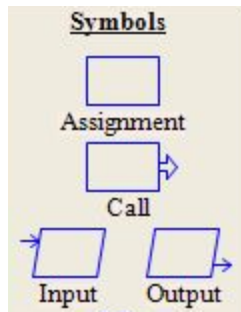


RAPTOR Syntax and Semantics

By Lt Col Schorsch

Program - an ordered collection of instructions that, when executed, causes the computer to behave in a predetermined manner.

Variable - A variable names a memory location. By using that variable's name you can store data to or retrieve data from that memory location. A **variable** has 4 properties: ① a name, ② a memory location, ③ a data type, ④ a value. You can assign a value to a variable using an assignment statement (see below). RAPTOR variables are declared on first use, they must be assigned a value on first use and based on that value its *data type* will be Number, String, or an Array of Numbers.



Data Type - A Data Type is the name for a group of data values with similar properties.

A Data Type has 4 properties: ① a name, ② a set of values, ③ a notation for *literals* of those values, ④ operations and functions which can be performed on those values.

RAPTOR has two simple data types: Number and String (Array data types are described later)

Type name	Literal Values	Operations grouped from lowest to highest precedence
Number	-32, 0, 1, 49, etc. -2.1, 3.1415, etc.	[=, <, <=, >, >=, /, !=], [+ , -], [* , / , rem, mod], [** , ^]
String	"Hello", "Bob", etc.	[=, <, <=, >, >=, /, !=], [+]

Operator - An operator directs the computer to perform some computation on data.

Operators are placed between the data (operands) being operated on (i.e. $X / 3$, $Y + 7$, $N < M$, etc.)

basic math operators: +, -, *, /, ^, **, rem, mod
 +, -, *, / are defined as one would expect, ** and ^ are exponentiation, ex $2^{**}4$ is 16 , $3^{**}2$ is 9 (remainder) and mod (modulus) return the remainder (what is left over) when the right operand divides the left operand, ex $10 \text{ rem } 3$ is 1 , $10 \text{ mod } 3$ is 1

Concatenation operator: +
 Joins strings and numbers (i.e. "Average is " + (Total / Number))

The following operators are only used in decisions (see Selection and Iteration)

Relational operators: =, !=, /=
 Used to compare numbers and strings, = is equals, != and / = are both not equals.
 <, >, >=, <= <, >, >=, <= are defined as expected. The result of a relational comparison is a Boolean value.

Logical operators:	and, or, not, xor	Expression	Result	Expression	Result	Expression	Result
		True and True	True	True or True	True	Not(True)	False
		True and False	False	True or False	True	Not(False)	True
		False and True	False	False or True	True	Not(True)	False
		False and False	False	False or False	False	Not(False)	True

not is true when other operand is true (but not when both operands are true).

Function - A function performs a computation on data and returns a value.

Functions use parentheses to indicate their data (i.e. $\text{sqrt}(4.7)$, $\text{sin}(2.9)$, etc.)

Basic math: sqrt, log, abs, ceiling, floor, abs
 sqrt returns the square root, ex $\text{sqrt}(4)$ is 2
 log returns the natural logarithm, ex $\log(e)$ is 1
 abs returns the absolute value, ex $\text{abs}(-9)$ is 9
 ceiling rounds up to a whole number, ex $\text{ceiling}(3.14159)$ is 4
 floor rounds down to a whole number, ex $\text{floor}(10/3)$ is 3

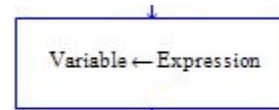
Trigonometry: sin, cos, tan, cot, arcsin, arccos, arctan, arccot
 Angles are in radians, ex $\text{sin}(\pi)$ is 0 .
 arctan and arccot are the two parameter versions of those functions. (i.e. $\text{arctan}(X/Y)$ is written in RAPTOR as $\text{arctan}(X,Y)$).

Miscellaneous: Length_Of, Random
 Length_Of returns the number of characters in a string ex $\text{Name} = \text{"Stuff"}$ followed by $\text{Length_Of}(\text{Name})$ is 5
 (also returns the number of elements in an array which you will learn later)
 Random Returns a random number between $[0.0,1.0)$
 (Random * X + Y extends the range by X and shifts it by Y)

Assignment Statement - An assignment statement is used to evaluate an *expression* and store the results in a *variable*. The *expression* is on the right hand side of the assignment operator, ←.

