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HP 41C PROGRAM SUBMITTAL FORM
PROGRAMMFORMBLATT/DOCUMENTATION DU PROGRAMME/GENERALITÀ SUL PROGRAMMA

Program Title
Programmtitel / Titre du programme / Titolo del programma: LINEAR PROGRAMMING (SIMPLEX METHOD) I

Category No. (Kategorie Nr. / Catégorie Nº / Categoria Nº): 009
Name (Rubrik / Rubrique / Nome della categoria): Industrial Production (Operational Research)

No. of program lines
Anzahl Programmzeilen / Nombre de lignes de programme / Nº di linee di programma: 328 (74 registers)

No. of data registers
Anzahl des benötigten Datenspeicher / Nombre de registres de données / Nº di registri utilizzati: $m^2+m.n+4m+2n+13$
m=restrictions
n=unknowns

Recommended HP 41C System configuration
Empfohlene System-Konfiguration / Configuration recommandée / Configurazione raccomandata
Port # 1: memory module
Port # 2: memory module ?
Port # 3: memory module ?
Port # 4: memory module ?

This program requires the following programs as subroutines:
Dieses Programm benutzt folgende Programme als Unterprogramme:
Ce programme utilise les programmes suivants comme sous-programmes:
Questo programma usa i seguenti programmi come subroutines:

HP Applications ROM
HP Applikations ROM / ROM d'application HP / ROM di applicazione HP:

Program Name:
Programm: / Nom du programme: / Programma:

Program Abstract
Kurzbeschreibung / Résumé / Breve descrizione del programma:

Linear Programming using the simplex method. The execution happens in 1 phase. This program is only restricted by the memory capacity available; it needs $74+m^2+m.n+4m+2n+13$ registers (m=registers,n=unknowns). The program solves minimisations as well as maximisations.

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ACKNOWLEDGMENT AND AGREEMENT
Erklärung und Ermächtigung/Déclaration et Autorisation/Dichiarazione e Autorizzazione

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Date (Datum / Date / Data): 22/10/80

Signature (Unterschrift / Signature / Firma): J Lienart

Application, Equations, Variables
Anwendung, Gleichungen, Veränderliche
Application, Equations, Variables
Applicazione, Equazioni, Variabili

Explanation of the abbreviations:
==========

RESTR? : How many restrictions?

VAR? : How many unknowns?

Xi,j: Xi of the jth restriction

...>.:0 : If the restriction is 'greater or equal' write 0
If the restriction is 'smaller or equal' write any number but not 0

R.S.i,0: Right-hand side of the ith restriction.

MAX=a MIN=b : If maximisation XEQa, if minimisation XEQb

Xi=...: The solution for Xi is. (i≠0)

Si=...: The rest of the ith restriction.

X0=...: (rarely) This means that the restriction has not been used and that the rest is..., the same as with Si but without the number of the restriction.

XX=...: The solution of the object-function

Operating limits and Warnings
Grenzen und Einschränkungen
Limites et restrictions
Limiti operativi e avvertenze

A test is incorporated in this program to verify if there are enough registers(memory) available to solve the problem. If you see NONEXISTENT after having given the number of restrictions, this means that you must extend the capacity using a size-instruction. If after the appearance of NONEXISTENT you execute X≤Y this gives you the number of the last required register. If you add 1 to this number this will give you the number of required registers ... the SIZE.

Example
Beispiel
Exemple
Esempio

$$\text{MAX } XX = 15X_1 + 45X_2$$

$$\begin{cases} X_2 \leq 50 \\ X_1 + 1,6X_2 \leq 240 \\ 0,5X_1 + 2X_2 \leq 162 \end{cases}$$

$$X_1, X_2 \geq 0$$

Sketch
Skizze
Croquis
Schizzo

PROGRAM DESCRIPTION III

(Example continued)
(Beispiel Fortsetzung)
(Exemple, suite)
(Esempio)

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PROGRAMMBESCHREIBUNG III
DESCRIPTION DU PROGRAMME III
DESCRIZIONE DEL PROGRAMMA III

