ENCE 202
FORTRAN
Handout 4

Introduction to FORTRAN

• A. J. Clark School of Engineering • Department of Civil and Environmental Engineering

by

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ENCE 202
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Functions and Subroutines

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- The objective herein is to use a top-down approach to solve complex problems by dividing them into a structured modular computational form
- The following topics are covered:
  - (1) standard functions,
  - (2) statement functions,
  - (3) function subprograms, and
  - (4) subroutine subprograms

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Functions and Subroutines

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- Standard (Library) Functions

SIN(*x*)	Sine of *x* (in radian)
COS(*x*)	Cosine of *x* (in radian)
TAN(*x*)	Tangent of *x* (in radian)
LOG(*x*)	Natural logarithm of *x*
LOG10(*x*)	Common (base 10) logarithm
.	
.	

Refer to attached Table for more functions

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Functions and Subroutines

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- Statement Functions
  - The statement should be used in the same unit of program where function is used and immediately after the specification statements (before any executable statements).

```
name (argument-list) = expression
```

Functions and Subroutines

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- Statement Functions (cont'd)
  - The function name follows the same rules of variables for type (real or integer). The argument list can be empty
  - Example:

```
REAL A, B, Z, T
  Z(A,B) = A+B
   :
  X = 3
  Y = 4
  T = Z(X,Y) + 2
  PRINT *, T
```

The result is T = 9

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Functions and Subroutines

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- Function Subprograms
  - The structure for a function subprogram is the same as a FORTRAN programs as follows:

FUNCTION name(*argument-list*)
Declaration part
Subprogram statements
RETURN
END

Functions and Subroutines

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- The statement return is not needed all the time
- It is used to return to the main program
- The computed value goes to the location were the function was called
- The result from the function is returned by the function name

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Functions and Subroutines

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- Example:

```
FUNCTION F(X,Y,N)
 REAL X, Y
 INTEGER N
 F = X**N + Y**N
 RETURN
 END
```

Functions and Subroutines

- The above function of the example can be called in the main program as follows:

```
W = F(A,B+3.0,2)
```

or

```
Z = F(R(I),SIN(A),K)
```


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Functions and Subroutines

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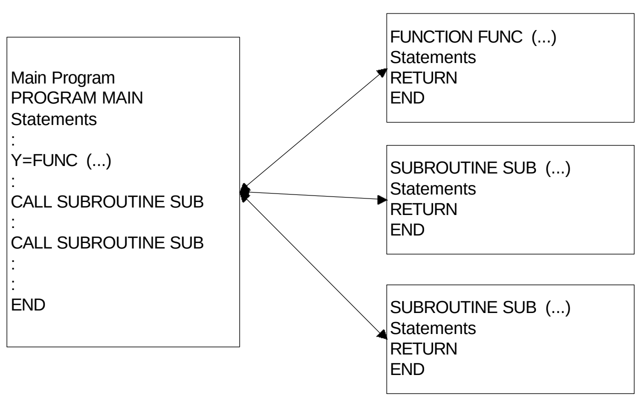

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Subroutines

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- Subroutine Subprograms
  - Similar to Function subprograms with the following differences:
    1. Functions return one value; whereas Subroutines return no value, one or more values.
    2. Returned values by Functions are their names; whereas Subroutine names do not return values, Subroutine output is part of the arguments
    3. A Function is referenced using its name in an expression; whereas subroutines are referenced by a CALL statement

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Subroutines

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- Structure of Subroutines

SUBROUTINE name(*argument-list*)
Declaration Part
Subprogram Statements
RETURN
END

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Subroutines

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- The input and output list is the argument list which can be empty
- The arrays in a subroutine can be of variable sizes that are declared using the DIMENSION or REAL statement (among others) with a size that is specified by a variable in the argument list
- In the main program, use CALL subroutine-name (argument-list) to execute the subroutine

Subroutines

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- Example:

```
      SUBROUTINE MEAN(X,N,Z)
      SUM = 0
      INTEGER N
      REAL X(N), Z, SUM
      DO 10 I = I, N
         SUM = SUM + X(I)
   10 CONTINUE
      Z = SUM/N
      RETURN
      END
```

Subroutines

- In the main program, the following is permissible:

```
REAL Y(100) , AVERAG
M = 10
CALL MEAN(Y,M,AVERAG)
```


Subroutines

- COMMON Statement
  - This statement is used to share information between main Program and Subprograms and among subprograms. It takes the following form:

```
COMMON list
```

  - The list is the list of variables or arrays separated by commas

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Subroutines

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- Example
  - In the main program, use
    COMMON A, B, C
  - In the subprograms, use
    COMMON X, Y, Z
  - The results of these two statements is that A takes on the same value as X, B takes on same values as Y, and C takes on the same value as Z.

