Example XPL0 Programs

Here's the traditional "Hello World" program:

```
code Text=12;
Text(0, "Hello World!")
```

"Text" is a built-in routine that outputs a string of characters. The zero (0) tells where to send the string. In this case it's sent to the display screen, but it could just as easily be sent to a printer, a file, or out a serial port by using a different number.

Guess

Let's write a more extensive program. This is a guessing game where the computer thinks of a number between 1 and 100, and we try to guess it. After each guess, the program tells us whether we are high or low. The program goes through these steps:

1. Think of a number between 1 and 100.
2. Get a guess from the keyboard.
3. Test the guess against the number.
4. Repeat steps 2 and 3 until the guess is the number.

Here are the same steps translated into XPL0:

```
begin
MakeNumber;
repeat  InputGuess;
        TestGuess
until Guess = Number
end
```

Note that the program is almost word for word the same as the description of the task. First we "make a number" then we repeatedly "input a guess" and "test the guess" until it's the number.

There needs to be more to this program since it does not tell how to make a number, input a guess, or test the guess. Each of these operations is a subroutine to the main program. In XPL0 these subroutines are called "procedures." Here's how to write each of these procedures.

```
procedure MakeNumber;
begin
Number:= Ran(100) + 1
end
```

This procedure generates a random number between 1 and 100 (inclusive) and puts that number into the variable called "Number".

```
procedure InputGuess;
begin
Text(0, "Input guess: ");
Guess:= IntIn(0)
end
```

This procedure displays the message: "Input guess: " on the monitor (output device 0) and gets a number (Integer In) from the keyboard (input device 0). In XPL0 nine different input and output devices can be called from the program. This enables direct access to the monitor, keyboard, printer, disk files, and other I/O devices.

```
procedure TestGuess;
begin
if Guess = Number then Text(0, "Correct!")
else
        if Guess > Number then Text(0, "Too high")
        else Text(0, "Too low");
CrLf(0)
end
```

This procedure is more complicated but still easy to understand. If the computer's number is equal to the guess then we execute one statement; if it's not equal then we execute another statement. If the numbers are equal, we tell the user that the guess is correct; if they are not equal, we test if the guess is high or low and tell the user. CrLf(0) starts a new line on the monitor (Carriage Return and Line Feed).

Here's the complete program:

```
code Ran=1, CrLf=9, IntIn=10, Text=12;
integer Guess, Number;

procedure MakeNumber;
begin
Number:= Ran(100) + 1
end;

procedure InputGuess;
begin
Text(0, "Input guess: ");
Guess:= IntIn(0)
end;

procedure TestGuess;
begin
if Guess = Number then Text(0, "Correct!")
else
        if Guess > Number then Text(0, "Too high")
        else Text(0, "Too low");
CrLf(0)
end;

begin
MakeNumber;
repeat  InputGuess;
        TestGuess
until Guess = Number
end
```

Two new items are shown. The command word 'code' is used to give names to intrinsics. Intrinsics are built-in subroutines that do common operations. For example, "Ran" is the name of the random-number intrinsic, and "Ran" is used to call this random-number generator as a subroutine. The second item is the command word 'integer'. This declares a name and allocates memory space for each variable that follows it.

Note that the main procedure is the last block in the program. An XPL0 program is read starting at the bottom to get the main flow and working upward to get the details in the procedures.

Here's an example of what this program does when it runs:

```
Input guess: 50
Too high
Input guess: 25
Too high
Input guess: 9
Too low
Input guess: 18
Correct!
```

It's generally a good practice to break a program up into subroutines, but something this simple would probably be written more like this:

```
include c:\cxpl\codesi;
integer Guess, Number;
begin
Number:= Ran(100)+1;
repeat  Text(0, "Input guess: ");
        Guess:= IntIn(0);
        Text(0, if Guess = Number then "Correct!"
                else if Guess > Number then "Too high"
                else "Too low");
        CrLf(0);
until Guess = Number;
end;
```

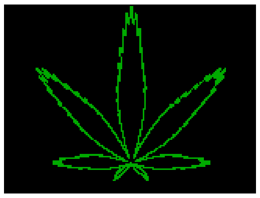
The 'include' command inserts a file called codesi.xpl, which resides in the cxpl directory on the c: drive. This file simply contains 'code' declarations for all the intrinsics. (The ".xpl" extension is assumed unless another extension is specified.)

