01532 D

Program Description I

Program Title: MOON LANDER WITH UNINTERRUPTABLE CONTINUOUS COUNTDOWN

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Program Description, Equations, Variables

This version of the moon lander replaces the pausing countdown of Standard Pac program #14 A with a continuous countdown during which all keyboard functions are locked out. If you wish, you can delete the countdown entirely and have the calculator blank out for several seconds before it asks for your burn.

You can record this program over your "protected" standard pac card but will need an additional half a card for data.

This program also has an onboard computer that provides advice on landing. The program also corrects errors in the standard pac program.

THE COUNTER To make counters, you must generate non-normalized numbers. The information below about non-normalized numbers and program overwriting is taken from the Personal Programmable Calculator Club Journal. If you want to know more about these and other tricks, write to the PPC Club at 2541 W Camden Place, Santa Ana, California 92704.

Key in the following program, taking care to put the steps at the indicated program lines.

```
001 f LBL A   31 25 11
002 GTO A     22 11
216 f LBL A   31 25 11
217 f GSB B   31 22 12
222 f LBL B   31 25 12
223 g MERGE   32 41
224 h PAUSE   35 72
```

NOTE: To enter step #216, press: GTO · 215 then key it in

Switch to run and have any two sided program on SIDE 2, ready

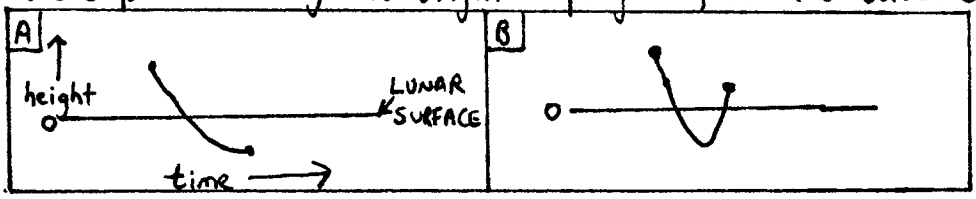
to push into the reader. (This program will not be overwritten or damaged.) Press [A] and push the prerecorded card in at the first pause in the program. The display will show Error after reading the card, so key [CLX] and see 10.00 in the display. Key in .000222211 then press [+] and see 10.00 in the display. Then do STO 0 500 STO 1 50 [CHS] STO 2 60 STO 3 . Now also press [Σ+] (so the data card you record will ask for another card whenever it is read.) Now press f w/DATA and record only the first side of the magnetic card. Press CLX to clear the display.

OVERWRITING Before keying in the moon lander program, practice overwriting on "protected" magnetic cards. Make a "correction card" that looks like the one below:

Insert the card into the left side of the calculator as far as it will go. Switch the calculator to w/PRGM and enter the "protected" card you want to overwrite, in the normal fashion for recording.

THE CORRECTIONS The versions of this game in the standard pac lets you fly through solid rock as part of your "perfect landing". The following maneuvers were permitted by the original program, but are solved correctly here.

FIGURE 1



The corrected program recognizes these as crashes, and gives the correct impact velocity. The basic algorithm is taken from the standard pac version, but the following tests are made: 1) Was the landing underground? (figure 1A), and 2) If you are going up, would you have crashed in the last second? (figure 1B).

THE EQUATIONS

$$a = 2b - g \quad (1)$$

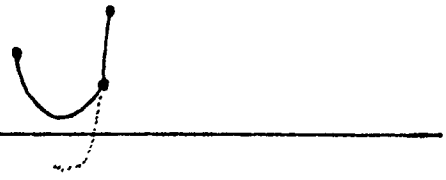
$$V = at + V_0 \quad (2)$$

$$X = \tfrac{1}{2}at^2 + V_0 t + X_0 \quad (3)$$

If a crash may have occurred, the program solves equation 3 for time of impact, with $X_{impact} = 0$ and $V_0 = V - a$ and $X_0 = X - \frac{a}{2} - V_0 = X + \frac{a}{2} - V$. Using equation 2, V_{impact} is calculated to be $-\sqrt{V^2 - 2aX}$.

Program steps 86-99 are to allow cases such as in figure 2. You have escaped hitting the surface, but later find yourself on a parabola that has real roots.

FIGURE 2



As long as the parabola you are on hasn't intersected with the surface in the last second, you are OK. (Ie. $|t_{impact}| > 1$)

THE AUTOMATIC PILOT Instead of inputting a burn when "0." is flashed, you can ask for advice on landing by pressing [C]. You get the following information:

b = Burn (the constant burn per turn needed to land at zero velocity)
$= \frac{1}{2}(g + V_o^2 / 2X_o)$

T = Time (number of such burns)
$= -2X_o/V_o$

Fuel needed = Burn x Time

The equations are derived from equations (1), (2) and (3) with $V = 0$ and $X = 0$.

NOTE: This does not necessarily give the most efficient way to land. It gives the correct burn assuming a constant burn for the rest of the landing.