Data Input Dateneingabe Données Dati	Keystrokes Tasten Touches Tasti	Result Resultat Résultat Risultato	Comments Kommentare Commentaires Commenti
	XEQ LP		You can also use the R/S key.
		VAR ?	
2	2 R/S	RESTR ?	
3	3 R/S	X1,1	
0	0 . R/S	X2,1	
1	1 R/S	...>.:0	You may key in anything
	1 R/S	R.S.1,0	e.g. in this case 1
50	50 R/S	X1,2	
1	1 R/S	X2,2	
1,6	1,6 R/S	...>.:0	Anything for example '2'
	2 R/S	R.S.2,0	
240	240 R/S	X1,3	
0,5	0,5 R/S	X2,3	
2	2 R/S	...>.:0	Again anything for example 12
12	12 R/S	R.S.3,0	(Except '0')
162	162 R/S	MAX=a MIN=b	
XEQ a	☒ 2+	X1,0	
15	15 R/S	X2,0	
45	45 R/S	...	
		...	
		...	
		...	
		X2,=35,0000	
	R/S	S1,=15,0000	
	R/S	X1,=184,0000	
	R/S	XX=4.335,0000	

PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

Line	Keystrokes	Comments	Line	Key pressed	Comments
01	x LBL "LP"		51	1	
	LBL C			FS? IND 03	
	T VAR?	How many variables?		CHS	
	PROMPT			STO IND Y	
05	STO 00		55	RCL 01	
	T RESTR?	How many restrictions?		1,001	
	PROMPT			STO 07	
	STO 01			*	
	3			ST+ 02	
10	10↑X		60	T R.S.	
	/			ARCL 03	
	1			PROMPT	
	+			STO IND 02	
	STO 10			RCL 07	
15	11,01		65	ST+02	
	STO 02			ISG 03	
	FIX 1			GTO 00	
	RCL 00			CF 00	
	RCL 01			T MAX=a MIN=b	
20	+		70	PROMPT	
	1		x	LBL 01	Subroutine
	+			RCL 00	to read the
	STO 05	Length of a row		3	X's
	RCL 01			10↑X	
25	3		75	/	
	+			ST+ 02	
	STO 03			RCL 03	
	XEQ 10			10	
	1			/	
30	−		80	1	
	INT	Place of the		+	
	STO 09	nr. of the restric-		GTO 04	
	RCL 00	tions.	x	LBL 02	
	+	Are there enough		T X	
35	0	memory registers#		ARCL 04	
	STO IND Y	available.		PROMPT	
	RCL 10			STO IND 02	
	STO 03			1	
x	LBL 00			ST+ 04	
40	XEQ 01	Read the X's	90	ISG 02	
	CF IND 03			GTO 02	
T	. . 2. . 0	Sign of the		RTN	
	PROMPT	restriction	x	LBL a	MAX
	X=0?			SF 00	
45	SF IND 03		95	x LBL b	MIN
	RCL 03	Construction		0	
	RCL 02	of the identity		STO 03	
	+	matrix		XEQ 01	
	1			RCL 00	
50	−		100	ST -02	

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PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

Line	Keystrokes	Comments	Line	Key pressed	Comments
001	x LBL 11	Change the	151	RCL 04	
	RCL IND 02	sign of the		RCL IND 06	
	CHS	object-function		RCL IND Z	
	STO IND 02			FS? 00	
005	ISG 02		155	CHS	
	GTO 11			+	
	RCL 01			FS? 00	
	2			CHS	
	+			X<=0?	
010	STO 03		160	GTO 03	
	XEQ 10			FS? 00	
	STO 04			CHS	
	RCL 10			SF 01	
	STO 03			X>Y?	
015	x LBL 07		165	GTO 06	
	FC? IND 03			FC? 00	
	GTO 03	No M-factors		GTO 03	
	XEQ 10			x LBL 06	
	RCL 04			STO 04	
020	STO 02		170	RCL 06	
	x LBL 08	Fill up the		STO 07	
	RCL IND 06	M-factors		LBL 03	
	6			ISG 06	
	10^X			GTO 12	
025	*		175	FC? 01	If there is
	STO IND 02			GTO 06	no entering
	RCL 07			RCL 05	variable, go
	STO 02			RCL 06	to the end
	ISG 06			RCL 04	and show the
030	GTO 08		180	-	solution.
	x LBL 03			INT	
	ISE 03			-	
	GTO 07			1	
	x LBL 12			-	
035	RCL 01		185	STO 02	Number of the
	1			RCL 10	variable
	+			STO 03	
	STO 03			x LBL 13	Which variable
	XEQ 10			XEQ 05	leaves the so-
040	-3		190	X>0?	lution?
	10^X			GTO 08	
	ST- 06			ISG 03	
	0			GTO 13	
	STO 04			T -X	There is no
045	STO 07		195	PACMPT	solution.
	CF 01			LBL 08	
	x LBL 12	Which variable		STO 04	
	RCL 06	enters the		RCL 03	
	RCL 05	solution.		STO 00	
050	+		200	x LBL 04	