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Subroutines

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- In general, the statement can be as follows:
  COMMON /name1/list1/ name2/list2 ...

  Example:

  In the main programs, use
    COMMON/N1/ X, Y, Z/N2/A, B, C/N3/D, E, F
  In subprogram 1, use
    COMMON/N1/ XX, YY, ZZ/N3/DD, EE, FF
  In subprogram 2, use
    COMMON/N3/DD, EE, FF

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Double Precision

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- Real data are commonly treated using single precision, i.e., single memory location for each number which corresponds to 32-bit word. The result is an accuracy of about 7 significant digits. Double precision allows for doubling the above quantities

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Double Precision

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- Use a type statement to specify double precision as follows:

```
DOUBLE PRECISION Z, X(2, 3)
FUNCTION F(X, Y)
DOUBLE PRECISION F, X, Y
END
```

- In writing or printing numbers 1.E-3 becomes 1.D-3

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Double Precision

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- In general, the read and write control is

  rDw.d

  where
  r = repetitions,
  w = width, and
  d = number of digits

Fortran Application Examples

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- Newton's Method (Numerical Analysis)
  - This program illustrates the Newton's method on the function:

$$f(x) = x^3 - 3x^2 - x + 9 = 0$$

  - Calls: NEWT
  - Output (form Function F)
    - X=Value of X at current iteration
    - F=Functional value at x

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Fortran Application Examples

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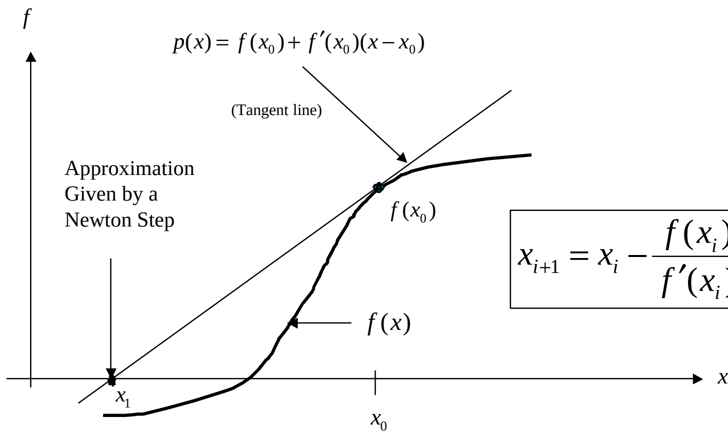

$$x_{i+1} = x_i - \frac{f(x_i)}{f'(x_i)}$$

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```
      PROGRAM NEWTON
      X0=-2.0
      EPS=0.00001
C
C     SUBROUTINE NEWT IS USED TO FIND A
C     ROOT STARTING WITH THE INITIAL GUESS
C     X0

      CALL NEWT(X0,X,EPS)
      STOP
      END
```

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```
      SUBROUTINE NEWT(X0,X,EPS)
C ****************************************************************************
C * FUNCTION: THE SUBROUTINE APPROXIMATES THE ROOT
C *               OF F(X)=0 GIVEN THE INITIAL POINT X0 AND
C *               THE DERIVATIVE FUNCTION DF(X) USING THE
C *               NEWTON METHOD
C * USAGE:
C *               CALL SEQUENC: CALL NEWT(X0,X,EPS)
C*                EXTERNAL FUNCTIONS/SUROUTINES:
C*                        FUNCTION F(X)
C*                        FUNCTION DF(X)
```

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```
C *     PARAMETERS:
C *     INPUT:
C *             X0=INITIAL ROOT APPROXIMATION
C *             EPS=ERROR BOUND
C *     OUTPUT:
C *             X=NEWTON APPROXIMATION OF THE ROOT
C *************************************************************************
C       **** INITIALIZATION ****
        X=X0-(F(X0)/DF(X0))
C       *** COMPUTE APPROXIMATE ROOT ITERATIVELY ***
```

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```
DO WHILE(ABS(X-X0) .GT. EPS)
  X0=X
  X=X0-(F(X0)/DF(X0))
END DO
RETURN
END
```


