STO 41	671 /	
622 *PI(TR+TL)="	672 PI	
623 XEQ "S"	673 /	
624 XEQ "PTR"	674 STO 47	
625 *PO(TP)="	675 "SDTP="	
626 XEQ "S"	676 FS? 07	
627 +	677 XEQ "S"	
628 STO 43	678 RTN	
629 *PT(TP)="	679*LBL "PTR"	
630 XEQ "S"	680 RCL 49	
631 PCL 39	681 X12	
632 +	682 4.3	
633 STO 44	683 *	
634 *PT(AC)="	684 1	
635 XEQ "S"	685 +	
636 FIX 3	686 RCL 28	
637 RTN	687 3	
638*LBL "ADTR"	688 Y1X	
639 RCL 05	689 *	
640 X12	690 RCL 24	
641 PI	691 *	
642 *	692 RCL 22	
643 STO 24	693 *	
644 "ADTR="	694 RCL 08	
645 FS? 07	695 *	
646 XEQ "S"	696 RCL 47	
647 PTM	697 *	
648*LBL "VTTR"	698 4400	
649 RCL 07	699 /	
650 RCL 05	700 STO 42	

## FUEL

### Fuel Flow as a function of Power

Introduction: This program determines the relationship between fuel flow rate and power required - Phantom Shaft Horsepower (PSHP) and the fuel flow rate ( $\dot{W}_f$ ) at specified velocities. This program runs in conjunction with POWER which must be loaded and the geometric and flight parameters loaded through step 19 in the step-by-step instructions. The input parameters are the number of engines (NENG),  $\hat{\alpha}$  (the fuel flow rate versus SHP ordinate intercept) and  $\hat{\beta}$  (the slope of the fuel flow rate versus SHP curve). The standard data set is used as well as those listed below.

Additional Programs Required: POWER

#### Equations

$$\dot{W}_f = (\text{PSHP} + P_T) \cdot \hat{\beta} \quad \text{Ref 2, Eqn 7D-11}$$

$$\text{PSHP} = \text{NENG} \cdot \hat{\alpha} \cdot \delta \cdot \sqrt{\theta} / \hat{\beta} \quad \text{Ref 2, Eqn 7D-9}$$

#### Additional Storage Registers

Storage Registers	Stored Quantity
49	PSHP - Phantom Shaft Horsepower
55	NENG - Number of engines
56	$\hat{\alpha}$ - Fuel Flow Rate vs SHP intercept
57	$\hat{\beta}$ - Slope of Fuel Flow Rate vs SHP curve

FUEL

			SIZE 060
INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1. Initialize the program		XEQ FUEL	*LOAD POWER*
2. Reminder flashes			NENG=?
3. Enter the number of engines	1	R/S	ALPHA HAT=?
4. Enter the sea level intercept of the fuel flow rate vs SHP	88.5	R/S	BETA HAT=?
5. Enter the slope of the fuel flow rate versus SHP curve	0.5	R/S	PSHP=177.0
6. Display Phantom horsepower		R/S	VF=?
7. Enter the forward velocity (kts)	100	R/S	VV=?
8. Enter the vertical velocity (fpm)	0	R/S	W DOT=652.6
9. Display Fuel Flow Rate (lb/hr)		R/S	ANOTHER VF?
10. Exit the program	0	R/S	0.0

# FUEL

```
01•LBL "FUEL"  
02 •*LOAD POWER*•  
03 AVIEW  
04 PSE  
05 "MENG=?"  
06 PROMPT  
07 STO 55  
08 "ALPHA HAT=?"  
09 PROMPT  
10 STO 56  
11 "BETA HAT=?"  
12 PROMPT  
13 STO 57  
14 1/X  
15 *  
16 *  
17 RCL 47  
18 *  
19 RCL 21  
20 518.688  
21 /  
22 SQRT  
23 *  
24 STO 49  
25 "PSHP="•  
26 APCL X  
27 AVIEW  
28 STOP  
29•LBL 10  
30 SF 03  
31 CF 02  
32 XEQ "VF"  
33 RCL 49  
34 RCL 44  
35 +  
36 RCL 57  
37 *  
38 "W DOT="•  
39 APCL X  
40 AVIEW  
41 STOP  
42 "ANOTHER VF?"  
43 PPROMPT  
44 X=0?  
45 GTO "COMP"  
46 GTO 10  
47•LBL "COMP"  
48 CF 03  
49 CF 02  
50 END
```

## HSE

### High Speed Effects

Introduction: This program calculates the high speed effects including both retreating blade stall and advancing blade Mach effects. Using main rotor geometric design parameters and the forward velocity as input variables, the collective and cyclic angles and the angle of attack at the tip of the blade at the 90 degree and 270 degree azimuth are determined. The change of power due to stall effects (\*P<S>) and the change in power due to Mach effects (\*P<M>) are computed and added to the total power required to furnish a corrected power required (P<C>). The collective, cyclic and blade angles of attack are not displayed, but may be obtained by recalling the applicable data register.

Due to the difficulties with the Retreating Blade Stall equations as listed in Ref. 1, this program assumes that the Coefficient of Profile Drag is doubled when the retreating blade tip angle of attack exceed the maximum angle by  $4^\circ$ , and also assumes that the change in power due to stall is linear.

This program must be run following POWER and uses the same standard data registers as POWER. Additional data registers are as shown below.

Maximum angle of attack (blade stall angle) must be entered, and a value other than zero must be entered for the blade twist. The normal range of values for twist is from -7 to -18 degrees.

Additional Programs Required: POWER

Equations:

$$2C_T/a\sigma = \lambda T_1 + \theta_0 T_2 + \theta_T T_3 + \theta_2 T_4 \quad \text{Ref 1, Eqn 8-19}$$

$$0 = \lambda A_{11} + \theta_0 A_{12} + \theta_T A_{13} + \theta_2 A_{14} \quad \text{Ref 1, Eqn 8-20}$$

$$\lambda = (V\alpha_3 - v_w)/V_T$$

$$\alpha_3 = \tan^{-1}(D_p/W) \quad \text{Ref 1, Eqn 8-4}$$

$$\mu = V_f/V_T \quad \text{Ref 1, Eqn 8-2}$$



Equations (Continued)

$$T_1 = .5(B^2 + .5\mu^2) \quad \text{Ref 1, Eqn 8-17}$$

$$T_2 = (.33B^3 + .5\mu^2B) \quad \text{Ref 1, Eqn 8-17}$$

$$T_3 = .25B^2(B^2 + \mu^2) \quad \text{Ref 1, Eqn 8-17}$$

$$T_4 = .5\mu(B^2 + .25\mu^2) \quad \text{Ref 1, Eqn 8-17}$$

$$A_{11} = 4(\mu B^2/2 - \mu^3/8)/B^2(B^2 - .5\mu^2) \quad \text{Ref 1, Eqn 8-18}$$

$$A_{12} = 8\mu B/3(B^2 - .5\mu^2) \quad \text{Ref 1, Eqn 8-18}$$

$$A_{13} = 2\mu B^2/(B^2 - .5\mu^2) \quad \text{Ref 1, Eqn 8-18}$$

$$A_{14} = (B^2 + 1.5\mu^2)/(B^2 - .5\mu^2) \quad \text{Ref 1, Eqn 8-18}$$

$$\theta_0 = \text{Collective Pitch Angle}$$

$$\theta_2 = \text{Longitudinal Cyclic Pitch Angle}$$

$$\theta_T = \text{Blade Twist Angle}$$

$$C_{do_s} = 2 C_{do} (\alpha_{90}^0 - \alpha_{max}^0)/4$$

$$*P<S> = P_o [C_{do_s}/C_{do}]$$

$$M_{crit} = 0.71 - |2.3| \alpha_{90} \text{ (rad)} \quad \text{Ref 1, Eqn 8-30}$$

$$M_{90} = M_{tip} (1 + \mu) \quad \text{Ref 1, Eqn 8-29}$$

$$M_d = M_{90} - M_{crit} - 0.06 \quad \text{Ref 1, Eqn 8-21}$$

$$C_{P_m} = (0.012\Delta M_d + 0.1\Delta M_d^3) \quad \text{Ref 1, Eqn 8-31}$$

$$*P<M> = C_{P_m} A_p V_T^3 \quad \text{Ref 1, Eqn 3-25}$$

## Additional Storage Registers

Storage Register	Stored Quantity
15	$\sigma$ - Solidity
16	<del>*P&lt;M&gt; - Change in Power due to Mach effects</del>
17	$\Delta M_d$ - Excess Mach over corrected critical value
46	$\theta_T$ - Twist angle
47	$\lambda$ = Inflow ratio
48	$\mu$ = Advance ratio ( $V_f/V_T$ )

