

# ENGR 0012 – Engineering Problem Solving

Goals for this week:

- Create arrays
- Perform math operations
- Use looping and branching in C++

Please submit your HW!  
(Old and new submission systems)

# Practice Problem

## What is the output? Why?

(a)  
(default)

```
#include <stdio.h>
#include <stdlib.h>
void main(void)
{
    float a = 3.2;
    int b = 5;
    double c = 28.4;

    printf("\n%f\n", a);
    printf("\n%d\n", b);
    printf("\n%lf\n", c);

    system("pause");
}
```

3.200000  
5  
28.400000

(b)

```
#include <stdio.h>
#include <stdlib.h>
void main(void)
{
    float a = 3.2;
    int b = 5;
    double c = 28.4;


    printf("\n%d\n", b/2);

    printf("\n%8.2f\n", a);
    printf("\n%-3.1lf\n", c);

    system("pause");
}
```

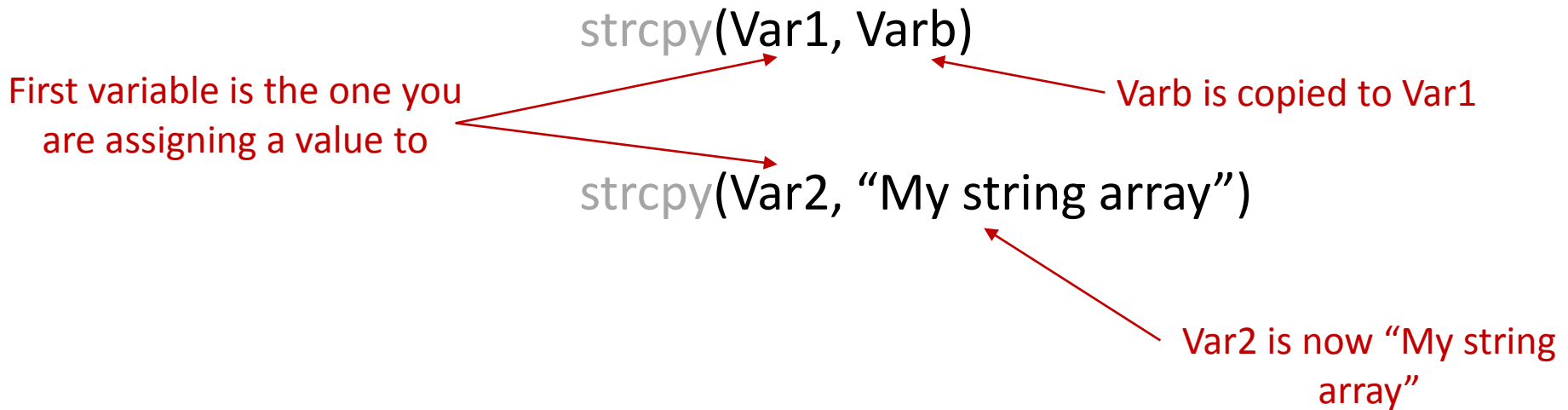
2  
\_\_\_\_3.20  
28.4

# We can declare string arrays in C

- If it's a single character → `char Var1='a'`
- If it's a string → `char Var2[20]`  Length of the string array
- Add elements one by one, with the last one being `\0`

Instead of adding elements one by one, use the `strcpy` command in the `string.h` library

- Use this format:



To use `printf` for a string array, use `%s`

```
printf("Here is Var2: %s",Var2)
```

For example:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

void main()
{
    char Var1 = 'a';
    char Var2[25];

    strcpy(Var2, "How are you?");

    //Use printf to print
    printf("\nThe letter is:%c", Var1);
    printf("\nThe string array is:%s\n", Var2);
}
```

```
The letter is:a
The string array is:How are you?
```

# Practice Problem

- Define a one-dimensional array
- Define a two-dimensional array
- Print the first element and last element of each of your arrays
- Define a string variable equal to “Programming in C” and print it to the screen

# C allows mathematical operations

- Addition +
- Subtraction –
- Multiplication \*
- Division /
- Remainder (for integers only) %



You can perform the operation in the program or within `printf`

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

void main()
{
    int A = 3, B = 7, C;
    float D = 3.0, E = 7.0, F;

    //Mathematical operations in program
    C = A + B;
    F = D + E;

    //Mathematical operations within printf
    printf("\nAdding these numbers C = %3d, F = %5.2f", C, F);
    printf("\nAdding these numbers C = %3d, F = %5.2f", A + B, D + E);
    printf("\n");
}
```

```
Adding these numbers C = 10, F = 10.00
Adding these numbers C = 10, F = 10.00
Press any key to continue . . .
```

