An introduction to Fortran

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Honours/Masters Introduction to Computing Course
Part I: Introduction to FORTRAN
A brief history of Fortran (and FORTRAN)

- developed in the 1950’s by IBM
- FOR(mula) TRAN(slation): written for doing Maths!
- Prior to FORTRAN, most code was written in assembly language (i.e., machine specific)
- 1961: FORTRAN IV
- 1966: FORTRAN 66
- 1977: FORTRAN 77 standard (now known as FORTRAN).
- 1990: significant new standard, Fortran 90
- 1995: Minor update to Fortran 90
- 2003: Further updates (incl. interface with C)
- 2008: most recent standard, including generic types and co-arrays
Punch cards

http://en.wikipedia.org/wiki/Fortran
The future?

Scientists from the RAND Corporation have created this model to illustrate how a “home computer” could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use and only unfortunately a hoax: http://www.snopes.com/inboxer/hoaxes/computer.asp#photo
When should *you* use Fortran?

- Fairly low level, compiled language. So not like matlab “solve ODE”, more like basic Maths, \( x = y + z; \ z = \sin(x) \), etc.

- Used commonly for numerical work, e.g. solving ODEs, PDEs. Not for things like writing computer operating systems (C) or scripting (python/perl/unix shell).

- Modern Fortran is a fully object-oriented language, similar to C++, but designed for solving mathematical problems.
Hello world in FORTRAN

program helloworld
implicit none
print*, 'hello world'
end
What a compiler does (I)

source code (.f or .f90 file) → assembler (e.g. x86, powerpc) → executable binary

“human language” → “machine code” → “a program you can run”

gfortran -o myprog helloworld.f

to run:
./myprog
What a compiler does (II):

program helloworld
implicit none
print*,'hello world'
end

gfortran -S hello.f90
Fortran variable types

program variables
implicit none
logical ihavebrain

ihavebrain = .true.
inum = 1
rnum = 1
dnum = 1.0d0

print*, 'vars=', ihavebrain, inum, rnum, dnum

diend
The evils of implicit types

• Implicitly in FORTRAN, undeclared variables starting with a-h and o-h are of type real, and i-n are of type integer.

God is real unless declared integer
Fortran variable types (well written)

program variables
implicit none
logical ihavebrain
integer inum
real rnum
double precision dnum

ihavebrain = .true.  ! check if we have a brain
inum = 1                ! number of brain cells
rnum = 1.0             ! fraction of brain cells used
dnum = 0.5d0        ! fraction working now

print*, 'vars=',ihavebrain,inum,rnum,dnum

end program variables
A bad FORTRAN example (Why you should ALWAYS use “implicit none”)

- what does this code do?

```
program badfort
  do 30 i=1.20
    print*,i
  30 continue
end
```

```
program badfort
  implicit none
  integer i
  do i=1.20
    print*,i
  enddo
end
```
Some basic good practice

• always use “implicit none” to avoid silly mistakes

• add comments to your code as much as possible. These are for YOU so you remember what you did/what you were thinking at the time.

• try to avoid writing the same bit of code more than once: cut and paste is convenient but deadly whilst writing programs! Use a short subroutine or function instead.
Basic maths operations

```fortran
program basicmaths
implicit none
real a,b,c,d,e

a = 1.
b = 2.
c = a + b
d = a*b
e = sqrt(b)

print*, 'a=', a, ' b=', b, ' c=', c, ' d=', d, ' e = ', e

end program basicmaths
```
Basic maths operations (in double precision)

```fortran
program basicmathsdbl
implicit none
double precision a,b,c,d

a = 1.0d0
b = 2.0d0
c = a + b
d = a*b
e = sqrt(b)

print*, 'a=',a,' b=',b,' c=',c,' d=',d,' e = ',e

end program basicmathsdbl
```
Arrays

program array1
implicit none
real rnum(3)

rnum(1) = 1.0
rnum(2) = 2.0
rnum(3) = 3.0

print*, 'rnum=', rnum

end program array1
Arrays II

program array2
implicit none
real rnum(3,2)

rnum(1,1) = 1.0
rnum(2,1) = 2.0
rnum(3,1) = 3.0
rnum(1,2) = 4.0
rnum(2,2) = 5.0
rnum(3,2) = 6.0

print*, ’rnum=’, rnum

end program array2
Logical constructs: if-then-else

program ifanimal
implicit none
logical :: isacow,hastwohorns
integer, parameter :: nhorns = 2

isacow = .true.
if (isacow) then  ! check if our animal is a cow
   print*,’ my animal is a cow...
   if (nhorns.eq.2) print*,’ ...with two horns’
else
   print*,’ my animal is not a cow’
endif

end program ifanimal
Logical constructs: if-then-elseif

```plaintext
isacow = .false.
isadog = .true.
!
!--here we check the type of animal
!(and the number of horns if it is a cow)
!
if (isacow) then   ! check if our animal is a cow
    print*,’ my animal is a cow...
    if (nhorns.eq.2) print*,’ ...with two horns’
elseif (isadog) then   ! or if it is a dog
    print*,’ my animal is a dog. Woof.’
else
    print*,’ my animal is not a cow or a dog’
endif
```
Fortran loops

program loop
implicit none
integer :: i

do i=1,10
   write(*,"(a,i2)") ' number ',i
enddo

end program loop
Formatted print

print*,'x=',x
print "(f6.3)", x
print "(a,2x,f6.3)", 'x = ',x
print "(' x= ',f6.3)",x
  print 10,x
10 format('x = ',f6.3)
Fortran loops: advanced