The Following Registers are used for storage after line 160

49	$\theta_0$ (Collective Pitch)
50	$\alpha_{270}$ (Retreating Blade Tip Angle of Attack)
52	*P<S> - Change in Power due to Blade Stall Effects
53	*P<M> - Change in Power due to Compressibility
54	$\alpha_{90}$ (Advancing Blade Tip Angle of Attack)
55	$\theta_2$ (Longitudinal Cyclic Pitch)

## HSE

SIZE 060

INSTRUCTION	INPUT	FUNCTION	DISPLAY
1. Initialize Program		XEQ HSE	TWIST<DEG>=?
2. Input Twist Angle (Degrees)	-9	R/S	a<MAX>=?x
3. Input max angle of attack (Degrees)	12.5	R/S	BLADE STALL
4. Output change in power due to stall (SHP)		R/S	*P<S>=668.2
5. Output change in power due to Mach (SHP)		R/S	*P<M>=393.8
6. Output total power including high speed effects (SHP)		R/S	PT<C>=3,3157.2

Note: This program may be accessed directly from POWER by answering the question "HI SPD?" with a Yes (Input <1>), or it may be run directly as shown above, provided that either POWER has previously be run or the data registers 1 through 19 plus 44 have been loaded with the correct values.

# HSE

01 *LBL "HSE"		
02 RCL 46		
03 57.3		
04 *		
05 "TWIST(DEG)=?"		
06 PROMPT		
07 57.3		
08 /		
09 STO 46		
10 RCL 16		
11 "a(MAX)=?"		
12 PROMPT		
13 STO 16		
14 RCL 37		
15 RCL 11		
16 /		
17 550		
18 *		
19 RCL 31		
20 2		
21 *		
22 +		
23 RCL 27		
24 /		
25 CHS		
26 STO 47		
27 RCL 18		
28 RCL 27		
29 /		
30 STO 48		
31 X↑2		
32 STO 55		
33 RCL 33		
34 X↑2		
35 STO 54		
36 RCL 55		
37 2		
38 /		
39 CHS		
40 RCL 54		
41 +		
42 STO 49		
43 RCL 48		
44 RCL 55		
45 *		
46 8		
47 /		
48 CHS		
49 RCL 54		
50 RCL 48		
51 *		
52 2		
53 /		
54 +		
55 4		
56 *		
57 RCL 49		
58 /		
59 RCL 54		
60 /		
61 STO 50		
62 RCL 33		
63 RCL 48		
64 *		
65 2.6667		
66 *		
67 RCL 49		
68 /		
69 STO 51		
70 RCL 48		
71 RCL 54		
72 *		
73 2		
74 *		
75 RCL 49		
76 /		
77 STO 52		
78 RCL 55		
79 1.5		
80 *		
81 RCL 54		
82 +		
83 RCL 49		
84 /		
85 STO 53		
86 RCL 55		
87 2		
88 /		
89 RCL 54		
90 +		
91 2		
92 /		
93 STO 56		
94 RCL 55		
95 2		
96 /		
97 RCL 54		
98 3		
99 /		
100 +		
101 RCL 33		
102 *		
103 STO 57		
104 RCL 54		
105 RCL 55		
106 +		
107 RCL 54		
108 *		
109 4		
110 /		
111 STO 58		
112 RCL 55		
113 4		
114 /		
115 RCL 54		
116 +		
117 RCL 48		
118 *		
119 2		
120 /		
121 STO 59		
122 RCL 29		
123 .15		
124 *		
125 RCL 15		
126 /		
127 STO 55		
128 RCL 47		
129 RCL 56		
130 *		
131 ST- 55		
132 RCL 46		
133 RCL 58		
134 *		
135 ST- 55		
136 RCL 55		
137 RCL 51		
138 *		
139 STO 17		
140 RCL 47		
141 RCL 50		
142 *		
143 RCL 46		
144 RCL 52		
145 *		
146 RCL 57		
147 *		
148 RCL 17		
149 +		
150 CHS		

# HSE

151 STO 17	201 /	251 RCL 27
152 RCL 53	202 RCL 48	252 *
153 RCL 57	203 X+2	253 RCL 27
154 *	204 4.3	254 3
155 RCL 59	205 *	255 Y+X
156 RCL 51	206 1	256 *
157 *	207 +	257 550
158 -	208 1/X	259 /
159 1/X	209 RCL 36	259 STO 52
160 RCL 17	210 *	260 GTO "MH"
161 *	211 *	261 LBL "NM"
162 STO 55	212 STO 53	262 0
163 RCL 53	213 "P<S)="	263 STO 52
164 *	214 ARCL X	264 LBL "MH"
165 RCL 47	215 AVIEW	265 RCL 52
166 RCL 50	216 STOP	266 "P<M)="
167 *	217 LBL "MP"	267 ARCL X
168 +	218 RCL 22	268 AVIEW
169 RCL 46	219 .11748	269 STOP
170 RCL 52	220 Y+X	270 RCL 52
171 *	221 2257.3	271 RCL 53
172 +	222 *	272 +
173 RCL 51	223 1/X	273 RCL 44
174 /	224 RCL 18	274 +
175 CHS	225 RCL 27	275 "P<HSE)="
176 STO 49	226 +	276 ARCL X
177 RCL 55	227 *	277 AVIEW
178 -	228 .77	278 STOP
179 RCL 46	229 -	279 GTO "VF"
180 +	230 RCL 54	280 LBL "NS"
181 RCL 48	231 .0401	281 "NO STALL"
182 1	232 *	282 AVIEW
183 +	233 +	283 STOP
184 1/X	234 STO 56	284 GTO "MP"
185 RCL 47	235 0	285 .END.
186 *	236 X>Y?	
187 +	237 GTO "NM"	
188 57.3	238 X<Y	
189 *	239 3	
190 STO 50	240 Y+X	
191 RCL 16	241 .1	
192 -	242 *	
193 0	243 RCL 56	
194 X>Y?	244 .012	
195 GTO "NS"	245 *	
196 X<Y	246 +	
197 "BLADE STALL:"	247 RCL 15	
198 AVIEW	248 *	
199 PSE	249 RCL 22	
200 4	250 *	

## POWER

### Helicopter Power Requirements

Introduction: The user inputs the basic geometric and flight parameters of the helicopter and the program determines the steady state power requirements to maintain that condition. High speed effects are not included but may be determined by running the high speed effects program (HSE) following this program. POWER requires no other subroutines to operate. It utilizes the Standard Data Set for storage registers 00 through 45, and additionally those listed below.

Additional Programs Required: None

Equations:

$$\{(h/d) - 1.55\} < 0? \text{ (In Ground Effect?)} \quad \text{Ref 1, Fig 2, pg 67}$$

$$(P_i/P_{i_{\text{OGE}}}) = 0.5147 + 1.3432(h/D) - 1.4569(h/D)^2 + 0.7080(h/D)^3 - 0.1276(h/D)^4 \quad \text{Ref 1, Eqn 3-8}$$

$$P_{\text{alt}} = P_{\text{ssl}}(1 - 6.875 \times 10^{-6} \cdot H)^{5.2561} \quad \text{Ref 2, Eqn 7D-5}$$

$$P_{\text{alt}} = P_{\text{ssl}}(1 - 6.8755 \times 10^{-6} \cdot H)^{4.2561} \quad \text{Ref 2, Eqn 7D-6}$$

$$C_T = W/\rho A (\pi R)^2 \quad \text{Ref 1, Eqn 2-23}$$

$$B = 1 - \sqrt{2C_T}/b \quad \text{Ref 1, Eqn 3-1}$$

$$v_i = (W/2\rho A)^{.5} \quad \text{Ref 1, Eqn 2-15}$$

$$P_i = (P_i/P_{i_{\text{OGE}}})(Tv_i/(550 \cdot B) \left\{ [1 + .25(v_f^2/v_i^2)] - .5(v_f^2/v_i^2) \right\}^{.5} \quad \text{Ref 1, Eqn 4-41}$$

$$P_o = (C_{d_o} \rho b c R v_T^3/4400)(1 + 4.3\mu^2) \quad \text{Ref 1, Eqn 4-53}$$

$$P_p = v_f^3 F_f \rho / 1100 \quad \text{Ref 1, Eqn 4-56}$$

$$P_c = TV_v/550 + (.5\rho F_v v_v^3)/550 \quad \begin{array}{l} \text{Ref 1, Eqn 4-28} \\ \text{Eqn 4-29} \end{array}$$

$$T_{\text{TR}} = 556 P_{\text{MR}} / (\Omega_{\text{MR}}^2 T_{\text{TR}}) \quad \text{Ref 1, Eqn 5-2}$$

