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An *incomplete*

Reference Manual

Beta 2   
7th October 2024

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# Getting started

## Technical platform

You can access the Elan Beta at: <https://elan-lang.org/beta/>

Elan is designed to run within the Chrome browser; correct operation within other browsers is not guaranteed.

## Demo programs

The Beta version includes a **Demo** button that offers a menu of demonstration programs that you can run:

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The best way to get started with Elan is to explore these demo programs. You can edit any of them and save your own copy locally.

## Changes and additions for Beta 2

### Language/grammar changes

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### Standard library changes

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### Changes to the editor

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### New Demo (example) programs

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## Still to be implemented..

The following lists a few of the *stand-out* items that are not yet implemented. (For a much longer list you are welcome to browse all the open items on our development project planning system – <https://github.com/elan-language/IDE/issues> . However, please bear in mind that those items are written by and for the development team – rather than for public discussion.)

### Editor

* **Debugger**. Ability to insert breakpoints, pause, single-step, and read the state of variables
* **Navigate** directly from use of an identifier to its definition
* **Renaming** of identifiers (variables, constants, parameters, function & procedure names)
* **Profile** configuration (exists as a proof of concept only at present). In future release you will be able to define multiple profiles and then assign a profile to each user name.
* Ability to switch on **anti-plagiarism** option (exists as a proof of concept only at present)
* Ability to perform all navigation and *actions* by keyboard or mouse (except entering code into fields, which must be done through the keyboard)
* **Auto-complete** (of names) is currently implemented for just a few kinds of field. This will be expanded, for example to offer auto-complete options within ‘expression’ fields.
* When calling a procedure, or using a function in an expression, **prompting** the user for each of the required arguments, with both parameter name and type required.

### Library methods and types

* Data file reading and writing (data file reading exists as a ‘mock up’ only in Beta 2)
* Stack, Queue, Set, Tree, Graph and other standard data structures (both mutable and immutable versions of each will be included as standard)
* Ability to call methods from *external* (JavaScript) libraries & frameworks

### Language

* Currently, the global. qualifier - to disambiguate between a global and a local identifier where two have the same name – works for function and procedure, but does not yet work for constant.

## If you have programmed in another language, the key differences to be aware of…

### Types

* Elan is a statically typed language. Basic types are Int, Float, Boolean, String.There are ready made data structures types Array, List, Dictionary. Elan supports user defined classes and enums, and there are several ready-made classes in the standard library such as BlockGraphics, File, Set, Stack, Queue, Tree, Graph … (only the first of these is in the Beta 2).

### Variables

* Variables are defined by a var statement, and re-assigned with a set statement
* Variable names (indeed all names in Elan) must begin with a lower-case letter
* Variables must be initialised with a literal value or an expression that yields a value, and the type of that value determines the type of the variable.
* There is no such thing as a global variable in Elan – variables are defined within main, or within a function or procedure and are visible only within that scope.

### Constants

* A constant is only ever defined at global level is set to a literal value of an *immutable* type: for example any of the four basic types or a List, but not an Array (see below).

### Let statement

* A let statement may be thought of as being between a constant and a variable. Like a variable a let may be defined only within a routine, but unlike a variable it may not be re-assigned once defined. It is recommended that you always use a let in preference to a var unless you *need* to be able to re-assign it.

### Arrays

* An Array is a mutable data structure – as it is in most languages.
* It may be initialised to a specific size, with each element set to an initial value (e.g. 0 for a Int or Float), but it may also be extended dynamically with the append or prepend method.
* A 2D array may also be created, accessed with a double index e.g. a[2][3]

### Testing for equality

* Elan tests for equality *by value* (not equality by reference) using the keywords is (for example if x is y) and isnt. The comparisons, >, <. >=, <= apply to numeric types (Int and Float) only. (There are methods for String comparison – see )

### Methods

* There are several types of method in Elan: standalone function, standalone procedure, instance function and instance procedure (both defined on a class), and system methods. These are expanded below.
* Elan does not support **overloaded** method names (methods with the same name, but different number or type of parameters). Every freestanding method must have a unique name distinct also from those in the standard library; instance methods must be unique within a class – but the same name may be used within different classes.

### Function

* An Elan **function** (whether standalone or an instance method on a class) must be *pure* function. It must return a value that is derived, solely and deterministically, from the arguments supplied as parameters. A function contains one, and only one, return statement which much be the last (or only) statement in the function body.
* A function may not generate side-effects, for example it may *not* for example:
  + Contain any print statements
  + Use any System methods within its expressions
  + Make a call to any procedure (since procedures are not pure)
  + Assign-to or mutate any parameter

### Procedure

* An Elan procedure may be thought of as a ‘command’. Like a function it may define parameters, but it does not return a value – because a procedure, necessarily makes changes: changes to one or more of the parameters (if the parameter definition is prefixed by out), and/or changes to the *system* by calling print or any of the system methods.
* A procedure exits after executing the last statement in the body – there is (deliberately) no mechanism to exit ‘early’ – thereby enforcing structured programming.
* A procedure is always executed via a call statement: either standalone, or as a ‘dot method’ on a named instance.

### System method

* System methods are all defined as part of the standard Elan library. Some are *like* procedures, returning no value, and are hence executed via the call statement. Others are *like* functions in that they return a value and are evaluated within an expression. However, unlike functions these system methods either have side-effects or external dependencies (or both). For that reason, no system method – whether resembling a procedure or a function – may be used within a user-defined function. They may only be used within main or a procedure.

### Object-oriented techniques

* The name given to a class must follow the rules for any Type name i.e. it must *start* with a capital letter.
* Every (concrete) class has a constructor – which is automatically added when you define a class. But it is not essential to define any code within that constructor.
* A property may be assigned (set) a new value within the constructor, or within a procedure method defined on the class or the sub-class. But a property may never be assigned by code outside the class. If you require this capability, you can write your own procedure methods (commonly called ‘setter’ methods) to do this. A function method may read properties, but not write to them.
* If the constructor or a procedure method defines a parameter with the same name as a property then using that name will refer to the parameter by default Whenever you access the property (for reading, or writing) within the constructor or a method on the class, then you must prefix the name with property. This is so that parameters may have the same name as properties, for example:  
  procedure setName(name as String)  
   set property.name to name  
  end procedure
* A concrete class may inherit from *one or more* abstract classes, but may not inherit from another concrete class. (This enforces the widely-recognised OOP design principle that ‘all classes should be abstract or final (not inheritable)’.)
* An abstract class may define abstract members (property, function, procedure) – which must always be implemented by any concrete sub-class. It may also define private members (property, function, procedure), which are visible to any concrete sub-class, but not visible from code outside the class hierarchy.
* An immutable class, may define properties or function methods, but not procedure methods (because the latter necessarily mutate the instance). Function methods may provide information derived from reading the properties, or may return a new instance based on the current one but with modifications (specified using the copy … with … construct). An abstract immutable class may define properties or function methods that are either abstract or private.

### Functional techniques

* Elan has very strong support for the functional programming paradigm, building on the foundation of its rigorous definition of a function. In addition:
* The standard library defines several ‘higher-order functions’ (HoFs) including map, filter and reduce that apply to any type that is ‘iterable’ (including String, Array and List).
* Any user-defined or standard-library function may be passed as an argument into a parameter, or associated with a name using a var or let statement – by preceding the name of the function with the keyword function.
* You may also define a lambda, inline as an argument in a function call, or assigned to a named value.
* Although pure functions, including HoFs, may work with mutable data structures (without actually mutating them), *immutable* data structures are considered a better fit for functional programming. Elan provides many *immutable*standard data structures, including String (immutable in most languages) and List (in contrast to many languages). You may also define your own immutable classes.

# The Elan editor – quick reference

## Navigation – using the keyboard

**Note**: For *Apple Mac* users: commands use of the **Ctrl** key in this reference, should be replaced by the **Cmd**key.

|  |  |  |  |
| --- | --- | --- | --- |
| **Keystroke** |  | **On a selected Frame** | **On a selected Field** |
| **Home** |  | First *peer-level* frame. | Move text-cursor to start of field. |
| **End** |  | Last *peer-level* frame. | Move text-cursor to end of field. |
| **Tab** |  | First *field* in frame. | Select next field within frame. Or from last field in a frame, select the frame itself.  (If the field has a selected option in the auto-complete popup list then Tab will use that option – the same as **Enter**) |
| **↑** |  | Select previous frame  (within peer-level only). | Select previous *frame*  (in tab order). |
| **↓** |  | Select next frame (within peer-level only). | Select next *frame*  (in tab order). |
| **←** |  | Select *parent* frame (if any). | Move text-cursor left within field. |
| **→** |  | Select first *child* frame (if any). | Move text-cursor right within field. |
| **Shift-↑** |  | *Add* prev. frame (peer-level) to current selection. | If auto-complete options are offered (drop-down list), move the selection *down* one in the list. (See also **Enter**) |
| **Shift-↓** |  | *Add* next frame (peer-level) to current selection. | If auto-complete options are offered (drop-down list), move the selection *up* one in the list. (See also **Enter**) |
| **Esc** |  | | Escape from field and select enclosing frame |
|  | | | |
| **Ctrl-o** |  | Toggle (expand/collapse) outlining on selected frame. | Toggle (expand/collapse) outlining on the frame enclosing this field. |
| **Ctrl-O**  (Ctrl-Shift-o) |  | Toggle (expand/collapse) outlining on *all* frames. | Toggle (expand/collapse) outlining on *all* frames. |

## Editing – using the keyboard

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Keystroke** |  | **On a selected Frame** | **On a selected Field** | |
| **Backspace** |  | On any ‘new code’ selector: delete the selector. (Note that *all* ‘new code’ selectors can be removed with the **+/-** button above the code pane).  On a new, unmodified, frame, or from any unedited field within that new frame: delete the whole frame and go back to the selector. This capability is to facilitate deleting a frame created unintentionally. As soon as any field has been edited, or any child frame added – the frame can only be deleted using Ctrl-Delete (see below). | Delete character to the left of the cursor. | |
| **Delete** |  |  | Delete the character to the right of the cursor. | |
| **Ctrl-Delete** or  **Ctrl-d** |  | Delete the selected frame, including any frames within it. |  | |
| **Enter** |  | Insert a selector-frame (‘new code’) *below* selected, at peer level – if permissible. | If auto-complete options are offered (as a drop-down list), enter the selected option into the field.  Otherwise, move to the next field (in the same frame) – like Tab.   For last field in frame only: insert ‘new code’ *after* this field. | |
| **Shift-Enter** |  | Insert a selector-frame (‘new code’) *above* selected, at peer level – if permissible | - | |
| **Ctrl-↑** |  | Move selected frame(s) up, *within peer level.* | - | |
| **Ctrl -↓** |  | Move selected frame(s) down, *within peer level.* | - | |
| **Ctrl-x** |  | Cut selected frame(s) into the scratchpad | - | |
| **Ctrl-v** |  | - | | Applies only to a selected ‘new code’ field. Paste the frame(s) added to the scratchpad in place of the ‘new code’ field. If any of the frames to be added is not compatible with the content of the ‘new code’ field then no action will take place. |
| **Ctrl-z** | <- Undo last operation NOT YET IMPLEMENTED -> | | | |
| **Ctrl-y** | <- Redo last undo NOT YET IMPLEMENTED -> | | | |

## 

## Mouse operation – quick reference

* To select a *frame*, click on the *keyword* at the start the frame. (You can successfully click in several other places within the frame, but the simplest rule to remember is click on the starting keyword).
* To select an additional frame (‘multi-select’), hold down the **Shift** key on the keyboard and click on the frame to add to the current selection. Note that all the multi-selected frames must be at peer-level (the same level of indentation and, unless global frames, must be within the same ‘parent’ frame.
* To select a field, click on the text (or, if empty, the prompt) shown for that field. Having selected the field, you may then click again at a particular place within the text to position the text cursor. (By default, when a field is selected the text cursor will be at the right-hand end of any existing text).
* To collapse a multi-line frame, double-click on the keyword at the start of the frame
* To expand a collapsed frame, double-click on the keyword at the start of the frame (or the ‘+’ symbol in front of it)

NOT YET IMPLEMENTED

* To move selected frame, or frames, up or down *within the same peer level* hold down the **Ctrl** key and drag the mouse, or move the scroll wheel
* Scrolling of options within the ‘autocomplete’ popup using the mouse wheel.