An *expression's* value (after it is evaluated) is stored in the *variable* on the left hand side of the ← operator. An *expression* must evaluate to a value of the same data type as the *variable* in which it is being stored.

Syntax:
 Variable ← Expression



Set Variable _____
 to Expression _____

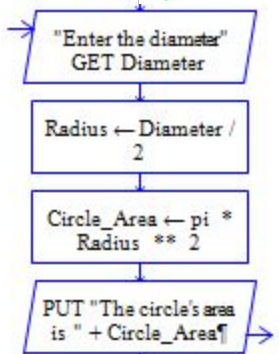
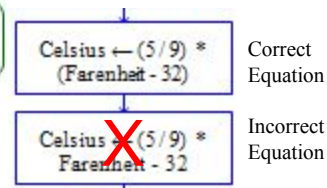
An *expression* is either a *variable*, a *literal*, or some *computation* (such as $3.14 * \text{Radius}$). A *literal* (such as 2.143 , 42 , "Help") evaluates to itself.

A *variable* evaluates to the data stored at its memory location. Evaluating a *computation* involves evaluating the literals, variables, operators and functions in the expression.

Age ← 21	The value 21 is stored in variable Age's memory location
Count ← Count + 1	The value that is stored in Count's memory location is incremented by 1
Force ← Mass * Acc	Mass and Acc are multiplied together, the product is stored in variable Force
Delta_X ← abs(X2 - X1)	Take the absolute value difference and store it in Delta_X
Name ← "Schorsch"	Assigns the string "Schorsch" to the variable Name's memory location

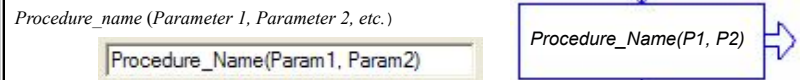
Order of operations matters!
 Precedence levels from lowest to highest
 [=, <, <=, >, >=, /, !=], [+ , -], [* , / , rem, mod], [** , ^]

Circle Area program:
 Given a diameter this program computes and displays the area of a circle with that diameter



Procedure Call - A procedure is a set of executable statements that have been given a name.

Calling a procedure executes the statements associated with that procedure.




The number and order of parameters in the call must match the expected number and order. The data types of the parameters in the call must match the expected data types of the parameters. Procedure parameters can be used to give (supply) a procedure with data or can accept (receive) data. Parameters must be variables if they receive a value. Parameters can be an expression (computation), variable or literal if they supply a value.

Delay_for(0.2)	delays execution for 2/10ths of a second
Clear_Console	erases the master console contents
Draw_Circle(X, Y, 7, Blue)	draws a blue circle at location X,Y with a radius of 7

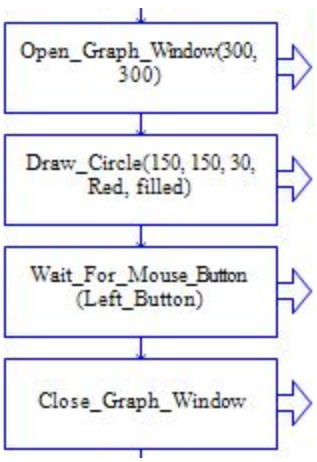
RAPTORGraph Syntax and Semantics

RAPTORGraph is a collection of procedures and functions that a RAPTOR programmer can use to create a graphics window, draw and animate graphical objects in that window, and interact with the graphics window using the keyboard and mouse.

Procedure calls occur only in call symbols. 

Function calls return a value and therefore can occur anywhere a value can occur. (i.e. in assignment, decision, and output statements and as procedure call parameters.)

This RAPTORGraph program:
 Opens a graphics window
 Draws a filled red circle
 Waits until the user presses the left mouse button
 Closes the window



Graphic window opening and closing procedures
 Open_Graph_Window(X_Size, Y_Size)
 Close_Graph_Window

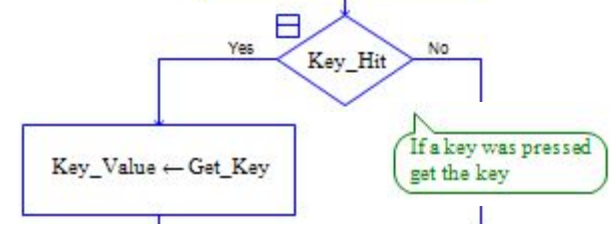
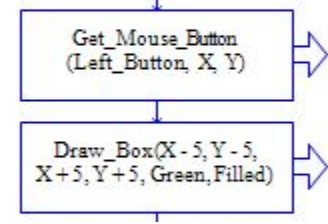
Graphic window "size" functions
 Get_Max_Width -> returns available screen pixel width
 Get_Max_Height -> returns available screen pixel height
 Get_Window_Width -> returns current window pixel width
 Get_Window_Height -> returns current window pixel height