# What is the difference between division and remainder?

(Note this is for integers - % is undefined for float and double)

*(for int A=3, B=7)*

- $B/A$  will give 2
- $B\%A$  will give 1 (3 goes into 7 2 times with a remainder = 1)
- $A/B$  will give 0

C allows mathematical functions –  
see your textbook to learn more!

- Remember to include the `math.h` library
- `pow` (not `^`) for exponents
  - `pow(x,y)` gives  $x$  to the power of  $y$

C allows mathematical functions –  
see your textbook to learn more!

- Numbers must be in radians for trig functions
  - So multiply degrees by  $\text{PI}/180$  before using these functions
  - But remember that  $\text{PI}$  must be defined by the user
- Natural log is `log` and base 10 log is `log10`

# What happens when different data types are used in mathematical operations?

- Two integers produce an integer
- Two reals produce a real
- Mix of reals and integers produces a real, but it will be stored according to how it was declared
- Numbers in arithmetic operations typed without a decimal point will be treated as integers, but it will be stored according to how it was declared

# What happens when different data types are used in mathematical operations?

```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    int IntA = 15, IntB = 2, IntC, IntD, IntE;
    double DoubleA = 15, DoubleB = 2, DoubleC, DoubleD, DoubleE;

    //Operations on integer variables
    IntC = IntA / IntB;
    IntD = 15 / 2;

    IntE = 15 / 2.0; //real, but IntE is an int

    //Operations on double variables
    DoubleC = DoubleA / DoubleB;
    DoubleD = 15 / 2; //integeres, but DoubleD is a double
    DoubleE = 15 / 2.0;

    printf("\nThe integer variables are IntC=%d, IntD=%d, and IntE=%d\n", IntC, IntD, IntE);
    printf("\nThe double variables are DoubleC=%lf, DoubleD=%lf, DoubleE=%lf\n", DoubleC, DoubleD, DoubleE);
}
```

The integer variables are IntC=7, IntD=7, and IntE=7

The double variables are DoubleC=7.500000, DoubleD=7.000000, DoubleE=7.500000  
Press any key to continue . . .

# What happens when different data types are used in mathematical operations?

```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    int IntA = 15, IntB = 2, IntC, IntD, IntE;
    double DoubleA = 15, DoubleB = 2, DoubleC, DoubleD, DoubleE;

    //Operations on integer variables
    IntC = IntA / IntB;
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}
```

The integer variables are IntC=7, IntD=7, and IntE=7

The double variables are DoubleC=7.500000, DoubleD=7.000000, DoubleE=7.500000  
Press any key to continue . . .

→  $15/2 = 7$

# What happens when different data types are used in mathematical operations?

```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    int IntA = 15, IntB = 2, IntC, IntD, IntE;
    double DoubleA = 15, DoubleB = 2, DoubleC, DoubleD, DoubleE;

    //Operations on integer variables
    IntC = IntA / IntB;
    IntD = 15 / 2;  $\longrightarrow 15/2 = 7$ 

    IntE = 15 / 2.0; //real, but IntE is an int

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    DoubleC = DoubleA / DoubleB;
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}
```

The integer variables are IntC=7, IntD=7, and IntE=7

The double variables are DoubleC=7.500000, DoubleD=7.000000, DoubleE=7.500000  
Press any key to continue . . .