## POWER

SIZE 060

INSTRUCTION	INPUT	FUNCTION	DISPLAY
1. Initialize Program		XEQ POWER	
2. Reminder flashes		R/S	NEED DATA?
3. Answer 1 for yes, 0 for no	1	R/S	W=?
4. Input weight (lbs)	20000	R/S	RV=?
5. Input main rotor rotational velocity (rad/sec)	27	R/S	b=?
6. Input number of main rotor blades	4	R/S	c=?
7. Input main rotor chord (ft)	1.75	R/S	Cdo=?
8. Input main rotor drag coefficient	.008	R/S	R=?
9. Input main rotor radius (ft)	26.8	R/S	FF=?
10. Input forward flat plate area (ft <sup>2</sup> )	25.7	R/S	FV=?
11. Input vertical flat plate area (ft <sup>2</sup> )	30.8	R/S	RV(TR)=?
12. Input tail rotor rotational velocity (rad/sec)	124.6	R/S	b(TR)=?
13. Input number of tail rotor blades	4	R/S	c(TR)=?
14. Input tail rotor chord (ft)	.81	R/S	Cdo(TR)=?
15. Input tail rotor drag coefficient	.008	R/S	R(TR)=?
16. Input tail rotor radius (ft)	5.5	R/S	L(Tail)=?

POWER

INSTRUCTION	INPUT	FUNCTION	DISPLAY
17. Input length of tail (ft)	30.5	R/S	RTR HT=?
18. Input rotor height above skid (ft)	11.2	R/S	SKID HT=?
19. Input skid height above ground (ft)	100	R/S	PA?
20. Do you know pressure altitude?			
a. Answer 1 for yes	1	R/S	PA=?
Input pressure altitude (ft)	0	R/S	TEMP(C)=?
Input temperature	59	R/S	VF=?
or b. Answer 0 for no	0	R/S	DA=?
Input density altitude (ft)	0	R/S	VF=?
21. Input forward 150 velocity (kt)		R/S	VV=?
22. Input vertical 0 velocity (ft/min)		R/S	
23. Output total aircraft power (SHP)		R/S	PT(AC)=1687.2
24. Output main rotor power (SHP)			PT(MR)=1647.8
25. Do you want high effects?			HI SPD?
26. 1 for Yes 0 for No		R/S	



# POWER

01*LBL "POWER"	51 PROMPT	101 *	151 YtX
02 FIX 1	52 STO 06	102 +	152 FS? 04
03 CF 02	53 RCL 08	103 RCL 26	153 GTO "PH0"
04 CF 03	54 *Cd0<TR>=?	104 4	154 FS? 05
05 "NEED DATA?"	55 PROMPT	105 YtX	155 STO 47
06 PROMPT	56 STO 08	106 -.1276	156*LBL "TEMP"
07 X=0?	57 RCL 05	107 *	157 *TEMP<F>=?
08 GTO "PGM"	58 *R<TR>=?	108 +	158 PROMPT
09 RCL 11	59 PROMPT	109 .5147	159 459.688
10 "W=?"	60 STO 05	110 +	160 +
11 PROMPT	61 RCL 10	111 STO 45	161 STO 21
12 STO 11	62 *L<TAIL>=?	112*LBL "AREA"	162 518.688
13 RCL 02	63 PROMPT	113 RCL 00	163 /
14 "RV=?"	64 STO 10	114 Xt2	164 1/X
15 PROMPT	65 RCL 14	115 PI	165 PCL 47
16 STO 02	66 *RTR HT=?	116 *	166 *
17 RCL 04	67 PROMPT	117 STO 23	167 GTO "PH0"
18 "b=?"	68 STO 14	118 RCL 05	168*LBL "DNA"
19 PROMPT	69*LBL "PGM"	119 Xt2	169 "DA=?"
20 STO 04	70 RCL 25	120 PI	170 PROMPT
21 RCL 01	71 *SKID HT=?	121 *	171 STO 20
22 "c=?"	72 PROMPT	122 STO 24	172*LBL "DEN"
23 PROMPT	73 STO 25	123*LBL "VT"	173 SF 04
24 STO 01	74 RCL 14	124 RCL 00	174 GTO "ICAO"
25 RCL 03	75 +	125 RCL 02	175*LBL "PH0"
26 *Cd0=?	76 RCL 00	126 *	176 STO 51
27 PROMPT	77 /	127 STO 27	177 .0023769
28 STO 03	78 2	128 RCL 05	178 *
29 RCL 00	79 /	129 RCL 07	179 STO 22
30 "R=?"	80 STO 26	130 *	180 FS? 05
31 PROMPT	81 1.55	131 STO 28	181 GTO "VF"
32 STO 00	82 -	132*LBL "DA"	182 RCL 20
33 RCL 12	83 X<0?	133 "PA?"	183 6.875 E-06
34 "FF=?"	84 GTO "GE"	134 PROMPT	184 *
35 PROMPT	85 1	135 X=0?	185 CHS
36 STO 12	86 STO 45	136 GTO "DNA"	186 1
37 RCL 13	87 GTO "AREA"	137 SF 05	187 +
38 "FV=?"	88*LBL "GE"	138 "PA=?"	188 518.688
39 PROMPT	89 RCL 26	139 PROMPT	189 *
40 STO 13	90 1.3432	140 STO 20	190 STO 21
41 RCL 07	91 *	141*LBL "ICAO"	191 518.688
42 *RV<TR>=?	92 RCL 26	142 6.875 E-06	192 /
43 PROMPT	93 Xt2	143 *	193 RCL 51
44 STO 07	94 -1 4569	144 CHS	194 *
45 RCL 09	95 *	145 1	195 STO 47
46 "b<TR>=?	96 +	146 +	196*LBL "VF"
47 PROMPT	97 RCL 26	147 FS? 05	197 CF 05
48 STO 09	98 3	148 5.2561	198*LBL "VV"
49 RCL 06	99 YtX	149 FS? 04	199 "VF=?"
50 "c<TR>"	100 .7088	150 4.2561	200 PROMPT

# POWER

201 1.68894	251 *	301 67.6
202 *	252 SQRT	302 X/Y?
203 STO 18	253 RCL 09	303 GTO "PI"
204 "VV=?"	254 /	304 RCL 40
205 PROMPT	255 CHS	305 RCL 22
206 60	256 1	306 /
207 /	257 +	307 RCL 24
208 STO 19	258 STO 34	308 /
209 CF 05	259*LBL "VI"	309 RCL 18
210 CF 04	260 FS? 02	310 /
211*LBL "CT"	261 RCL 40	311 2
212 FS? 02	262 FC? 02	312 /
213 GTO 07	263 RCL 11	313 STO 32
214 RCL 11	264 RCL 22	314*LBL "PI"
215 RCL 23	265 /	315 FS? 02
216 /	266 FS? 02	316 RCL 32
217 RCL 22	267 RCL 24	317 FC? 02
218 /	268 FC? 02	318 RCL 31
219 RCL 27	269 RCL 23	319 FS? 02
220 X↑2	270 /	320 RCL 40
221 /	271 2	321 FC? 02
222 STO 29	272 /	322 RCL 11
223 GTO "TL"	273 STO 58	323 *
224*LBL 07	274 RCL 18	324 FS? 02
225 RCL 40	275 X↑2	325 RCL 34
226 RCL 24	276 RCL 58	326 FC? 02
227 /	277 /	327 RCL 33
228 RCL 22	278 2	328 /
229 /	279 /	329 FS? 02
230 RCL 28	280 STO 59	330 1
231 X↑2	281 X↑2	331 FC? 02
232 /	282 1	332 RCL 45
233 STO 30	283 +	333 *
234*LBL "TL"	284 SQRT	334 550
235 FS? 02	285 RCL 59	335 /
236 GTO 09	286 -	336 FS? 02
237 RCL 29	287 SQRT	337 STO 41
238 2	288 RCL 58	338 FC? 02
239 *	289 SQRT	339 STO 35
240 SQRT	290 *	340*LBL "PO"
241 RCL 04	291 FS? 02	341 RCL 01
242 /	292 STO 32	342 RCL 04
243 CHS	293 FC? 02	343 *
244 1	294 STO 31	344 RCL 00
245 +	295 FS? 02	345 /
246 STO 33	296 GTO 11	346 PI
247 GTO "VI"	297 FC? 02	347 /
248*LBL 09	298 GTO "PI"	348 STO 15
249 RCL 30	299*LBL 11	349 FS? 02
250 2	300 RCL 18	350 RCL 28