WARNING: The machine only takes burns that are positive integers. A landing must involve an integral burn or combination of integral burns. If you use the exact advice given by the calculator, the advice will get rounded off to the nearest integer.

WARNING:

DO NOT PRINT OUT NON-NORMALIZED NUMBERS ON THE HP97. THIS MAY CAUSE THE PRINTER TO LOCK ON AND BURN OUT IN A FEW SECONDS. IF THIS HAPPENS BY MISTAKE, TURN THE MACHINE OFF IMMEDIATELY.

MARK YOUR DATA CARD "DON'T PRINT" EVEN IF YOU OWN AN HP 67, since someone else may borrow the card someday.

HEWLETT PACKARD WILL NOT REPAIR THE HP97 ON YOUR WARRANTY IF THIS OCCURS - you are using non-normalized numbers at your own risk.

Reference: PPC Journal Vol. 4 No. 1 Page 13

01532D Program Description II

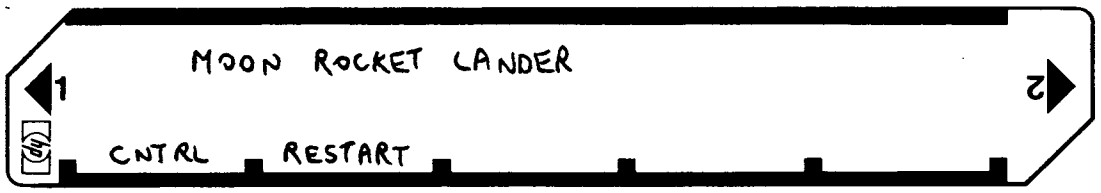
Sketch(es)

Sample Problem(s) Read in side 1 of data card and both sides of program card.
Start by pressing [A] → -50.0500, your velocity and altitude, 60., your fuel; -00XXX----- 00 where the X's are a decrementing counter. When the zero comes into the display press [C] and you are told that a burn of 3.75 units of fuel each turn for 20.00 turns, using up a total of 75.00 units of fuel is the way to land using a constant burn. Next, 60. appears to remind you how much fuel you have available. When the zero appears, enter your choice of burn.

Solution(s)
I have never seen a landing using less than 49 units of fuel. If you discover one, please let me know.

Reference(s) - Original Program is HP 67 Standard Pac SD-14A
- HP 65 "Key Notes" Winter 1976 Vol 2 Number 2
- PPC Journal Special Issue A

01532D User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Read in side 1 of the data card			crd
2.	Read in both sides of the program card			
3	Optional: blank out the countdown if presently in non-blanked mode, OR switch back to non-blanked mode if presently in blanking mode.		D	
4	Start manual descent		A	V. ALT fuel left COUNTDOWN OR BLANK 0.
5	When zero is flashed, either: a) Key in burn *	BURN		V. ALT Fuel left COUNTDOWN OR BLANK 0.
	b) Ask for advice on landing		C	BURN TIME FUEL NEEDED FUEL LEFT COUNTDOWN OR BLANK 0.
6.	Go to step 5 until you land (flashing zero) or crash (flashing impact velocity)			
7	If you survived last landing attempt, go to step 2 for another try			
	* If you miss the burn window and flameout, press B for a new engine start		B	