# Expressions

One of the most important constructs in programming is the ‘expression’. An expression is evaluated to return a value. An expression is made up of the following possible elements:

* Literal value
* Named value
* Operators (including brackets)
* Function calls

## Literal value

A literal value is where a value is written ‘literally’ in the code, such as 3.142 – in contrast to a value that is referred to by a name.

The following data types may be written as literal values (follow the links to view the form of each literal value):

Int, Float, Boolean, String, Error! Reference source not found., Error! Reference source not found., Dictionary, ImmutableDictionary, Tuple

## Named value

A named value is a value that is associated with a name rather than being defined literally in code.

There are various kinds of named value:

Constant, Variable, Parameter, Index, Enum

#### Identifer

For all kinds of named values, the name must follow the rules for an ‘identifier’ – it must start with a lower-case letter, followed by any combination of lower-case and upper-case letters, numeric digits, and the \_ (underscore) symbol. It may not contain spaces or other symbols. Once a named value has been defined, it can be referred to by the name.

### Constant

Explanatory video: <https://www.youtube.com/watch?v=KxkCDnYWkZ0&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=10>

A constant defines a named value that cannot change.

A constant is always defined at ‘global’ level (directly within a file) and are global in scope. A constant may not be defined within any method. (However, see the Error! Reference source not found.).

The name of a constant follows the rules for any Identifer.

The value to which a constant is set must be a Literal value, of one of the following types: Int, Float, Boolean, String, Error! Reference source not found., ImmutableDictionary

Examples:

constant phi set to 1.618

constant maxHits set to 10

constant warningMsg set to "Limit reached"

constant fruit set to {"apple", "orange", "banana"}

constant black set to 0x000000

constant red set to 0xff0000 constant scrabbleValues set to {"A":1, "B":3, "C":3, "D":2, "E":1, "F":4, "G":2, "H":4, "I":1, "J":8, "K":5, "L":1, "M":3, "N":1, "O":1, "P":3, "Q":10, "R":1, "S":1, "T":1, "U":1, "V":4, "W":4, "X":8, "Y":4, "Z":10}

constant colours set to {Suit.clubs:black, Suit.diamonds:red, Suit.hearts:red, Suit.spades:black}

(In the last example above, Suit is an Enum)

### Variable

A variable is a named value where the value may change during the running of the program.

The name of a variable follows the rules for all identifiers

A variable is defined using a Var statement and may be re-assigned using a Set statement

Elan is a statically-typed language, so that each variable always has a defined type and any value assigned to that variable must be compatible with that type.

### Parameter

* A parameter is a specific kind of variable, defined as part of a method (Procedure or Function) for the purpose of capturing an argument being passed into that method.
* See also Parameter passing.

### IndexedValue

If a variable that is of an indexable type then an index, or a range, may be applied to the variable within an expression. For example:

var a set to "Hello World!"  
print a[4]  
print a[4..7]

See also: Using an Array, Using a Dictionary.

**Important:** unlike in many languages, in Elan, indexes (whether, single index, multiple index, or index range) are only ever used for *reading* value(s). Writing a value to a specific index location is done through a method such as:

* putAt on an Array
* withPutAt on a List
* putAtKey on a Dictionary
* withPutAtKey on an ImmutableDictionary

### Enum

Explanatory video: <https://www.youtube.com/watch?v=k0IPAnNCDh0&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=19&pp=gAQBiAQB>

An enum – short for ‘enumeration’ – is the simplest form of ‘user-defined type’ , specifying a set of values, each defined as a name, such that a variable of that type must always hold one of those values.

#### Type name

The name given to an enum (see below), which must begin with a capital, is used as the Type name, when passing a value to or from a procedure of function.

#### Defining an enum

Example

enum Status incomplete, ready, running, stopped, invalid

Further examples of enum may be seen in Cards.

#### Using an enum

The value is specified by the type name for the specified enum, followed by a dot and the value name, for example:

var x set to Status.ready

#### Notes

* Enums are *read-only* – once they have been defined it is not possible to add, remove, or update the values.

Example:

enum Suit clubs, diamonds, hearts, spades

## Operator

### Arithmetic operators

Arithmetic operators can be applied to Float or Int arguments, but the result is always a Float:

* 2^3 gives 8
* 2/3 gives 0.666…
* 2\*3 gives 6
* 2 + 3 gives 5
* 2 - 3 gives -1
* 11 mod 3 gives 2
* 11 div 3 gives 3 (integer division)

Arithmetic operators follow the conventional rules for precedence i.e. ‘BIDMAS’ (or ‘BODMAS’ \_

**Note:** When combining div or mod with *any* other operators within an expression, *insert brackets to avoid ambiguity* e.g.:

(5 + 6) mod 3

The minus sign may also be used as a unary operator, and this takes precedence over binary operators so:

* 2\*-3 gives -6

Note the Elan editor automatically puts spaces around the + and – *binary* operators, but not around ^,/,\*. This is just to reinforce, visually, the precedence.

### Logical operators

Logical operators are applied to Boolean argument(s) and return a Boolean result.

* and and or are binary operators
* not is a unary operator.

The operator precedence is not -> and -> or.

Example:

function xor(a as Boolean, b as Boolean) return Boolean  
 return a and not b or b and not a  
end function

Implements an ‘exclusive or’.

### Equality testing

Equality testing uses the is and isnt keywords with two arguments. The arguments may be of any type.

* a is b returns true, if a and b are both of the same type and their values are equal. The only exception is that if one argument is of type Float and the other is of type Int, then is will return true if their values are the same (i.e. are the same whole number).
* isnt returns the opposite of is

Note that quality testing in Elan is *always* ‘equality by value’. There is no such thing as ‘equality by reference’ in Elan.

**Notes**

* Where a binary operator is expected, as soon as you type is the editor will automatically insert a space after it. To enter isnt you need to delete the space (using the **Backspace** key) and then type nt

### Numeric comparison

The numeric comparison operators are:

* > for ‘greater than’
* < for ‘less than’
* >= for ‘greater than or equal to’
* <= for ‘less than or equal to’

Each is applied to two arguments of type Float, but any variable of expression that evaluates to an Int type may always be used where a Float is expected.

**Notes**

* These operators cannot be applied to strings. Use the methods isBefore and isAfter to compare strings alphabetically.
* Where a binary operator is expected, as soon as you type < or > the editor will automatically insert a space after it. To enter >= or <= you need to delete the space (using the **Backspace** key) and then type =

### Combining operators

You can combine operators of different kinds e.g. combining numeric comparison with logical operators in a single expression. However the rules of precedence between operators of different kinds are complex. It is strongly recommend that you *always* use brackets to disambiguate such expressions, for example:

(a > b) and (b < c)

(a + b) > (c -d)

## Function call

An expression may simply be a function call, or it may include one or more function calls within it. Examples:

print sinDeg(30)  
var x set to sinDeg(30)^2 + cosDeg(30)^2  
var name set to inputString("Your name”)  
print name.upperCase()

**Notes:**

* The third example (above) is not strictly a function call, but is a System methods call. System methods may only be used within the Main routine or a Procedure, because they have external dependencies or side effects.
* The fourth is an example of a
* Dot methods call – upperCase being a ‘dot method’ that may be applied to any instance (variable or literal) of the type String.

# Procedural programming

## Main routine

Explanatory video: <https://www.youtube.com/watch?v=Tg1SKYcrF4E&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=8>

A file must have a main method *if it is intended to be run as program*. (You may however develop and test code that does *not* have a main method – either as a coding exercise, or for subsequent use within another program).

The main method defines the start point when a program is run.

The main method does not have to be at the top of the file, but this is a good convention to follow.

There may *not* be more than one main method in a file – and the global selector (above) will not show the main option when one already exists in the file.

Example:

main

var li set to [3, 6, 1, 0, 99, 4, 67]

call inPlaceRippleSort(li)

print li

end main

## Input/Output

### Printing to the Console

Explanatory video: <https://www.youtube.com/watch?v=NGYQQeAuKAg&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=20&t=2s>

The simplest way to print is with the print statement.

* See also print & printTab (standard library procedures).

### Inputting data from the keyboard

Explanatory video: <https://www.youtube.com/watch?v=ziYfalHJ9q4&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=21>

See Input methods

Also the readKey system method on BlockGraphics

### Simple BlockGraphics

Explanatory video: <https://www.youtube.com/watch?v=JbLtgVil7fI&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=22>

See On BlockGraphics

### Reading and writing data files

See   
The limitation of this simple approach is that – because these methods depend on an unseen random number generator that changes state each time either method is called – the methods may only be used within main or a procedure. You may generate random numbers in this way and pass the resulting number(s) into a function as Float or Int Type(s), but you may not generate a random number using these methods include a function.

#### Generating random numbers within a function

It is possible to create and use random numbers within a function, but it requires a different approach and is a little more complex, using a special *type* named Random (note that the R is capitalised). You must always create the *first* Random (using the system method firstRandom) within main or a procedure but you can pass this into a function and generate further random numbers within that function – because the next number is generated in a deterministic fashion from the previous Random number, using a ‘pseudo random sequence’. Example of use:

main

  var rnd set to firstRandom()

  var dice set to 0

  for i from 1 to 10 step 1

    set (dice, rnd) to rollDice(rnd)

  end for

end main

function rollDice(rnd as Random) return (Int, Random)

  return (rnd.valueInt(1, 6), rnd.next())

end function

Note that calling firstRandom() uses the system clock as the ‘seed’ value, and hence will be different each time you run the program. It is also possible to create a pseudo-random sequence that will be the same each time the program is run – and this is primarily intended for testing purposes. To create the fixed sequence replace **firstRandom()** with **firstRandomInFixedSequence()**, but leave the rest of your code unchanged.

Reading & writing data files

## Using variables

Explanatory video: <https://www.youtube.com/watch?v=g6Byq0vhYw8&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=9&t=34s>

### Var statement

The var statement is used to define, and initialise, a new variable.

The name given to the variable must follow the rules for an Identifer.

The value to which the new variable is initialised may be a literal value, or a more complex expression. Either way, the resulting value defines the type for that variable.

### Set statement

The set statement is used to assign a new value to an existing variable. The new value must be of the same type (or a type compatible with) that of the variable.

A set statement may not assign a new value to a parameter – see Parameter passing.

## Conditions & selection

Elan supports the two forms of ‘selection’ most widely-used in procedural programming: the If statement and the Switch statement.

(Elan also supports the If expression, which, although often thought of as a Functional programming technique, may be used within procedural programming also – within any expression.)

### If statement

Explanatory video: <https://www.youtube.com/watch?v=2l4m3Acl_2g&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=13>

### Switch statement

Explanatory video: <https://www.youtube.com/watch?v=NdmqUCpNTYQ&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=17&pp=gAQBiAQB>

#### Case clause

#### Default clause

A default clause may be added only within a switch statement. See Switch for more information. If a default statement is used within a switch, there may only be one, and it must follow all the case statements.