program loop
integer :: i

loop1: do i=1,10
    write(*,"(a,i2)"), ' number ',i
    if (i.eq.5) exit loop1
enddo loop1

end program loop
Reading and writing to/from the terminal

program hello
character(len=20) :: name

print "(‘---’,2x,a,2x,’---’)",’welcome to the hello program’

print*,’ please enter your name’
read(*,*) name

write(*,*) ’hello ’,name
write(6,*) ’I like the name ’//trim(name)
write(*,”(a)”) ’I once had a friend called ’//trim(name)

end program hello
Writing to a file

program nametofile
character(len=20) :: name
integer :: npets

print*, ’please enter your name’
read(*,*) name
print*, ’how many pets do you have?’
read(*,*) npets

open(unit=1,file=’myname.txt’,status=’replace’)
write(1,* ) name
write(1,* ) npets
close(unit=1)

end program nametofile
Opening a file and reading content

program namefromfile
character(len=20) :: name

open(unit=3,file='mynname.txt',status='old')
read(3,*) name
read(3,*) npets
close(unit=3)

write(*,*) 'hello ',name
write(*,*) 'I see you have ',npets,' pets'

end program namefromfile
Subroutines

program callsub
implicit none
real :: x1,y1,z1

x1 = 3.
y1 = 4.
call mysub(x1,y1,z1)
print*, 'z1=', z1

contains

subroutine mysub(x,y,z)
implicit none
real, intent(in) :: x,y
real, intent(out) :: z

z = sqrt(x**2 + y**2)

end subroutine mysub

end program callsub
Functions

program callfunc
implicit none
real :: x1,y1,z1
real :: zfunc

x1 = 3.
y1 = 4.
z1 = zfunc(x1,y1)
print*, 'z1= ', z1

end program callfunc

function zfunc(x,y)
implicit none
real, intent(in) :: x,y
real :: zfunc

zfunc = sqrt(x**2 + y**2)

end function zfunc
Part II: A simple FORTRAN primer...
Part III: Advanced Fortran (Fortran 90)
Fortran 90

- files end in .f90
- lines can be longer than 72 characters, do not have to start in column 6
- powerful array notation \( a = b + c \) where \( a, b \) and \( c \) are arrays
- new intrinsic functions e.g., dot_product, trim, matmul
- modules: all subroutines should go in a module that is “used” by the calling routine - allows interfaces to be checked. Modules also replace weird things like COMMON blocks.
- dynamic memory allocation (allocatable arrays) and pointers
- derived data types
- recursive subroutines and functions
Fortran 95

• very minor update to Fortran 90

• where/elsewhere statement

• forall
Fortran 2003

• interoperability with C

• intrinsic functions for getting command line arguments, environment variables etc. (previously these had been compiler extensions)

• Fortran 2003 is fully object oriented.
Fortran 2008

- Co-array fortran for parallel computing
f90 vs f77

```fortran
program xdoty
  implicit none
  real x(3),y(3),xdoty

  x(1) = 1.
  x(2) = 1.
  x(3) = 1.
  y(1) = 0.
  y(2) = 0.
  y(3) = 3.

  xdoty = x(1)*y(1) + x(2)*y(2) + x(3)*y(3)
  print*,' xdoty = ',xdoty
end
```

```fortran
program xdoty
  implicit none
  real, dimension(3) :: x,y
  real :: xdoty

  x(:) = 1.
  y(1:2) = 0.
  y(3) = 3.

  xdoty = dot_product(x,y)
  print*,' xdoty = ',xdoty
end program xdoty
```
program animalsounds
implicit none
character(len=20) :: myanimal
character*20 :: youranimal

myanimal = 'himalayan yak'
write(*,*,ADVANCE='NO') 'my animal says '

select case(trim(myanimal))
case('cow')
   write(*,*) 'moo'
case('zebra','donkey','mutated horse')
   write(*,*) 'a kind of donkey-like braying'
case default
   write(*,*) 'an unspecified non-human sound'
end select

end program animalsounds
module circles
implicit none
real, parameter :: pi = 3.1415926536

public :: area
private
contains
!
! a function to calculate the area
!
real function area(r)
  implicit none
  real, intent(in) :: r

  area = pi*r**2   ! area of a circle
end function area
end module circles
Using the module

program getarea
  use circles
  implicit none
  logical :: bored

  print*, ' pi = ', pi

  bored = .false.
  do while (.not.bored)
    print*, ' enter r'
    read*, r
    if (r < 0) then
      bored = .true.
    else
      print*, ' the area is ', area(r)
    endif
  enddo
end program getarea
Compiling multiple files

gfortran -o myprog myprog.f90 mysub.f90
Compiling multiple files (in steps)

gfortran -o mysub.o -c mysub.f90
gfortran -o myprog.o -c myprog.f90
gfortran -o myprog mysub.o myprog.o
Makefiles

• easy way to compile a program consisting of multiple source files

• just type “make” instead of having to remember all the separate commands

• we will type a simple example together
Fortran 90 Exercise

- write a subroutine that solves (returns all the real roots of) a cubic equation using the exact solution for a cubic.

- put this in a module

- use this module in a program that reads the coefficients for the cubic as input from the user, calls the subroutine you wrote to solve it, and checks the answer.

- use the prompting module provided in the fortran_examples directory to interface with the user

- write a Makefile that will compile your program with the cubic module and the program in different files.
Advanced Fortran 90

- write a second version of your cubic solver subroutine that works on double precision input