# What happens when different data types are used in mathematical operations?

```
#include <stdio.h>
#include <stdlib.h>
```

```
void main()
```

```
{
```

```
    int IntA = 15, IntB = 2, IntC, IntD, IntE;
```

```
    double DoubleA = 15, DoubleB = 2, DoubleC, DoubleD, DoubleE;
```

```
    //Operations on integer variables
```

```
    IntC = IntA / IntB;
```

```
    IntD = 15 / 2;
```

```
    IntE = 15 / 2.0; //real, but IntE is an int
```

15/2.0 = 7.5

IntE=7

```
    //Operations on double variables
```

```
    DoubleC = DoubleA / DoubleB;
```

```
    DoubleD = 15 / 2; //integeres, but DoubleD is a double
```

```
    DoubleE = 15 / 2.0;
```

```
    printf("\nThe integer variables are IntC=%d, IntD=%d, and IntE=%d\n", IntC, IntD, IntD);
```

```
    printf("\nThe double variables are DoubleC=%lf, DoubleD=%lf, DoubleE=%lf\n", DoubleC, DoubleD, DoubleE);
```

```
}
```

The integer variables are IntC=7, IntD=7, and IntE=7

The double variables are DoubleC=7.500000, DoubleD=7.000000, DoubleE=7.500000  
Press any key to continue . . .

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```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    int IntA = 15, IntB = 2, IntC, IntD, IntE;
    double DoubleA = 15, DoubleB = 2, DoubleC, DoubleD, DoubleE;

    //Operations on integer variables
    IntC = IntA / IntB;
    IntD = 15 / 2;

    IntE = 15 / 2.0; //real, but IntE is an int

    //Operations on double variables
    DoubleC = DoubleA / DoubleB;
    DoubleD = 15 / 2; //integeres, but DoubleD is a double
    DoubleE = 15 / 2.0;

    printf("\nThe integer variables are IntC=%d, IntD=%d, and IntE=%d\n", IntC, IntD, IntE);
    printf("\nThe double variables are DoubleC=%lf, DoubleD=%lf, DoubleE=%lf\n", DoubleC, DoubleD, DoubleE);
}
```

The integer variables are IntC=7, IntD=7, and IntE=7

The double variables are DoubleC=7.500000, DoubleD=7.000000, DoubleE=7.500000  
Press any key to continue . . .

15/2 = 7.5

# What happens when different data types are used in mathematical operations?

```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    int IntA = 15, IntB = 2, IntC, IntD, IntE;
    double DoubleA = 15, DoubleB = 2, DoubleC, DoubleD, DoubleE;

    //Operations on integer variables
    IntC = IntA / IntB;
    IntD = 15 / 2;

    IntE = 15 / 2.0; //real, but IntE is an int

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    DoubleC = DoubleA / DoubleB;
    DoubleD = 15 / 2; //integeres, but DoubleD is a double
    DoubleE = 15 / 2.0;

    printf("\nThe integer variables are IntC=%d, IntD=%d, and IntE=%d\n", IntC, IntD, IntE);
    printf("\nThe double variables are DoubleC=%lf, DoubleD=%lf, DoubleE=%lf\n", DoubleC, DoubleD, DoubleE);
}
```

The integer variables are IntC=7, IntD=7, and IntE=7

The double variables are DoubleC=7.500000, DoubleD=7.000000, DoubleE=7.500000  
Press any key to continue . . .

15/2 = 7

DoubleD=7.000000

# What happens when different data types are used in mathematical operations?

```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    int IntA = 15, IntB = 2, IntC, IntD, IntE;
    double DoubleA = 15, DoubleB = 2, DoubleC, DoubleD, DoubleE;

    //Operations on integer variables
    IntC = IntA / IntB;
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    IntE = 15 / 2.0; //real, but IntE is an int

    //Operations on double variables
    DoubleC = DoubleA / DoubleB;
    DoubleD = 15 / 2; //integeres, but DoubleD is a double
    DoubleE = 15 / 2.0;  $\longrightarrow 15/2.0 = 7.5$ 

    printf("\nThe integer variables are IntC=%d, IntD=%d, and IntE=%d\n", IntC, IntD, IntE);
    printf("\nThe double variables are DoubleC=%lf, DoubleD=%lf, DoubleE=%lf\n", DoubleC, DoubleD, DoubleE);
}
```

The integer variables are IntC=7, IntD=7, and IntE=7

The double variables are DoubleC=7.500000, DoubleD=7.000000, DoubleE=7.500000  
Press any key to continue . . .

# Practice Problem

## What is the output? Why?

```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    float a = 11, c;
    int b = 3, d, e;

    printf("%f\n", a);
    printf("%d\n", b);

    c = a / b;
    d = a / b;

    e = b / 2.0;

    printf("The value of c is %4.2f\n", c);
    printf("The value of d is %05d\n", d);
    printf("The value of e is %d\n", e);
}
```

*How many total characters?*  
*How many after the decimal?*

# Practice Problem

## What is the output? Why?