## Loops & iteration

### For loop

Explanatory video: <https://www.youtube.com/watch?v=D8HF3386FtI&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=12&pp=gAQBiAQB>

### Each loop

Explanatory video: <https://www.youtube.com/watch?v=kTMfiH7wXOs&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=14&pp=gAQBiAQB>

### While loop

Explanatory video: <https://www.youtube.com/watch?v=Uwp_7Eh2P88&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=15&pp=gAQBiAQB>

### Repeat loop

Explanatory video: <https://www.youtube.com/watch?v=b-kD417YopM&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=16&pp=gAQBiAQB>

## Procedure

The main routine may delegate work to one or more procedures, and for this reason procedures are often described as sub-routines. A procedure may also delegate work to other procedures.

Like a function, a procedure may define parameters; unlike a function, a procedure does not return a value. However, unlike a function, a procedure can have ‘side effects’ - indeed it must have side-effects otherwise there would be no point in calling it! For this reason the statements within a procedure can:

* Include print statements (or methods).
* include input methods or other ‘system’ methods (such as random number generation).
* call other procedures (or itself if ‘recursion’ is required).
* Modify a parameter, provided that parameter definition is preceded by the keyword out (see Function
* A function is a method that returns a value, of a specified type, that is derived from the argument values which are passed into the function and are captured by the parameters. Example:

function binarySearch(list as [String], item as String) return Boolean

var result set to false

if list.length() > 0

then

var mid set to list.length() div 2

var value set to list[mid]

if item is value

then

set result to true

else if isBefore(item, value)

set result to binarySearch(list[..mid], item)

else

set result to binarySearch(list[mid + 1..], item)

end if

end if

return result

end function

Functions (in contrast to procedures) may be called (evaluated) within an expression, or as an expression, for example:

var result set to binarySearch(fruit, wanted)

**Notes**:

* The function must contain one and only one return statement, which must the last statement in the function. This is automatically created by the function frame and may not be moved or deleted.
* Simple functions may consist only of the a return statement incorporating an expression. The following example uses an ‘if expression’ :

function north(cellNo as Int) return Int

return if cellNo > 39 then cellNo - 40 else cellNo + 1160

end function

* The return *type* is specified in the function signature (the top-line). The return statement must return a value compatible with this type.
* Each parameter defined in the function signature must specify a name, and a type separated by the as keyword. Multiple parameter definitions are separated by commas.
* A function may not:
  + Create any side effect. This includes not using the print or input methods, creating random numbers (though a random number may be created outside the function and passed in as a Int or Float value), or making a call to any procedure (since procedures may, and typically will, have side effects).
  + Re-assign (set) any parameter. Note that, unlike in a procedure, a parameter definition on a function may not use the out keyword.
  + Modify the contents of an Array or Dictionary using an index. (However, a function may ‘modify’ the contents of a List (or ImmutableDictionary)– because the supporting methods for those operations return a new data structure.
  + A function may define no parameters, but in this case it is really acting like a constant – always returning the same value. (However, unlike an actual constant, a parameter-less function may calculate its fixed value by making use of other functions and constants.)
* Parameter passing).

Example:

procedure inPlaceRippleSort(out list as [Int])

var changes set to true

var lastComp set to list.length() - 2

repeat

set changes to false

for i from 0 to lastComp step 1

if list[i] > list[i + 1]

then

var temp set to list[i]

set list[i] to list[i + 1]

set list[i + 1] to temp

set changes to true

end if

end for

set lastComp to lastComp - 1

end repeat when not changes

end procedure

Procedures are used within a call statement, for example:

main

var li set to [3, 6, 1, 0, 99, 4, 67]

call inPlaceRippleSort(li)

print li

end main

**Notes**:

* Parameters for a procedure are defined exactly the same way as for a function.

### Call statement

A call statement is used to call a standalone Input/Output

### Printing to the Console

Explanatory video: https://www.youtube.com/watch?v=NGYQQeAuKAg&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=20&t=2s

The simplest way to print is with the print statement.

* See also print & printTab (standard library procedures).

### Inputting data from the keyboard

Explanatory video: https://www.youtube.com/watch?v=ziYfalHJ9q4&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=21

See Input methods

Also the readKey system method on BlockGraphics

### Simple BlockGraphics

Explanatory video: https://www.youtube.com/watch?v=JbLtgVil7fI&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=22

See On BlockGraphics

### Reading and writing data files

See   
The limitation of this simple approach is that – because these methods depend on an unseen random number generator that changes state each time either method is called – the methods may only be used within main or a procedure. You may generate random numbers in this way and pass the resulting number(s) into a function as Float or Int Type(s), but you may not generate a random number using these methods include a function.

#### Generating random numbers within a function

It is possible to create and use random numbers within a function, but it requires a different approach and is a little more complex, using a special *type* named Random (note that the R is capitalised). You must always create the *first* Random (using the system method firstRandom) within main or a procedure but you can pass this into a function and generate further random numbers within that function – because the next number is generated in a deterministic fashion from the previous Random number, using a ‘pseudo random sequence’. Example of use:

main

  var rnd set to firstRandom()

  var dice set to 0

  for i from 1 to 10 step 1

    set (dice, rnd) to rollDice(rnd)

  end for

end main

function rollDice(rnd as Random) return (Int, Random)

  return (rnd.valueInt(1, 6), rnd.next())

end function

Note that calling firstRandom() uses the system clock as the ‘seed’ value, and hence will be different each time you run the program. It is also possible to create a pseudo-random sequence that will be the same each time the program is run – and this is primarily intended for testing purposes. To create the fixed sequence replace **firstRandom()** with **firstRandomInFixedSequence()**, but leave the rest of your code unchanged.

Reading & writing data files

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The value to which the new variable is initialised may be a literal value, or a more complex expression. Either way, the resulting value defines the type for that variable.

### Set statement

The set statement is used to assign a new value to an existing variable. The new value must be of the same type (or a type compatible with) that of the variable.

A set statement may not assign a new value to a parameter – see Parameter passing.

## Conditions & selection

Elan supports the two forms of ‘selection’ most widely-used in procedural programming: the If statement and the Switch statement.

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#### Case clause

#### Default clause

A default clause may be added only within a switch statement. See Switch for more information. If a default statement is used within a switch, there may only be one, and it must follow all the case statements.

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### For loop

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### Each loop

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Procedure, for example:

A close up of text

Description automatically generated

It may also be used to call a Procedure method on an instance of a class, for example:



**Notes:**

* A call statement cannot be used to call a function.
* The procedure call cannot form part of an expression (because it does not produce a value)

See also Function

A function is a method that returns a value, of a specified type, that is derived from the argument values which are passed into the function and are captured by the parameters. Example:

function binarySearch(list as [String], item as String) return Boolean

var result set to false

if list.length() > 0

then

var mid set to list.length() div 2

var value set to list[mid]

if item is value

then

set result to true

else if isBefore(item, value)

set result to binarySearch(list[..mid], item)

else

set result to binarySearch(list[mid + 1..], item)

end if

end if

return result

end function

Functions (in contrast to procedures) may be called (evaluated) within an expression, or as an expression, for example:

var result set to binarySearch(fruit, wanted)

**Notes**:

* The function must contain one and only one return statement, which must the last statement in the function. This is automatically created by the function frame and may not be moved or deleted.
* Simple functions may consist only of the a return statement incorporating an expression. The following example uses an ‘if expression’ :

function north(cellNo as Int) return Int

return if cellNo > 39 then cellNo - 40 else cellNo + 1160

end function

* The return *type* is specified in the function signature (the top-line). The return statement must return a value compatible with this type.
* Each parameter defined in the function signature must specify a name, and a type separated by the as keyword. Multiple parameter definitions are separated by commas.
* A function may not:
  + Create any side effect. This includes not using the print or input methods, creating random numbers (though a random number may be created outside the function and passed in as a Int or Float value), or making a call to any procedure (since procedures may, and typically will, have side effects).
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Parameter passing

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  + A function may define no parameters, but in this case it is really acting like a constant – always returning the same value. (However, unlike an actual constant, a parameter-less function may calculate its fixed value by making use of other functions and constants.)

## Parameter passing

The arguments provided to a method (function or procedure) are *always* passed ‘by value’ and not ‘by reference’.

However, *if*…

* the method is a procedure AND
* the type of the argument is a ‘reference type’ AND
* that type is *mutable* such as an Array, a Dictionary, or a user-defined class that is not specified as immutable.

then it is possible to *mutate* the parameter that holds that argument within the procedure, such that any reference to the argument outside the procedure will ‘see’ the changes. However, this can only be done in a procedure (not a function) and if the parameter definition is prefixed by the keyword out.

A good example of this is an ‘in-place sort’ procedure. In the following code the arr parameter is mutated in the two highlighted lines:

procedure inPlaceRippleSort(out arr as [Int])

var changes set to true

var lastComp set to arr.length() - 2

repeat

set changes to false

for i from 0 to lastComp step 1

if arr [i] > arr [i + 1]

then

var temp set to arr [i]

set arr[i] to arr[i + 1]

set arr[i + 1] to temp

set changes to true

end if

end for

set lastComp to lastComp - 1

end repeat when not changes

end procedure

Note however that:

* In a function you may not mutate *any* parameter
* In a procedure you may not *re-assign* any parameter

## Error/Exception handling

### Try statement

### Throw statement

## Comments

Explanatory video: <https://www.youtube.com/watch?v=Vv2hD3EobKU&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=11>

Comments:

* may be added at global level – as well as within other constructs.
* always start with a # followed by a space and then free-form text. The text field may be left empty
* are a single line, though if the text is long enough the line may be wrapped within the editor
* are always on their own line. It is it not possible to add a comment after, or within, a line of code.

# Object-oriented programming

## Class

A class is user-defined type – offering far richer capability than an enum.

### Definition

Here is an example of class definition – taken from the *Snake OOP* demo program:

class Apple

constructor(board as Board)

set property.board to board

end constructor

property board as Board

property location as Square

procedure newRandomPosition(snake as Snake)

repeat

var ranX set to randomInt(0, board.width - 1)

var ranY set to randomInt(0, board.height - 1)

set location to new Square(ranX, ranY)

end repeat when not snake.bodyCovers(location)

end procedure

function updateGraphics(gr as BlockGraphics) return BlockGraphics

return gr.withBlock(location.x, location.y, red)

end function

end class

**Notes:**

A class *must* have:

* A name that, like any other type, must begin with a capital letter.
* A constructor (added automatically by the class frame), which may be used for setting up the values of properties. The constructormay, optionally, define parameters – to force the calling code to provide initial values. However, it is not necessary to write any code within the constructor if you have no need to initialise properties. Code in the constructor may make use of any functions – and follows the same constraints as a function (i.e. may not call any procedure, whether defined on the class or outside).

A class *may* define:

* Properties – see Property
* Function methods – see Function method
* Procedure methods – see Procedure method

### Inheritance

A regular (concrete) class may inherit from one or more *abstract* classes – see Abstract clas. The concrete class must define for itself a concrete version of every abstract property and abstract method defined in the abstract class(es) that it inherits from.

### Using a class

A class is instantiated using the keyword new followed by the class name and brackets, which should enclose the comma-separated arguments required to match the parameters (if any) defined on the constructor for that class. For example (also from the *Snake OOP* demo):

var board set to new Board(40, 30)

var currentDirection set to Direction.up

var snake set to new Snake(board, currentDirection)

var apple set to new Apple(board)

The created instance may then be used within expressions, like any other variable.

### Abstract class

An immutable class is created by selecting the word immutable in front of the keywork class *when* the class is created using the frame. (It is not possible to make a class immutable retrospectively. However it is possible to create a new immutable class and then cut and paste suitable methods and properties from an existing class.

**Notes:**

* An immutable class may define only properties and function methods.
* Properties may be set only within the constructor. Thereafter an instance of an immutable class may only be ‘modified’ by a function method that returns a copy of the current instance with specified differences – see below.
* Each property must be of an immutable type e.g. a simple value type, immutable list, or another (or same) immutable class.
* An abstract class may inherit from one or more other abstract classes.