Weed

This little ditty is for the mathematically inclined. The liberal use of comments (set off with backslashes "\") explain what's going on.

```
\Weed.xpl       15-Jan-2009
\Plots the "Weed" function
```

```
include c:\cxpl\codesi; \intrinsic routine declarations

define  S = 100.,       \size of plotted image (scale factor)
        N = 32000.,     \number of points plotted
        Pi2 = 3.14159265*2.;
integer X, Y;           \graphic coordinates (pixels)
real    A, D;           \angle and distance (polar coordinates)

begin
SetVid($12);            \set 640x480 graphics with 16 colors
A:= 0.;                 \for A:= 0 to Pi2 do...
repeat
 D:= (1.+Sin(A)) * (1.+.9*Cos(8.*A)) * (1.+.1*Cos(24.*A)) * (.9+.05*Cos(200.*A));
 X:= Fix(D*Cos(A)*S);   \convert polar to rectangular coordinates
 Y:= Fix(D*Sin(A)*S);
 Point(X+320, 400-Y, 2\green\);
 A:= A + Pi2/N;
until A >= Pi2;
X:= ChIn(1);            \wait for a keystroke
SetVid($03);            \restore normal text mode
end;
```



Ignore the hairy math for a moment and notice the intrinsic routine called SetVid. This sets the video mode to hex 12 (decimal 18), which is a graphic display mode.

The intrinsics Sin and Cos convert angles to their sine and cosine values. Real numbers (also called floating-point numbers) are used along with integers. The intrinsic Fix converts a real number to its closest integer.

The Point intrinsic plots the resulting coordinates on the screen.

SetVid is also used to restore the display to its normal text mode after ChIn (Character In) gets a character from the keyboard.

Clock

This shows how calls to DOS functions (which also work under Windows) can be used to display the time of day, for example 12:03:45.

```
\Clock.xpl      15-Jan-2009
\Display the current time of day

inc     c:\cxpl\codesi;         \include intrinsic code declarations


proc    NumOut(N);              \Output a 2-digit number, including leading zero
int     N;
begin
if N <= 9 then ChOut(0, ^0);
IntOut(0, N);
end;    \NumOut


proc    ShowTime;               \Display current time (e.g: 12:03:45)
int     Reg;
begin
Reg:= GetReg;                   \get address of array with copy of CPU registers
Reg(0):= $2C00;                 \call DOS function 2C (hex)
SoftInt($21);                   \DOS calls are interrupt 21 (hex)
NumOut(Reg(2) >> 8);            \the high byte of register CX contains the hours
ChOut(0, ^:);
NumOut(Reg(2) & $00FF);         \the low byte of CX contains the minutes
ChOut(0, ^:);
NumOut(Reg(3) >> 8);            \the high byte of DX contains the seconds
end;    \ShowTime


begin   \Main
repeat  ChOut(0, $0D);          \carriage return moves to the start of the line
        ShowTime;               \call routine to show the current time
until ChkKey;                   \keep repeating until a key is struck
end;    \Main
```

The intrinsics GetReg and SoftInt are used to access DOS and BIOS routines. GetReg returns the address of an array where a copy of the processor's hardware registers are stored. Values (such as $2C00 in the example) can be stored into this array. When SoftInt is called, the values in the array are loaded into the processor's registers and the specified interrupt ($21 in the example) is called.

ChOut outputs a character (such as ":") to the display, and IntOut outputs an integer value to the display. ChkKey checks the keyboard for a keystroke.

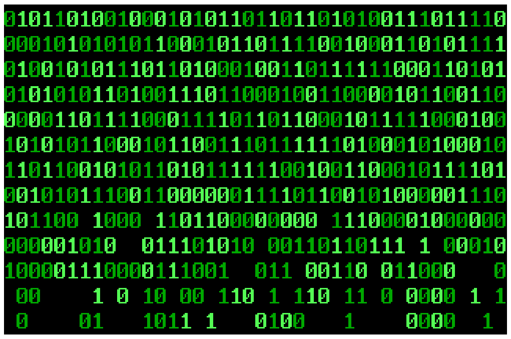
The AND operator "&" and the SHIFT operator ">>" manipulate the individual bits in an integer.