# POWER

351 FC? 02	401 RCL 18	
352 RCL 27	402 3	
353 3	403 Y↑X	451 RCL 10
354 Y↑X	404 RCL 12	452 X=0?
355 FS? 02	405 *	453 GTO "MN"
356 RCL 05	406 RCL 22	454 /
357 FC? 02	407 *	455 STO 40
358 RCL 00	408 1100	456 SF 02
359 <del>MR</del> *	409 /	457 GTO "CT"
360 <del>ENTER</del>	410 STO 37	458*LBL "PT"
361 FS? 02	411*LBL "PC"	459 RCL 41
362 RCL 06	412 RCL 19	460 RCL 42
363 FC? 02	413 3	461 +
364 <del>RCL 01</del>	414 Y↑X	462 STO 43
365 *	415 RCL 13	463 RCL 39
366 FS? 02	416 *	464 +
367 RCL 09	417 RCL 22	465 STO 44
368 FC? 02	418 *	466 FS? 03
369 RCL 04	419 2	467 GTO 13
370 *	420 /	468 "PT(AC)=-"
371 FS? 02	421 550	469 ARCL X
372 RCL 08	422 /	470 AVIEW
373 FC? 02	423 ST+ 37	471 STOP
374 RCL 03	424 RCL 19	472*LBL "MN"
375 *	425 RCL 11	473 RCL 39
376 4400	426 *	474 "PT(MR)=-"
377 /	427 2	475 ARCL X
378 RCL 22	428 /	476 AVIEW
379 *	429 550	477 STOP
380 STO 52	430 /	478 "HI SPD?"
381 RCL 18	431 ST- 35	479 PROMPT
382 FS? 02	432 RCL 19	480 X=0?
383 RCL 28	433 RCL 11	481 GTO "VV"
384 FC? 02	434 *	482 GTO "HSE"
385 RCL 27	435 550	483*LBL 13
386 /	436 /	484 END
387 X↑2	437 STO 38	
388 4.3	438 RCL 35	
389 *	439 +	
390 1	440 RCL 36	
391 +	441 +	
392 RCL 52	442 RCL 37	
393 *	443 +	
394 FC? 02	444 STO 39	
395 STO 36	445*LBL "THRUST"	
396 FS? 02	446 RCL 39	
397 STO 42	447 550	
398 FS? 02	448 *	
399 GTO "PT"	449 RCL 02	
400*LBL "PP"	450 /	

## VE

### Maximum Endurance Velocity

Introduction: This program finds the minimum power required and thus the velocity and power required for maximum endurance. It works with POWER which must be loaded with the geometric and flight parameters (up through and including step 19 in the step-by-step instructions). Upper and lower velocity bounds and the velocity step increment are input and VE outputs the velocity and power required for maximum endurance. VE utilizes the same storage registers as POWER and additionally those listed below. No new equations are employed.

Additional Programs Required: POWER

Additional Storage Registers:

Storage Register	Quantity Stored
48	Velocity increment (kts)
50	V-STOP - Stopping velocity (kts)
51	scratch

VE

			SIZE 060
INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1. Initialize program		XEQ VE	*LOAD POWER*
2. Reminder flashes			V-START=?
3. Input lower bound velocity (kts)	50	R/S	INCR=?
4. Input increment (kts)	10	R/S	V-STOP=?
5. Input upper bound Velocity (kts)	150	R/S	V(END)=90
6. Output maximum endurance velocity (kts)		R/S	P(END)=1058

Note: For increased accuracy, after first run, narrow the bounds, decrease the increment and re-run the program.

VE

01*LBL "VE"	21 *	41 RCL 50
02 "LOAD POWER"	22 STO 48	42 RCL 18
03 RVIEW	23 "V-STOP=?"	43 X<=Y?
04 PSE	24 PROMPT	44 GTO 12
05 "OR PWRC"	25 1.68889	45*LBL 15
06 RVIEW	26 *	46 CF 03
07 PSE	27 STO 50	47 RCL 19
08 SF 03	28*LBL 12	48 RCL 48
09 "V-START=?"	29 RCL 44	49 -
10 PROMPT	30 STO 51	50 1.68889
11 1.68889	31 RCL 48	51 /
12 *	32 ST+ 18	52 FIX 0
13 STO 18	33 CP 02	53 "W<END>="
14 0	34 XEQ "CT"	54 ARCL X
15 STO 19	35 RCL 51	55 RVIEW
16 CF 02	36 RCL 44	56 STOP
17 XEQ "CT"	37 X<=Y?	57 RCL 51
18 "INCR=?"	38 GTO 14	58 "P<END>="
19 PROMPT	39 GTO 15	59 ARCL X
20 1.68889	40*LBL 14	60 RVIEW
		61 END

## VMR

### Maximum Range Velocity

Introduction: This program determines the maximum range velocity of a given configuration helicopter. The user loads POWER with the basic geometric and flight parameters (up through and including step 19 in the POWER step-by-step instructions). Lower and upper velocity bounds are input by the user, as well as the velocity increment for getting from the lower and upper bound. The phantom shaft horsepower of the aircraft is also entered. This can be determined by first running FUEL. VMR then iterates through POWER in order to determine the minimum ratio of the sum of total power and phantom power  $\langle PT(AC) + PSHP \rangle$  to VF. This is the point of tangency of a line drawn from the point of zero velocity to the power versus velocity curve. This point of tangency is the point of maximum range for the aircraft. VMR utilizes the same storage registers as POWER, and additionally those listed below,

Additional Programs Required: POWER

Equations:

$$\tan \phi = \langle PT(AC) + PSHP \rangle / VF$$

Definition of  $\tan \phi$

Additional Storage Registers:

Storage

Register Stored Quantity

48	Velocity increment (kt)
49	PSHP - Phantom shaft horsepower (SHP)
50	V-STOP - stopping velocity (kt)
54	scratch

VMR

			SIZE 060
INSTRUCTION	INPUT	FUNCTION	DISPLAY
1. Initialize program		XEQ VMR	
2. Reminder flashes			*LOAD POWER*
3. Reminder flashes			PSHP=?
4. Input phantom shaft horsepower (SHP)	300	R/S	V-START=?
5. Input lower bound velocity (kt)	50	R/S	INCR=?
6. Input increment (kt)	10	R/S	V-STOP=?
7. Input upper bound velocity (kt)	160	R/S	VMR= 140
8. Output max range velocity (kt)		R/S	P(VMR)= 1379
9. Output max range power (SHP)			

NOTE: To increase accuracy, repeat procedure with 10 kt between the lower and upper bounds and an increment of 1 kt.



