TEXAS INSTRUMENTS
Calculator Products Division

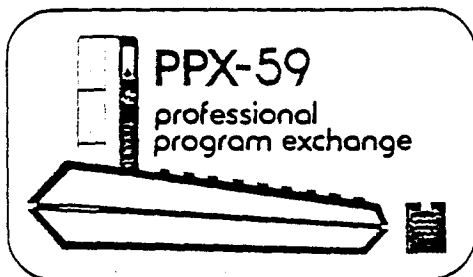
Submission Abstract

Program Title Prime Factors of an Integer		Rev. B
Abstract of Program Computes prime factors of an integer N in order of increasing magnitude. Automatically senses whether a printer is used to determine whether to stop when each prime factor is determined, or to print the prime factor and continue.		
User Benefits: Fast. Eliminates dependence on tables. Handles numbers larger than those found in tables.		
Category Number <u>39</u>	Required Progs. <u>None</u>	Prog. Steps <u>196</u>
		PC-100A Needed <input type="checkbox"/> Library <input type="checkbox"/> Module ID <input type="checkbox"/>
Submittal Agreement <p>All of the information forwarded herewith is contributed to Texas Instruments on a nonconfidential, nonobligatory basis; no relationship, confidential or otherwise express or implied, is established with Texas Instruments by this contribution. The submitter retains his or her copyright on this material and grants to Texas Instruments a non-exclusive, world-wide, royalty-free license to exercise any of the rights granted to an owner of copyright by law. To my knowledge, this is an original work, which does not infringe the copyright of another and contribution of this information to Texas Instruments by me does not breach any obligation to any other person or organization relating to proprietary or confidential information.</p>		Submission Checklist <input checked="" type="checkbox"/> Recorded <input checked="" type="checkbox"/> Magnetic Cards <input checked="" type="checkbox"/> Submission Abstract <input checked="" type="checkbox"/> Program Description <input checked="" type="checkbox"/> User Instructions <input checked="" type="checkbox"/> Sample Problem <input checked="" type="checkbox"/> Listing <input type="checkbox"/> _____ <input type="checkbox"/> _____
Signature <u>Palmer O. Hanson, Jr.</u> Date <u>12 Oct 1980</u> Name <u>Palmer O. Hanson, Jr.</u> Mbr. No. <u>917659</u> Address <u>2149 14th Avenue SW</u> Tel. No. <u>813-581-1850</u> City <u>Largo</u> State <u>Florida</u> Zip <u>33540</u>		

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Program Description

Program Title: Prime Factors of an Integer	Rev. B
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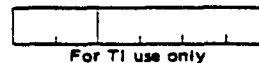
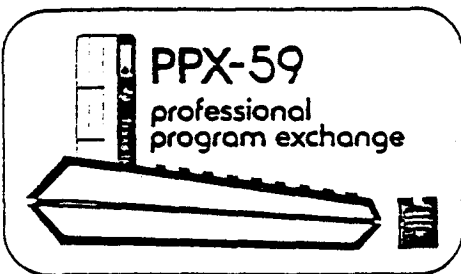
Method, Equations, Sketches, Limitations, References, Error Recovery:

This program finds prime factors in the same manner as PPX program number 398075 as originally submitted by Daniel Drucker of Royal Oak, Michigan on July 18, 1978 but includes the following corrections and additions:

1. An automatic printer sensing routine is provided such that the program simply prints out each prime factor as it is found and proceeds to test for additional prime factors if a printer is used, but stops with each prime factor in the display if a printer is not used.
2. The documentation for the original program indicated that scientific notation was used internally to obtain a speed increase of about three per cent. In practice, the original program provided the increased speed only for the calculation of the first prime factor since the CLR at location 26 returned the calculator to standard format at the time the first prime factor was displayed. In the revised program the CLR is maintained to provide a normal display and printout, but an EE is added later to return to scientific mode for subsequent calculations.
3. The original program could be used for eleven or twelve digit input values, but the EE which was used to set scientific mode at the start of the program had to be replaced with a Nop (code 68) to prevent the data in the guard digits from being discarded. That idiosyncrasy was corrected in the revision so that eleven or twelve digit numbers could be analyzed without altering the program.

