INF 102
FORTH

History of Forth

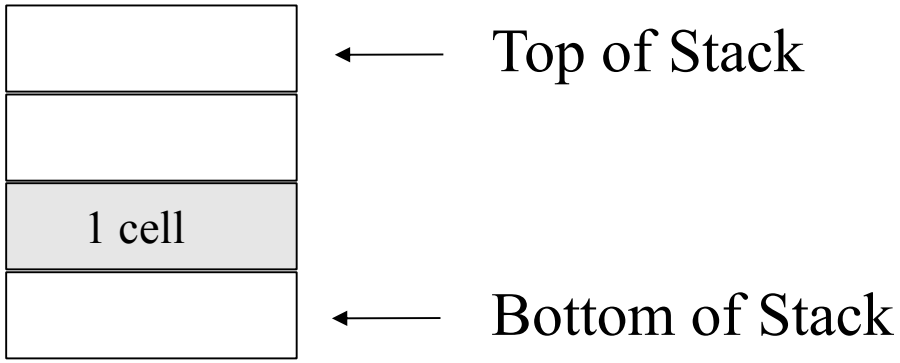
- Forth was developed by Chuck Moore in the 1960s (see Forth - The Early Years by C. Moore and The Evolution of Forth by E. Rather, et al).
- Original use for Forth was to perform instrument control, data acquisition, and least-squares curve-fitting at NRAO and Kitt Peak.
- Became a formal programming language in 1977 with Forth-77 standard. Subsequent standards were Forth-79 and Forth-83 by the Forth Standards Team.
- First commercial Forth system for IBM-PC introduced in 1982 by Laboratory Microsystems, Inc.
- Became an ANSI standard language in 1994, resulting in ANS-Forth.

Overview of Forth

- Forth is interactive
  - Perform computations directly at the Forth prompt.
  - Define and examine variables and constants
  - Define and execute new Forth *words* (individual subroutines).
  - Execute operating system commands.

Overview of Forth

- Forth syntax is derived from use of a data stack.
  - The basic method of passing arguments to, and obtaining results from, Forth words is through the data stack.



Overview of Forth

- Forth maintains a list of words, a ***dictionary***.

```
words
WORD            WORDS           FIND            '               [']
[               ]               CREATE          DOES>           >BODY
FORGET          COLD            ALLOT           ?ALLOT          LITERAL
EVALUATE        IMMEDIATE       CONSTANT        FCONSTANT       VARIABLE
FVARIABLE       CELLS           CELL+           CHAR+           DFLOATS
DFLOAT+         SFLOATS         SFLOAT+         ?               @
!               2@              2!              A@              C@
C!              W@              W!              F@              F!
DF@             DF!             SF@             SF!             SP@
RP@             >R              R>              R@              2>R
2R>             2R@             ?DUP            DUP             DROP
SWAP            OVER            ROT             -ROT            NIP
TUCK            PICK            ROLL            2DUP            2DROP
2SWAP           2OVER           2ROT            DEPTH           BASE
BINARY          DECIMAL         HEX             1+              1-
2+              2-              2*              2/              DO
?DO             LOOP            +LOOP           LEAVE           UNLOOP
I               J               BEGIN           WHILE           REPEAT
UNTIL           AGAIN           IF              ELSE            THEN
CASE            ENDCASE         OF              ENDOF           RECURSE
BYE             EXIT            QUIT            ABORT           ABORT"
```