All command words, such as 'integer' and 'include', can be abbreviated to their first three letters.

Matrix

Here's a 5-line screen saver:

```
include c:\cxpl\codesi;                    \standard library 'code' definitions
repeat  Cursor(Ran(80), Ran(25));          \randomly select location on screen
        Attrib(if Ran(2) then 10 else 2);  \randomly select light or dark green
        ChOut(6, Ran(2)+^0);               \randomly output an ASCII 0 or 1
until   ChkKey;                            \run until a key is struck
```



```
0101101001000101011011011010100111011110
0001010101011000101101111001000110101111
0100101011101101000100110111111000110101
0101010110100111011000100110000101100110
0000110111100011110110110001011111000100
1010101100010110011101111110100010100010
1101100101011010111111001001100010111101
0010101110011000000111101100101000001110
101100 1000 1101100000000 1110001000000
000001010  011101010 00110110111 1 00010
1000011100000111001  011 00110 011000   0
 00     1 0 10 00 110 1 110 11 0 0000 1 1
 0    01    1011 1   0100    1     0000  1
```

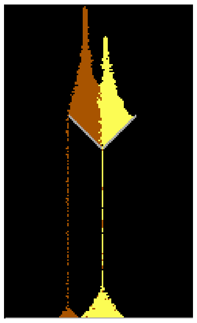
The intrinsic Cursor sets the column and row on the screen where characters will appear. The upper-left corner is 0,0.

The Attrib intrinsic specifies the attributes (usually the foreground and background colors) used for displaying characters on device 6. The argument "if Ran(2) then 10 else 2" is an example of an "if expression," which is different than the more common "if statement." It's equivalent to the C expression "rand()%2 ? 10 : 2". If Ran(2) returns a zero value, it's interpreted as being false; while any non-zero value (such as 1) is treated as being true. Thus the argument evaluates to either 2 (for false) or 10 (for true). These are the values of the two shades of green for EGA (and newer) video modes.

Sand

Here's an example that uses arrays and graphics to simulate falling grains of sand.

```
\Sand.xpl       25-Jan-2010
\Falling Sand Simulation

include c:\cxpl\codesi;         \standard library 'code' definitions

define  Grains = 2000;          \number of grains of sand
int     Gx(Grains), Gy(Grains), \screen pixel coordinates of each grain
        I, Dir;                 \index, direction
define  Black=0, Brown=6, White=7, Yellow=$E;

[SetVid($13);                               \set 320x200 graphics
Move(140, 70);  Line(160, 90, White);       \draw funnel (with thick
Move(140, 71);  Line(160, 91, White);       \ sides that won't leak)
Move(182, 70);  Line(162, 90, White);
Move(182, 71);  Line(162, 91, White);
Move(100, 199); Line(219, 199, White);      \draw floor

for I:= 0 to Grains-1 do                    \make sand at two spouts
        if I&1  \odd?
        then [Gx(I):= 150;  Gy(I):= 1]
        else [Gx(I):= 163;  Gy(I):= 20];
repeat
    for I:= 0 to Grains-1 do                \for all the grains of sand ...
        [Point(Gx(I), Gy(I), Black);        \erase grain's initial position
        if ReadPix(Gx(I), Gy(I)+1) = Black  \is grain above empty location?
        then Gy(I):= Gy(I)+1                \yes: move straight down
        else [Dir:= Ran(3)-1;               \no: randomly fall right or left
             if ReadPix(Gx(I)+Dir, Gy(I)+1) = Black
             then [Gx(I):= Gx(I)+Dir;  Gy(I):= Gy(I)+1];
             ];                             \draw grain at its new position
        Point(Gx(I), Gy(I), if I&1 then Brown else Yellow);
        ];
    repeat until port($3DA) & $08;              \wait for vertical retrace
until ChkKey;                                   \continue until a key is struck
SetVid($03);                                    \restore text mode (for DOS)
];                                              \that's all folks ...
```



First, note that brackets [ ] can be used in place of 'begin' and 'end'. This should make C programmers feel more at home.