Not yet implemented – the copy … with expression.

### Immutable class

An immutable class is created by selecting the word immutable in front of the keywork class *when* the class is created using the frame. (It is not possible to make a class immutable retrospectively. However it is possible to create a new immutable class and then cut and paste suitable methods and properties from an existing class.

**Notes:**

* An immutable class may define only properties and function methods.
* Properties may be set only within the constructor. Thereafter an instance of an immutable class may only be ‘modified’ by a function method that returns a copy of the current instance with specified differences – see below.
* Each property must be of an immutable type e.g. a simple value type, immutable list, or another (or same) immutable class.

## Property

Examples:

property height as Int

property board as Board

property head as Square

property body as [Square]

* A property is defined on a Class and must specify a name (conforming to Identifer rules) and a Type.
* A property may be marked private – in which case it is visible only by code within the class.
* If not marked private, a property may be read – but may not be written. Properties may only be modified from outside the class by means of a Procedure method.
* A property may be given an initial value in the constructor.
* If the property is not initialised within the constructor then it will automatically be given the empty value for that type. You may test whether a property contains this default value by writing e.g.:

if head is empty Square

* If a variable or parameter is defined within a method on the class with the same name as a property then the parameter/variable will take precedence. However, you may disambiguate between a property and parameter/variable with the same name using the property. qualifier. This is a commonly used in ‘set’ procedure methods’, and in the constructor, for example:

constructor(board as Board)

set property.board to board

end constructor

procedure setHeight(height as Int)

set property.height to height

end procedure

## Function method

A function method follows the same syntax and rules as a freestanding (global) function. The differences are:

* A function method is always referenced (used) by code outside the class using ‘dot-syntax’ on an instance.
* A function method may directly reference (read only) any property defined on the class as though it were a variable/parameter.

### asString() method

* asString method. This is just a regular function method with a specific name, no parameters and returning a String. If defined for a class, then if an instance of the class is printed, the asString function method will automatically be used. Typically asString will return a string made up of one or more of the property values, perhaps with additional text, or the results of function calls.

## Procedure method

A ‘procedure method’ follows the same syntax and rules as a freestanding (global) procedure. The differences are:

* A procedure method, like a function method, is always referenced (used) by code outside the class using ‘dot-syntax’ on an instance.
* A procedure method may read, or write to, any property defined on the class.

# Functional programming

Elan is designed to support the ‘functional programming’ paradigm.

Unlike in most ‘mixed-paradigm’ programming languages, *all* functions in Elan are ‘pure functions’: Elan does not permit any function to create ‘side-effects’, and enforces that the returned value is derived solely, and deterministically, from the values passed into the function’s parameters. This applies whether or not you are actively seeking to write code according to the functional programming approach.

When writing code according to the functional programming paradigm the aim is to write as much as possible of the program’s logic and behaviour within pure functions; to use the Main routine and Procedure calls solely for implementing input/output; and to keep both main and procedures ‘as thin as possible’. Elan’s in-built support for character-mapped BlockGraphics is a good example of this pattern: almost all the work can be done using the in-built *functions*, such as withBlock, which may be used within your own user-defined functions. Only the draw method – which is the only one that actually changes the display - is a procedure, and this must be called from within main, or a procedure. (See On BlockGraphics.)

*Although it is not a requirement to do so*, adopting the functional programming paradigm also means that, wherever possible, functions should avoid using procedural code constructs: sequence, loop, and branch. Here are some examples of functions that *don’t* use any of those procedural code constructs:

function w(c as Int) return Int

return if (c mod 40) > 0 then c - 1 else c + 39

end function

function possibleAnswersAfterAttempt(prior as {String}, attempt as String, mark as String) return {String}

return prior.filter(lambda w as String => markAttempt(attempt, w) is mark).asList()

end function

function nextGeneration(cells as [Boolean]) return [Boolean]

let cellRange be range(0, cells.length() - 1)

let next be cellRange.map(lambda n as Int => nextCellValue(cells, n))

return next.asArray()

end function

In the examples above we can see several patterns/techniques that are widely used in functional programming in place of procedural code constructs:

* (Top example) Use of an If expression, instead of using an If statement.
* (Middle example) Use of Higher order functions – in this case, filter – together with a Passing a function as a reference

If you are passing a reference to a freestanding function as an argument into a HoF (as distinct from defining a lambda) then you provide the name of that function, but precede it with the keyword function. For example:

…

var passes set to allPupils.filter(function passedMathsTest)

…

function passedMathsTest(p as Pupil) as Boolean

return p.mathsPercent > 35

end function

**Notes:**

* When passing in a reference function passMathsTest, the name is preceded by function, and that no parameters (or brackets) are added to the name as they would have been if you were *evaluating* (calling) the function at that point.
* Lambda, instead of writing a loop
* Use of a Let statement (instead of the Var statement) to calculate intermediate values.

These are explained below.

## If expression

The ‘if expression’ is *in certain respects* similar to an If statement, but with the following differences:

* It is written entirely within a single expression. This is possible because the if expression always returns a value.
* There is always a single then and a single else clause, and each clause contains just a single expression. The if expression returns the result of evaluating one of these two expressions, according to whether the condition evaluates to true or false.
* These if expressions may be ‘nested’ within each other, using brackets around each nested if expression where there could be any ambiguity.

Some more examples:

return if c < 1160 then c + 40 else c – 1160

return if isGreen(attempt, target, n) then setChar(attempt, n, "\*") else attempt

return if attempt[n] is "\*" then attempt else (if isYellow(attempt, target, n) then setChar(attempt, n, "+") else setChar(attempt, n, "\_"))

The last example contains a nested if expression.

## Let statement

A let statement may be used only within a function, where its purpose is to calculate an intermediate result for use within one or more subsequent expressions. This may be for any of the following reasons:

* To avoid duplicating code, where the same sub-expression would otherwise be written more than one
* To break up a complex expression just for clarity or readability
* To overcome the restriction (in Elan) that
* Dot methods calls may not be chained.

Here is an example of let statements in use:

let wordCounts be allRemainingWordCounts(possAnswers, possAttempts)

let best be wordCounts.reduce(wordCounts.head(), lambda bestSoFar as WordCount, newWord as WordCount => betterOf(bestSoFar, newWord, possAnswers))

return best.word

You are never *required*  to use a let statement: you may always use a var instead. But if you are willing to use let where you can, it is considered a good practice in functional programming. let may be thought of as somewhere between a Constant and a Variable but also has unique characteristics:

* Like a variable and a constant, a let statement defines a new named value.
* Like a constant, but unlike a variable, the named value defined by a let may not be subsequently re-assigned.
* Unlike a constant (which may only be defined at global level) a let is defined within main or any method.
* Unlike a constant, the value specified in a let may be defined by an expression i.e. may make use of other variables and constants.

## Higher order functions (HoFs)

A ‘higher order function’ is one that takes in a reference to another function as a parameter, or (less commonly) that returns a reference to another function as its result.

### Standard HoFs

The Elan standard library contains several HoFs that are widely recognised and used within functional programming. See On any Iterable - Higher order functions (HoFs)

### Passing a function as a reference

If you are passing a reference to a freestanding function as an argument into a HoF (as distinct from defining a lambda) then you provide the name of that function, but precede it with the keyword function. For example:

…

var passes set to allPupils.filter(function passedMathsTest)

…

function passedMathsTest(p as Pupil) as Boolean

return p.mathsPercent > 35

end function

**Notes:**

* When passing in a reference function passMathsTest, the name is preceded by function, and that no parameters (or brackets) are added to the name as they would have been if you were *evaluating* (calling) the function at that point.

### Lambda

A lambda is lightweight means to define a function ‘in line’. You typically define a lambda:

* If the functionality it defines is needed only in one location - typically for a particular call to a HoF.
* If you need to capture a local variable in the implementation. (This is called ‘closing around a variable’)

The syntax for a lambda is as follows:

* Start with the keyword lambda
* Parameter definitions, comma-separated, follow the same form as parameter definitions in a function or procedure – but with no surrounding brackets.
* The => symbol, which is usually articulated as ‘returns’ or ‘yields’ or even ‘fat arrow’.
* An expression that makes use of the parameter(s) – and may also make use of other variables in scope.

Example:

function liveNeighbours(cells as [Boolean], c as Int) return Int

let neighbours be neighbourCells(c)

let live be neighbours.filter(lambda i as Int => cells[i])

return live.length()

end function

**Notes**:

* Although a lambda is commonly defined ‘inline’ (as shown above) it is possible to assign a lambda to a variable and hence to re-use it within the scope of that variable.
* Although a lambda will *usually* define at least one parameter, it is possible to define a lambda with no parameter, just returning an expression – in which case it acts just like a locally defined variable, but with the advantage (useful in rare circumstances) that the expression is evaluated ‘lazily’ i.e. only when the lambda is *used*. The following example uses both these techniques within a function:

function safeSquareRoot(x as Float) return Float  
 let root be lambda => sqrt(x)  
 return if x < 0 then 0 else root()  
end function

### Defining your own Hofs

TODO

The Iter type

The Func type

## Working with immutable types

You may pass mutable and/or immutable types into a function. However, you may not call any procedure on, not otherwise mutate any of those values passed as parameters.

That said, if you are wanting to learn to write code according to the the functional programming paradigm, it is desirable to work exclusively with immutable types. Elan provides very good support for these, both in the form of standard immutable data structures (initially Error! Reference source not found. and ImmutableDictionary) and user-defined Immutable class.

## Copy…with

NOT YET IMPLEMENTED

the copy…with syntax provides an easy-to-use mechanism for ‘updating’ one or more properties on an instance of an Immutable class. It returns a new instance that is a copy of the original, with all properties the same except where specified otherwise (in the ‘to clauses’ following the with). This general-purpose mechanism avoids the need to write an individual Function method for updating each property individually and copying the others, or a constructor that requires all properties.

When implemented, the syntax will be:

let d2 be copy d with height to 3, width to 4

where height and width are both properties of d. You can specify as many properties to change as required, each ‘to clause’ separated by a comma from the previous.

# Tests

Explanatory video: <https://www.youtube.com/watch?v=nz2JUtFEumc&list=PLhZaBW7EbafOPO4YyuovGI1prCViAeVKM&index=30>

Example of a test method:

A screen shot of a computer code

Description automatically generated

**Notes:**

* Giving a name to a test is optional – you may have multiple test methods with no name. If you do specify a name, it must conform to the rules of any identifier – starting with a lower-case letter. The name may be the same as an existing function or procedure. There is no potential for confusion, because a test method may not be called from within other methods.
* test methods may be written anywhere in the code, at the global (file) level.
* A test method may contain multiple assert statements. When tests are run, the test runner (part of the Elan IDE) will attempt to run all assert statements and show the pass/fail outcome alongside each one. However, if the test hits a runtime error (as distinct from an assert failure) then execution of the test will stop and remaining asserts will be shown as not run.
* In addition to assert statements a test may contain call, var and let statements.

## Assert statement

An assert statement may be added only with a test. For examples of use see Property

Examples:

property height as Int

property board as Board

property head as Square

property body as [Square]

* A property is defined on a Class and must specify a name (conforming to Identifer rules) and a Type.
* A property may be marked private – in which case it is visible only by code within the class.
* If not marked private, a property may be read – but may not be written. Properties may only be modified from outside the class by means of a Procedure method.
* A property may be given an initial value in the constructor.
* If the property is not initialised within the constructor then it will automatically be given the empty value for that type. You may test whether a property contains this default value by writing e.g.:

if head is empty Square

* If a variable or parameter is defined within a method on the class with the same name as a property then the parameter/variable will take precedence. However, you may disambiguate between a property and parameter/variable with the same name using the property. qualifier. This is a commonly used in ‘set’ procedure methods’, and in the constructor, for example:

constructor(board as Board)

set property.board to board

end constructor

procedure setHeight(height as Int)

set property.height to height

end procedure

## Function method

A function method follows the same syntax and rules as a freestanding (global) function. The differences are:

* A function method is always referenced (used) by code outside the class using ‘dot-syntax’ on an instance.
* A function method may directly reference (read only) any property defined on the class as though it were a variable/parameter.

