

Functions and subroutines in Fortran

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Procedure basics

1. Procedures in contains clause

```
Program foo
  < declarations>
  < executable statements >
  Contains
    < procedure definitions >
End Program foo
```

Two types of procedures: functions and subroutines. More later.

2. Subroutines

```
subroutine foo()  
  implicit none  
  print *, "foo"  
  if (something) return  
  print *, "bar"  
end subroutine foo
```

- Looks much like a main program
- Ends at the end, or when return is reached
- Note: return does not return anything
- Activated with

```
call foo()
```

3. Subroutine with argument

Code:

```
program printing
  implicit none
  call printint(5)
contains
  subroutine printint(invalue)
    implicit none
    integer :: invalue
    print *,invalue
  end subroutine printint
end program printing
```

Output

[funcf] printone:

5

4. Subroutine can change argument

Code:

```
program adding
  implicit none
  integer :: i=5
  call addint(i,4)
  print *,i
contains
  subroutine addint(inoutvar,addendum)
    implicit none
    integer :: inoutvar,addendum
    inoutvar = inoutvar + addendum
  end subroutine addint
end program adding
```

Output

[funcf] addone:

9

Parameters are always 'by reference'!

Function vs Subroutine

Subroutines can only 'return' results through their parameters.

Functions have an actual return result.

5. Function example

Code:

```
program plussing
  implicit none
  integer :: i
  i = plusone(5)
  print *,i
contains
  integer function plusone(invalue)
    implicit none
    integer :: invalue
    plusone = invalue+1 ! note!
  end function plusone
end program plussing
```

Output

[funcf] plusone:

6

6. Function definition and usage

- `subroutine` vs `function`:
compare `void` functions vs non-void in C++.
- Return type, keyword `function`, name, parameters
- Function body has statements
- Result is returned by assigning to the function name
- Use: $y = f(x)$

7. Why a 'contains' clause?

```
Program NoContains
  implicit none
  call DoWhat()
end Program NoContains

subroutine DoWhat(i)
  implicit none
  integer :: i
  i = 5
end subroutine DoWhat
```

Warning only, crashes.

```
Program ContainsScope
  implicit none
  call DoWhat()
contains
  subroutine DoWhat(i)
    implicit none
    integer :: i
    i = 5
  end subroutine DoWhat
end Program ContainsScope
```

Error, does not compile

8. Why a 'contains' clause, take 2

Code:

```
Program NoContainTwo
  implicit none
  integer :: i=5
  call DoWhat(i)
end Program NoContainTwo

subroutine DoWhat(x)
  implicit none
  real :: x
  print *,x
end subroutine DoWhat
```

Output

```
[funcf] nocontaintype:
nocontain2.F90:15:16:

      15 |      call DoWhat
          |      (i)
          |
          |      1
Warning: Type
mismatch in
argument 'x' at
(1); passed
INTEGER(4) to
REAL(4) [-
Wargument-
mismatch]
7.00649232E-45
```

At best compiler warning if all in the same file

Exercise 1

Write a program that asks the user for a positive number; negative input should be rejected. Fill in the missing lines in this code fragment:

Code:

```
program readpos
  implicit none
  real(4) :: userinput
  print *, "Type a positive number:"
  userinput = read_positive()
  print *, "Thank you for", userinput
contains
  real(4) function read_positive()
    implicit none
    !! ...
  end function read_positive
end program readpos
```

Output

[funcf] readpos:

Type a positive
number:

No, not -5.00000000

No, not 0.00000000

No, not -3.14000010

Thank you for
2.48000002

9. Procedure arguments

Arguments are declared in procedure body:

```
subroutine f(x,y,i)
  implicit none
  integer,intent(in) :: i
  real(4),intent(out) :: x
  real(8),intent(inout) :: y
  x = 5; y = y+6
end subroutine f
! and in the main program
call f(x,y,5)
```

declaring the 'intent' is optional, but highly advisable.

10. Fortran nomenclature

The term dummy argument is what Fortran calls the parameters in the procedure definition:

```
subroutine f(x) ! 'x' is dummy argument
```

The arguments in the procedure call are the actual arguments:

```
call f(x) ! 'x' is actual argument
```

11. Parameter passing

- Everything is passed by reference.
Don't worry about large objects being copied.
- Optional intent declarations:
Use `in`, `out`, `inout` qualifiers to clarify semantics to compiler.

12. Intent checking

Compiler checks your intent against your implementation. This code is not legal:

```
subroutine ArgIn(x)
  implicit none
  real,intent(in) :: x
  x = 5 ! compiler complains
end subroutine ArgIn
```


13. Why intent checking?

Self-protection: if you state the intended behaviour of a routine, the compiler can detect programming mistakes.

Allow compiler optimizations:

```
x = f()  
call ArgOut(x)  
print *,x
```

Call to f removed

```
do i=1,1000  
  x = ! something  
  y1 = .... x ....  
  call ArgIn(x)  
  y2 = ! same expression as y1
```

y2 is same as y1 because x not changed

(May need further specifications, so this is not the prime justification.)

Exercise 2

Write a subroutine `trig` that takes a number α as input and passes $\sin \alpha$ and $\cos \alpha$ back to the calling environment.

Exercise 3

Take your prime number testing function `test_if_prime`, and use it to write a program that prints multiple primes:

- Read an integer `how_many` from the input, indicating how many (successive) prime numbers should be printed.
- Print that many successive primes, each on a separate line.
- (Hint: keep a variable `number_of_primes_found` that is increased whenever a new prime is found.)

Turn it in!

- If you have compiled your program, do:
`coe_primef yourprogram.F90`
where 'yourprogram.F90' stands for the name of your source file.
- Is it reporting that your program is correct? If so, do:
`coe_primef -s yourprogram.F90`
where the -s flag stands for 'submit'.
- If you don't manage to get your code working correctly, you can submit as incomplete with
`coe_primef -i yourprogram.F90`
- Use the -d debug flag for more information.

14. Saved values

Local variable is initialized only once,
second time it uses its retained value.

Code:

```
integer function maxof2(i,j)
  implicit none
  integer,intent(in) :: i,j
  integer :: max=0
  if (i>max) max = i
  if (j>max) max = j
  maxof2 = max
end function maxof2
```

Output

[funcf] save:

```
Comparing:  1   3
           3
Comparing: -2  -4
           3
```