```
#include <stdio.h>
#include <stdlib.h>

void main()
{
    float a = 11, c;
    int b = 3, d, e;

    printf("%f\n", a);
    printf("%d\n", b);

    c = a / b;
    d = a / b;

    e = b / 2.0;

    printf("The value of c is %4.2f\n", c);
    printf("The value of d is %05d\n", d);
    printf("The value of e is %d\n", e);
}
```

```
11.000000
3
The value of c is 3.67
The value of d is 00003
The value of e is 1

Press any key to continue . . .
```

*How many total characters?*  
*How many after the decimal?*

# What happens when different data types are used in mathematical operations?

- A cast operator can be used to assign a data type to a variable
- Thus if C is to be a real:  $C = (\text{double})A/B$
- or if it is to be an integer:  $C = A/(\text{int})B$

# Practice Problem

- Write a short program that defines four variables: two integers (a and b) and two doubles (c and d)
  - Assign values of a and c within the program
  - Ask the user to provide values of b and d (use `scanf`)
- Create a variable that will be equal to  $a+c$ , one equal to  $a+b$ , and one equal to  $d$  to the power of 2 (include `<math.h>` library)
  - Note: You'll end up defining additional variables, so be sure to declare them at the beginning of your program! Should they be integers or doubles?
- Print out all the integer variables and all the double variables to the screen
- Include comments!

Submit .cpp file called "Mena\_Time\_CMathGr#" ("Mena\_10am\_CMathL01") into Classwork folder



C has some helpful assignment operators that we can use as shortcuts when coding

- `i++` increments `i` by 1 after an operation (post-increment)
  - So you can use `i++` instead of `i=i+1`
- `i--` decreases `i` by 1 after an operation (post-increment)
  - So you can use `i--` instead of `i=i-1`
- `++i` increments `i` by 1 before an operation (pre-increment)
- `--i` decreases `i` by 1 before an operation (pre-increment)

# What is the difference between pre increment and post increment?

- Try this:

```
#include <stdio.h>
#include <stdlib.h>
void main()
{
    int i = 1, j = 1, k = 0, m = 0;
    printf("i=%d, j=%d, k=%d, m=%d\n", i, j, k, m);
    k = i++;
    m = ++j;
    printf("i=%d, j=%d, k=%d, m=%d\n", i, j, k, m);
}
```

This means k=i,  
then increment i

This means first  
increment j, then  
m=j

