7 Advanced Topics

7.1 Aims

By the end of this worksheet you will be able to:

- Use array functions
- Create larger programs aided by "Flow Charts"

7.2 Array Functions

FORTRAN provides a number of intrinsic functions that are useful for working with arrays. Among these are some which are specifically aimed at working with matrices and vectors.

MATMUL	**Matrix/vector**	**Matrix multiplication of two matrices or a matrix and a vector.**
DOT_PRODUCT	**Vector**	**Scalar (dot) product of two vectors**
TRANSPOSE	**Matrix**	**Transpose of a matrix**
MAXVAL	**Any array**	**Maximum value of an array, or of all the elements along a specified dimension of an array.**
MINVAL	**Any array**	**Minimum value of an array, or of all the elements along a specified dimension of an array.**
SUM	**Any array**	**Sum of all the elements of an array, or of all the elements along a specified dimension of an array.**

Program **matrixmul.f95**, demonstrates the use of these functions. Additionally, it includes two subroutines that are likely to be useful when handling matrix/array manipulations: **fill_array** which fills the array elements and **outputra** which prints the values of the array elements to the screen. This program is also an example of **dynamic memory allocation**.

```
program matrixmul
!demonstrates use of matmul array function and dynamic
!allocation of array
     real,  allocatable, dimension(:,:) :: ra1,ra2,ra3
     integer                            :: size
!initialize the arrays
     print*, 'Shows array manipulation using SQUARE arrays.'
     print*, 'Allocate the space for the array at run time.'
     print*, 'Enter the size of your array'
     read *, size
     allocate(ra1(size,size),ra2(size,size),ra3(size,size))
     print*, 'enter matrix elements for ra1 row by row'
     call fill_array(size,ra1)
     print*, 'enter matrix elements for ra2 row by row'
     call fill_array(size,ra2)
!echo the arrays
     print *,'ra1'
      call outputra(size,ra1)
```

```
      print *,'ra2'
      call outputra(size,ra2)
!demonstrate the use of matmul and transpose intrinsic
!functions
      ra3=matmul(ra1,ra2)
      print *,'matmul of ra1 and ra2'
      call outputra(size,ra3)
      ra3=transpose(ra1)
      print *,'transpose of ra1'
      call outputra(size,ra3)
      deallocate(ra1,ra2,ra3)
      end program matrixmul
!-------------------------------------------------------
      subroutine outputra(size,ra)
      implicit none
!will output a real square array nicely
      integer                              :: size,row,col
      real,dimension(size,size)            :: ra
      character                            :: reply*1
      do row =1,size
         write(*,10) (ra(row,col),col=1,size)
10    format(100f10.2)
!as we don't know how many numbers are to be output, specify
!more than we need - the rest are ignored
      end do

print*,'_____________________________________________________'
      print*,'Hit a key and press enter to continue'
      read *,reply
      end subroutine outputra
!-------------------------------------------------------
      subroutine fill_array(size,ra)
      implicit none
!fills the array by prompting from keyboard
      integer                           :: row,col,size
      real                              :: num
      real, dimension(size,size)        :: ra
      do row=1,size
         do col=1,size
         print *, row,col
         read *,num
         ra(row,col)=num
         end do
      end do
      end subroutine fill_array
```

Exercise 7.1

Write a program to read in 2 square matrices (of any size). Confirm that the matrices obey the rule

$$(AB)^T = B^T A^T$$

where A^T is the transpose of matrix A.

Exercise 7.2

Write a program that will read a 3 X 3 matrix from a data file. In the program, include a subroutine that will generate any cofactor **cof** of the matrix **mat**. Call the subroutine cofactor and use these arguments:

```
subroutine cofactor(i,j,mat,cof)
implicit none
real :: mat(3,3),minor(2,2),cof
integer :: elrow,elcol
! cof – the cofactor of matrix mat for element i,j
.
.
```

Exercise 7.3

Use the program you developed Exercise 7.2 to calculate the **determinant** of a 3 X 3 matrix.