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Applications of Forth

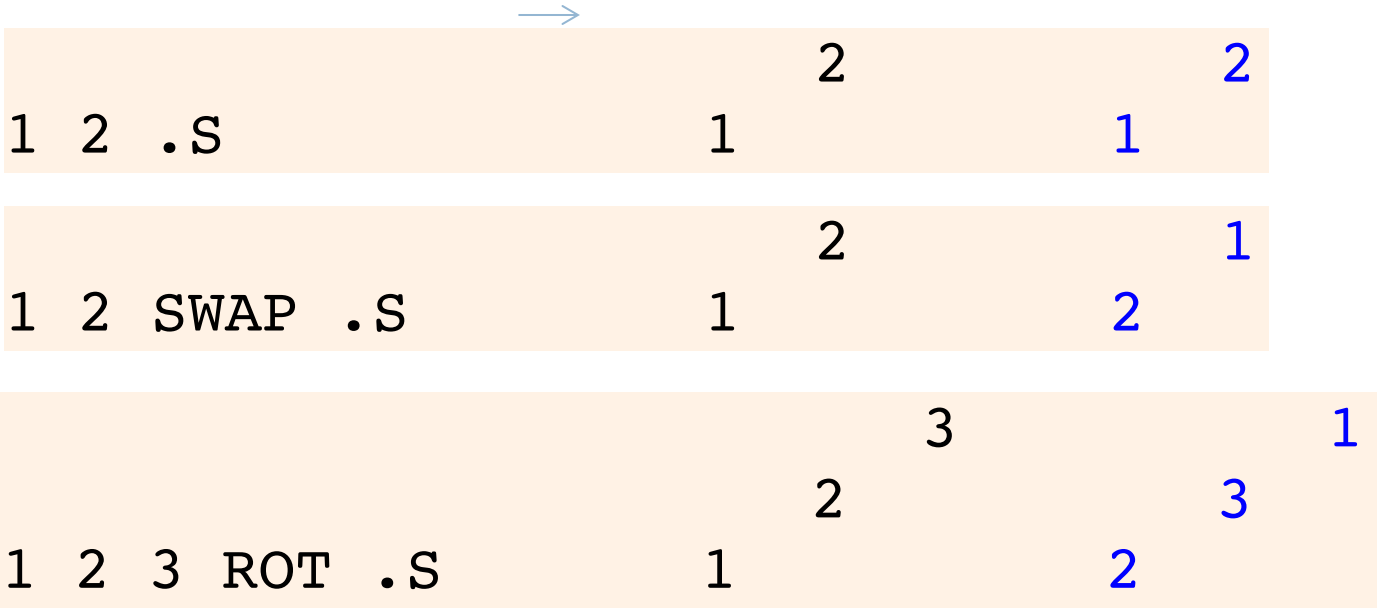
- Embedded Systems:
  - smart cards, robotics, Fed-Ex package trackers, embedded web servers, space applications
- Software Tools Development
  - writing cross-assemblers and disassemblers
  - writing parsers and programming languages
  - scripting and software testing
- Application Development
  - editors, word processors, games, circuit modeling, VLSI design, ...
- Laboratory Automation
  - Hardware Interfacing
  - Data acquisiton, data logging
  - Instrument control
- Engineering and Scientific Computing
  - Data analysis
  - Simulation and modeling
  - Visualization
- Exploratory Computing
  - algorithm development
  - artificial intelligence programming, cellular automata, evolutionary programming

Forth Language

Stack Operations:

```
DUP   SWAP   ROT    DROP   OVER
>R    R>     ?DUP   NIP    TUCK
PICK  .S     .      2DUP   ...
```

Examples:



Forth Language

Integer Arithmetic:

```
+     -      *       /     */
MOD   /MOD   1+      1-
NEGATE       ABS
```

Examples:

```
3 8 * . 24 ok

56 5 MOD . 1 ok
```

Forth Language

Relational Operators:

```
 =   <    >    <=    >=
0=   0<   ...
```

Examples:

```
1 3 < . -1 ok

4 0= .  0 ok

-5 -2 <= .  -1 ok
```

Forth Language

Bitwise Operators:

```
AND     OR      XOR   INVERT
LSHIFT  RSHIFT  2*    2/
```

Example:

```
: byte-swap ( n – m )
    DUP 8 RSHIFT SWAP 255 AND 8 LSHIFT OR ;

4096 byte-swap .  16 ok
```

Forth Language

Branching:

```
IF ... THEN
IF ... ELSE ... THEN
CASE ... OF ... ENDOF ... ENDCASE
```

Example:

```
: even?   ( n -- )
    2 MOD 0= IF ." YES" ELSE ." NO" THEN ;

5 even?  NO ok
8 even?  YES ok
```

Forth Language

Looping:

```
DO ... LOOP          ?DO ... LOOP
DO ... +LOOP         ?DO ... +LOOP
I  J
BEGIN ... AGAIN
BEGIN ... UNTIL
BEGIN ... WHILE ... REPEAT
```

Example:

```
: 2^  ( n — 2^n)  1 SWAP LSHIFT ;

: pow2-sum ( n — m | sum of terms 2^i, i=0,n-1)
0 SWAP 0 ?DO  i 2^ + LOOP ;

 10 pow2-sum .  1023 ok
```

Forth Language

Indefinite Loop Example:

```
: pad2 ( n – m | m is next power of 2, >= n)
DUP 0 <= IF DROP 1 THEN 1
BEGIN
  2DUP >
WHILE
  2*
  REPEAT
  NIP ;

348 pad2 . 512 ok
```

Forth Language

Recursion Example:

```
\ Find the greatest common divisor of two
\ integers

: gcd  ( n1 n2 -- gcd )
    ?DUP IF SWAP OVER MOD RECURSE THEN ;

1050 432 gcd .  6 ok
```

From A Beginner's Guide to Forth by J.V. Noble

Forth Resources

- Forth Programmers Handbook
- Forth Code Index
- comp.lang.forth

Forth in Python:

http://openbookproject.net/py4fun/forth/forth.html