```
i=1, j=1, k=0, m=0
i=2, j=2, k=1, m=2
Press any key to continue . . . _
```

There are some other assignment operators:

$=$        $+=$        $-=$        $*=$        $/=$        $\%=$

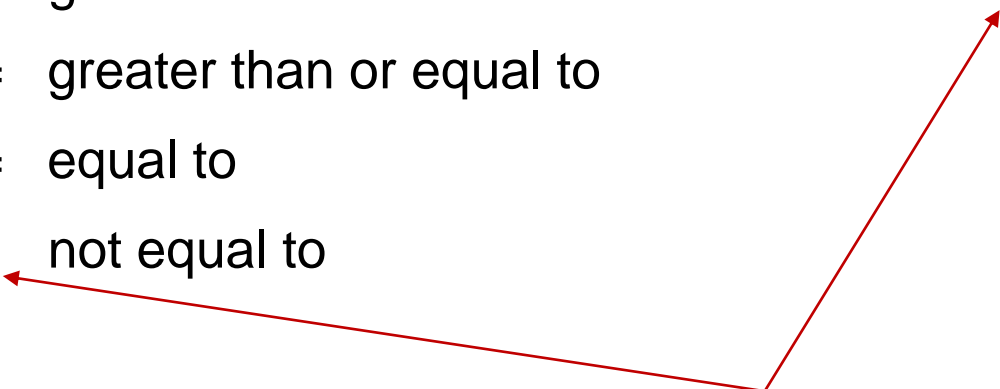
- $x += 2$  is equivalent to  $x = x + 2$
- $x -= 3$  is equivalent to  $x = x - 3$
- $x *= -5$  is equivalent to  $x = x * -5$
- $x /= 7$  is equivalent to  $x = x / 7$
- $x \%= 4$  is equivalent to  $x = x \% 4$

# See your textbook for more information on the rules of precedence

- Pretty much the same as MATLAB
- Pre and post increments are included in the rules and can make a difference in results

In C, we can use if statements, switch-case, and loops, but there will be some differences in syntax

<	less than	&&	AND
<=	less than or equal to		OR
>	greater than	!	NOT