Keyboard input procedure
 Wait_For_Key

Keyboard input functions
 Key_Hit -> returns True / False (whether a key was pressed)
 Get_Key -> returns the numeric ASCII value of the pressed key
 Get_Key_String -> returns a string value of the pressed key

Drawing procedures
 Put_Pixel(X, Y, Color)
 Draw_Line(X1, Y1, X2, Y2, Color)
 Draw_Box(X1, Y1, X2, Y2, Color, Filled/Unfilled)
 Draw_Circle(X, Y, Radius, Color, Filled/Unfilled)
 Draw_Ellipse(X1, Y1, X2, Y2, Color, Filled/Unfilled)
 Draw_Arc(X1, Y1, X2, Y2, StartX, StartY, EndX, EndY, Color)
 Clear_Window(Color)
 Flood_Fill(X, Y, Color)
 Display_Text(X, Y, String Expression, Color)
 Display_Number(X, Y, Number Expression, Color)

This RAPTORGraph program:
 Draws a 10 by 10 Green box
 centered on a user's mouse click



RAPTORGraph Colors
 Black, Blue, Green, Cyan, Red, Magenta, Brown, Light_Gray, Dark_Gray, Light_Blue, Light_Green, Light_Cyan, Light_Red, Light_Magenta, Yellow, White
 (Get_Pixel returns 0 for Black, 1 for Blue, ..., 16 for White)

Mouse input procedures
 Wait_for_Mouse_Button(Which_Button)
 Get_Mouse_Button(Which_Button, X, Y)

Mouse input functions
 Mouse_Button_Pressed(Which_Button) -> returns True / False
 Mouse_Button_Released(Which_Button) -> returns True / False
 Get_Mouse_X -> returns X coordinate of mouse location
 Get_Mouse_Y -> returns Y coordinate of mouse location

Graphics window query function
 Get_Pixel(X, Y) -> returns the number code for the color of the pixel at (X, Y)

How to animate an object in RAPTORGraph
 Place the following inside of a loop
 Draw some an object relative to an X,Y point with the drawing procedures
 Delay_For some small time period
 Draw the object again in white (i.e. erase it)
 Update the X,Y point where you are drawing by some small offset

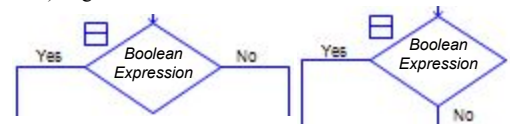
RAPTOR Syntax and Semantics – Selection and Iteration Control Structures

Decision - A decision is part of a Selection or Iteration (loop) statement.

A decision symbol (its value during execution) determines which way execution will continue. Use relational operators (and logical operators) to get a Boolean value for the decision.

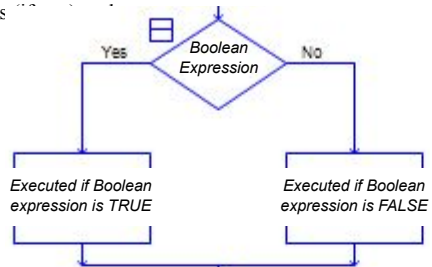
Relational: =, <, <=, >, >=, /=, !=

Logical: and, or, not, xor



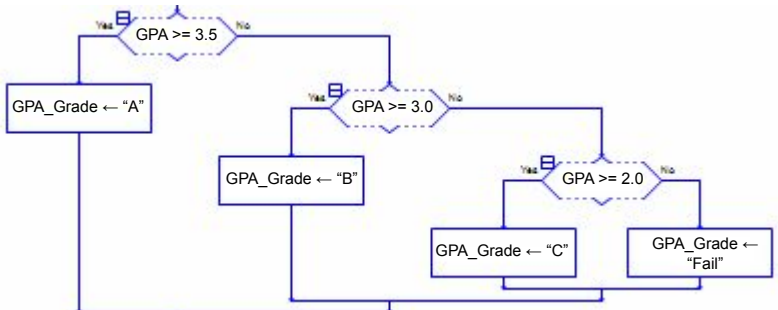
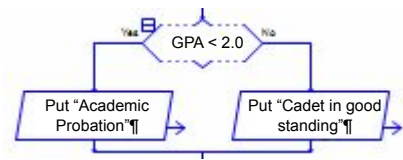
Selection Statement - A selection statement is used to decide whether or not to do something, or to decide which of several things