A couple new intrinsics, Move and Line, are used to draw a funnel and a floor. ReadPix returns the color of a pixel, and thus is the opposite of the Point intrinsic.

Besides the 'repeat' command, a common way to repeatedly execute some code is with the 'for' command. Here it's used to execute blocks of code that manipulate each individual grain of sand.

The last new item is the 'port' command. This provides access to the PC's input and output ports. Here it's used to detect the video system's vertical retrace signal. Since this normally occurs 60 times per second, it's used to regulate the speed of the animation.

Puzzle

Here's a little game - a sliding block puzzle. The goal is to rearrange the numbers so they match the order on the keypad. For example, on the first move, the 7 can be slid to the right by pressing the 2 key. Pressing a non-numeric key ends the program.

```
\Puzzle.xpl     8-Feb-2010
\Sliding Block Puzzle - match the numbers with the keypad

code    Rem=2, ChIn=7, ChOut=8, CrLf=9, Clear=40;
int     Box, Key, Hole, Tbl, K, I;

[Box:= [0, ^1, ^2, ^3,          \starting configuration
           ^4, ^5, ^6,
           ^8, ^7, ^ ];
Hole:= 9;                       \index for hole position
loop    [Clear;                 \show the puzzle
        for I:= 1 to 9 do
                [ChOut(0, Box(I)); ChOut(0, ^ );
                if Rem(I/3) = 0 then CrLf(0);
                ];
        Key:= ChIn(1);                          \get move
        K:= Key - ^0;
        if K>=1 and K<=9 then                   \is it legal?
                [Tbl:= [0,7,8,9,4,5,6,1,2,3];   \convert key to match Box
                K:= Tbl(K);
                if K-3=Hole or K+3=Hole or      \can move up or down?
                  (K-1=Hole or K+1=Hole) and (K-1)/3 = (Hole-1)/3 \same row?
                then    [Box(Hole):= Box(K);    \move block into hole
                        Hole:= K;               \move hole into block
                        Box(Hole):= ^ ;
                        ];
                ]
        else quit;
        ];
];
```

Not only are brackets [ ] used as an abbreviation for begin-end's, but they're also used to set up arrays of constant values. Here they set the initial positions of the numbered "blocks."

A more general way to form a loop besides the 'repeat' and 'for' commands is to use a 'loop' command. The advantage is that the loop can be exited at any point with the 'quit' command. (This is similar to the 'break' command used by other languages.)

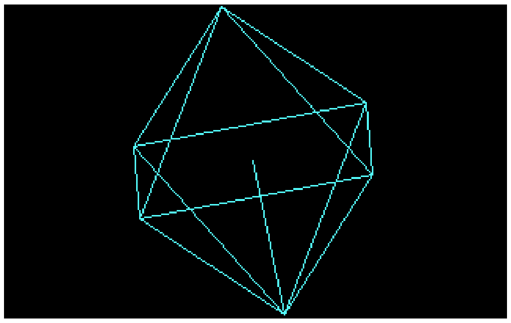
The Clear intrinsic erases the screen and sets the cursor position to the upper-left corner (location 0,0). The Rem intrinsic returns the remainder of I/3, which in this case is used to start three new lines with the CrLf (Carriage Return and Line Feed) intrinsic.

Partly to make Pascal programmers feel more at home, the command words 'and', 'or' and 'xor' were added to the language. These are alternatives for XPL0's traditional symbols "&", "!" and "|"; and they perform exactly the same operations. The words might make a program a little easer to read and understand.