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PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

Line Zeile Ligne Linea	Keystrokes Tastenfolge Touches Tasti	Comments Kommentar Commentaires Commenti	Line Zeile Ligne Linea	Key pressed Tastenfolge Touches Tasti	Comments Kommentar Commentaires Commenti
201	XE9 05		251	RCL IND 08	Execute the
	X<= 0?			RCL 04	transformati
	GTO 03			*	on the other
	RCL 04			ST - IND 06	rows
205	X<=Y?		255	1	
	GTO 03			ST+ 08	
	X<>Y			ISG 06	
	STO 04	← Variable leaving		GTO 18	
	RCL 03	the solution		LBL 03	
210	STO 00	← and its number	260	DSE 03	
	x LBL 03			GTO 16	
	ISG 03			GTO 17	Go back to
	GTO 04			x LBL 05	← the start.
	RCL 00			XE9 10	Subroutine
215	STO 03		265	RCL 05	helping to
	RCL 09	Replace the		+	find the
	+	old number by		1	leaving
	RCL 02	the number of		-	variable
	1	the new variable		RCL 06	
220	+		270	RCL 02	
	STO IND Y			+	
	XE9 10			RCL IND Y	
	STO 07			RCL IND Y	
	RCL 02			X=0?	
225	+		275	RTN	
	RCL IND X			/	
	STO 04			RTN	
	x LBL 15	Execute the		x LBL 06	Print the
	RCL 04	transformation		RCL 10	solution.
230	ST/ IND 06	on the choosen	280	STO 03	
	ISG 06	row		10	
	GTO 15			STO 08	
	RCL 01			LBL 14	
	2			RCL 05	
235	+		285	ST+ 08	
	STO 03			RCL 03	
	x LBL 16			RCL 09	If the numbe
	RCL 03			+	of a variab
	RCL 00			RCL 05	in the solu-
240	INT		290	RCL 01	tion is big-
	X=Y?			-	ger than th
	GTO 03			1	number of
	RCL 07			-	variables:
	STO 08			RCL IND Y	thismeans
245	XE9 10		295	X<=Y?	that we are
	RCL 02			GTO 03	doing with
	+			-	the rest of
	RCL IND X			CHS	a restricti
	STO 04			S	and in this
250	x LBL 13		300	GTO 06	case we

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PROGRAM LISTING
PROGRAMMAUFLISTUNG
LISTAGE DU PROGRAMME
LISTATO DI PROGRAMMA

Line Zeile Ligne Linea	Keystrokes Tastenfolge Touches Tasti	Comments Kommentar Commentaires Commenti	Line Zeile Ligne Linea	Key pressed Tastenfolge Touches Tasti	Comments Kommentar Commentaires Commenti
301	X LBL 03	print 'S'	51		
	T X	instead of			
	LBL 06	'X'			
	FIX 0				
305	ARCL X		55		
	T I =				
	FIX 4				
	ARCL IND 08				
	PROMPT				
310	ISG 03		60		
	GTO 14				
	RCL 05				
	STO 08				
	T XX=	The solution			
315	ARCL IND 08	of the object	65		
	PROMPT	function			
	LBL 10				
	RCL 03				
	INT				
320	RCL 05		70		
	X				
	1,001				
	X				
	RCL 05				
325	-		75		
	11,01				
	+				
	STO 06				
30			80		
35			85		
40			90		
45			95		
50			100		