Fortran Application Examples

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```
C       FUNCTION F IS CALLED BY NEWT TO CALCULATE
C       FUNCTIONAL VALUES FOR THE PASSED POINT X
        FUNCTION F(X)
        F=X**3-3.0*X**2-X+9.0
        WRITE(6,10)X,F
10      FORMAT(22X,F16.7,4X,F16.7)
        RETURN
        END
```

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```
C
C         FUNCTION DF(X) IS CALLED BY NEWT TO CALCULATE
C         THE DERIVATIVE AT X
C
          FUNCTION DF(X)
          DF=3.0*X**2-6.0*X-1.0
          RETURN
          END
```

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- Area of a Circle
  - Demonstrating the use of Input and Output files

```
          PROGRAM AREA_CIRCLE
          DIMENSION DIA(10), AREA(10)
          OPEN(5,FILE='TEST.DAT', STATUS='UNKNOWN')
          OPEN(6,FILE='TEST.OUT', STATUS='UNKNOWN')
          PI=22./7
          DO 1 I=1,10
          READ(5,*)DIA(I)
          AREA(I)=PI*DIA(I)**2/4
          WRITE(6,*)DIA(I),AREA(I)1
    1     CONTINUE
          END
```

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- INPUT File (area.dat)

```
1
2
3
6
8
9
5
7
9
11
```

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- OUTPUT File (area.out)

```
1.00000  0.785714
2.00000  3.14286
3.00000  7.07143
6.00000  28.2857
8.00000  50.2857
9.00000  63.6429
5.00000  19.6429
7.00000  38.5000
9.00000  63.6429
11.0000  95.0714
```

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Fortran Application Examples

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- Numerical Analysis
  - The Trapezoidal Rule of Integration

$$\int_{x_1}^{x_n} f(x)dx \approx h\left[\frac{1}{2}f(x_0)+f(x_1)+\ldots+f(x_{n-1})+\frac{1}{2}f(x_n)\right]$$

$$h = x_{i+1} - x_i$$

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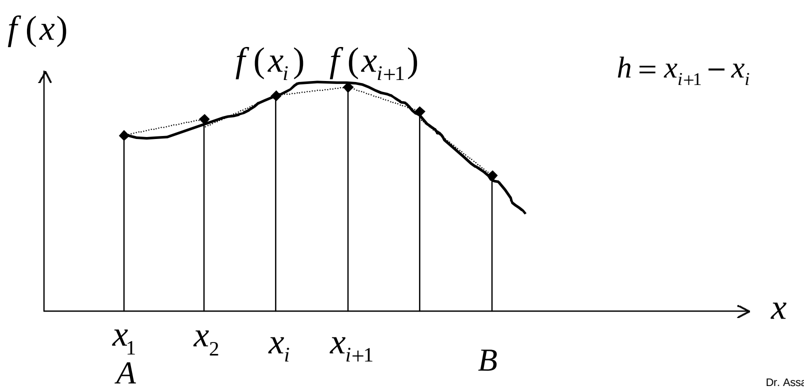
- Numerical Analysis
  - The Trapezoidal Rule of Integration



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Fortran Application Examples

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- Numerical Analysis
  - Need for Trapezoidal Formula
    - Complex Integral that can not be evaluated analytically

$$\int \frac{x\cos(x^2)}{e^x}\,dx$$

    - Set of discrete values obtained from experiments

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Fortran Application Examples

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- Numerical Analysis
  - The Trapezoidal Rule of Integration

```
PROGRAM TRAPEZOID
A=0.0
B=10.0
N=10

CALL TRAP(A,B,N,EST)
WRITE(5,*)EST
END
```

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Fortran Application Examples

■ The Trapezoidal Rule of Integration (cont'd)

```
      SUBROUTINE TRAP(A,B,N,E)
      H = (B-A)/N
      E = (F(A)+F(B))/2.0
      IF (N.GT.1) THEN
      X=A
      DO 1 I=1, N-1
        X=X+H
        E = E+F(X)
1     CONTINUE
      END IF
      E=E*H
      RETURN
      END
```


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■ The Trapezoidal Rule of Integration (cont'd)

```
      FUNCTION F(X)
      F = 1+(x**2*exp(x))/(1+x)
      RETURN
      END
```