### asString() method

* asString method. This is just a regular function method with a specific name, no parameters and returning a String. If defined for a class, then if an instance of the class is printed, the asString function method will automatically be used. Typically asString will return a string made up of one or more of the property values, perhaps with additional text, or the results of function calls.

## Procedure method

A ‘procedure method’ follows the same syntax and rules as a freestanding (global) procedure. The differences are:

* A procedure method, like a function method, is always referenced (used) by code outside the class using ‘dot-syntax’ on an instance.
* A procedure method may read, or write to, any property defined on the class.

# Functional programming

Elan is designed to support the ‘functional programming’ paradigm.

Unlike in most ‘mixed-paradigm’ programming languages, *all* functions in Elan are ‘pure functions’: Elan does not permit any function to create ‘side-effects’, and enforces that the returned value is derived solely, and deterministically, from the values passed into the function’s parameters. This applies whether or not you are actively seeking to write code according to the functional programming approach.

When writing code according to the functional programming paradigm the aim is to write as much as possible of the program’s logic and behaviour within pure functions; to use the Main routine and Procedure calls solely for implementing input/output; and to keep both main and procedures ‘as thin as possible’. Elan’s in-built support for character-mapped BlockGraphics is a good example of this pattern: almost all the work can be done using the in-built *functions*, such as withBlock, which may be used within your own user-defined functions. Only the draw method – which is the only one that actually changes the display - is a procedure, and this must be called from within main, or a procedure. (See On BlockGraphics.)

*Although it is not a requirement to do so*, adopting the functional programming paradigm also means that, wherever possible, functions should avoid using procedural code constructs: sequence, loop, and branch. Here are some examples of functions that *don’t* use any of those procedural code constructs:

function w(c as Int) return Int

return if (c mod 40) > 0 then c - 1 else c + 39

end function

function possibleAnswersAfterAttempt(prior as {String}, attempt as String, mark as String) return {String}

return prior.filter(lambda w as String => markAttempt(attempt, w) is mark).asList()

end function

function nextGeneration(cells as [Boolean]) return [Boolean]

let cellRange be range(0, cells.length() - 1)

let next be cellRange.map(lambda n as Int => nextCellValue(cells, n))

return next.asArray()

end function

In the examples above we can see several patterns/techniques that are widely used in functional programming in place of procedural code constructs:

* (Top example) Use of an If expression, instead of using an If statement.
* (Middle example) Use of Higher order functions – in this case, filter – together with a Passing a function as a reference

If you are passing a reference to a freestanding function as an argument into a HoF (as distinct from defining a lambda) then you provide the name of that function, but precede it with the keyword function. For example:

…

var passes set to allPupils.filter(function passedMathsTest)

…

function passedMathsTest(p as Pupil) as Boolean

return p.mathsPercent > 35

end function

**Notes:**

* When passing in a reference function passMathsTest, the name is preceded by function, and that no parameters (or brackets) are added to the name as they would have been if you were *evaluating* (calling) the function at that point.
* Lambda, instead of writing a loop
* Use of a Let statement (instead of the Var statement) to calculate intermediate values.

These are explained below.

## If expression

The ‘if expression’ is *in certain respects* similar to an If statement, but with the following differences:

* It is written entirely within a single expression. This is possible because the if expression always returns a value.
* There is always a single then and a single else clause, and each clause contains just a single expression. The if expression returns the result of evaluating one of these two expressions, according to whether the condition evaluates to true or false.
* These if expressions may be ‘nested’ within each other, using brackets around each nested if expression where there could be any ambiguity.

Some more examples:

return if c < 1160 then c + 40 else c – 1160

return if isGreen(attempt, target, n) then setChar(attempt, n, "\*") else attempt

return if attempt[n] is "\*" then attempt else (if isYellow(attempt, target, n) then setChar(attempt, n, "+") else setChar(attempt, n, "\_"))

The last example contains a nested if expression.

## Let statement

A let statement may be used only within a function, where its purpose is to calculate an intermediate result for use within one or more subsequent expressions. This may be for any of the following reasons:

* To avoid duplicating code, where the same sub-expression would otherwise be written more than one
* To break up a complex expression just for clarity or readability
* To overcome the restriction (in Elan) that
* Dot methods calls may not be chained.

Here is an example of let statements in use:

let wordCounts be allRemainingWordCounts(possAnswers, possAttempts)

let best be wordCounts.reduce(wordCounts.head(), lambda bestSoFar as WordCount, newWord as WordCount => betterOf(bestSoFar, newWord, possAnswers))

return best.word

You are never *required*  to use a let statement: you may always use a var instead. But if you are willing to use let where you can, it is considered a good practice in functional programming. let may be thought of as somewhere between a Constant and a Variable but also has unique characteristics:

* Like a variable and a constant, a let statement defines a new named value.
* Like a constant, but unlike a variable, the named value defined by a let may not be subsequently re-assigned.
* Unlike a constant (which may only be defined at global level) a let is defined within main or any method.
* Unlike a constant, the value specified in a let may be defined by an expression i.e. may make use of other variables and constants.

## Higher order functions (HoFs)

A ‘higher order function’ is one that takes in a reference to another function as a parameter, or (less commonly) that returns a reference to another function as its result.

### Standard HoFs

The Elan standard library contains several HoFs that are widely recognised and used within functional programming. See On any Iterable - Higher order functions (HoFs)

### Passing a function as a reference

If you are passing a reference to a freestanding function as an argument into a HoF (as distinct from defining a lambda) then you provide the name of that function, but precede it with the keyword function. For example:

…

var passes set to allPupils.filter(function passedMathsTest)

…

function passedMathsTest(p as Pupil) as Boolean

return p.mathsPercent > 35

end function

**Notes:**

* When passing in a reference function passMathsTest, the name is preceded by function, and that no parameters (or brackets) are added to the name as they would have been if you were *evaluating* (calling) the function at that point.

### Lambda

A lambda is lightweight means to define a function ‘in line’. You typically define a lambda:

* If the functionality it defines is needed only in one location - typically for a particular call to a HoF.
* If you need to capture a local variable in the implementation. (This is called ‘closing around a variable’)

The syntax for a lambda is as follows:

* Start with the keyword lambda
* Parameter definitions, comma-separated, follow the same form as parameter definitions in a function or procedure – but with no surrounding brackets.
* The => symbol, which is usually articulated as ‘returns’ or ‘yields’ or even ‘fat arrow’.
* An expression that makes use of the parameter(s) – and may also make use of other variables in scope.

Example:

function liveNeighbours(cells as [Boolean], c as Int) return Int

let neighbours be neighbourCells(c)

let live be neighbours.filter(lambda i as Int => cells[i])

return live.length()

end function

**Notes**:

* Although a lambda is commonly defined ‘inline’ (as shown above) it is possible to assign a lambda to a variable and hence to re-use it within the scope of that variable.
* Although a lambda will *usually* define at least one parameter, it is possible to define a lambda with no parameter, just returning an expression – in which case it acts just like a locally defined variable, but with the advantage (useful in rare circumstances) that the expression is evaluated ‘lazily’ i.e. only when the lambda is *used*. The following example uses both these techniques within a function:

function safeSquareRoot(x as Float) return Float  
 let root be lambda => sqrt(x)  
 return if x < 0 then 0 else root()  
end function

### Defining your own Hofs

TODO

The Iter type

The Func type

## Working with immutable types

You may pass mutable and/or immutable types into a function. However, you may not call any procedure on, not otherwise mutate any of those values passed as parameters.

That said, if you are wanting to learn to write code according to the the functional programming paradigm, it is desirable to work exclusively with immutable types. Elan provides very good support for these, both in the form of standard immutable data structures (initially Error! Reference source not found. and ImmutableDictionary) and user-defined Immutable class.

## Copy…with

NOT YET IMPLEMENTED

the copy…with syntax provides an easy-to-use mechanism for ‘updating’ one or more properties on an instance of an Immutable class. It returns a new instance that is a copy of the original, with all properties the same except where specified otherwise (in the ‘to clauses’ following the with). This general-purpose mechanism avoids the need to write an individual Function method for updating each property individually and copying the others, or a constructor that requires all properties.

When implemented, the syntax will be:

let d2 be copy d with height to 3, width to 4

where height and width are both properties of d. You can specify as many properties to change as required, each ‘to clause’ separated by a comma from the previous.

.

The test frame defines two fields:

A group of yellow squares with blue and purple letters

Description automatically generated

The result is typically a function call, but may also be a variable defined earlier in the test. The expected value should be a literal value or a variable, both fields should produce the same Type.

**Notes:**

* If the result type is Float and you do not wish to specify all decimal places, then you may use the round function, for example:  
  assert round(1/3, 2) is 0.33
* You cannot call a procedure directly within a float, but you can test some procedures by calling them and then testing the values of any parameters that the procedure is expected to have modified, for example:

A close up of a computer code

Description automatically generated

# Types

## Int

An integer is a whole number i.e. with no ‘fractional’ component.

### Type name

Int

### Defining a literal integer

var meaningOfLife set to 42

### Default value

0

### Constraints

* Maximum value: 253 – 1 which is just over 9 x 1015
* Minimum value: -(253 – 1)

If either limit is exceeded the number will automatically be represented as a Float, with possible loss of precision.

### Notes

* An Int may always be passed as an argument into a method that requires a Float.

## Float

Float is short for ‘floating-point number’ – a number that may have both an integer and fractional part.

### Type name

Float

### Defining literal floating-point value

var a set to 1.618

### Constraints

Since Elan compiles to JavaScript, the constraints on floating point numbers are those of JavaScript:

* Maximum value: just over 1 x 10308
* Minimum value: approx. 5 x 10-324

For greater detail, refer to the official JavaScript documentation

### Notes

* A variable that has been defined as being of type Float may not be passed as an argument into a method that requires an Int, nor as an index into an Array, *even if the variable contains no fractional part*. However, it may be converted into an Int before passing, using the functions floor() (the integer value left by removing any fractional part) or ceiling() (if the Float value *does* have a fractional part, the ‘ceiling’ will the lowest integer greater than the Float value).
* If you wish to define a variable to be of type Float but initialise it with a whole number then add .0 on the end of the whole number, for example: var a set to 3.0.

## Boolean

A Boolean value is either true or false.

### Type name

Boolean

### Defining a literal Boolean

var a set to true

true and false must be written lower-case

### Default value

false

## String

A String represents ‘text’ – a sequence of zero or more characters.

### Type name

String

### Defining a literal string value

var a set to "Hello"

String are always delineated by double-quote marks

### Default value

"" – known as ‘empty string’.

### Notes

* As on most programming languages, strings are *immutable*. When you apply any operation or function with the *intent* of modifying an existing string, the existing string is never modified. Instead the function or operation will return a *new* string that is based on the original, but with the specified differences.
* Strings may be appended using the plus operator, for example print "Hello" + " " + "World".
* A newline may be inserted within a string as \n, for example: print "Hello\nWorld".
* You may insert single-quote marks – ' – within a string.
* Elan strings are automatically interpolated: you may insert the values of variables, or simple expressions within a string, by enclosing them in curly-braces. For example (assuming that the variables a and b are already defined as integers) :  
   print "{a} times {b} equals {a\*b}.”
* It is not *currently* possible to include ", {, or } *directly* within a literal string. However they can be inserted into a string by creating the character from the Unicode, for example:  
  print "This is a double quote mark: " + **stringForUnicode**(34)

Or even by inserting the unicode within curly-braces:

print "{**stringForUnicode**(123)} and {**stringForUnicode**(125)}"

## Regex

The type Regex permits a regular expression to be passed as a parameter, or returned by a function.