Crystal

Fluorite crystals are octahedral in shape. Here's a simple 3D animation of a tumbling octahedron.

```
\Crystal.xpl    15-Feb-2010
\Tumbling Octahedron

include c:\cxpl\codesi;                  \intrinsic code declarations
real    X, Y, Z;                         \arrays: 3D coordinates of vertices
int     I;
define  Size=150.0, Sz=0.008, Sx=0.013; \drawing size and tumbling speeds
define  Color=3;                         \line color = cyan

\Coordinates of octahedron, ordered to allow continuous line to trace all edges
[X:= [0.0, 1.0, 1.0, 0.0,-1.0,-1.0, 0.0,-1.0, 1.0, 0.0, 1.0,-1.0, 0.0, 0.0];
 Y:= [1.4, 0.0, 0.0, 1.4, 0.0, 0.0,-1.4, 0.0, 0.0,-1.4, 0.0, 0.0, 1.4, 0.0];
 Z:= [0.0, 1.0,-1.0, 0.0, 1.0,-1.0, 0.0, 1.0, 1.0, 0.0,-1.0,-1.0, 0.0, 0.0];

SetVid($12);                             \set 640x480 graphics with 16 colors
repeat  Clear;                           \erase screen
        Move(Fix(X(0)*Size) + 640/2,  Fix(Y(0)*Size) + 480/2);
        for I:= 1 to 13 do
                Line(Fix(X(I)*Size) + 640/2,  Fix(Y(I)*Size) + 480/2,  Color);
        Sound(0, 1, 1);                  \delay 1/18 second, to reduce flicker
        for I:= 0 to 13 do
                [X(I):= X(I) - Y(I)*Sz; \rotate vertices in X-Y plane
                 Y(I):= Y(I) + X(I)*Sz;
                 Y(I):= Y(I) - Z(I)*Sx; \rotate vertices in Y-Z plane
                 Z(I):= Z(I) + Y(I)*Sx;
                ];
until ChkKey;                            \run until a key is struck
SetVid(3);                               \restore text mode (for DOS)
];
```



Although an octahedron only has 6 vertices, the constant arrays X, Y and Z define 14 coordinates in 3D space. The reason for this is that it makes drawing the edges a little simpler because they can all be drawn as a continuous series of line segments.

The Sound intrinsic is used, with the sound turned off, to provide a short delay. This not only regulates the tumbling speed but also reduces flicker. Normally flicker would be eliminated by drawing on an off-screen buffer that's quickly copied to display memory, but for simplicity, lines are drawn (and erased) directly on the visible display memory.

The code that rotates the vertices is a simplification of the normal rotation equations:

```
        X' = X*cos(ang) - Y*sin(ang)
        Y' = Y*cos(ang) + X*sin(ang)
```

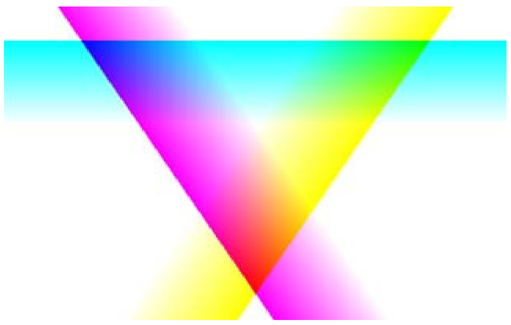
If you let the program run long enough, you'll see what's wrong with this simplification.

RGB

RGB, of course, stands for red, green and blue. In this example a 24-bit graphics mode, which is only available in the 32-bit version of XPL0, is used to display spectrums of colors.

```
\RGB.xpl        11-Mar-2010
\Display test patterns using 24-bit color
\Compile with 32-bit XPL0 (xpx.bat - for VESA graphics)

include c:\cxpl\codes;          \intrinsic 'code' declarations
int     Neg;                    \boolean: show negative image


func    DotProd(V1, V2);        \Return dot product of two 2D vectors
int     V1, V2;                 \V1 dot V2 = |V1|*|V2|*cos(ang)
int     DP;
begin
```

```
DP:= (V1(0)*V2(0) + V1(1)*V2(1)) >> 7;
if DP > 255 then DP:= 0;        \(also truncates negative dot product to 0)
return if Neg then 255-DP else DP;
end;    \DotProd


int     X, Y, R, G, B, Vr, Vg, Vb, V(2);

begin   \Main
SetVid($112);                   \set 640x480 graphics with 24-bit color
Vr:= [   0,-256];               \coordinates of equilateral triangle
Vg:= [-222, 128];               \ with origin at center of screen
Vb:= [ 222, 128];               \256*sin(30)=128; 256*sin(60)=222
Neg:= false;                    \start with positive image
loop    begin
        for Y:= 0 to 480-1 do   \for all the pixels on the screen...
            for X:= 0 to 640-1 do
                begin
                V(0):= X-320;  V(1):= Y-240+60; \form vector from center
                R:= DotProd(Vr, V);             \(60 = centering fudge factor)
                G:= DotProd(Vg, V);
                B:= DotProd(Vb, V);
                Point(X, Y, R<<16 + G<<8 + B);
                end;
        if ChIn(1) = $1B\Esc\ then quit;
        Neg:= not Neg;          \keystrokes alternate images until Esc key
        end;
SetVid(3);                      \restore normal text mode
end;    \Main
```



Although it really doesn't matter in this example, notice that codes.xpl is included instead of codesi.xpl. 32-bit XPL0 has a slightly different set of intrinsic routines than the 16-bit versions.