The remaining description essentially quotes the documentation for the original version with changes only where where required to reflect the revisions described above.

This program tests positive numbers less than or equal to $\text{Int}(\sqrt{N})$ to determine whether they divide N. First 2, 3, 5, and 7 are tested. Numbers greater than 7 are used as test divisors only if they are not divisible by 2, 3, 5, or 7. Each group of 210 consecutive numbers contains 48 such

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Continuation Sheet

Continued From: ☒ Program Description ☐ User Instructions ☐ Stmt. of Example

Program Title:	Prime Factors of an Integer	Rev.	B
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numbers to be used as test divisors. When a test divisor D divides N evenly (in which case D is necessarily prime) D is either printed or displayed and N is replaced by its unfactored portion $U = N/D$. The last prime divisor is flashed indicating that factorization is complete. N itself appears as a flashing divisor (the first divisor displayed) when N is prime. Approximately every sixth test divisor is compared with $\text{Int}(\sqrt{U})$ so that the program will terminate promptly when U is prime. (Note: A program which compares every test divisor with $\text{Int}(\sqrt{U})$ will run slightly faster for certain small primes, but will squander a great deal of time when the divisors are not all small).

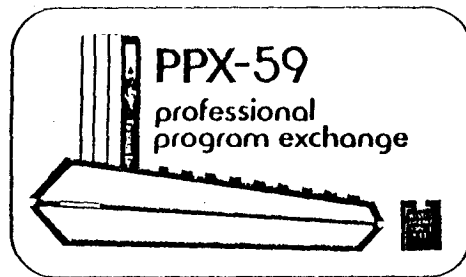
The program uses scientific notation internally to increase its speed by about three per cent. The program can be applied for eleven or twelve digit numbers by synthesizing the values in scientific notation. For example, to enter the twelve digit number 111,111,111,111 press 1,111,111,111 x 100 + 11 = .

A rough estimate of running time for the program is given by the formula $T = \frac{1}{4} \text{minimum}(F_0, \text{Int}(\sqrt{N}))$

where F_0 is the smallest prime factor of N . Here running time is taken to mean only the time to the display or printout of the first factor. The estimate is too small when F_0 is small and too large when N is a large prime.

The printer sensing routine (locations 074 through 078) uses a negative display value to trigger an error if the printer is connected, and Op 19 to set flag seven in response to the error. Printout or stopping with the prime factor in the display is then controlled by the IfFlg 7 at location 029 through 032.

The Op 69 command uses the callup of an illegal Op code to cause a flashing display without altering the value in the display. (Locations 055/056)



User Instructions

Program Title <u>Prime Factors of An Integer</u>			
<u>N</u>			
Partition (OP 17) Parentheses Levels			
<u>479,59</u>	<u>1</u>	t Register	<input checked="" type="checkbox"/>
Angular Mode (if applicable)	SBR Levels <u>2</u>	Absolute Addresses	<input checked="" type="checkbox"/>
Library Module ID		Disturbs Pending Operations	<input checked="" type="checkbox"/>

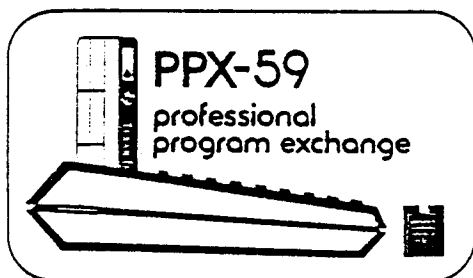
USER DEFINED KEYS	
A	Solve
B	
C	
D	Subroutine
E	Subroutine
A'	
B'	
C'	
D'	
E'	

DATA REGISTERS (INV)	
0	N
1	u
2	Int \sqrt{u}
3	D
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
0	
1	
2	
3	
4	