01532D Program Listing I

STEP	KEY ENTRY	KEY CODE	COMMENTS
001	f LBL A	31 25 11	START
	RCL 1	34 01	store initial conditions
	STO 6	33 06	
	RCL 2	34 02	
	STO 7	33 07	
	RCL 3	34 03	
	STO 8	33 08	
	f LBL 9	31 25 09	divide altitude (x) by 1000 for combined display of VV.0XXX
	RCL 6	34 06	
010	DSP 4	23 04	
	EEX	43	
	4	04	
	÷	81	
	RCL 7	34 07	take into account negative velocities
	h CF 2	35 61 02	
	f x<0	31 71	
	h SF 2	35 51 02	
	h ABS	35 64	
	+	61	
020	h F? 2	35 71 02	
	CHS	42	
	h PAUSE	35 72	display VV.0XXX
	h PAUSE	35 72	
	f LBL 1	31 25 01	DOES COUNTDOWN
	DSP 0	23 00	display fuel left
	RCL 8	34 08	
	h PAUSE	35 72	
	h F? 0	35 71 00	decrementing counter or blanked out display
	f LBL 8	31 25 08	
030	1	01	
	RCL 0	34 00	
	÷	81	
	CLX	44	
	h PAUSE	35 72	
	h ABS	35 64	accept only positive integer burns
	f RND	31 24	
	f LBL 5	31 25 05	
	RCL 8	34 08	if all fuel used, determine crash velocity
	h x≠y	35 52	
040	g x>y	32 81	
	GTO 2	22 02	
	STO -8	33 51 08	a = 2b - g where g = 5 and burn units are arbitrary. $x = x_0 + v_0 + \frac{a}{2}$ (ie for t = 1) $v = v_0 + a$
	2	02	
	x	71	
	5	05	
	-	51	
	STO 9	33 09	
	2	02	
	÷	81	
050	RCL 6	34 06	
	+	61	
	RCL 7	34 07	
	+	61	
	RCL 9	34 09	
	STO + 7	33 61 07	
	h R↓	35 53	
	STO 6	33 06	
	RCL 7	34 07	if going up now, see if have really crashed in the last second
	f x>0	31 81	
060	GTO 0	22 00	
	f LBL 3	31 25 03	
	RCL 6	34 06	find out where you are
	f INT	31 83	
	f x>0	31 81	if didn't hit moon, go for another burn
	GTO 9	22 09	
	f x<0	31 71	if hit moon, determine impact velocity
	GTO 0	22 00	
	DSP 0	23 00	if exactly on surface, show velocity ≤ 0
	RCL 7	34 07	
070	f x>0	31 81	
	CLX	44	
	f LBL 4	31 25 04	FLASH IMPACT VELOCITY
	h PAUSE	35 72	
	GTO 4	22 04	
	f LBL 0	31 25 00	CRASH VELOCITY
	RCL 7	34 07	don't crash if not on impact path (if $v^2 - 2ax < 0$)
	g x^2	32 54	
	RCL 6	34 06	
	RCL 9	34 09	
080	x	71	
	2	02	
	x	71	
	-	51	
	f x<0	31 71	
	GTO 3	22 03	
	f $\sqrt{x}$	31 54	you are on a crash path with $v_{impact} = -\sqrt{v^2 - 2ax}$ except if $\frac{-\sqrt{v^2-2ax}}{a} < \frac{v}{a}$ where you are going up but wouldn't have crashed within the previous second.
	CHS	42	
	DSP 0	23 00	
	RCL 9	34 09	
090	÷	81	
	RCL 7	34 07	
	RCL 9	34 09	
	÷	81	
	g x≤y	32 71	
	GTO 4	22 04	
	h x≠y	35 52	
	RCL 9	34 09	
	x	71	
	GTO 4	22 04	
100	f LBL 2	31 25 02	FUEL = 0
	RCL 8	34 08	free fall crash velocity, $v = \sqrt{v_0^2 + 2ax_0}$
	2	02	
	.	83	
	5	05	
	-	51	
	STO + 6	33 61 06	
	2	02	
	x	71	
	STO + 7	33 61 07	
110	RCL 6	34 06	
	1	01	
	0	00	

REGISTERS

0	1	2	3	4	5	6	7	8	9
NON NORMALIZED NUMBER	$x_0 = 500$	$V_0 = -50$	$fuel_0 = 60$			x	V	fuel	Accel.
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Program Listing II

01532D

STEP	KEY ENTRY	KEY CODE	COMMENTS
	x	71	
	RCL 7	34 07	
	g x^2	32 54	
	+	61	
	f $\sqrt{x}$	31 54	
	CHS	42	
	GTO 4	22 04	
120	f LBL B	31 25 12	FLAME-OUT RECOVERY
	5	05	
	STO - 8	33 51 08	
	0	00	
	GTO 5	22 05	
	f LBL C	31 25 13	BURN, TIME, FUEL
	DSP 2	23 02	for v=0 use a special loop
	RCL 7	34 07	
	f x=0	31 51	
	GTO 6	22 06	
130	h 1/x	35 62	$t = -2x_0/v_0$
	CHS	42	
	2	02	
	x	71	
	RCL 6	34 06	
	x	71	
	ENTER	41	save a copy of t
	h 1/x	35 62	$burn = \frac{\left(g + \frac{v_0^2}{2x_0}\right)}{2}$
	RCL 7	34 07	
	x	71	
140	CHS	42	
	5	05	
	+	61	
	2	02	
	÷	81	
	f LBL 7	31 25 07	DISPLAY ADVICE
	f - x -	31 84	Burn
	h x⇌y	35 52	
	f - x -	31 84	Time (t)
	x	71	
150	f - x -	31 84	Fuel needed
	GTO 1	22 01	Do countdown
	f LBL 6	31 25 06	if v=0 use burn of 2
	1	01	
	ENTER	41	
	2	02	
	GTO 7	22 07	
	f LBL D	31 25 14	CHANGE COUNTDOWN
	h F? 0	35 71 00	change the status of flag zero.
	GTO fd	22 31 14	
160	h SF 0	35 51 00	
	h RTN	35 22	
	g LBL fd	32 25 14	
	h CF 0	35 61 00	
	h RTN	35 22	

STEP	KEY ENTRY	KEY CODE	COMMENTS
170			
180			
190			
200			
210			
220			

LABELS

A	B	C	D	E
START	RESTART	BURN, TIME, FUEL	CHANGE COUNTDOWN	
a	b	c	d	e
			used	
0 CRASH VELOCITY	1 DOES COUNTDOWN	2 fuel = 0	3 crash	4 flash
5 used	6 v = 0	7 DISPLAY ADVICE	8 used	9 NEXT SECOND

FLAGS

0 counter ON/OFF
1
2 sign
3

SET STATUS

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