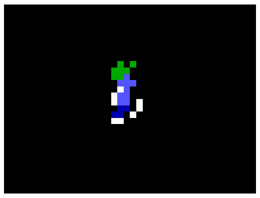
In the previous examples intrinsics such as Sin, ChIn, and ChkKey were used. These each return a value and are used as values so they act as "functions" rather than as ordinary subroutines (or "procedures"). In this example a function called DotProd is defined. The command word 'func' is used instead of 'proc' to make this distinction, but the important feature is the word 'return' which is used to return a value.

Notice the difference in the way the arrays Vb and V(2) are declared. Vb doesn't need the "(2)" because the two integers are reserved in memory and set up by the constant array.

Walker

Here's a simple animation that features a famous little guy from "Lemmings."

```
\Walker.xpl     22-Feb-2010
\Compile with 32-bit XPL0 (xpx.bat)

include c:\cxpl\codes;

proc    ShowGuy(Frame, X0, Y0); \Display a frame of the walking guy
int     Frame, X0, Y0;          \frame (0..7), and its upper-left coordinate
int     GuyImage, X, Y, Color;
[GuyImage:=
[[$00020000, $00222200, $00229000, $00099900, $000F9000, $000F9000, $000F9000, $00011000, $00F11000, $000FF000],
 [$00020200, $00222000, $00229000, $00099900, $000F9000, $00F99000, $00F990F0, $000110F0, $00110F00, $00FF0000],
 [$00000000, $00220200, $00222000, $00029000, $00099900, $00FF9000, $00F99000, $0FF99F00, $00111110, $0FF001FF],
 [$00000000, $00222200, $00229000, $00099900, $000F9000, $000F9000, $00F99000, $00011000, $0FF11100, $0F00FF00],
 [$00020000, $00222200, $00229200, $00299900, $000F9000, $0009F000, $000F9000, $00011000, $00F11000, $000FF000],
 [$00020000, $00222200, $00229000, $00099900, $000F9000, $0009F000, $0009F0F0, $000110F0, $00110F00, $00FF0000],
 [$00002000, $00220200, $00222000, $00029000, $00099900, $0009F000, $0009F000, $00099F00, $00111110, $0FF001FF],
 [$00000000, $00022000, $00229200, $00299900, $000F9000, $000F9000, $0009F000, $00011000, $0F111100, $0F00FF00]];
for Y:= 0 to 10-1 do                \for 10 horizontal scan lines...
        [Color:= GuyImage(Frame, Y);    \get colors for 8 horizontal pixels
        for X:= 7 downto 0 do           \plot pixels from right to left
                [Point(X+X0, Y+Y0, Color&$0F);
                Color:= Color>>4;
                ];
        ];
];      \ShowGuy


int     Posn;                           \position of walker
[SetVid($13);                           \set 320x200 graphics
loop for Posn:= 0 to 320-1 do           \move position across screen
        [ShowGuy(Posn&7, Posn, 100);    \show a frame of guy at position
        Sound(0, 2, 1);                 \delay about 1/9 second
        if KeyHit then quit;            \terminate program on key stroke
        ];
SetVid($03);                            \restore text mode (for DOS)
];
```



Because it was convenient to pack the 8-pixel-wide images into 32 bits, 32-bit XPL0 was used. Each image is 8x10. Only the first 16 colors of the 256 colors available in mode $13 graphics are used.

By masking the position with 7 (Posn&7), the 8 images (0..7) in the 2-dimensional constant array are displayed in sequence as the guy moves across the screen (0..319).

The Sound intrinsic is used to regulate speed. The arguments are: volume (0), number of system clock ticks to wait (2), and pitch (1, which we don't care about since the volume is zero).

