An Interactive Expression Evaluator

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Introduction

ABACUS is a simple interactive expression evaluator available as a program under ORVYL or as a multiple-user subsystem under MILTEN. ABACUS was originally written at SLAC in the fall of 1974. Some of its features are:

- FORTRAN-like expression evaluation
- Standard mathematical functions
- User-defined variables
- Pseudo-variables and functions for terminal I/O
- IF-THEN-ELSE expressions
- Looping expressions (FOR, UNTIL, WHILE)
- Hexadecimal input and output, when requested
- User-defined functions
- WYLBUR-like modification of commands, expressions, and functions
- File storage of user-defined functions

To run ABACUS when ORVYL is up, simply type "CALL ABACUS". (You, or your LOGON file, must have already executed a "SET ORV" command.) To temporarily return to WYLBUR, type "wylbur"; to then return to ABACUS, type "abacus". To terminate ABACUS, type "exit".

To start a MILTEN subsystem version of ABACUS if ORVYL is not up and ABACUS is not already running, type "EXEC FROM WYL.CG.LJS.LIB#ABACUS ON CAT". This will start an ABACUS job which will allow any number of people to sign on simultaneously. When the job has started, type "abacus" as a command to WYLBUR to enter ABACUS. If you have started the ABACUS job, it would considerate not to cancel it if other people are using it.

The prompt for ABACUS is a colon (:) to distinguish it from the normal WYLBUR prompt (?). The response to a colon prompt may be an expression or a command. What follows is a brief explanation-by-example of the expressions; the full syntax is included at the end.
(1) **SIMPLE_EXPRESSIONS**

**FORTRAN-like arithmetic expressions may be entered directly.** More than one may be entered on a single line.

```
: 2+2
 4

: 1+3*sin(.34)
 2.0004613

: e^x(50.5)/2  atan(.34)
 4.2740671E+21  0.32773851
```

The following elements may be used in such expressions:

a) **Decimal constants:** 2 2.2 -2.2e-4

b) **Hex constants** (constants with leading zeroes and no decimal point): 01c43e 0a 012 0413a469b0
If the number of digits after the zero is less than 9, it is interpreted as a right-adjusted fixed-point integer. If there are 9 or more digits after the zero, it is interpreted as a left-adjusted floating-point number.

c) **Functions** (most FORTRAN functions are available):
   
   sin(0.46)  sqrt(abs(log(.5)-1))
   (You can also define functions; see section 6)

d) **Variables** (8 characters or less)
Two variables are predefined: PI and E

e) **Operators.** The following list is in increasing order of operator strength:

   + -   binary (2-operand) addition and subtraction
   * /   binary multiplication and division
   **    exponentiation
   + -   unary (prefix) plus and minus
   !     factorial  n!=gamma(n+1)

f) **Parentheses may be used wherever needed to override the operator precedence rules.**

   2*(a+b)  (n+1)!
All expressions are evaluated using double-precision floating point arithmetic. Operations which involve only integers and integer functions are computed to more precision than integer arithmetic would allow (at least 53 bits) and no low-bit errors will occur. Results are printed in what ABACUS deems to be a 'reasonable' format depending on the value; in particular, integers are printed as such.

(2) ASSIGNMENT EXPRESSIONS

Variables are created by assigning them a value.

: x=sin(pi/3)
  0.8660254

Since assignments are expressions, they may be used as part of larger expressions.

: sqrt(y=exp(3.4))
  5.4739474

Undefined variables are prompted for when their value is needed. Any expression can be used to define them.

: log2(bignum)
UNDEFINED VAR
BIGNUM: 2**8
  8

(3) PSEUDO-VARIABLES and PSEUDO-FUNCTIONS

INPUT (abbreviated INP), OUTPUT (abbreviated OUT), and OUTNL are functions that can be used to input and output values to the terminal. These are useful primarily in looping statements and functions.