If the *Boolean Expression* is TRUE, execute the left hand path otherwise execute the right hand path



If the value of the variable GPA is greater than 3.0 then execute the statement Put ("Dean's List") otherwise do nothing

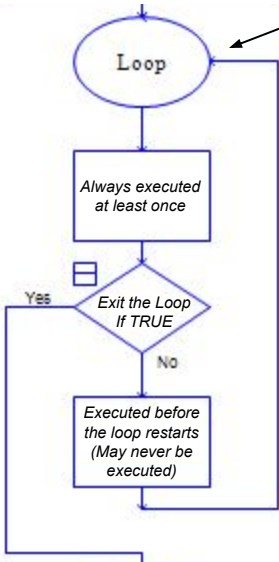
If a student's GPA is less than 2.0 then execute the statement Put ("Academic probation") otherwise execute the statement Put ("Cadet in good standing")



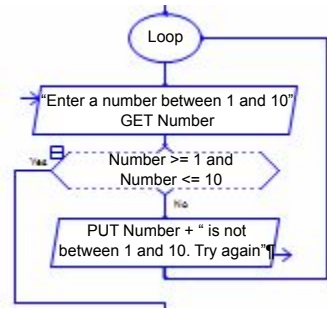
This last example requires several decision statements as there are several decisions (more than two possible paths). The code assigns a nominal "grade" based on a student's GPA. The "pattern" of these selection statements is called cascading selections.

Iteration Statement (loop statement) –

An Iteration statement enables a group of statements to be executed more than once. Use **I.T.E.M** (Initialize, Test, Execute, and Modify) to ensure your loop (and **loop control variable**) are correct.



A **Condition Controlled Loop** (basic loop) repeats its statements until a condition (the decision statement) becomes true.

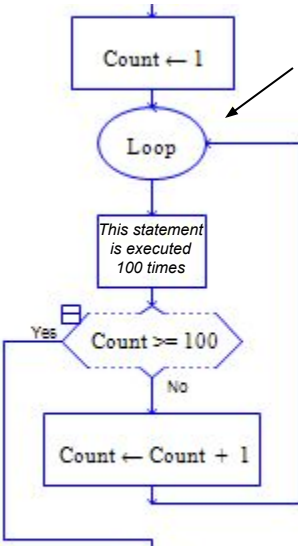


Initialize (and modify) the loop control variable

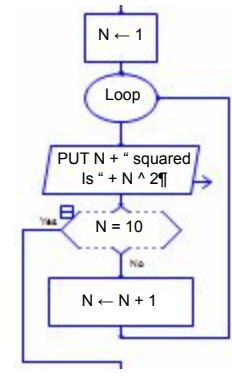
Test the loop control variable

Execution step

The validation loop above will continue to execute until the user enters a number between 1 and 10. Number is the loop control variable.



A **Count Controlled Loop** repeats its statements a fixed number of times. (This executes the loop 100 times because of the decision: Count >= 100).



Initialize the loop control variable (above the loop)

Execution step

Test the loop control variable

Modify the loop control variable

The count controlled loop above executes exactly 10 times (it displays the numbers 1 through 10 and the squares of those numbers). Count is the loop control variable.

RAPTOR Syntax and Semantics - Arrays

Array variable - Array variables are used to store many values (of the same type) without having to have many variable names. Instead of many variables names a count-controlled loop is used to gain access (index) the individual elements (values) of an array variable.

RAPTOR has one and two dimensional arrays of numbers. A one dimensional array can be thought of as a sequence (or a list). A two dimensional array can be thought of as a table (grid or matrix).

To create an array variable in RAPTOR, use it like an array variable. i.e. have an index, ex. Score[1], Values[x], Matrix[3,4], etc.

All array variables are indexed starting with 1 and go up to the largest index used so far. RAPTOR array variables grow in size as needed.

The assignment statement

```
GPA[24] ← 4.0
```

assigns the value 4.0 to the 24th element of the array GPA.

If the array variable GPA had not been used before then the other 23 elements of the GPA array are initialized to 0 at the same time. i.e. The array variable GPA would have the following values:

1	2	3	4	23	24
0	0	0	0	0	0	0	4.0

The initialization of previous elements to 0 happens only when the array variable is created. Successive assignment statements to the GPA variable affect only the individual element listed.