One subtlety is that the left column in each image is set to all 0's, which is the color of the background. This automatically erases the trailing edge of the guy as he walks across the screen.

There's no penalty when the optimizing compilers are used to write 10-1 instead of 9, or 320-1 instead of 319. These 'for' loops are written this way to emphasize that they execute 10 and 320 times respectively, because they start counting at 0.

Caser

This shows an easy way to manipulate files using DOS's redirection symbols "<" and ">". This particular example converts a text file that might contain all capital letters into lower case, except when the capital letter is at the start of a sentence.

```
\Caser.xpl      15-Mar-2010
\Usage: caser < filename.txt > filename.doc

include c:\cxpl\codes;
int Start, Ch;

[Start:= true;
repeat  Ch:= ChIn(1);
        if Ch>=^A and Ch<=^Z and not Start then Ch:= Ch+$20
        else case Ch of ^., ^!, ^?, ^:: Start:= true other [];
        ChOut(0, Ch);
        if Ch>=^A and Ch<=^Z then Start:= false;
until   Ch = $1A\EOF\;
];
```

The "<" indicates that the file name typed on the command line is to be used for input instead of the keyboard, and the ">" indicates that characters that would normally go to the display screen are instead to go to the file specified for output. In the program, ChIn(1) now gets characters from the input file, and ChOut(0, Ch) now sends characters to the output file. The input file must be terminated with an end-of-file character ($1A). (Under Windows this must be run from a Command Prompt.)

The 'case' statement tests for the several ways that a sentence might end. It's equivalent to "if Ch=^. or Ch=^! or Ch=^? or Ch=^: then Start:= true".

Howdy

XPL0 doesn't have built-in commands to handle strings like BASIC does. For instance, this common example in BASIC:

```
INPUT "What is your name: ", N$
PRINT "Howdy "; N$
```

would have to be written in XPL0 something like this:

```
string  0;
code    ChIn=7, CrLf=9, Text=12;
int     I;
char    Name(128);

[Text(0, "What is your name? ");
I:= 0;
loop    [Name(I):= ChIn(0);                     \buffered keyboard input
        if Name(I) = $0D\CR\ then quit;         \Carriage Return = Enter key
        I:= I+1;
        ];
Name(I):= 0;                                    \terminate string
Text(0, "Howdy "); Text(0, Name); CrLf(0);
];
```

The "string 0" command changes the convention that XPL0 uses for terminating strings. It changes it to terminating them with a zero byte instead of setting the most significant bit on the last character. This feature is not available in the interpreted compiler, XPLI (x.bat).

The keyboard buffer can hold a maximum of 128 characters, so to prevent the possibility of overflowing the Name array, at least this many bytes are reserved.

When the ChIn(0) intrinsic is first called, it collects characters from the keyboard until the Enter key is struck. It then returns to the XPL0 program where one character is pulled from the buffer each time ChIn(0) is called. When the Enter key (which is the same as a carriage return, $0D) is pulled, the program quits the loop. A zero byte is stored in place of the Enter key to mark the end of the string.

Factorial

Many people who get a new scientific calculator like to give it something to ponder, and they often discover that 69 factorial is the calculation that takes the longest time. This is because it does 68 multiplies (2*3*4...*68*69), and in scientific notation with a 2-digit exponent the largest number can only have 100 digits.

Since it would be too easy to write a program that finds the smallest number whose factorial has at least 100 digits (it's 70), we'll write a program that finds the smallest number whose factorial has at least a billion (1E9) digits.

Obviously straightforward multiplication isn't going to work because the largest number that can be represented by XPL0's double-precision reals is 1.79E308, which is a far cry from a billion digits. Here's how to find the answer using logarithms:

```
\N!.xpl         2-Mar-2010
\Use 32-bit XPL0 (xpx.bat) for speed and accuracy
include c:\cxpl\codes;
real    N, A;
[N:= 0.0;  A:= 0.0;
repeat  N:= N + 1.0;
        A:= A + Log(N);
until A >= 1E9-1.0;
RlOut(0, N);
];
```

If this program intrigues you, you'll probably be interested in Project Euler. It offers hundreds of similar challenges. Although XPL0 has been used to solve at least 102 of the problems on this site, it's not posted as one of the recognized languages because so few people use it. Perhaps you can help change that.