## VMR

01♦LBL "VMR"	38 XEQ "CT"
02 "LOAD POWER"	39 RCL 44
03 AVIEW	40 RCL 49
04 PSE	41 +
05 CF 02	42 RCL 18
06 SF 03	43 /
07 "PSHP=?"	44 RCL 51
08 PROMPT	45 X>Y?
09 STO 49	46 GTO 02
10 "V-START=?"	47 GTO 03
11 PROMPT	48♦LBL 02
12 1.68889	49 RCL Y
13 *	50 STO 51
14 STO 18	51 RCL 50
15 0	52 RCL 18
16 STO 19	53 X<=Y?
17 XEQ "CT"	54 GTO 01
18 RCL 44	55♦LBL 03
19 RCL 49	56 RCL 18
20 +	57 RCL 48
21 RCL 18	58 -
22 /	59 STO 18
23 STO 51	60 1.68889
24 "INCR=?"	61 /
25 PROMPT	62 FIX 0
26 1.68889	63 "VMR="
27 *	64 ARCL X
28 STO 48	65 AVIEW
29 "V-STOP=?"	66 STOP
30 PROMPT	67 CF 02
31 1.68889	68 XEQ "CT"
32 *	69 RCL 44
33 STO 50	70 "P<VMR>="
34♦LBL 01	71 ARCL X
35 RCL 48	72 AVIEW
36 ST+ 18	73 STOP
37 CF 02	74 END

WT

(WT LT - Light)  
(WT MED - Medium)  
(WT HV - Heavy)

Helicopter Weight Estimation

Introduction: These programs are designed to provide by an iterative process, weight estimations to be used in determining final helicopter design weight. Curve fit equations determine the majority of component weight values, such as tail structure and landing gear systems. Equations are listed with the assignment of non-standard storage registers for user modification, if desired. The equations are from ref. 2, Page 20 f. The user must enter into storage the initial values defined in Storage Registers 01 - blade radius (ft); 03 - blade chord (ft); 05 - rotational velocity (rad/sec); 06 - empty weight (lbs); 07 - number of people; 09 - person weight (lbs); 09 - cargo weight (lbs); 33 - fuel weight (lbs); 34 - total power (SHP); 36 - number of engines; and 37 - engine weight and/or transmission weight (lbs), if specified.

The program will determine revised empty weight, gross weight and total power requirement based on weight computations plus a percentage change based on prior value. (a 10% or less change is usually desired). The program allows the user to input specific transmission and/or engine weights, or it will generate its own curve fit values. In addition, the user may choose to retain initial inputted values or to revise inputs during subsequent iterations of the program.

The program defines useful load as the sum of both number of people (times the person weight specified) and the cargo weight.

All three programs utilize very similar storage registers and prompt similar requests. Program WT MED is demonstrated in the following example.

WT MED (Illustrated)

			Size 060
INSTRUCTION	INPUT	FUNCTION	DISPLAY
1. Initialize Program		XEQ WT MED	R=?
2. Input Radius (ft)	25	R/S	c=?
3. Input chord (ft)	1.9	R/S	b=?
4. Input blade number	4	R/S	RV=?
5. Input RV (rad/sec)	28.8	R/S	We=?
6. Input empty Weight (lbs)	9000	R/S	PEOPLE=?
7. Input People	3	R/S	PERSON WT=?
8. Input Person Wt (lbs)	250	R/S	CARGO=?
9. Input cargo wt (lbs)	6000	R/S	FUEL(lb)=?
10. Input fuel weight (lbs)	3500	R/S	PT(SHP)=?
11. Input total power (SHP)	1600	R/S	NENG=?
12. Input number of engines	2	R/S	ACTWT or R/S? ENG WT(E) =?
Given the option, User choses to input actual weight (ACTWT) specified			
13a. Input specified Engine weight	750	R/S	ACWT or R/S=? TRAN WT(E)=?
14a. Input specified Transmission weight	1600	R/S	REV We= 9276.7

WT MED

INSTRUCTION	INPUT	FUNCTION	DISPLAY
15. Determine Revised Total Weight (lbs)		R/S	WG=19526.
16. Determine Revised PT (SHP)		R/S	REV PT= 2057.1
17. Determine % Error		R/S	ER(%)= -9.83
13b. Input ENG WT (Accepting Curve fit value)		R/S	ACTWT or R/S? TRANS WT =?
Having accepted Curve fit value for Engine weight, User accepts Curve fit value for Transmission weight			
14b. Accept Transmission weight and output revised Empty weight		R/S	REV We= 8509.4
<p>If user accepted curvefit values for Steps 13b, and 14b, Resultant values for Steps 14,15,16,17 would be:  REV We= 8509.4, REV WG= 18759.4,  REV PT= 1959.4, and ER(%)= -6.14</p> <p>User accepts these values or seeks additional iteration with new empty weight, total weight, and total power (results from Steps 14,15,16).</p>			
18. Seeks additional iteration		R/S	ENG WT(E) =?
19. See Step 12 above and repeat  or			
20. Re-initialize program		XEQ WT MED	R=?

Weight Estimating Relationships  
Storage Register Utilization  
Light Helicopter

Storage Register	Stored Quantity
01	We - Empty weight (lbs)
03	People - Number of passengers and crew
05	Cargo - Weight of cargo (lbs)
06	Fuel (lbs) - Fuel weight (lbs)
07	PT (SHP) - Total power (SHP)
08	Neng - Number of engines
09	Gross weight (lbs) $W_g = 1.73 \cdot W_e^{.378}$
10	Total tail surface area (sq ft) $Stt = 0.264 \cdot e^{(.0135 H_p)}$
11	Body surface area (sq ft) $S_b = 194.274 \cdot \ln(W_g) - 1306.779$
12	Main rotor system weight (lbs) $W_1 = 408.562 \cdot \ln(S) - 1142.917$
13	Tail rotor system weight (lbs) $W_{2A} = 2.219 \cdot e^{(.0005 W_g)}$
	Tail rotor structure weight (lbs) $W_{2B} = 19.131 \cdot \ln(Stt) - 32.414$
14	Body weight (lbs) $W_3 = 0.00901 \cdot S_b^{1.917}$
15	Landing gear weight (lbs) $W_4 = -0.0539 \cdot W_g + 200.912$
16	Nacelle weight (lbs) $W_5 = 34.0$
17	Propulsion Engine weight (lbs) $W_{6A} = -0.0896 \cdot HP + 221.338$

LIGHT HELICOPTER

Storage Register	Stored Quantity
18	Drive system weight (lbs) $W6B = 17.190 \cdot e^{(.0009 W_g)}$
19	Fuel tanks weight (lbs) $W6C = 0.384 \cdot (\text{Fuel}/6.5)^{1.0710}$
20	Flight controls weight (lbs) $W7 = 0.000000000128 \cdot W_g^{3.469}$
21	Auxiliary power system weight (lbs) $W8 = 0.0$
22	Flight instruments weight (lbs) $W9 = 24.571 \cdot e^{(.0004 \text{ HP})}$
23	Hydraulics system weight (lbs) $W10 = 0.0$
24	Electrical system weight (lbs) $W11 = -51.0661 \cdot \ln(S_b) + 367.947$
25	Avionics system weight (lbs) $W12 = 105.0 + \text{Special (if any)}$
26	Furnishings weight (lbs) $W13 = 19.8 e^{(.372 \text{ People})} + e^{(-.033 S_b)}$
27	Air and Ice system weight (lbs) $W14 = -22.371 \cdot \ln(S_b) + 143.396$
28	Load and Handling equipment weight (lbs) $W15 = 0.0$
33	R - Main rotor radius (ft)
34	c - Main rotor chord (ft)
35	b - Number of blades
36	Person Wt - Weight of an individual (lbs)
37	RV - Main rotor rotational velocity (rad/sec)

LIGHT HELICOPTER

Storage Register	Stored Quantity
38	Scratch
39	Scratch
40	Scratch

Weight Estimating Relationships  
Storage Register Utilization  
Medium Helicopter

Register	Stored Quantity
01	We - Empty weight (lbs)
03	People - Number of passengers and crew
05	Cargo - Weight of cargo (lbs)
06	Fuel (lbs) - Fuel weight (lbs)
07	PT (SHP) - Total power (SHP)
08	Neng - Number of engines
09	Gross weight (lbs) $W_g = 16239.43 \cdot \ln(W_e) - 130252.76$
10	Total tail surface area (sq ft) $Stt = 0.0376 \cdot H_p - 8.106$
11	Body surface area (sq ft) $S_b = 636.081 \cdot e^{(.000011 W_g)}$
12	Main rotor system weight (lbs) $W1 = 11.0702 \cdot S - 168.888$
13	Tail rotor system weight (lbs) $W2A = 0.00438 \cdot W_g + 12.470$
	Tail rotor structure weight (lbs) $W2B = 2.411 \cdot Stt - 19.531$
14	Body weight (lbs) $W3 = 0.282 \cdot S_b^{1.272}$
15a or	Landing gear weight (lbs) - Wg less than 6000 lbs $W4 = 0.015 \cdot e^{(.000062 W_g + 8.020)}$
15b	Landing gear weight - Wg greater than 6000 lbs $W4 = 301.577 \cdot \ln(W_g) - 2319.890$
16	Nacelle weight (lbs) $W5 = 0.02 \cdot e^{(.000062 W_g + 8.02)}$