The argument of INPUT should be one or more variable names, whose values will be requested at the terminal. The argument of OUTPUT or OUTNL should be one or more variables or expressions, whose values will be written to the terminal. OUTPUT writes the values but does not necessarily go to the next line; OUTNL forces a new line to begin after the values are written. OUTNL is particularly useful in conjunction with FOR-loops for printing tables. OUTNL can also be used without arguments to force a new line.
The value of these pseudo-functions is the value of the last argument.

\[ \text{input}(a) ** 2 \]
\[ a = 3 \]
\[ 9 \]

\[ 1 + \text{output}(a, 3 * 4) \]
\[ a = 3 \quad 12 \quad 13 \]

INPUT, OUTPUT, and OUTNL can also be used as pseudo-variables, that is, without an argument list. Whenever INPUT is used in an expression, a new value will be requested from the terminal; whenever OUTPUT or OUTNL is assigned a value, that value will be written to the terminal.

There is a special variable named AC whose value is always the last number written to the terminal.

(4) LOOPING EXPRESSIONS

(A) FOR Loops

An "Algol-style" FOR-TO-BY loop can be used. The body can be a single expression or multiple expressions enclosed in DO...END.

\[ s = 0; \text{for } i = 1 \text{ to } 10 \ s = s + 1 \]
\[ 0 \quad 55 \]

\[ \text{for } x = 0 \text{ to } 10 \text{ by } .5 \text{ do } y = x ** 2 \quad s = s + y \text{ end} \]
\[ 772.5 \]
\[ y \]
\[ 100 \]

The initial value and the increment are assumed to be 1 if omitted. If the terminating value is omitted, the loop continues until the attention key is pressed or an error is encountered.

The "value" of these expressions (the result printed automatically) is the last expression evaluated in the body. Often, however, other results will be stored in variables or printed from within the loop by the OUTPUT pseudo-function or pseudo-variable.

\[ \text{for } i \text{ outnl}(i, \exp(i)) \]
\[ I = 1 \quad 2.7182818 \]
\[ I = 2 \quad 7.3890561 \]
\[ I = 3 \quad 20.085537 \]
\[ I = 4 \quad 54.598150 \]
\[ I = ... \]

(ATTN pressed)

ABORTED
(B) LOOP...REPEAT

A sequence of statements enclosed between LOOP and REPEAT will be executed repeatedly until one of the following occurs:

1. An embedded WHILE logical-expression is false
2. An embedded UNTIL logical-expression is true
3. The ATTN key is pressed
4. An error occurs

: loop out=sin(inp) repeat
INPUT: 1
0.84147098
INPUT: pi/2
1
INPUT: *** (ATTN pressed)
ABORTED

: loop inp(x); while x>0; out(sqrt(x)) repeat
X: 100
10
X: 10
3.1622777
X: 0
0 (returns last expression evaluated and stops)

The logical-expression used for WHILE, UNTIL, and (see next section) IF-THEN-ELSE can be any combination of arithmetic expressions with the relational operators LT, LE, GT, GE, NE, EQ (or < <= > >= =/=) and the logical operators NOT, AND, OR. (Note that '=' can often not be used as an abbreviation for 'eq' because it conflicts with the use of '=' as the assignment operator within expressions).

The semicolons used to separate expressions in the examples are optional.
(5) **IP-THEN-ELSE EXPRESSIONS**

The IP-THEN-ELSE construction is a conditional expression: its value is the THEN expression if the condition is true, and the ELSE expression otherwise. If the ELSE is omitted, the value is 0 if the condition is false.

```
: loop output = if inp(x)<0 then sin(x) else 1-cos(x) repeat
X: 1
0.45969769
X: -1
-0.84147098
X: ***
```

(ATTN pressed)

The THEN and ELSE expressions are not limited to simple arithmetic; they can be any of the complex expression types available, or a list of expressions enclosed in **DO ... END**.

```
: FOR X IF SIN(X) LT .5 THEN DO OUTNL FOR Y TO 5 OUT(X*Y) END
3 6 9 12 15
4 8 12 16 20
5 10 15...
```

(ATTN pressed)

ABORTED
(6) DEFINING FUNCTIONS

Functions may be defined (or re-defined) with the DEFINE command. Those functions may then be used wherever a built-in function may be used.