FLAGS	0	1	2	3	4	5	6	Printer, included	8	9
-------	---	---	---	---	---	---	---	----------------------	---	---

STEP	PROCEDURE	ENTER	PRESS		OUTPUT/MODE (see legend below)
	<u>With Printer</u> Enter integer to be factored and find prime factors.	N		A	Print out N followed by prime factors in order of increasing magnitude. Stops with last factor flashing in display
1	<u>Without Printer</u> Enter integer to be factored and find smallest prime factor.	N		A	Smallest prime factor in display. Display flashes ^N if N is prime or if $ N < 2$.
2	Optional Step			$x \geq t$ $x \geq t$	Unfactored part of N is displayed. This step is not required, but may be done if desired.
3	Find next factor			$R \div 5$	Next factor in display. Display flashes if it is the largest prime factor.
4	Repeat 3 as necessary.				

Modes: n* - Printed only (n) - Displayed briefly (Pause)
(n)* - Printed and displayed



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Sample Problem

Prime Factors of an Integer Rev. B

Statement of Example

Examples are given for operation with and without a printer. In addition, an example is given to illustrate the three per cent slowdown which occurs if scientific mode is not used internally.

The problem used for the printer example and for the illustration of the speed effects of scientific notation is the value 987654321 which factors into 3, 3, 17, 17, 379721.

The problem used for the example without a printer is 8463839 which factors into 23, 71, 71, 73.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
<u>Example with a printer:</u>			
987654321	A	<p>Calculator stops after about 2 minutes 19 seconds with 379721 flashing in the display. The printout which includes the input value is:</p> <pre> 987654321. 3. 3. 17. 17. 379721. </pre>	
<u>Example of effect of not using scientific mode internally:</u>			
	GTO 035 LRN 2nd-Nop LRN GTO 079 LRN 2nd-Nop	<p>035 52 in the display 036 61 in display</p> <p>079 52 in the display 080 24 in the display</p> <p><small>Modes: n* — Printed only (n) — Displayed Briefly (Pause) ni* — Printed and displayed</small></p>	

* Over

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Exchange
Sample Problem (cont'd)

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ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
<u>Example of effect of not using scientific mode internally (cont):</u>			
987654321	LRN A	Calculator stops after about 2 minutes 23 seconds with 379721 flashing in the display and the same printout as shown above. This indicates that scientific mode saves about four seconds for this problem.	
<u>Example without a printer:</u>			
8463839	A	Calculator stops with 23 in the display after about ten seconds.	23 is the first prime factor.
	$\times \Rightarrow t$	367993 in the display.	367993 is the unfactored part.
	$\times \Rightarrow t$	23 in the display.	
	R/S	Calculator stops with 71 in the display after about eleven seconds.	71 is the second prime factor.
	$\times \Rightarrow t$	5183 in the display.	5183 is the remaining un-factored part.
	$\times \Rightarrow t$	71 in the display.	
	R/S	Calculator stops with 71 in the display after about two seconds. (Note: It is not necessary to view the un-factored part--that step will be skipped this time.)	Another 71 is the third prime factor.
	R/S	Calculator stops with 73 flashing in the display after about two seconds.	73 is the last prime factor.
	CLR	Stops flashing display.	
	RCL 00	8463839 in display.	This option permits viewing the original integer to be tested.

Modes: n* — Printed only (n) — Displayed Briefly (Pause)
int — Printed and displayed