A regular expression may be defined as a literal, bounded by forward slashes, for example:

var email set to /[a-z09\_]\*/

See also: Regular expressions

## Date and Time

NOT YET IMPLEMENTED

## Arrays and Lists

### Quick reference

|  |  |  |
| --- | --- | --- |
|  | **Array** | **List** |
| Type form | [String] | {String} |
| Literal | ["plum", "pear"] | {"plum", "pear"} |
| Literal empty | empty [String] | empty {String} |
| Initial size (filled with default values) | var a set to createArray(10, 0)  2D: create2DArray(8, 8, "")  In each case, the last argument is the value to which each element is initialised, and defines the type of elements in the Array | Not applicable |
| Read from position | a[3]  2D: **board[3][4]** | a[3] |
| Read range | a[5..9] | A[5..9)] |
| Put a value | call a.putAt(3, "pear")  2D: **call board.putAt2D(3,4,"K")** | set a to a.withPutAt(3, "pear) |
| Append/Prepend | call a.append("pear")  call a.prepend("pear")  call a.appendList(anotherList)  call a.prependList(anotherList) | Note that + appends a *list* to a list. So if you wish to append/prepend a single *item* then it should be enclosed in square brackets to make it into a list containing one item.  Append: set a to a + {"pear"}  Prepend: set a to {"pear"} + a  Append/prepend a list:  set x to listA + listb |
| Insert | call a.insertAt(3, "pear") | set a to a.withInsertAt(3, "pear) |
| Remove by index | call a.removeAt(3) | set a to a.withRemoveAt(3) |
| Remove by value | call a.removeFirst("pear")  call a.removeAll("pear") | set a to a.withRemoveFirst ("p")  set a to a.withRemoveAll ("p") |
| Deconstruction into head (first element) and tail (all the rest) | Not applicable | var x:xs set to myList  set h:t to myList  discarding either the head or tail: var \_:tail set to myList var head:\_ set t myList |

### List

A List is a simple data structure that holds multiple elements of the same type.

A list – just like a String – is *immutable*. You can still insert, delete, or change elements in a List, but the methods for these operations do not modify the input list: they return a new list based on the input list but with the specified differences.

#### Type name

The type is specified in the following form:

{String} for a list of type String

{Int} for a list of type Int

{{Int}} for a list of lists of type Int

Note that the syntax for the alias type name is similar to that for an Array but using curly braces { } instead of square brackets [ ]. The same is true for literals…

#### Defining a literal

var fruit set to {"apple", "orange", "pear"}

#### Using a List

Try these examples:

var fruit set to empty {String}

print fruit

set fruit to fruit + "apple"

set fruit to fruit + "pear"

print fruit

set fruit to "orange" + pear

print fruit[0]

print fruit.length()

print fruit[fruit.length() -1]

var head:tail set to fruit

print head

print tail

### Array

An ‘Array’ is a simple data structure that holds multiple elements of the same type.

Unlike a list, an Array is *mutable* – meaning that the elements within the data structure can be altered without creating a new Array from the old.

The type is specified in the following form:

[String] for an Array of type String

[Int] for an Array of type Int

Note that the syntax for the alias type name is similar to that for an List but using square brackets [ ] instead of curly braces. The same is true for literals…

Where, in this example, String represents the type of each element. The element type could be any value type – Int, Boolean, Float, String – or the name of a specific class such as Player or an enum such as Direction. It may also be another data structure, including another Array, (sometimes referred to as a ‘nested array’) for example:

#### Creating an Array

An Array may be defined in ‘literal’ form, ‘delimited’ by square brackets, and with all the required elements are separated by commas. The elements may be literal values (all of the same type):

var fruit set to ["apple", "orange", "pair"]

including ‘nested arrays’:

var coordinates set to [[3.4, 0.1, 7.8], [1, 0, 1.5], [10, -1.5, 25]]

or variables (provided they are all of the same type):

var values set to [x, y, z]

or a mixture of literal values and variables (all of the same type):

var values set to [3.1, y, z]

where y and z are existing variables of type Float.

You may also define an array of a specified size, with each element initialised to the same value, for example:

var fruit set to createArray(20, "")

will create an Array of type String with exactly 20 elements, each initialised to an empty String and:

var scores set to createArray(12, 100.0)

will create an Array of type Float with exactly 12 elements, each initialised to 100.0.

#### Using an Array

Elements are read using an index in square brackets – the *first* element being element [0]. The last element of an Array of size 10 will therefore be accessed by the index [9].

Attempting to read an element *by index*, where that element does not exist, will result in an ‘Index out of range’ runtime error.

Unlike in many programming you may *not* modify data by index: elements are *modified* by calling the putAt procedure on the array.

Try these examples (the last one will produce an error – make sure you understand why):

var a set to new createArray(10, 0)

print a

print a.length()

call a.putAt(0, 3)

call a.putAt(1, 7)

print a

print a[0]

print a[a.length() -1]

print a[a.length()]

Unlike in some languages, Elan Arrays may be dynamically extended, using append and prepend methods.

var a set to createArray(3, 0)

var b set to createArray(3, 10)

print a

print b

a.append(3)

b.prepend(7)

print a

print b

a.appendArray(b)

print a

### 2-dimensional Array

In Elan, as in many languages, a ‘2D array’ is just an Array of Arrays. However, Elan provides a couple of convenient short-cut methods for working with such data structures:

var board set to create2DArray(8, 8, "")

will create an Array of Arrays with a total of 64 elements each of type String, and initialised to an empty String. The type is determined by the type of the third parameter, which might be an Int, Boolean, or user-defined type. It need not be an empty value. The ‘2D Array’ need not be square.

You can modify individual elements in this data structure using:

call board.putAt2D(3,4,"K")

and you can read individual elements with a double index, for example:

for col from 0 to 7 step 1

for row from 0 to 7 step 1

print board[col][row]

end for

end for

## Dictionaries

There are two forms of dictionary in Elan: an ordinary Dictionary (which is mutable) and an ImmutableDictionary.

### Quick reference

|  |  |  |
| --- | --- | --- |
|  | **Dictionary** | **Immutable Dictionary** |
| Type form | [String:Int] | {String:Int} |
| Literal | ["a":1, "b":4] | {"a":1, "b":4} |
| Literal empty | empty [String:Int] | empty {String:Int} |
| Read the value for a given key | d["a"] | d.getKey("a") |
| Get all keys, or all values | d.keys() and d.values() Both return an immutable list of the appropriate type | |
| Define (or change) a value associated with a key | set d["c"] to 7 | set d to d.withKey("c", 7) |
| Remove both key and value | call d.removeKey("c") | set d to d.withRemoveKey("c") |

### Dictionary

#### Type name

In the following example, Int is the type of the ‘key’ and String is the type of the value associated with a specific key:

[Int, String]

Important: For both Dictionary and ImmutableDictionary the value type can be any type, including e.g. a specific type of class, a List, another Dictionary or another data structure. However, the *key* type must be one of: Int, Float, String, Boolean, or a specific type of enum.

#### Defining a literal

A literal Dictionary is defined as a comma-separated list of ‘key:value pairs’ surrounded by square brackets e.g:

var scrabbleValues set to ["a":1, "b":3, "c":3, "d":2]

#### Using a Dictionary

Try these examples:

var dict set to new [String, Int]

print dict

set dict["a"] to 3

print dict["a"]

call dict.removeByKey("a")

print dict

Constraints

* Key values must be unique
* There is no difference in syntax between *adding* an entry with a new key, and setting a new value for an existing key: if the key does not exist in the dictionary, it will be added.

### ImmutableDictionary

An immutable dictionary may be defined in a constant. For examples, see Snake (OOP) and Cards.

#### Type name

Type name takes the following form:

{Int, String}

#### Defining a literal

A literal Dictionary is defined as a comma-separated list of ‘key:value pairs’ surrounded by curly braces e.g:

var scrabbleValues set to {"a":1, "b":3, "c":3, "d":2}

#### Using an ImmutableDictionary

Try these examples:

var immD set to new {String, Int}

print immD

set immD to immD.withKeyValue("a", 3)

print immD.getValueByKey("a")

set immD to immD.withRemoveByKey("a")

print immD

## Tuple

A tuple is a way of holding a small number values of *different* types together as a single reference. A common usage scenarios include:

* Holding a pair of x and y coordinates (each a floating point number) as a single unit.
* Allowing a function could pass back a result, together with, say a string message and/or a Boolean flag indicating whether the operation was successful

A tuple is considered a ‘lightweight’ alternative to defining a specific class *for some purposes*.

### Type name

Written as a comma-separated list of the type of each member, surrounded by round brackets:

(Int, Int, Int)

(String, Boolean)

### Defining a literal tuple

A tuple is defined, where it is needed, by two or three elements – which variables, or literal values), separated by commas and surrounded by round brackets, for example:

var point1 set to (3.769, 4.088)

### Using a tuple

* You may pass a tuple into a function, or return one from a function, for example:

var d set to distanceBetween(point1, (12.34, 20.0))

* You may access (read) the individual elements within a tuple using methods first, second, and third for example:

var x = point1.first()

* An existing tuple (point1 below) may be ‘deconstructed’ into two new variables:

var x, y set to point1

or into existing variables of the correct type:

var a set to 3

var b set to 4

set a, b to point1

* The ‘discard’ symbol \_ (underscore) may also be used when deconstructing a tuple, if there is no need to capture one (or more) specific elements:  
    
  var x, \_ set to point1

### Constraints

* Tuples are currently limited to having two or three members, which may be of the same or different types.
* As in most languages, Elan tuples are *immutable*. Once defined they are effectively ‘read only’: you cannot alter any of the elements in a tuple, nor (unlike an List for example) can you create a new tuple from an existing one with specified differences
* If you invoke the method third on a tuple that has only two members you will get a run-time error.
* You cannot deconstruct a tuple into a *mixture* of new and existing variables

## Func

A function may be passed as an argument into another function (or a procedure), or returned as the result of calling another function. This pattern is known as ‘higher order function’, and is a key idea in the functional programming paradigm. To define a function that takes in another function as a parameter, or returns a function, you need to specify the *type* of the function, just as you would specify the *type* of every parameter and the return type for the function.

### Type name

The *type* of any function starts with the word Func, followed by angle brackets defining type of each parameter, and the return type for that function, following this syntax:

Func<of String, String, Int => Boolean>

The example above defines the type for a function that defines *three* parameters, of type String, String, and Int respectively, and returns a Boolean value. For example this type would match that of a function definition that started:

Function charactersMatchAt(a as String, b as String, position as Int) return Boolean

## Identifying and comparing types with ‘typeof’

The type of a variable (or literal) may be identified by preceding it with the typeof operator, which generates a String representation of the type. This may also be used to test and compare the type(s) of data items. Try the following:

A computer code with text

Description automatically generated with medium confidence

# Standard Library Functions

While Elan is still at Beta release, this is a document in progress. Where explanations are incomplete or missing, you *might* find some assistance by searching for the merh

## Standalone functions

Standalone functions always return a value and are therefore used in contexts that expect a value, such as in the right-hand side of a variable declaration (var) or assignment (set), either on their own or within a more complex expression. All standalone *library* functions require at least one argument to be passed in brackets – corresponding to the parameters defined for that function.