: define hyp(a,b)=sqrt(a**2+b**2)
: define sumsq(x) = sum=sum+x**2 ; outnl(x**2)
: def f(x) = if x le 1 then 1 else x*f(x-1)
: def table = for i outnl(i,exp(i))

Functions may be defined to have zero or more formal arguments, which are local to the body of the function. Functions may be called recursively. Functions defined with the same name as a built-in functions will supercede the latter until erased. The body of a function may be a single expression or multiple expressions separated by semicolons; the maximum length is about 150 characters. The value of the function is the last expression evaluated.

The single-line restriction for functions is occasionally inconvenient, and a facility for multi-line functions may eventually be added. In the meantime, complicated functions may be constructed by "chaining", that is, by having functions call other functions as the last expression.

(6A) MODIFYING FUNCTIONS

The "modify" command allows modifications to be made to an existing function without entirely retyping it. The function is displayed and can be modified in the same way as the WYLBUR modify command for lines of the active file.

: mod hyp
    HYP(A,B) = SQRT(A**2+B**2)
ALTERS?
    HYP(A,B) = SQRT(A**2-B**2)
ALTERS?
(6B) **SAVING AND RESTORING FUNCTIONS**

Functions which have been defined can be saved in a file for later use. In the ORVYL version of ABACUS, the PUT and GET commands transfer functions between ABACUS internal storage and ORVYL files. In the MILLEN subsystem version of ABACUS, the SAVE and USE commands transfer functions between ABACUS internal storage and WYLBUR datasets or libraries. Note that, unlike the WYLBUR or ORVYL commands of the same name, the active file does not participate in the transfer. In both cases the syntax of the commands is much like those of ORVYL or WYLBUR.

**ABACUS under ORVYL examples:**

: put chebyshev
: get tri.diagonal user whw gro cg

**ABACUS under MILLEN subsystem examples:**

: save #fcts
: save laplace on scr001
: use fourier on wyl003 user ohs gro th nclist

**Notes:**

- The operand "nolist" on the "use" or "get" command prevents the functions from being listed as they are read.

- The initial default volume is "CAT", which may be changed by the "set volume" command (q.v.).

- If you attempt to save a dataset, member, or file which already exists, it will prompt with "OK TO REPLACE?". You may anticipate the question and add 'rep' to the command.

- Sequential datasets are always created in WYLBUR edit format. Library members are saved in the appropriate format for the library. ORVYL files are (currently) saved in PRINT format.

- In addition to function definitions, files that are loaded may contain any valid ABACUS commands (except another "use", "save", "get", or "put" command). You may create such files from WYLBUR. (ORVYL files should be saved in PRINT format.)
(7) **BUILT-IN FUNCTIONS**

1. **Functions of one argument**

   A. **Trigonometric**

   (Angles are assumed to be in radians unless changed by a "set degrees" or "set radians" command.)

   SIN  COS  TAN  ASIN  ACOS  ATAN

   B. **Hyperbolic**

   SINH  COSH  TANH

   C. **Logarithmic**

   EXP  LOG  LOG10  LOG2

   D. **Miscellaneous**

   SQRT

   ERF  ERFC

   GAMMA  LGAMMA

   E. **Truncation, Conversion**

   ABS  (absolute value)

   INT  (truncation towards zero, INT(1.5)=1, INT(-1.5)=-1)

   FLOOR

   CEILING  (can be abbreviated CEIL)

   DEG  (convert to degrees from radians)

   RAD  (convert to radians from degrees)
2. **Functions of two arguments**

**COMB(N,K)**  
The number of combinations of $N$ things taken $K$ at a time.  
$\text{COMB}(N,K) = \frac{N!}{(K!)(N-K)!}$

**PERM(N,K)**  
The number of permutations of $N$ things taken $K$ at a time.  
$\text{PERM}(N,K) = \frac{N!}{K!}$

**MOD(A,B)**  
The remainder of $A$ divided by $B$. (Extended to generalized residue for non-integral arguments.)  
Examples: $\text{mod}(10,3)$ is 1, $\text{mod}(3.4,1.5)$ is 0.4

3. **Miscellaneous functions**

**DUMP(address,length)**  
This returns the value of the 'length' bytes in memory beginning at 'address'.  
'length' must be 1, 2, 3, or 4, and is assumed to be 4 if omitted.
(8) **COMMANDS**

Commands may be entered at any time. If the prompt is for a variable, the same prompt will be re-issued after the command has been executed. Most keywords can be abbreviated with the first three or more letters.