>=	greater than or equal to		
==	equal to		
!=	not equal to		

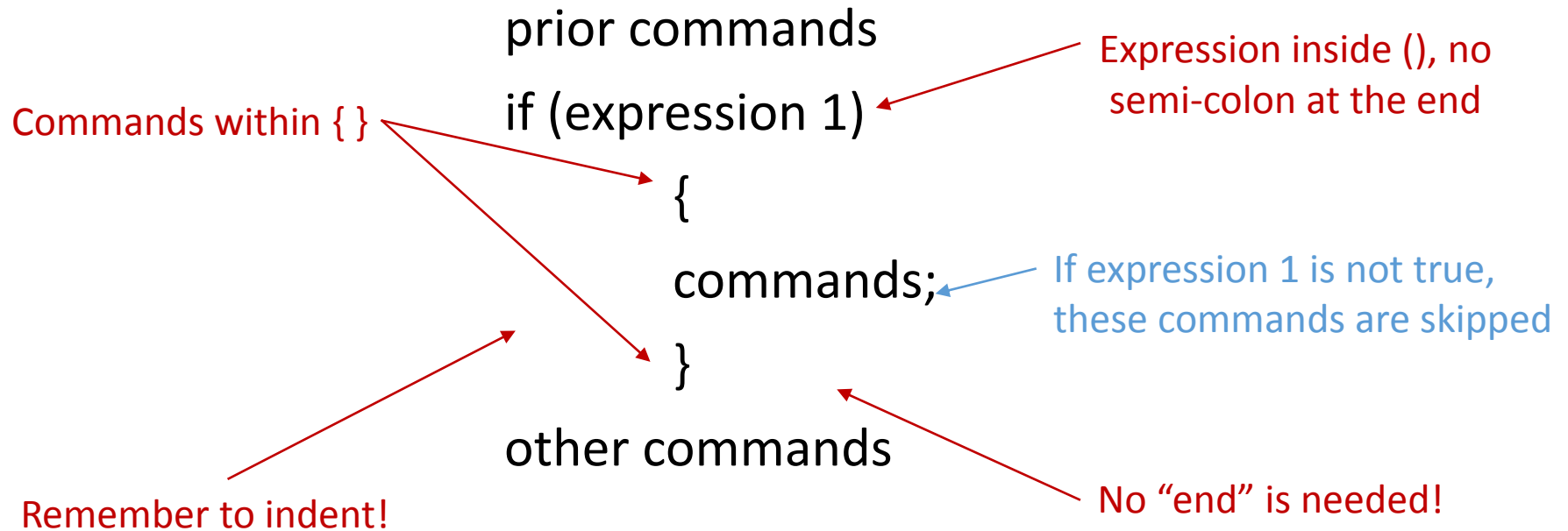


Differs from MATLAB

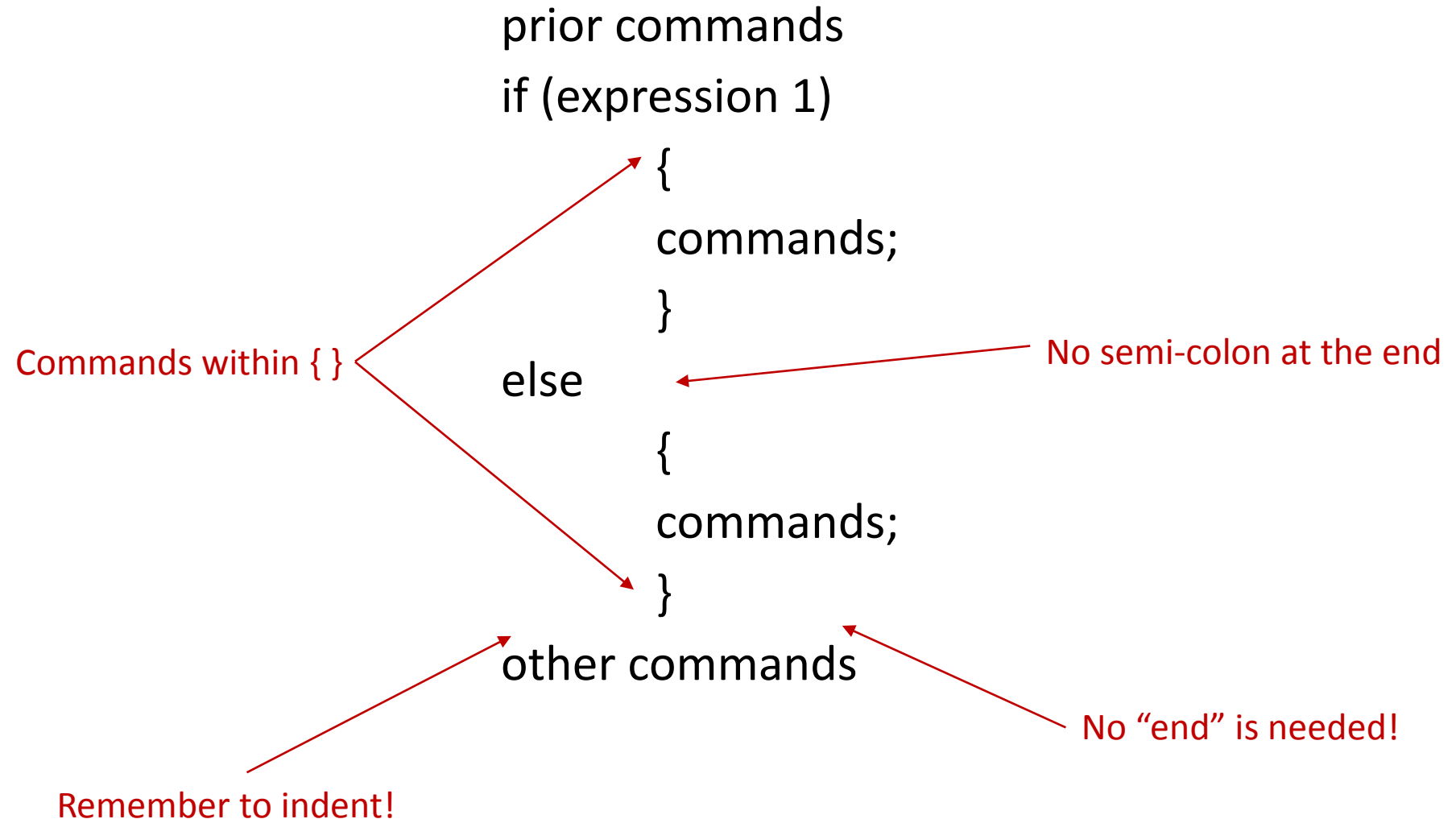
# Remember the difference between = and ==

- Tip: Avoid using == with floats or doubles
  - C will check so many significant figures that a very small difference (.0000001) might be interpreted as not equal – depending on your program, this might not be the case
- Instead use something like this:  
`if fabs(a-b)<.0000001`

One-conditional if statements in C are similar to MATLAB, with some differences in syntax



If-else statements in C are similar to MATLAB, with some differences in syntax

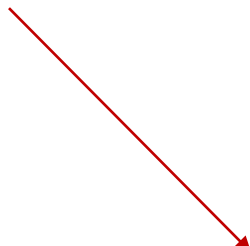




If-else-if statements in C are similar to MATLAB, with some differences in syntax

Two separate words!