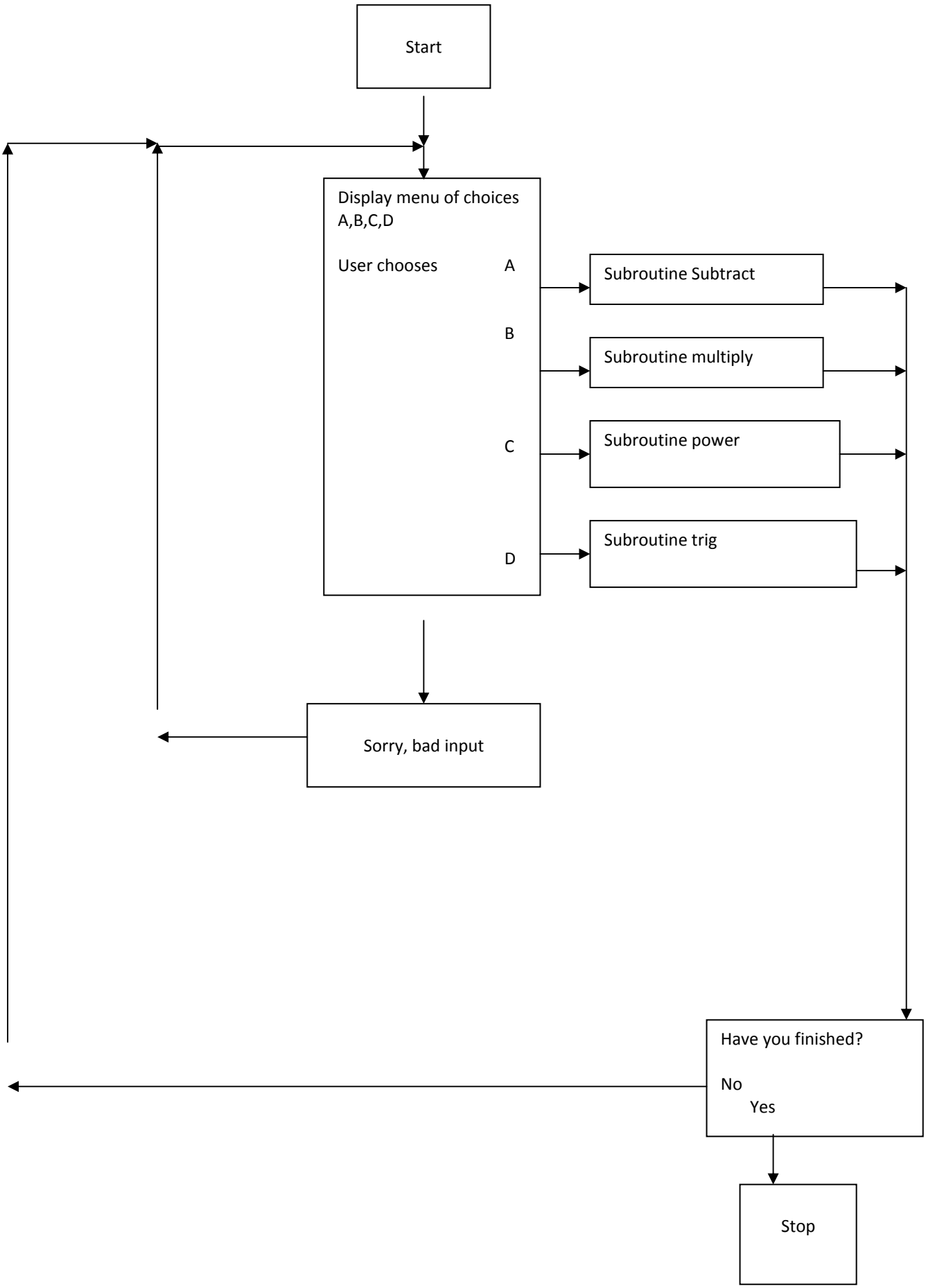
7.3 Writing REAL programs - Flow Charts

Now that you know all the main elements of FORTRAN 95, you are in a position to apply your skills to writing REAL programs. Unlike most of the exercises in these worksheets, REAL programs tend to be rather large. In large programs, the underlying logic can often be difficult to follow.

It helps, therefore, both in the devising of a program and later in its maintenance, to have a plan of what you intend the program to do. Let's take, as an example, a program that works like a calculator.

The flowchart is shown on the next page. The logic of the program, as a whole, is clear. Details like what will happen in the subroutines is glossed over at this stage.

In commercial programming, flowcharts are usually formalized, with specific shapes for boxes that do different things. That need not concern us here. Essentially, we use flowcharts to provide a 'map' of the underlying logic flow in the program – what connects with what.


Start
Display menu of choices
A,B,C,D
User chooses
A
B
C
D
Subroutine Subtract
Subroutine multiply
Subroutine power
Subroutine trig
Sorry, bad input
Have you finished?
No
Yes
Stop