# Mathcad Lecture #3 In-class Worksheet
# Functions

At the end of this lecture, you should be able to:
- find and use intrinsic Mathcad Functions for fundamental, trigonometric, and if statements
- construct compound if functions using AND, OR, XOR, NOT operators
- create user-defined functions
- construct use-defined functions with appropriate units
- decide when a user-defined function is needed

## 1. Intrinsic Mathcad Functions
- Mathcad has a myriad of mathematical functions.
- You have already used several of them which are available on the calculator tool palette.
- Several common functions are found in the table to the right.
- You can see all the functions available, as well as a description of each, by clicking on the **f(x)** button

### *Practice*

1. Calculate the following: floor of π, ceil of π, the remainder of dividing π by 3.

2. Round π to 5 decimal places.

3. Let x = 0.9 and calculate the following: $e^x$, $\log_{10}(x)$, $\log_{2}(x)$, $\ln(x)$

### *Trigonometric Functions*

- All trigonometric function are available and are obtained by typing the name followed by ()'s.
- x is assumed to be in radians unless specified otherwise.

## 2. User-Defined Functions

One of the powerful features of Mathcad is the ability to define your own functions.  This is very helpful when doing engineering calculations and will be used often.

### *Syntax*

To create a function:
1. Type the desired function name
2. Type (x) where x is the variable of the function.
3. Type  : to give you :=
4. Define the expression in terms of x.

Note: you can use more then one variable in a function, simply separate each with a comma.

### *Demonstration*

## *Important Point 1*

The parameter names in the argument list of the function are really just place holders. When I evaluate the function, I can use other variables which contain the numerical values I want to use in evaluation.

## Important Point 2

If you pass a function variables or numbers with incorrect units, the function will either not evaluate or return incorrect units.

## 3. Creating Functions Which Require Specific Units

In engineering, we often need physical properties, such as heat capacities, to do design calculations. We usually obtain these by looking up an equation in a handbook. For example, the heat capacity of liquid water is dependent upon the temperature and can be found using the following equation.

$$\frac{Cp(T/_{\circ F})}{BTU/_{lbmol \cdot ^\circ F}} = 18.4613 - 0.013584T + 7.24045 \cdot 10^{-5} T^2 - 1.87335 \cdot 10^{-7} T^3 + 2.14815 \cdot 10^{-10} T^4$$

The T/°F of the equation means the temperature must be in units of °F. The BTU/(lbmol*°F) means the heat capacity returned by the equation is in those units. Our challenge is to write a Mathcad function that always returns the correct heat capacity based upon the equation given above.

Before creating the function lets look at how Mathcad handles units and unit conversions.

## *Demonstration*

$A := 18.4613$   $B := -0.01358$   $C := 7.24045 \cdot 10^{-5}$   $D := -1.87335 \cdot 10^{-7}$   $E := 2.14815 \cdot 10^{-10}$

If you don't place units in, the function doesn't know what units the temperature is in.

We write the expression to force the number passed to the function to always be in °F.

**Key Points:**
- The term in ()'s forces Mathcad to convert any temperature passed to the function into °F as required by the original expression.
- Multiplying the entire expression by the correct units allows us to use the function in subsequent calculations and let Mathcad do the unit conversions.

## *Practice*

The Reynold's number is a **dimensionless** quantity used to characterize fluid flow. For a circular pipe, the Reynold's number is defined as $Re = \dfrac{\rho D v}{\mu}$, where $\rho$ and $\mu$ are the density and viscosity of the fluid, D is the diameter of the pipe, and v is the velocity of the fluid through the pipe. Calculate the Reynold's number if water, at 2 degrees Celsius, travels down a 2 in diameter pipe at 3 m/s. The density and viscosity of water can be found from the expressions below. The molecular weight of water is 18.02 gm/mol.

$$\frac{\mu\left(\dfrac{T}{K}\right)}{Pa \cdot s} = \exp\left[-52.843 + \frac{3703.6}{T} + 5.8660\ln(T) - 5.879 \cdot 10^{-29} T^{10.0000}\right]$$

$$\frac{\rho\left(T/{}_{\circ}C\right)}{lbmol \cdot ft^{-3}} = 7.98187 + 0.00138771T + 2.87476 \cdot 10^{-6} T^2 - 1.94845 \cdot 10^{-9} T^3 + 3.72428 \cdot 10^{-13} T^4$$