Maze

Here's one last example that shows how a 3-dimensional array and recursion are used to generate random mazes.

```
\Maze.xpl       24-Jul-2009
\Random Maze Generator

def     Cols=10, Rows=6;                \dimensions of the maze (cells)
int     Cell(Cols+1, Rows+1, 3);        \cells (plus right and bottom borders)
```

```
def     LeftWall, Ceiling, Connected;   \attributes of each cell (= 0, 1 and 2)

code    Ran=1, CrLf=9, Text=12;         \intrinsic routines


proc    ConnectFrom(X, Y);      \Connect cells starting from cell X,Y
int     X, Y;
int     Dir, Dir0;
[Cell(X, Y, Connected):= true;  \mark current cell as connected
Dir:= Ran(4);                   \randomly choose a direction
Dir0:= Dir;                     \save this initial direction
repeat  case Dir of             \try to connect to cell at Dir
          0: if X+1<Cols then if not Cell(X+1, Y, Connected) then      \go right
                [Cell(X+1, Y, LeftWall):= false; ConnectFrom(X+1, Y)];
          1: if Y+1<Rows then if not Cell(X, Y+1, Connected) then      \go down
                [Cell(X, Y+1, Ceiling):= false;  ConnectFrom(X, Y+1)];
          2: if X-1>=0 then if not Cell(X-1, Y, Connected) then        \go left
                [Cell(X, Y, LeftWall):= false;   ConnectFrom(X-1, Y)];
          3: if Y-1>=0 then if not Cell(X, Y-1, Connected) then        \go up
                [Cell(X, Y, Ceiling):= false;    ConnectFrom(X, Y-1)]
        other   [];             \(never occurs)
        Dir:= Dir+1 & $03;      \next direction
until   Dir = Dir0;
];      \ConnectFrom


int X, Y;
[for Y:= 0 to Rows do
    for X:= 0 to Cols do
        [Cell(X, Y, LeftWall):= true;           \start with all walls and
         Cell(X, Y, Ceiling):= true;            \ ceilings in place,
         Cell(X, Y, Connected):= false;         \ and all cells disconnected
        ];
Cell(0, 0, LeftWall):= false;                   \make left and right doorways
Cell(Cols, Rows-1, LeftWall):= false;

ConnectFrom(Ran(Cols), Ran(Rows));              \randomly pick a starting cell

for Y:= 0 to Rows do                            \display the maze
        [CrLf(0);
        for X:= 0 to Cols do
                Text(0, if X#Cols & Cell(X, Y, Ceiling)  then "+--" else "+  ");
        CrLf(0);
        for X:= 0 to Cols do
                Text(0, if Y#Rows & Cell(X, Y, LeftWall) then "|  " else "   ");
        ];
];
```

The maze consists of a rectangular array of cells, each with a wall on its left side and a ceiling above. When the maze is generated, some of these walls and ceilings are eliminated to form "Connected" pathways.

The 'case' command executes one of the four statements that follow depending on the value in Dir, which is either 0, 1, 2 or 3. Doubly nested 'for' loops are used in the main procedure to set up the array and then to display the maze. The values 'true' and 'false' are used to indicate the presence of a wall or ceiling and whether or not a cell is connected to other cells, thus forming pathways.

Note that the second 'def' (define) declaration does not specify any values. In this case the values assigned are 0, 1 and 2. The names are "enumerated" so each has a distinct value.

Because the ConnectFrom procedure calls itself (recurses), this program is doing more than meets the eye. If you redefine Cols and Rows to be much larger, you'll need to use 32-bit XPL0 to avoid a stack overflow.

```
+--+--+--+--+--+--+--+--+--+--+
               |  |           |
+  +--+--+--+  +  +  +  +--+  +
|  |     |     |  |  |  |     |
+  +  +--+  +--+  +  +  +--+--+
|  |              |  |        |
+  +--+--+--+--+  +  +--+--+  +
|     |     |  |  |  |     |  |
+  +  +  +  +  +  +  +  +--+  +
|  |  |  |  |     |     |  |  |
+  +  +  +  +--+--+--+  +  +  +
|  |     |              |
+--+--+--+--+--+--+--+--+--+--+
```