8A. **"SET" Commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>set degrees</td>
<td>Change to degrees for trig functions. (Default is radians)</td>
</tr>
<tr>
<td>set radians</td>
<td>Use radians for trig functions.</td>
</tr>
<tr>
<td>set digits n</td>
<td>Display numbers with n significant digits. (Default is 8)</td>
</tr>
<tr>
<td>set hexadecimal</td>
<td>Display results in hex. This doesn't affect input; hex numbers are still entered with a leading zero. (Default is decimal output.)</td>
</tr>
<tr>
<td>set decimal</td>
<td>Return to decimal output.</td>
</tr>
<tr>
<td>set fuzz xxx</td>
<td>Set the relative tolerance for floating point comparisons to xxx. The initial fuzz is $1.4E-14$.</td>
</tr>
<tr>
<td>set mode retry</td>
<td>In &quot;retry&quot; mode, the previous command or expression will be listed to allow modification when an error occurs, or when a null line (just a carriage return) is entered (see Note 3).</td>
</tr>
<tr>
<td>set mode noretry</td>
<td>In &quot;noretry&quot; mode, the previous command or expression will be listed for modification only in response to &quot;&lt;ATTN&gt;&quot;. See note 3. The default mode is &quot;noretry&quot;.</td>
</tr>
<tr>
<td>set volume vvvvvv</td>
<td>Change the default volume for &quot;use&quot; and &quot;save&quot; commands to vvvvvv. The default volume is &quot;CAT&quot;.</td>
</tr>
</tbody>
</table>
8B.  "SHOW" Commands

show digits  Display current output precision.
show radians  Display current trig mode.
show degrees  ("degrees" or "radians")
show trig
show vars  Display all variables and their values.
show variables
show fcts  Display all functions, both built-in and
show functions  user-defined.
show ufcts  Display only user-defined functions.
show ufunctions
show mode  Show whether "mode retry" or "mode no retry"
           is in effect.
show volume  Display the current default volume.
show fuzz  Display the relative tolerance used for
           floating-point comparisons.
show hex  Display the current output mode.
show decimal  ("hexadecimal" or "decimal" output)

8C.  Other Commands

modify xxx  Display function xxx and allow it to be
            changed. The modifications are entered
            exactly as if the Wylbur "modify" command
            had been given for a line of the active
            file. See Note 3.
Erase the listed variables. (This is useful if the variable table has overflowed. The current limit is 25 variables.)

Erase the listed user-defined functions. (This is useful if you are getting "no more room" or "stack overflow" error messages.)

Erase all variables.

Erase all user-defined functions.

Erase all variables and user-defined functions.

Send a suggestion. (About ABACUS, presumably. Comments, complaints, etc. are most welcome.)

Give a brief explanation of some ABACUS features.

(Same as regular TO command)

Return to WYLBUR.

(ORVYL version only) Execute xxx as a WYLBUR or ORVYL or MILTEN command, then return to ABACUS.

(ORVYL version only) An abbreviation for "WYLBUR xxx".

Return to MILTEN.

Execute xxx as a milten command.

(Same as MILTEN logoff/logon. WYLBUR logoff/logon will NOT prompt you with OK TO CLEAR?)

(ORVYL version only) Terminate ABACUS and return to ORVYL immediately. All function definitions and defined variable will disappear.

See section 6B.

" " " "

" " " "

" " " "
Notes about commands:

1. Any unrecognized SHOW or SET commands are sent to MILTEN. In the ORVYL version, they are also sent to WYLBUR and ORVYL.

2. Most long keywords can be abbreviated by their first three or more letters.

3. Wylbur-like modifications (in response to the prompt "ALTERS?") may be used in the following circumstances:
   A) After a "modify <fctname>" command
   B) After appending "@<ATTN>" to the end of an input line
   C) By entering "@<ATTN>" as an input line (the previous command or expression will be listed for modification)
   D) By entering a null line (just a carriage return) in "retry" mode.
   E) After an error has occurred in "retry" mode.