### unicode

stringForUnicode(code as Int) return String

Converts a unicode value (expressed in decimal or hexadecimal notation) into a single character string. For example:

A close-up of text

Description automatically generated

### parseAsInt and parseAsFloat

parseAsInt(inp as String) return (Boolean, Int)  
and   
parseAsFloat(inp as String) return (Boolean, Float)

parseAsInt attempts to parse the input String as an Int. Returns a 2-tuple, the first value of which is Boolean, with true indicating whether or not the parse has succeeded, and the second value being the resulting Int. parseAsFloat does the equivalent for floating point. Usage:

print parseAsInt("31") yields (true, 31)

print parseAsFloat("31") yields (true, 31)

print parseAsInt("31.2") yields (false, 0)

print parseAsFloat("31.2") yields (true, 31.2)

print parseAsInt("0") yields (true, 0)

print parseAsInt("0") yields (true, 0)

Notes:

* Any string that parses as an Int will also parse as a Float
* If the parse has failed the second value will default to zero – so you should always check the first value to see if this is a correct parse, or just the default.
* You can ‘deconstruct’ the tuple into two variables e.g  
  var (outcome, value) = parseAsInt(myString)
* One usage for these parsing methods is for validating inputs, but note that there is an easier way to do this – see Input methods.

### floor, ceiling, and round

floor(inp as Float) return Int

returns the nearest integer value *below* (or equal to) the argument value. Usage:

print floor(2.5) yields 2

ceiling(inp as Float) return Int

returns the nearest integer value *above* (or equal to) the input value. Usage:

print ceiling(2.5) yields 3

round(inp as Float, places as Int) return Float

Rounds the input number of decimal places specified as the second argument (an Int). Usage:

print round(3.14159, 3) yields 3.142

### Maths functions

pi -returns the constant Float value 3.141592653589793

Each of the following functions takes a single argument of type Float and returns a Float.

abs - returns the absolute value of the input.

acos - returns the arccosine of the input, as radians.

asin - returns the arcsine of the input value, as radians.

atan - returns the arctangent of the input value, as radians.

acosDeg - returns the arccosine of the input, as degrees.

asinDeg - returns the arcsine of the input, as degrees.

atanDeg - returns the arctangent of the input, as degrees.

cos - returns the cosine of input interpreted as radians.

cosDeg - returns the cosine of input interpreted as degrees.

exp - returns ex, where x is the argument, and e is Euler's number (2.718…)

logE - returns the natural logarithm of the input.

log10 - returns the base-10 logarithm of the input.

log2 - returns the base-2 logarithm of the input.

sin - returns the sine of the input interpreted as radians.

sinDeg - returns the sine of input interpreted as degrees.

sqrt - returns the positive square root of the input.

tan - returns the tangent of the input interpreted as radians.

tanDeg - returns the tangent of input interpreted as degrees.

degToRad – converts input from degrees to radians.

radToDeg – converts input from radians to degrees.

Examples of the maths functions being used:

A screenshot of a computer code

Description automatically generated

### Regular expressions

The method matchesRegex is applied to a String using dot-syntax and requires a Regex parameter, specified as a literal or as variable of Regex, for example:

A close-up of a computer code

Description automatically generated

### Bitwise functions

bitAnd(a as Int, b as Int) return Int

bitOr(a as Int, b as Int) return Int

bitXor(a as Int, b as Int) return Int

bitNot(a as Int) return Int

bitShiftL(a as Int, places as Int) return Int

bitShiftR(a as Int, places as Int) return Int

Examples of the bitwise functions being used

A screenshot of a computer code

Description automatically generated

The result of bitNot(a), where a is 13, being -14 might be a surprise. But this is because the bitwise functions assume that the arguments are represented as 32-bit *signed*  integers. So 13 is represented as 00000000000000000000000000001101, applying bit not will give 11111111111111111111111111110010 which is the 32-bit 2s-complement representation of -14

### Creating Arrays of specific sizes

The following methods return an Array, of a specified size, and with all elements initialised to a specified value. Although the resulting Array *may* still be expanded subsequently (by using the add procedure), the *typical* use for these two methods is for cases that would originally have used a traditional (fixed-size) ‘array’.:

createArray(size as Int, initialValue as Type) return [Type]

where Type is one of the following types: Int, Float, Boolean, String or any type of enum.

There is also a variant of the method that creates a ‘2-dimensional’ rectangular array (actually an Array of Arrays)

create2DArray(noOfrows as Int, noOfColumns as Int, initialValue as T) return [[Type]]

See also: Lists - Quick reference.

## Standalone procedures

### print & printTab

print(arg as String)

printTab(tabPosition as Int, arg as String)

These procedures may be called as an alternative to using the print *statement*. The differences are that the print or printTab *procedure*:

* does not automatically add a ‘newline’ at the end, so you may subsequently print something else on the same line. If you wish to use the print procedure and include one or more newlines in specific places, just include \n (the standard form for a newline) within the string.
* Require the data to be printed to be of type String. If you want to print a value of another type, you will either need to add .asString() to it, or put the value into braces within an ‘interpolated’ string.

For print, the data to be printed is the only argument. For example:

for I from 1 to 10 step 1  
 call print("{i}")  
end for

printTab helps in the layout of information printed to the console, in particular, the printing of columns of data. printTab works like the print procedure, but requires an additional argument specifying the tab position (number of characters from the left of the display). For example:

call printTab(0, "No.")  
call printTab(10, "Square")  
call printTab(20, "Cube\n")  
for x from 1 to 10 step 1  
 call printTab(0, x.asString())  
 call printTab(10, "{x^2}")  
 call printTab(20, "{x^3}\n")  
end for

### pause

pause(milliSeconds as Int)

Pauses the execution of the program for a specified number of milliseconds (minimum 1). For example, to pause for 1/10th of a second:

call pause(100)

There are two uses of pause:

* to control the speed of events – for example in a dynamic game
* to allow the Console and/or BlockGraphics displays to refresh. See Error! Reference source not found. and Error! Reference source not found.. (For this purpose, pause(1) is sufficient to enable the display refresh and causes minimum delay in program execution).

### clearConsole

procedure clearConsole()

Equivalent to pressing the Clear button on the Console, but automatically at specific point(s) in the program execution:

call clearConsole()

## System methods

‘System methods’ refers to a set of specific methods provided by the Elan standard library, that depend on the system (outside of the Elan language) in some way. They *appear* to work like functions – in that they return a value – and may be used within an expression in the same way as a regular function, *but may be used only inside* main *or a* procedure*.* This is because each system method has a dependency on something more than the arguments (if any) passed into it, and/or generates side effects. Thus, system methods are *not* ‘pure’ functions.

### Input methods

Input methods provide some validation of the input type and, optionally, values. Each of these methods, also defines a prompt string, which will be printed immediately before, and on the same line, as the input cursor – and will be repeated if a given user-input is not valid.

inputString(prompt as String) return String  
inputStringWithLimits(prompt as String, minLength as Int, maxLength as Int) return String  
inputStringFromOptions(prompt as String, options as {String}) return String  
inputInt(prompt as String) return Int  
inputIntBetween(prompt as String, min as Int, max as Int) return Int  
inputFloat(prompt as String) return Float  
inputFloatBetween(prompt as String, min as Float, max as Float) return Float

Examples of use:

var name set to inputString("Your name? ", 2, 50)

var name set to inputStringWithLimits("Your name? ", 2, 50)

var action set to inputStringFromOptions("Action ?", {"add", "remove", "exit")?

Note that the options must be specified as an *immutable* list i.e. within curly braces if specified as a literal list, as above.

var moveSquares set to inputInt("Move squares)

var age set to inputInt("Your age in years? ", 5, 21)

var payment set to inputFloatBetween("Payment value: ", 0.0, 99.99)

### Clock

clock() return Int

The clock methods returns an integer representing the current time in milliseconds since ‘the epoch’ (midnight, January 1, 1970 UTC). This is useful for measuring elapsed time. For example:

var startTime set to clock()  
# Your code here  
print "Elapsed time in milliseconds {clock - startTime}"

### Random numbers

There are two ways to create random numbers in Elan. The first is the simpler to understand and uses either of these two system method:

random() return Float

returns a random Float in between 0 and 1, and:

randomInt(min as Int, max as Int) return Int

takes two integer arguments – a lower-bound followed by an upper-bound - and returns a random integer value between those two (inclusive) values.

Examples of use:

var probability set to random()

var dice set to randomInt(1, 6)

The limitation of this simple approach is that – because these methods depend on an unseen random number generator that changes state each time either method is called – the methods may only be used within main or a procedure. You may generate random numbers in this way and pass the resulting number(s) into a function as Float or Int Type(s), but you may not generate a random number using these methods include a function.

#### Generating random numbers within a function

It is possible to create and use random numbers within a function, but it requires a different approach and is a little more complex, using a special *type* named Random (note that the R is capitalised). You must always create the *first* Random (using the system method firstRandom) within main or a procedure but you can pass this into a function and generate further random numbers within that function – because the next number is generated in a deterministic fashion from the previous Random number, using a ‘pseudo random sequence’. Example of use:

main

  var rnd set to firstRandom()

  var dice set to 0

  for i from 1 to 10 step 1

    set (dice, rnd) to rollDice(rnd)

  end for

end main

function rollDice(rnd as Random) return (Int, Random)

  return (rnd.valueInt(1, 6), rnd.next())

end function

Note that calling firstRandom() uses the system clock as the ‘seed’ value, and hence will be different each time you run the program. It is also possible to create a pseudo-random sequence that will be the same each time the program is run – and this is primarily intended for testing purposes. To create the fixed sequence replace **firstRandom()** with **firstRandomInFixedSequence()**, but leave the rest of your code unchanged.

### Reading & writing data files

Data file handling is not yet implemented. However, a ‘mock-up’ of the API for reading data files exists, illustrated here:

A white background with red text

Description automatically generated

When the API is properly implemented, the argument passed into the openRead system method (myFile in the example above) will specify the filename.

*For the current mockup*, however, the argument must be a reference to a string holding the content of the file – defined as a constant within the code, as shown in the example above.

## Dot methods

‘dot-methods’ are invoked on a variable or property of the appropriate type, using ‘dot syntax’.

### On a String

upper(input as String) as String

Returns a new string based on the input with all alpha-characters in upper-case.

lower(input as String) as String

Returns a new string based on the input with all alpha-characters in upper-case.

contains(partString as String) return Boolean

Takes a single parameter of type String, and returns a Boolean value indicating whether or not that argument string is contained within the string on which contained was called. Usage:

var a set to "Hello World!"  
print a.contains("ello")

prints true

trim() return String

returns a new string based on the string on which the method is called, but with any leading or trailing spaces removed.

indexOf(partString as String) return Int

The following methods are used for comparing strings alphabetically – for example in a sort routine.

isBefore(otherString as String) return Boolean

isAfter(otherString as String) return Boolean

isBeforeOrSameAs(otherString as String) return Boolean

isAfterOrSameAs(otherString as String) return Boolean

asUnicode() return Int

Returns the Unicode (integer) value for a character. If the string is more than one character long, the Unicode value returned is that for the *first* character in the string only.

### On an Array

In contrast to a List, an Elan Array is a *mutable* data structure. It has the behaviour of a traditional array, but may also be dynamically extended in size.

See also: Quick reference

Functions:

myArray.contains(item) returns true or false

myArray.asList() returns a List containing the same elements as the Array on which the method was called. This is often used to permit an Array to be passed into a function that has been designed to accept a List.

The following are all procedures, so invoked in a call statement, for example:

call fruit.append("banana")  
call fruit.appendList(anotherList)  
call fruit.insertAt(4, "cherry”)  
call fruit.prepend("melon”)  
call fruit.prependList(anotherList)  
call fruit.putAt(2, "grape")  
call fruit.removeAll("apple")  
call fruit.removeAt(3)  
call fruit.removeFirst("apple")

### 2D Array

If you have an Array of an Array of a given type (typically, though not necessarily, created by the create2DArray method then you may set a value using putAt2D, for example.:

call board.putAt2D(3,4,"King")

### On List

**Important**: in Elan, a List is *immutable.* Methods never *modify* the List on which they are called: instead they return a *new* List based on the original but with the specified differences – the same as happens for an ordinary String.