MEDIUM HELICOPTER

Storage Register	Stored Quantity
17	Propulsion Engine weight (lbs)- One engine $W6A = 130.0 + 0.451 \cdot HP$
	Two or more engines $W6A = 295.0 + 0.188 \cdot HP$
18	Drive system weight (lbs) $W6B = 741.460 \cdot \ln(HP) - 4542.042$
19	Fuel tanks weight (lbs) $W6C = 363.24 \cdot \ln(\text{Fuel}/6.5) - 1656.521$
20	Flight controls weight (lbs) $W7 = 210.858 \cdot e^{(.000059 W_g)}$
21	Auxiliary power system weight (lbs)- One engine $W8 = 0.0$
	Two Or more engines $W8 = 190.0$
22	Flight instruments weight (lbs) $W9 = 56.0975 \cdot \ln(HP) - 312.237$
23	Hydraulics system weight (lbs) $W10 = 0.00362 \cdot W_g + 11.553$
24	Electrical system weight (lbs) $W11 = 481.735 \cdot \ln(S_b) - 2794.530$
25	Avionics system weight (lbs) $W12 = 250 + \text{Special (if any)}$
26	Furnishings weight (lbs) $W13 = 0.175 \cdot S_b + 22.0 \cdot \text{People} - 10.0$
27	Air and Ice system weight (lbs) $W14 = 122.458 \cdot \ln(S_b) - 730.252$
28	Load and Handling equipment weight (lbs) $W15 = 84.5$
33	R - Main rotor radius (ft)

MEDIUM HELICOPTER

Storage Register	Stored Quantity
35	b - Number of blades
36	Person Wt - Weight of an individual (lbs)
37	RV - Main rotor rotational velocity (rad/sec)
38	Scratch
39	Scratch
40	Scratch

Weight Estimating Relationships  
Storage Register Utilization  
Heavy Helicopter

Storage Register	Stored Quantity
01	We - Empty weight (lbs)
03	People - Number of passengers and crew
05	Cargo - Weight of cargo (lbs)
06	Fuel (lbs) - Fuel weight (lbs)
07	PT (SHP) - Total power (SHP)
08	Neng - Number of engines
09	Gross weight (lbs) $W_g = 4.975 \cdot W_e^{.887}$
10	Total tail surface area (sq ft) $Stt = 60.127 \cdot e^{(.000145 \text{ HP})}$
11	Body surface area (sq ft) $Sb = 426.378 \cdot e^{(.000045 W_g)}$
12	Main rotor system weight (lbs) $W1 = 707.174 \cdot e^{(.00539 S)}$
13	Tail rotor system weight (lbs) $W2A = 324.550 \cdot \ln(W_g) - 3021.510$
	Tail rotor structure weight (lbs) $W2B = -18.0 + 2.830 Stt$
14	Body weight (lbs) $W3 = 2.9818 \cdot Sb - 1321.921$
15	Landing gear weight (lbs) $W4 = 258.358 \cdot e^{(.000041 W_g)}$
16	Nacelle weight (lbs) $W5 = 0.014 \cdot (0.241 W_g)^{1.136}$
17	Propulsion Engine weight (lbs) - One engine $W6A = 348.0 + 0.910 \cdot \text{HP}$

## HEAVY HELICOPTER

Register	Stored Quantity
18	Drive system weight (lbs) $W6B = 0.999 \cdot HP^{.939}$
19	Fuel tanks weight (lbs) $W6C = 454.619 \cdot (Fuel/6.5)^{-.0566}$
20	Flight controls weight (lbs) $W7 = 0.0034 \cdot W_g^{1.224}$
21	Auxiliary power system weight (lbs) $W8 = 139.0$
22	Flight instruments weight (lbs) $W9 = 68.266 \cdot \ln(HP) - 387.598$
23	Hydraulics system weight (lbs) $W10 = 0.000000663 \cdot W_g^{1.863}$
24	Electrical system weight (lbs) $W11 = 9.780 \cdot Sb^{.539}$
25	Avionics system weight (lbs) $W12 = 325 + \text{Special (if any)}$
26	Furnishings weight (lbs) $W13 = 0.159 \cdot Sb + 18.11 \cdot \text{People}$
27	Air and Ice system weight (lbs) $W14 = 117.771 \cdot \ln(sb) - 710.594$
28	Load and Handling equipment weight (lbs) $W15 = -72.0 + (0.111 \cdot Sb) + (3.49 \cdot \text{People})$

HEAVY HELICOPTER

Storage Register	Stored Quantity
33	R - Main rotor radius (ft)
34	c - Main rotor chord (ft)
35	b - Number of blades
36	Person Wt - Weight of an individual (lbs)
37	RV - Main rotor rotational velocity (rad/sec)
38	Scratch
39	Scratch
40	Scratch

WT LT

01*LBL "WT LT"	51 STO 07	101 *	151 AVIEW
02 RCL 33	52 RCL 08	102 +	152 PSE
03 "P=?"	53 "NENG=?"	103 STO 13	153 SF 21
04 PROMPT	54 PROMPT	104 ST+ 29	154 "TRAN WT(Σ)=?"
05 STO 33	55 STO 08	105*LBL "W3"	155 PROMPT
06 RCL 34	56*LBL "WG"	106 RCL 11	156 STO 18
07 "c=?"	57 RCL 01	107 1.917	157 ST+ 29
08 PROMPT	58 .378	108 Y↑X	158*LBL "W6C"
09 STO 34	59 Y↑X	109 .00901	159 RCL 06
10 *	60 173.701	110 *	160 6.5
11 RCL 35	61 *	111 STO 14	161 /
12 "b=?"	62 STO 09	112 ST+ 29	162 1.071
13 PROMPT	63*LBL "STT"	113*LBL "W4"	163 Y↑X
14 STO 35	64 RCL 07	114 RCL 09	164 .384
15 "S"	65 .0135	115 -.0539	165 *
16 RCL 34	66 *	116 *	166 STO 19
17 *	67 E↑X	117 200.912	167 ST+ 29
18 RCL 33	68 .264	118 +	168*LBL "W7"
19 *	69 *	119 STO 15	169 RCL 09
20 STO 02	70 STO 10	120 ST+ 29	170 3.469
21 RCL 37	71*LBL "Sb"	121*LBL "W5"	171 Y↑X
22 "RV=?"	72 RCL 09	122 34	172 1.281 E-10
23 PROMPT	73 LN	123 STO 16	173 *
24 STO 37	74 194.274	124 ST+ 29	174 STO 20
25 RCL 01	75 *	125*LBL "W6A"	175 ST+ 29
26 "We=?"	76 1306.779	126 RCL 07	176*LBL "W8"
27 PROMPT	77 -	127 -.0896	177 0
28 STO 01	78 STO 11	128 *	178 STO 21
29 RCL 03	79*LBL "W1"	129 221.388	179 ST+ 29
30 "PEOPLE=?"	80 RCL 02	130 +	180*LBL "W9"
31 PROMPT	81 LN	131 STO 17	181 RCL 07
32 STO 03	82 408.562	132 CF 21	182 .0004
33 RCL 36	83 *	133 "ACTWT OR R/S"	183 *
34 "PERSON WT=?"	84 1142.917	134 AVIEW	184 E↑X
35 PROMPT	85 -	135 PSE	185 24.571
36 STO 36	86 STO 12	136 SF 21	186 *
37 RCL 03	87 STO 29	137 "ENG WT(Σ)=?"	187 STO 22
38 *	88*LBL "W2A"	138 PROMPT	188 ST+ 29
39 STO 04	89 RCL 09	139 STO 17	189*LBL "W10"
40 RCL 05	90 .0005	140 ST+ 29	190 0
41 "CARGO=?"	91 *	141*LBL "W6B"	191 STO 23
42 PROMPT	92 E↑X	142 RCL 09	192 ST+ 29
43 STO 05	93 2.219	143 .0008	193*LBL "W11"
44 RCL 06	94 *	144 *	194 RCL 11
45 "FUEL (LB)=?"	95*LBL "W2B"	145 E↑X	195 LN
46 PROMPT	96 32.414	146 17.198	196 -51.0661
47 STO 06	97 -	147 *	197 *
48 RCL 07	98 RCL 10	148 STO 18	198 367.947
49 "PT (SHP)=?"	99 LN	149 CF 21	199 +
50 PROMPT	100 19.131	150 "ACTWT OR R/S"	200 STO 24