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USER INSTRUCTIONS I

PROGRAMMABLAUF I
INSTRUCTIONS D'EMPLOI I
NORME OPERATIVE I

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Résultat Risultato
1	Key in Program.			
2	Start Program		XEQ LP	VAR ?
3	Key in the desired numbers.			RESTR ?
				...>.:0
				R.S.i,0
				MAX=a MIN=b
				Xi,0
	Perhaps the memory-capacity is too small; in this case execute the following steps:			
			XEQ LP	VAR ?
			4	RESTR ?
			3	NONEXISTENT
			X≤Y	54
			XEQ SIZE	SIZE ...
			SIZE 055	54
			XEQ LP	VAR ?
			4	RESTR ?
			3	X1,1
			...	...
			...	...
	If the program shows '-X' this means that there is no solution.			
	You can also avoid X0 in the solution by adding the following program lines after line number 014	015	STO 03	
		016	LBL 20	
		017	RCL 09	
		018	RCL 03	
		019	+	
	If you have enough data registers available, this simplifies the lecture of the solution.	020	RCL 00	
		021	RCL 03	
		022	INT	
		023	+	
		024	STO IND Y	
		025	ISG 03	
		026	GTO 20	

USER INSTRUCTIONS II

PROGRAMMABLAUF II
INSTRUCTIONS D'EMPLOI II
NORME OPERATIVE II

Step Schritt Pas Passo	Instructions Operation Instructions Istruzioni	Variables Dateneingabe Données Dati	Function(s) Taste(n) Touche(s) Tasti	Result Resultat Resultat Risultato
			...	...
			STO 09	STO 09
	ERROR IN LINE 033	REPLACE	RCL 00 BY	RCL 01
			+	+
	(This error affects only		...	...
	the test of the memory-size)			
	ATTENTION !!!!!	034	...	
	The program lines to remove	035	0	
	Xo from the solution and to	036	STO IND Y	
	replace the notation by Si		RCL 01	
	must be put after program		STO 06	
	line 036		1	
			STO 03	
			LBL 14	
	(This addition is not necessary		RCL 09	
	it affects only the design of		RCL 03	
	the solution)		+	
			RCL 00	
			RCL 03	
			+	
			STO IND Y	
			1	
			ST + 03	
			DSE 06	
			GTO 14	
		(037)	RCL 10	
			STO 03	
			...	
	Attention a memory-size of at least			
	011 is required to use the			
	program and the memory-size-test			

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REGISTERS, STATUS, FLAGS

REGISTERBELEGUNG, FLAGS, BETRIEBSARTEN
REGISTRES, INDICATEURS, MODES OPÉRATOIRES
REGISTRI, MODI OPERATIVI, FLAGS

Registers
Datenspeicher
Registres de données
Registri

00	...	50	
	RESTR ///		
	...		
	...		
	...		
05	Number of columns	55	
	If you subtract n, you find the		
	... location-1 of the dual		
	...		solution.
	Location-1 of the number of the		
10	RESTR for ISG restrictions.		
	From here you find the matrix.		
15		65	
20		70	
25		75	
30		80	
35		85	
40		90	
45		95	
		99	

Status
Betriebsart
Modes opératoires
Modi operativi

Size $m^2+3m+3n$ +m.n+13 Total Reg. Size+74

			User Mode
Eng ☐	Fix ☐	Sci ☐	On ☒
Deg ☐	Rad ☐	Grad ☐	Off ☐

Purpose / Flags

	Purpose (Bedeutung / Signification / Scopo)	SET	CLEAR	
00	MAX or MIN	X		⇒MAX
01	If the flag is		X	⇒At the end
02	set this means			this means
03	that the restric-			that the
04	tion is			solution is
05	'smaller or equal'			found.
06				
07				
08				
09				
10				
11	Audio execute			
12				
13				
14				
15				
16				
17				
18				
19				
20				
21	Printer Enable			
22	Number Input			
23	Alpha Input			
24	Range Ignore			
25	Error Ignore			
26	Audio Enable			
27	User Mode			
28	Decimal Point			
29	Digit Grouping			

Assignments
Tastenbelegung / Assignations / Assegnamenti

Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)	Function (Funktion / Fonction / Funzione)	Key (Taste / Touche / Tasto)