For example, the following successive assignment statements

```
GPA[20] ← 1.7
```

```
GPA[11] ← 3.2
```

would place the value 1.7 into the 20th position of the array, and would place the value 3.2 into the 11th position of the array.

i.e. $GPA[20] \leftarrow 1.7$

1	2	3	4	23	24
0	0	0	0	0	0	0	4.0
						3.2	
							1.7

An array variable name, like GPA, refers to ALL elements of the array. Adding an *index* (position) to the array variable enables you to refer to any specific element of the array variable.

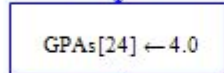
Two dimensional arrays work similarly.

i.e. Table[7,2] refers to the element in the 7th row and 2nd column.

Individual elements of an array can be used exactly like any other variable. E.g. the array element GPA[5] can be used anywhere the number variable X can be used.

The Length_Of function can be used to determine (and return) the number of elements that are associated with a particular array variable.

For example, after all the above, Length_Of (GPA) is 24.



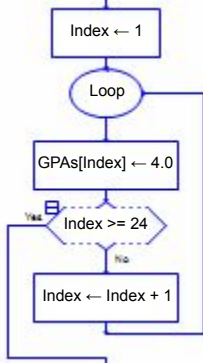
Array variables in action- Arrays and count-controlled loop statements were made for each other.

Notice in each example below the connection between the Loop Control Variable and the array index!

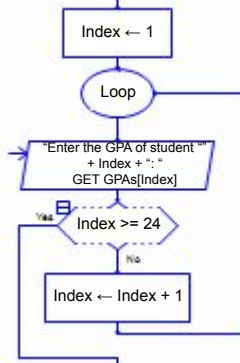
Notice how the Length_Of function can be used in the count-controlled loop test!

Notice that each example below is a count-controlled loop and has an Initialize, Test, Execute, and Modify part (I.T.E.M.)

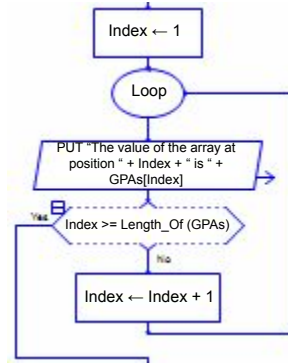
Assigning values to an array variable



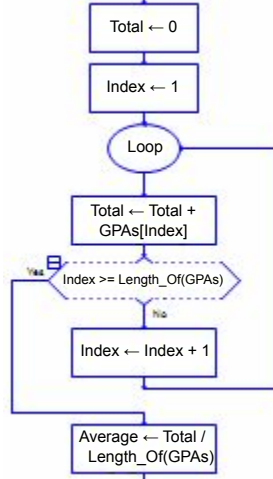
Reading values into an array variable



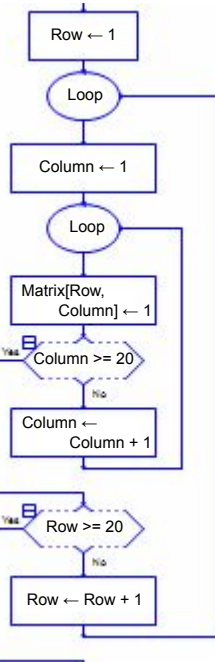
Writing out an array variable's values



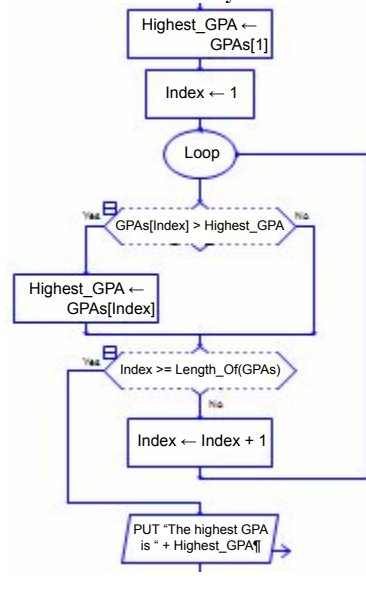
Computing the total and average of an array variable's values



Initialize the elements of a two dimensional array (A two dimensional array requires two loops)



Find the largest value of all the values in an array variable



Find the INDEX of the largest value of all the values in an array variable