WT LT

201 ST+ 29	251 ST+ 29	301 2
202*LBL "W12"	252 "CARGO"	302 PI
203 RCL 07	253 RCL 05	303 *
204 .003	254 ST+ 29	304 "DENSITY"
205 *	255 "PEOPLE WT"	305 .0023769
206 E+X	256 RCL 04	306 *
207 1120.354	257 "NEW WT"	307 RCL 33
208 *	258 ST+ 29	308 X+2
209 LM	259 "WG="	309 *
210 -122.282	260 ARCL 29	310 SORT
211 *	261 AVIEW	311 "B"
212 1062.004	262 XEQ "PT"	312 .97
213 +	263 "REV PT="	313 *
214 STO 25	264 ARCL 07	314 1/X
215 ST+ 29	265 AVIEW	315 RCL 29
216*LBL "W13"	266 ADV	316 1.5
217 RCL 03	267 RCL 09	317 Y+X
218 .372	268 RCL 29	318 *
219 *	269 -	319 RCL 07
220 E+X	270 RCL 29	320 +
221 19.8	271 /	321 550
222 *	272 100	322 /
223 RCL 11	273 *	323 STO 07
224 -.033	274 "ER<%=)"	324 RTN
225 *	275 ARCL X	325 END
226 E+X	276 PROMPT	
227 +	277 RCL 29	
228 STO 26	278 STO 09	
229 ST+ 29	279 GTO "W1"	
230*LBL "W14"	280*LBL "PT"	
231 RCL 11	281 .125	
232 LM	282 RCL 35	
233 -22.371	283 *	
234 *	284 RCL 34	
235 143.396	285 *	
236 +	286 "Cdo"	
237 STO 27	287 .01	
238 ST+ 29	288 *	
239*LBL "W15"	289 "DENSITY"	
240 0	290 .0023769	
241 STO 28	291 *	
242 "NEW We"	292 RCL 37	
243 ST+ 29	293 3	
244 "REV We="	294 Y+X	
245 ARCL 29	295 *	
246 AVIEW	296 RCL 33	
247 RCL 29	297 4	
248 STO 01	298 Y+X	
249 "FUEL WT"	299 *	
250 RCL 06	300 STO 07	

WT MED

01*LBL "WT MED"	51 STO 07	101 ST+ 29	151 RCL 07
02 RCL 33	52 RCL 08	102*LBL "W3"	152 .24
03 "P=?"	53 "NENG=?"	103 RCL 11	153 *
04 PROMPT	54 PROMPT	104 1.272	154 130
05 STO 33	55 STO 08	105 Y+X	155 +
06 RCL 34	56*LBL "WG"	106 .282	156 STO 17
07 "C=?"	57 RCL 01	107 *	157 CF 21
08 PROMPT	58 LN	108 STO 14	158 "ACTWT OR R/S"
09 STO 34	59 16239.43	109 ST+ 29	159 AVIEW
10 *	60 *	110 RCL 09	160 PSE
11 RCL 35	61 130252.76	111 6000	161 SF 21
12 "b=?"	62 -	112 X>Y?	162 "ENG WT(Σ)=?"
13 PROMPT	63 STO 09	113 GTO "W41"	163 PROMPT
14 STO 35	64*LBL "STT"	114*LBL "W42"	164 STO 17
15 "S"	65 RCL 07	115 RCL 09	165 ST+ 29
16 RCL 34	66 .0376	116 LN	166 GTO "W6B"
17 *	67 *	117 301.577	167*LBL "W6A2"
18 RCL 33	68 8.106	118 *	168 RCL 07
19 *	69 -	119 2319.89	169 .19
20 STO 02	70 STO 10	120 -	170 *
21 RCL 37	71*LBL "Sb"	121 STO 15	171 350.4
22 "RV=?"	72 RCL 09	122 ST+ 29	172 +
23 PROMPT	73 .000011	123 GTO "W5"	173 STO 17
24 STO 37	74 *	124*LBL "W41"	174 CF 21
25 RCL 01	75 E+X	125 RCL 09	175 "ACTWT OR R/S"
26 "We=?"	76 636.001	126 .000062	176 AVIEW
27 PROMPT	77 *	127 *	177 PSE
28 STO 01	78 STO 11	128 8.02	178 SF 21
29 RCL 03	79*LBL "W1"	129 +	179 "ENG WT(Σ)=?"
30 "PEOPLE=?"	80 RCL 02	130 E+X	180 PROMPT
31 PROMPT	81 11.0702	131 .025	181 STO 17
32 STO 03	82 *	132 *	182 ST+ 29
33 RCL 36	83 168.888	133 STO 15	183*LBL "W6B"
34 "PERSON WT=?"	84 -	134 ST+ 29	184 RCL 07
35 PROMPT	85 STO 12	135*LBL "W5"	185 LN
36 STO 36	86 STO 29	136 RCL 09	186 741.460
37 RCL 03	87*LBL "W2A"	137 .000062	187 *
38 *	88 RCL 09	138 *	188 4542.042
39 STO 04	89 .00438	139 8.02	189 -
40 RCL 05	90 *	140 +	190 STO 18
41 "CARGO=?"	91 12.47	141 E+X	191 CF 21
42 PROMPT	92 +	142 .02	192 "ACTWT OR R/S"
43 STO 05	93*LBL "W2B"	143 *	193 AVIEW
44 RCL 06	94 RCL 10	144 STO 16	194 PSE
45 "FUEL (LB)=?"	95 2.411	145 ST+ 29	195 SF 21
46 PROMPT	96 *	146 1	196 "TRAN WT(Σ)=?"
47 STO 06	97 +	147 RCL 08	197 PROMPT
48 RCL 07	98 19.531	148 X>Y?	198 STO 18
49 "PT (SHP)=?"	99 -	149 GTO "W6A2"	199 ST+ 29
50 PROMPT	100 STO 13	150*LBL "W6A1"	200*LBL "W6C"



WT MED

201 RCL 06	251 481.735	301 ST+ 29	351 "DENSITY"
202 6.5	252 *	302 "PEOPLE WT"	352 .0023769
203 /	253 2794.53	303 RCL 04	353 *
204 LN	254 -	304 "NEW WG"	354 RCL 33
205 363.24	255 STO 24	305 ST+ 29	355 X+2
206 *	256 ST+ 29	306 "WG="	356 *
207 1656.521	257*LBL "W12"	307 ARCL 29	357 SORT
208 -	258 RCL 07	308 AVIEW	358 "B"
209 STO 19	259 .139	309 XEQ "PT"	359 .97
210 ST+ 29	260 *	310 "REV PT="	360 *
211*LBL "W7"	261 77.823	311 ARCL 07	361 1/X
212 RCL 09	262 +	312 AVIEW	362 RCL 29
213 .000059	263 STO 25	313 ADV	363 1.5
214 *	264 ST+ 29	314 RCL 09	364 Y+X
215 E+X	265*LBL "W13"	315 RCL 29	365 *
216 210.858	266 RCL 03	316 -	366 RCL 07
217 *	267 22	317 RCL 29	367 +
218 STO 20	268 *	318 /	368 550
219 ST+ 29	269 10	319 100	369 /
220*LBL "W8"	270 -	320 *	370 STO 07
221 0.	271 RCL 11	321 "ER(<?>)"	371 RTN
222 STO 21	272 .175	322 ARCL X	372 END
223 ST+ 29	273 *	323 PROMPT	
224 1	274 +	324 RCL 29	
225 RCL 08	275 STO 26	325 STO 09	
226 X<=Y?	276 ST+ 29	326 GTO "W1"	
227 GTO "W9"	277*LBL "W14"	327*LBL "PT"	
228 190	278 RCL 11	328 .125	
229 STO 21	279 LN	329 RCL 35	
230 ST+ 29	280 122.458	330 *	
231*LBL "W9"	281 *	331 RCL 34	
232 RCL 07	282 730.252	332 *	
233 LN	283 -	333 "Cdo"	
234 56.0975	284 STO 27	334 .01	
235 *	285 ST+ 29	335 *	
236 312.237	286*LBL "W15"	336 "DENSITY"	
237 -	287 84.5	337 .0023769	
238 STO 22	288 STO 28	338 *	
239 ST+ 29	289 "NEW Me"	339 RCL 37	
240*LBL "W10"	290 ST+ 29	340 3	
241 RCL 09	291 "REV Me="	341 Y+X	
242 .00362	292 ARCL 29	342 *	
243 *	293 AVIEW	343 RCL 33	
244 11.553	294 RCL 29	344 4	
245 +	295 STO 01	345 Y+X	
246 STO 23	296 "FUEL WT"	346 *	
247 ST+ 29	297 RCL 06	347 STO 07	
248*LBL "W11"	298 ST+ 29	348 2	
249 RCL 11	299 "CARGO"	349 PI	
250 LN	300 RCL 05	350 *	