```
prior commands
if (expression 1)
    {
        commands;
    }
else if (expression 2)
    {
        commands;
    }
else
    {
        commands;
    }
other commands
```



Commands within { }

Remember to indent!

No semi-colon at the end of  
if, else if, else

No “end” is needed!

# Let's try an example

- Write a program that asks the user to type in number 1, 2, or 3
- If the user types 1, print “You chose 1”; if the user types 2, print “You chose 2”; if the user types 3, print “You chose 3”; otherwise print “You didn’t choose any of the options”

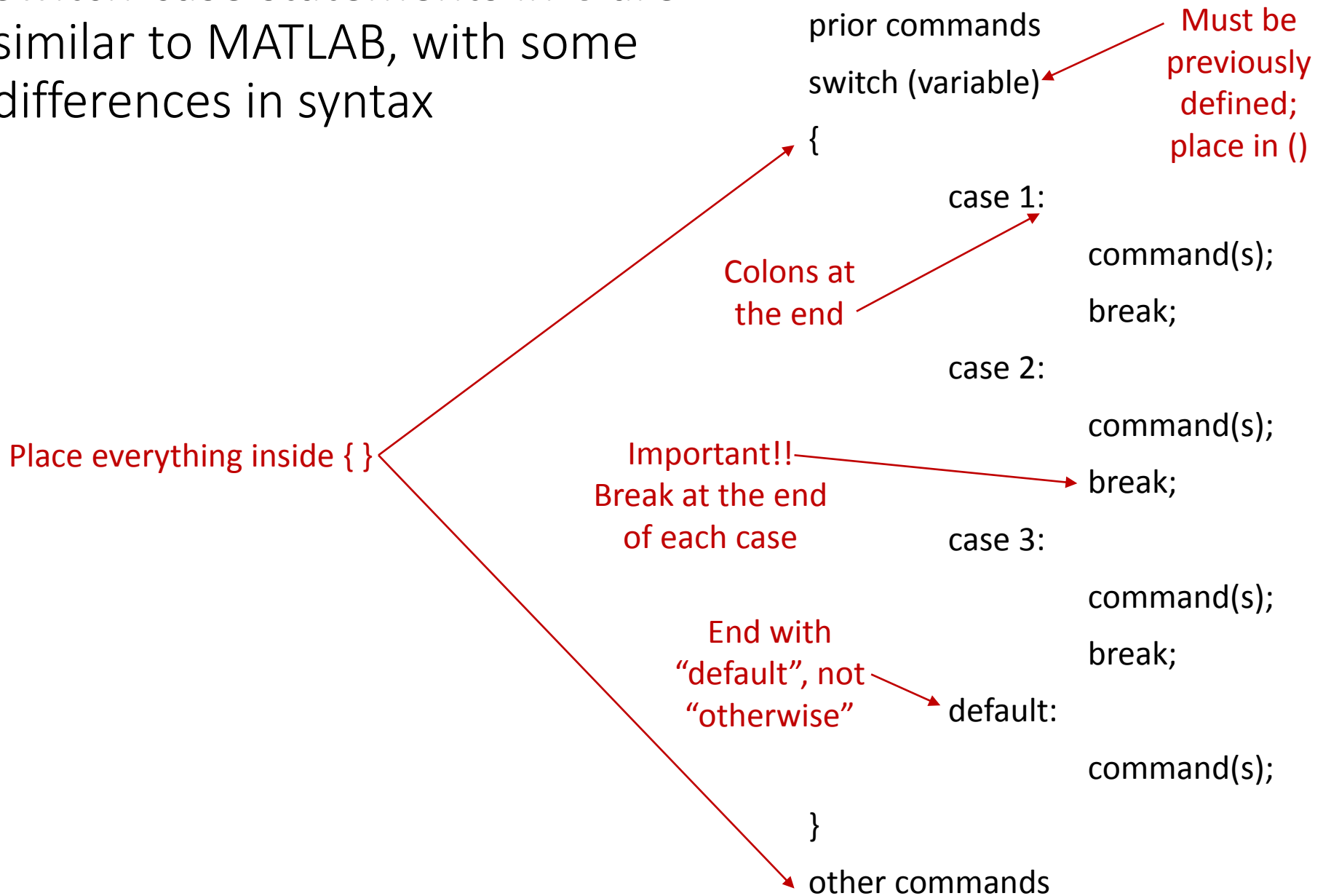
```
#include <stdio.h>
#include <stdlib.h>