See also: Lists - Quick reference

These are all functions

myList.contains(item) returns true or false

myList.asArray() returns a new Array with the same contents as myList

The following functions all return a new List, copied from the list on which the function was called, but with the differences specified by the function:

myList.withInsertAt(4, "cherry”)

myList.withPutAt(2, "grape")

myList.withRemoveAt(3)

myList.withRemoveFirst("apple")

myList.withRemoveAll("apple")

### On a Dictionary

See also: Dictionaries - Quick reference

putAtKey

removeAtKey

keys

values

### On a ImmutableDictionary

See also: Dictionaries - Quick reference

hasKey

withPutAtKey

withRemoveAtKey

### On a Tuple

first

second  
third

These methods return a specified element within the tuple (tuples being limited to a maximum of three elements). Usage

var t set to (3, "apple", true)

print t.first()

print t.second()

print t.third()

### On BlockGraphics

**Important**: BlockGraphics are designed to work best at 100% browser magnification. At larger magnifications, all the blocks will not necessarily be shown; at smaller magnifications there may be gaps between the blocks.

Examples of using the dot-methods on BlockGraphics may be found in the following example programs:

* Snake (OOP)
* Life

Both functions and procedures are called on an instance of BlockGraphics using dot notation.

#### Functions

Note that because the BlockGraphics type is immutable, all functions that appear to modify the contents (i.e. those starting put…) return a new instance of type BlockGraphics with the difference(s) specified. This instance will need to be assigned either to the original variable, or to a new one.

withBlock(x as Int, y as Int, colour as Int) return BlockGraphics

withText(x as Int, y as Int, text as String, foreground as Int, background as Int) return BlockGraphics

withUnicode(x as Int, y as Int, unicode as Int, foreground as Int, background as Int) return BlockGraphics

withBackground(backgroundColour as Int) return BlockGraphics

getChar(x as Int, y as Int) return String

getForeground(x as Int, y as Int) return Int

getBackground x as Int, y as Int) return Intbackground

getDetails(x as Int, y as Int) return (String, Int, Int)

Note that colours are represented as integer values, corresponding to the standard RGB colour scheme as used in all web graphics. The following basic colours are predefined as global constants: black, grey, white, red, green, blue, yellow, brown.

Note that when defining your own colours it can be helpful to use the hexadecimal notation, for example:

constant lightBlue set to 0x80abff

#### Procedures

These procedure are all called on an instance of BlockGraphics using dot notation:

draw()

clearGraphics()

clearKeyBuffer()

#### System methods

As with other system methods, these may only be called from within main or a procedure.

getKeystroke() return String

getKeystrokeWithModifier() return (String, String)

Example use where gr is an instance of type BlockGraphics:

var k set to gr.getKeystroke()

* If the user has pressed a key that key will be returned as a String.
* If no key has been pressed, the method will return an empty string: "".
* If the key is a printable character, it will be returned as a single-character string, for example: "a", "X","3",":"
* Non-printable keys are returned as words, for example: **"Space"**, **"Backspace"**,"**Enter","ArrowDown"**
* **getKeystrokeWithModifier** allows you to check whether the keystroke was ‘modified’ by, for example, the **Shift**, **Ctrl**, or **Alt** keys. The method returns a 2-tuple consisting of the key and the modifier (which may be an empty string). Learn how this works with this example:

clearKeyBuffer()

All keystrokes go into ‘queue’ called the keyboard ‘buffer’. If you are reading keys (see Error! Reference source not found. ) and you wish to prevent the user from adding keystrokes faster than they can be consumed, then:

call clearKeyBuffer()

### On an instance of a class

typeAndProperties returns a string that summarises the instance on which the function is called, including the name of the class and the value of all properties.

### On any Iterable - Higher order functions (HoFs)

These dot methods are called on any ‘iterable’ type, which includes concrete Lists, Strings, or iterables returned by other functions. As ‘higher order functions’ they take either a lambda or a reference to a function as one of their arguments.

**Important:** Several of these methods return an abstract type named Iterable. The result may easily be turned into a form that can be printed, or passed into other functions, by appending .asList() or .asArray() at the end of the expression.

*These are not yet fully documented* but, for readers familiar with HoFs from another language, some examples are shown below.

Filter

Usage (from example program

Turing machine):

let matches be rules.filter(lambda r as Rule => (r.currentState is currentState) and (r.currentSymbol is tape[headPosition]))

map

Usage (from example program Life):

let next be cellRange.map(lambda n as Int => nextCellValue(cells, n))

reduce

Usage (from example program

An implementation of a Turing Machine as a single class, with a separate (immutable) class to capture the transition rules.

Wordle solver):

let d2 be possibleAnswers.reduce(d, lambda dd as {String:Int}, possAnswer as String => incrementCount(dd, possAnswer, attempt))

max and min

Both functions may be applied to an Iter<Float> e.g. a [Float] or {Float} and return the maximum/minimum value found therein.

var a set to {33, 4, 0,99, 82, 55}

print "Max: {a.max()} Min: {a.min()}"

maxBy and minBy

Alternative implementations of max and min that take. Usage:

var a set to {33, 4, 0,99, 82, 55}

print a.maxBy(lambda x as Int => x mod 10)

any

Returns **true** or **false** indicating whether any of the members of the iterable individually pass the test defined by the lambda (which itself returns a **Boolean**). Usage:

var a set to {33, 4, 0,99, 82, 55}

print a.any(lambda x as Int => x > 50)

sortBy

*Additional sort methods will be introduced in a later Beta.*

For now, sortBy takes a lambda that takes two arguments (of the same type as that of the iterable being sorted) and compares them, returning an integer, with one of the values -1, 0, 1, to indicated whether the first argument should be placed before, after, or just adjacent to (does not matter whether before or after) the second argument in the sorted result. Example:

var source set to {2, 3, 5, 7, 11, 13, 17, 19, 23, 27, 31, 37}

print source.sortBy(lambda x as Int, y as Int => if x > y then 1 else -1)

The following are not HoFs, but are included here because they are most likely to be used *with* one of the HoFs listed above.

range(first as Int, last as Int) as Iter<of Int>

returns an Iiterable that will produce all the integer values between the two argument values.

### On many different types

asString

asIter

length

head returns the first item in an Array or a List

# Example programs

The Demo button on the Elan Beta provides a range of example programs that you can explore, and run, including the following list. In the full release – Elan v1.0 – the Demo button will, deliberately, not appear by default, but it can be specified (in the editable profile) to be shown if desired.

### Snake (OOP)

An implementation of the popular ‘Snake’ game – using OOP with classes for Snake, Apple, Square, and Board. Uses the BlockGraphics pane.

### Binary Search

An implementation of the ‘binary search’ algorithm in a single function, with small main routine to demonstrate it in use, and automated tests.

### Merge sort

A recursive implementation of the ‘merge sort’ algorithm in two functions, complete will a small main routine to demonstrate it in use, and automated tests.

### Life

An implementation of Conway’s famous ‘Game of Life` simulation using the BlockGraphics pane, and with automated tests.

### Turing machine

An implementation of a Turing Machine as a single class, with a separate (immutable) class to capture the transition rules.

### Wordle solver

This program is capable of solving a Wordle, and in ‘hard mode’ (where each guess must be a possible answer). It solves 99% of all possible Wordle puzzles in 6 or fewer attempts, with an average of just 3.67 attempts.

### Cards

This is not a working card game – just a sketch to show the beginnings of a Card class, with associated enums and constants, that may easily be rendered on the BlockGraphics display.

# Index to all keywords

abstract - see Abstract class

and - see Logical operators

as - see Procedure & Function

assert - see Error! Reference source not found.

be - see If expression

The ‘if expression’ is *in certain respects* similar to an If statement, but with the following differences:

* It is written entirely within a single expression. This is possible because the if expression always returns a value.
* There is always a single then and a single else clause, and each clause contains just a single expression. The if expression returns the result of evaluating one of these two expressions, according to whether the condition evaluates to true or false.
* These if expressions may be ‘nested’ within each other, using brackets around each nested if expression where there could be any ambiguity.

Some more examples:

return if c < 1160 then c + 40 else c – 1160

return if isGreen(attempt, target, n) then setChar(attempt, n, "\*") else attempt

return if attempt[n] is "\*" then attempt else (if isYellow(attempt, target, n) then setChar(attempt, n, "+") else setChar(attempt, n, "\_"))

The last example contains a nested if expression.

Let statement

call - see Procedure

case - see Switch statement

catch - see Error/Exception handling

class - see Object-oriented programming

constant - see Constant

constructor - see Object-oriented programming

copy - see Cop

default - see Switch statement

div - see Arithmetic operators

each - see Each loop

else - see Elan supports the two forms of ‘selection’ most widely-used in procedural programming: the If statement and the Switch statement.

(Elan also supports the If expression, which, although often thought of as a Functional programming technique, may be used within procedural programming also – within any expression.)

If statement

empty – see Error! Reference source not found. Dictionaries Using a class

end – (in conjunction with another keyword) defines the end of most multi-line constructs

enum - see Enum

false – see Boolean

for - see For loop

from - see For loop

function - see Function and Passing a function as a reference

global - TODO

if - see Elan supports the two forms of ‘selection’ most widely-used in procedural programming: the If statement and the Switch statement.

(Elan also supports the If expression, which, although often thought of as a Functional programming technique, may be used within procedural programming also – within any expression.)

If statement & Error! Reference source not found.

immutable - see Immutable class

import – (Not yet implemented)

in - see Each loop

inherits - see Inheritance

is - see Equality testing

isnt - see Equality testing

lambda - see Passing a function as a reference

If you are passing a reference to a freestanding function as an argument into a HoF (as distinct from defining a lambda) then you provide the name of that function, but precede it with the keyword function. For example:

…

var passes set to allPupils.filter(function passedMathsTest)

…

function passedMathsTest(p as Pupil) as Boolean

return p.mathsPercent > 35

end function

**Notes:**

* When passing in a reference function passMathsTest, the name is preceded by function, and that no parameters (or brackets) are added to the name as they would have been if you were *evaluating* (calling) the function at that point.

Lambda

let - see If expression

The ‘if expression’ is *in certain respects* similar to an If statement, but with the following differences:

* It is written entirely within a single expression. This is possible because the if expression always returns a value.
* There is always a single then and a single else clause, and each clause contains just a single expression. The if expression returns the result of evaluating one of these two expressions, according to whether the condition evaluates to true or false.
* These if expressions may be ‘nested’ within each other, using brackets around each nested if expression where there could be any ambiguity.

Some more examples:

return if c < 1160 then c + 40 else c – 1160

return if isGreen(attempt, target, n) then setChar(attempt, n, "\*") else attempt

return if attempt[n] is "\*" then attempt else (if isYellow(attempt, target, n) then setChar(attempt, n, "+") else setChar(attempt, n, "\_"))

The last example contains a nested if expression.

Let statement

library - TODO

main - see Main routine

mod - see Arithmetic operators

new - see Using a class

not - see Logical operators

of - see Types

or - see Logical operators

out – see Parameter passing

print - see Printing to the Console

private - see Object-oriented programming

procedure - see Procedure

property - see Object-oriented programming

repeat - see Repeat loop

return - see Function

set - see Using variables

step - see For loop

switch - see Switch statement

test - see Error! Reference source not found.

this - see Object-oriented programming

throw - see Error/Exception handling

to - see For loop

true - see Boolean

try - see Error/Exception handling

typeof - see Identifying and comparing types with ‘typeof’

var - see Using variables

while - see While loop

with - see Cop