WT HV

01*LBL "WT HV"	51 STO 07	101 AVIEW	151 .000198
02 RCL 33	52 RCL 08	102 PSE	152 *
03 "R=?"	53 "NENG=?"	103 SF 21	153 E+X
04 PROMPT	54 PROMPT	104 "ENC WT(Σ)=?"	154 565.507
05 STO 33	55 STO 08	105 PROMPT	155 *
06 RCL 34	56 RCL 31	106 STO 17	156 STO 17
07 "c=?"	57 "TANDEM?"	107 ST+ 29	157 ST+ 29
08 PROMPT	58 PROMPT	108*LBL "W2A"	158 RCL 11
09 STO 34	59 STO 31	109 RCL 09	159 LN
10 *	60*LBL "WG"	110 LN	160 3467.291
11 RCL 35	61 RCL 01	111 324.55	161 *
12 "b=?"	62 .887	112 *	162 22118.298
13 PROMPT	63 Y+X	113 3021.51	163 -
14 STO 35	64 4.975	114 -	164 STO 14
15 "S"	65 *	115*LBL "W2B"	165 ST+ 29
16 RCL 34	66 STO 09	116 RCL 10	166*LBL "W4"
17 *	67*LBL "STT"	117 2.83	167 RCL 09
18 RCL 33	68 RCL 07	118 *	168 .000041
19 *	69 .000145	119 +	169 *
20 STO 02	70 *	120 18.0	170 E+X
21 RCL 37	71 E+X	121 -	171 258.358
22 "PY=?"	72 60.127	122 STO 13	172 *
23 PROMPT	73 *	123 ST+ 29	173 STO 15
24 STO 37	74 STO 10	124*LBL "W3"	174 ST+ 29
25 RCL 01	75*LBL "Sb"	125 RCL 11	175*LBL "W5"
26 "We=?"	76 RCL 09	126 2.9818	176 RCL 09
27 PROMPT	77 .000045	127 *	177 .2041
28 STO 01	78 *	128 1321.921	178 *
29 RCL 03	79 E+X	129 -	179 1.136
30 "PEOPLE=?"	80 426.378	130 STO 14	180 Y+X
31 PROMPT	81 *	131 ST+ 29	181 .014
32 STO 03	82 STO 11	132 RCL 31	182 *
33 RCL 36	83*LBL "W1"	133 X(=0?)	183 STO 16
34 "PERSON WT=?"	84 RCL 02	134 GTO "W4"	184 ST+ 29
35 PROMPT	85 .00539	135 0	185*LBL "W6B"
36 STO 36	86 *	136 STO 10	186 RCL 07
37 RCL 03	87 E+X	137 STO 13	187 .959
38 *	88 707.174	138 RCL 09	188 Y+X
39 STO 04	89 *	139 .000041	189 .999
40 RCL 05	90 STO 12	140 *	190 *
41 "CARGO=?"	91 STO 29	141 E+X	191 STO 18
42 PROMPT	92*LBL "W6A"	142 567.688	192 CF 21
43 STO 05	93 RCL 07	143 *	193 "ACTWT OR R/S"
44 RCL 06	94 .91	144 STO 11	194 AVIEW
45 "FUEL (LB)=?"	95 *	145 RCL 12	195 PSE
46 PROMPT	96 348	146 2	196 SF 21
47 STO 06	97 +	147 *	197 "TRAN WT(Σ)=?"
48 RCL 07	98 STO 17	148 STO 12	198 PROMPT
49 "PT (SHP)=?"	99 CF 21	149 STO 29	199 STO 18
50 PROMPT	100 "ACTWT OR R/S"	150 RCL 07	200 ST+ 29

201\*LBL \*W6C\*  
202 RCL 06  
203 6.5  
204 /  
205 -.0566  
206 Y+X  
207 454.619  
208 \*  
209 STO 19  
210 ST+ 29  
211\*LBL \*W7\*  
212 RCL 09  
213 1.224  
214 Y+X  
215 .00334  
216 \*  
217 STO 20  
218 ST+ 29  
219\*LBL \*W8\*  
220 139.0  
221 STO 21  
222 ST+ 29  
223\*LBL \*W9\*  
224 RCL 07  
225 LN  
226 68.266  
227 \*  
228 387.598  
229 -  
230 STO 22  
231 ST+ 29  
232\*LBL \*W10\*  
233 RCL 09  
234 1.863  
235 Y+X  
236 .000000663  
237 \*  
238 STO 23  
239 ST+ 29  
240\*LBL \*W11\*  
241 RCL 11  
242 .539  
243 Y+X  
244 9.78  
245 \*  
246 STO 24  
247 ST+ 29  
248\*LBL \*W12\*  
249 RCL 07  
250 LN

251 16744.967  
252 \*  
253 100666  
254 -  
255 .536  
256 Y+X  
257 1.9  
258 \*  
259 STO 25  
260 ST+ 29  
261\*LBL \*W13\*  
262 RCL 11  
263 .159  
264 \*  
265 RCL 03  
266 18.11  
267 \*  
268 +  
269 STO 26  
270 ST+ 29  
271\*LBL \*W14\*  
272 RCL 11  
273 LN  
274 117.771  
275 \*  
276 710.594  
277 -  
278 STO 27  
279 ST+ 29  
280\*LBL \*W15\*  
281 RCL 03  
282 3.49  
283 \*  
284 72  
285 -  
286 RCL 11  
287 .111  
288 \*  
289 +  
290 STO 28  
291 \*NEW We\*  
292 ST+ 29  
293 \*REV We=\*  
294 ARCL 29  
295 AVIEW  
296 RCL 29  
297 STO 01  
298 \*FUEL WT\*  
299 RCL 06  
300 ST+ 29

WT HV

301 \*CARGO\*  
302 RCL 05  
303 ST+ 29  
304 \*PEOPLE WT\*  
305 RCL 04  
306 \*NEW MG\*  
307 ST+ 29  
308 \*MG=\*  
309 ARCL 29  
310 AVIEW  
311 XEQ \*PT\*  
312 \*REV PT=\*  
313 ARCL 07  
314 AVIEW  
315 ADV  
316 RCL 09  
317 RCL 29  
318 -  
319 RCL 29  
320 /  
321 100  
322 \*  
323 \*ER(?)\*  
324 ARCL X  
325 PROMPT  
326 RCL 29  
327 STO 09  
328 GTO \*W1\*  
329\*LBL \*PT\*  
330 .125  
331 RCL 35  
332 \*  
333 RCL 34  
334 \*  
335 \*CDO\*  
336 .01  
337 \*  
338 \*DENSITY\*  
339 .0023769  
340 \*  
341 RCL 37  
342 3  
343 Y+X  
344 \*  
345 RCL 33  
346 4  
347 Y+X  
348 \*  
349 STO 07  
350 2

351 PI  
352 \*  
353 \*DENSITY\*  
354 .0023769  
355 \*  
356 RCL 33  
357 X+2  
358 \*  
359 SQRT  
360 \*B\*  
361 .97  
362 \*  
363 1/X  
364 RCL 29  
365 1.5  
366 Y+X  
367 \*  
368 RCL 07  
369 +  
370 550  
371 /  
372 STO 07  
373 RTN  
374 END

**END**

**FILMED**

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*1-86*

**DTIC**