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LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	91	R/S		053	01	01		106	14	D	
001	76	LBL		054	99	PRT		107	06	6	
002	14	D	Forms next	055	69	DP	Causes	108	14	D	
003	44	SUM	test value D	056	69	69	flashing	109	04	4	
004	03	03	in R03	057	81	RST	Exit	110	14	D	
005	43	RCL		058	42	STD		111	02	2	
006	01	01		059	01	01	Store	112	14	D	
007	55	+	Calculate	060	34	FX	the	113	04	4	
008	43	RCL	u/D	061	59	INT	u	114	15	E	
009	03	03		062	42	STD	and	115	06	6	
010	75	-		063	02	02	INT√u	116	14	D	
011	22	INV	IF fractional	064	92	RTN		117	06	6	
012	59	INT	part ≠ 0,	065	76	LBL		118	14	D	
013	29	CP	D is not prime	066	11	A	Enter	119	02	2	
014	67	EQ	to u. Go	067	98	ADV	and	120	14	D	
015	00	00	get a new	068	99	PRT	Print	121	06	6	
016	19	19	divisor	069	42	STD	N	122	14	D	
017	54)		070	00	00	Store N	123	04	4	
018	92	RTN		071	71	SBR	in R00	124	14	D	
019	54)	IF D is	072	00	00	set u=N	125	02	2	
020	71	SBR	prime, set	073	58	58	in R01	126	15	E	
021	00	00	u=u/D	074	94	+/-		127	06	6	etc
022	58	58		075	69	DP	Sets ↑	128	14	D	
023	43	RCL		076	07	07	Flag ? if	129	04	4	
024	01	01	Print	077	69	DP	Printer is	130	14	D	
025	32	X/↑	or	078	19	19	used	131	06	6	
026	35	CLR	Display	079	52	EE	convert	132	14	D	
027	43	RCL	D	080	24	CE	scientific	133	08	8	
028	03	03		081	02	2	Use 2 as	134	14	D	
029	87	IFF	in	082	42	STD	first Test	135	04	4	
030	07	07	normal	083	03	03	Divisor	136	14	D	
031	00	00	mode	084	71	SBR	Go to	137	02	2	
032	34	34		085	00	00	test of 2	138	15	E	
033	91	R/S		086	45	45		139	04	4	
034	99	PRT		087	01	1	test of	140	14	D	
035	52	EE	scientific	088	14	D	3	141	02	2	
036	61	GTD		089	02	2	Test of	142	14	D	
037	00	00		090	15	E	5	143	04	4	
038	43	43		091	02	2	Test of	144	14	D	
039	76	LBL	Entry to	092	14	D	7	145	08	8	
040	15	E	test whether	093	04	4	Test of	146	14	D	
041	44	SUM	u is prime	094	14	D	11	147	06	6	
042	03	03		095	02	2	Add 2	148	14	D	
043	43	RCL		096	14	D	and test	149	04	4	
044	03	03		097	04	4	Add 4	150	15	E	
045	32	X/↑		098	14	D	and test	151	06	6	
046	43	RCL	Get the	099	02	2	Add 2	152	14	D	
047	02	02	new INT√u	100	14	D	and test	153	02	2	
048	77	GE		101	04	4	Add 4, test	154	14	D	
049	00	00		102	15	E	Is D too big				
050	05	05		103	06	6					
051	35	CLR	Exit if	104	14	D	etc				
052	43	RCL	u is prime	105	02	2					

MERGED CODES

62	72	83
63	73	84
64	74	92

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LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
155	04	4	↓				7 and will be used as test divisors.				
156	14	D									
157	06	6									
158	14	D									
159	02	2									
160	14	D	etc.								
161	06	6									
162	15	E									
163	06	6									
164	14	D									
165	04	4									
166	14	D									
167	02	2									
168	14	D									
169	04	4									
170	14	D									
171	06	6									
172	14	D									
173	02	2									
174	15	E									
175	06	6	↓								
176	14	D									
177	04	4									
178	14	D									
179	02	2									
180	14	D									
181	04	4									
182	14	D									
183	02	2									
184	14	D									
185	01	1									
186	00	0									
187	15	E									
188	02	2									
189	14	D									
190	01	1									
191	00	0									
192	14	D									
193	61	GTD	Return to form test divisors from the next group of 210 consecutive numbers. 48 of the 210 are not divisible by 2, 3, 5, or								
194	00	00									
195	95	95									

62	PO	63	STO	64	GTO
63	PO	73	RCL	84	PO
64	PO	74	SUM	92	INV