   All the Wylbur editing characters are allowed (r,d,i,l,n, and b) except "£<ATTN>" and "$<ATTN>".

   Prompts for alteration will continue until either:
   A) A null response (just a carriage return) in which case the function will be re-defined or the command re-executed.
   B) <ATTN> as the only input. The function will be unchanged or the command will not be re-executed.
(9) **DETAILED EXPRESSION SYNTAX**

Notation:  [optional item]  [ choose this ]
   [ or this ]
   [ or this ]

The superscript 0 means the item may be repeated.

**General Arithmetic Expression**

\[
\begin{align*}
\langle \text{ID} \rangle & = \langle \text{AEXPR} \rangle \\
\{ & \text{for} \ <\text{VAR} \ [\text{=}\langle \text{AEXPR} \rangle \ [\text{to} \ <\text{AEXPR} \rangle \ [\text{by} \ <\text{AEXPR} \rangle \} \\
\{ & <\text{AEXPR} \} \\
\{ & \text{until} <\text{LEXPR} \}^0 \\
\{ & \text{loop} \ [\text{while} <\text{LEXPR} \] \text{ repeat} \\
\{ & <\text{AEXPR} \} \\
\{ & \text{do} \ [\text{[} <\text{AEXPR} \] }^0 \text{ end} \\
\{ & \text{if} <\text{LEXPR} \] \text{ then} <\text{AEXPR} \ [\text{else} <\text{AEXPR} \] \\
\{ & <\text{AEXPS} \}
\end{align*}
\]

**Simple Arithmetic Expression**

\[
\langle \text{AEXPS} \rangle := <\text{AEXPR}>
\]

**Arithmetic Term**

\[
\langle \text{ATEM} \rangle := \langle \text{AFACOR} \rangle
\]
Arithmetic Factor

\[ \langle \text{AFactor} \rangle ::= \langle \text{APrim} \rangle \ [ \star \star \langle \text{APrim} \rangle ] \]

Arithmetic Primary

\[ \langle \text{APrim} \rangle ::= [ + ] [ - ] [ \langle \text{CCnst} \rangle ] [ \star ] \]
\[ \langle \text{APrim} \rangle ::= ( \langle \text{APrim} \rangle ) \]

\[ \langle \text{VAr} \rangle ::= \{ \langle \text{ID} \rangle \} \]
\[ \langle \text{VAr} \rangle ::= \{ \langle \text{ID} \rangle \{ \langle \text{AExpr} \rangle \} \} \]
\[ \langle \text{VAr} \rangle ::= \{ \langle \text{ID} \rangle \{ \langle \text{AExpr} \rangle , \langle \text{AExpr} \rangle \} \} \]

\[ \langle \text{ID} \rangle ::= \text{A letter followed by 0-7 letters or digits with no imbedded blanks.} \]

\[ \langle \text{CONST} \rangle ::= \text{A constant - fixed point, floating point, or hexadecimal - with no imbedded blanks.} \]

Logical Expression

\[ \langle \text{LEXP} \rangle ::= \langle \text{LTERM} \rangle \ [ \text{or} \langle \text{LTERM} \rangle ] \star \]
\[ \langle \text{LTERM} \rangle ::= \langle \text{IFactor} \rangle \ [ \text{and} \langle \text{IFactor} \rangle ] \star \]

\[ \langle \text{IFactor} \rangle ::= \{ \text{lt} \lt \} \]
\[ \langle \text{IFactor} \rangle ::= \{ \text{le} \leq \} \]

\[ \langle \text{IFactor} \rangle ::= \{ \text{not} \} \langle \text{AExpr} \rangle \]
\[ \langle \text{IFactor} \rangle ::= \{ \text{gt} \gt \} \]
\[ \langle \text{IFactor} \rangle ::= \{ \text{ge} \geq \} \]
\[ \langle \text{IFactor} \rangle ::= \{ \text{eq} \} \]
\[ \langle \text{IFactor} \rangle ::= \{ \text{ne} \neq \} \]

(L. SHUSTEK 10/12/74)