A1 := −52.843   B1 := 3703.6   C1 := 5.8660   D1 := −5.879·10$^{-29}$

A2 := 7.98187   B2 := 0.00138771   C2 := 2.87476·10$^{-6}$   D2 := −1.94845·10$^{-9}$   E2 := 3.72428·10$^{-13}$

# 4. The if function

## *Syntax*

if(*condition, true, false*)

- True and false can be functions, text, letters, numbers, etc.
- Different conditions can be found on the Boolean tool palette.

## *Demonstration*

## *Compound Logical Expressions*

| Operator | Symbol on Tool Palette | Description |
|---|---|---|
| And | ∧ | Returns 1 if both x and y are non-zero (true). Returns 0 otherwise. |
| Or | ▮ ∨ ▮ | Returns 1 if either x or y are non-zero (true). Returns 0 otherwise. |
| Exclusive or, xor | ▮ ⊕ ▮ | Returns 1 if either x or y, but not both, are non-zero (true). Returns 0 otherwise. |
| Not | ¬▮ | Returns 1 if x is zero (false). Returns 0 otherwise |

| Less than | $\textbf{I} < \textbf{I}$ | Returns 1 if x < y, 0 otherwise |
|---|---|---|
| Greater than | $\textbf{I} > \textbf{I}$ | Returns 1 if x > y, 0 otherwise |
| Equal to | $\textbf{I} = \textbf{I}$ | Returns 1 if x + y, 0 otherwise |
| Not Equal to | $\textbf{I} \neq \textbf{I}$ | Returns 1 if x does not equal y, 0 otherwise |

## *Demonstration*

Imagine that the temperature of the reactor must be kept above 170 °C to keep the reaction going and below 200 °C to prevent excessive pressure from forming in the vessel.  Write a simple logical function to determine if the reaction temperature is in the correct range.

## *Practice*

Write a logical function to turn on a drainage pump if the liquid height in a holding tank exceeds 3.1 *meters* <u>and</u> inlet flow rate exceeds 24.5 *gal/min*. If both of these conditions are met, the output from the function should equ 1.0, otherwise the output should equal 0 (zero).

## *Extra Practice*

For x between 0 and 1, the series expansion of ln(1+x) is

$$\ln(1 + x) = \sum_{i=1}^{n} (-1)^{i+1} \frac{x^i}{i}$$

The series is exact if n = ∞, but such a computation is computationally impossible.

*Construct a function named ln1x which accepts two parameters ($x$ and $n$) and calcualtes ln(1+x) according to the seried above.  Do a small parametric study to determine now many terms are needed to obtain accuracy out to the 6th decimal place.  Check the results against the instrinsic Mathcad function.*

| Functions | Description |
| --- | --- |
| exp(x), $e^x$ | The number *e* raised to the power of x. |
| log(x,[b]) | Base b logarithm of x.  (b=10 by default) |
| ln(x) | Natural logarithm of x |
| x! | Factorial of x. |
| max(a,b,c,…) | The value of the largest argument. |
| min(a,b,c,…) | The value of the smallest argument. |
| mean(a,b,c,…) | The average of a,b,c,… |
| floor(x) | The largest integer less than or equal to x. |
| ceil(x) | The smallest integer greater than or equal to x. |
| round(x,n) | The number x rounded to n decimal places.  If n is omitted, x is rounded to the nearest integer.  If n<0, x is rounded to the lefts of the decimal point. |
| trunc(x) | The integer part of x |
| mod(x,y) | The reminder of dividing x by y |
| if(*condition,true,false*) | If *condition* is true (non-zero), returns *true*.  If *condition* is false, returns *false*. |
| $\sum$ (calculus toolbar) | $\sum_{i=1}^{n} f(i)$, summation |
| $\prod$ (calculus toolbar) | $\prod_{i=1}^{n} f(i)$, product |