int main()
{
    //Create variable
    int your_choice;

    //Request user input
    printf("Please type 1, 2, or 3\n\n");
    scanf("%d", &your_choice);

    //Print appropriate result
    if (your_choice == 1)
    {
        printf("You chose 1\n");
    }
    else if (your_choice == 2)
    {
        printf("You chose 2\n");
    }
    else if (your_choice == 3)
    {
        printf("You chose 3\n");
    }
    else
    {
        printf("You didn't choose any of the options\n");
    }
}
```

Switch-case statements in C are similar to MATLAB, with some differences in syntax



# Let's try an example

- Write a program that asks the user to type in number 1, 2, or 3
- If the user types 1, print “You chose 1”; if the user types 2, print “You chose 2”; if the user types 3, print “You chose 3”; otherwise print “You didn’t choose any of the options”
- Now convert to switch-case!

# Loops in C are similar to MATLAB, with some differences in syntax

- while loops
- do while loops (*didn't see this in MATLAB*)
- for loops

With while loops, we typically don't know the number of times it will be executed, and it needs to be initialized

Sample typical code:

```
prior commands;  
i=5;
```

```
while (expression1)  
{  
    commands;  
    i=i+1;  
}
```

```
other commands;
```

Expression in ();  
no semi-colons

No "end"!

Sample alternative code:

```
prior commands;  
j=5;
```

```
while (j)  
{  
    printf("\nj= %d\n\n",j);  
    j=j-1;  
}
```

Evaluated as  
true/false; false  
when j=0

Remember to define the variable types for  
conditions and counters (such as i and j here)

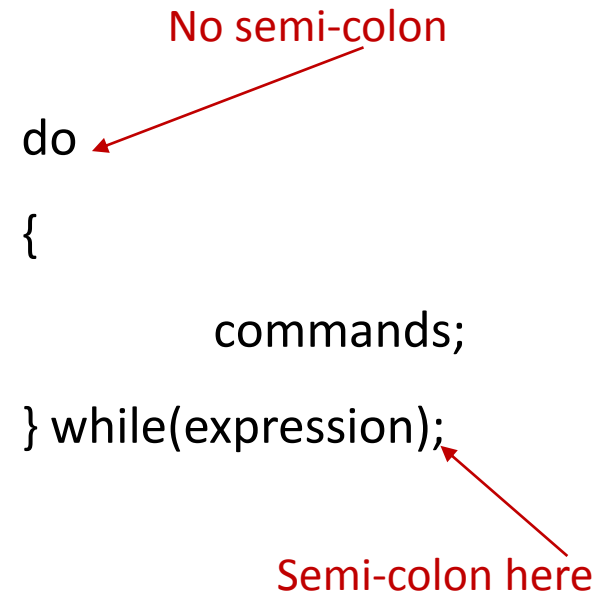
With do-while loops, we typically don't know number of times it will be executed, but will be done at least once

- Doesn't need to be initialized
- Expression is checked after the commands

```
do  
{  
    commands;  
} while(expression);
```

No semi-colon

Semi-colon here

The diagram shows a do-while loop structure. The word 'do' is on the first line, followed by an opening curly brace '{' on the second line. The third line contains the word 'commands;'. The fourth line contains the closing curly brace '}' followed by 'while(expression);'. A red arrow points from the text 'No semi-colon' to the 'do' keyword. Another red arrow points from the text 'Semi-colon here' to the semicolon at the end of the 'while' condition.



Let's look at some examples:

1. Write a program that uses a while loop to loop 5 times and print out the loop number

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1. Write a program that uses a while loop to loop 5 times and print out the loop number

```
#include <stdio.h>
#include <stdlib.h>

int main(void)
{
    int i;
    i = 1;

    //While loop
    while (i <= 5)
    {
        printf("Loop number %d in the while_loop\n", i);
        i = i + 1;
    }
}
```

Let's look at some examples:

2. Write a program that asks the user to provide a number and then multiplies that number by 9. The program should then ask the user if he/she wants to run the program again. Use a do-while loop.

Let's look at some examples:

2. Write a program that asks the user to provide a number and then multiplies that number by 9. The program should then ask the user if he/she wants to run the program again. Use a do-while loop.

```
#include <stdio.h>
#include <stdlib.h>

int main(void)
{
    //Declare variables
    int k, mult_answer;
    char answer;

    //Use a do-while loop
    do
    {
        //Get input from user
        printf("\nEnter an integer to multiply by 9:\n\n");
        scanf("%d", &k);

        //Multiply
        mult_answer = k * 9;

        //Print to screen
        printf("\nThe answer is: %d\n\n", mult_answer);

        //Ask user - run again?
        printf("\nWould you like to do this again (y/n)?\n\n");
        scanf(" %c", &answer);
    } while (answer == 'y' || answer == 'Y');
}
```

You can use the `toupper` command to help prevent input errors – it converts a character to an upper case (you need `#include <ctype.h>`)

```
do
{
    commands;

    while(toupper(answer)!='Y' && toupper(answer)!='N')
    {
        printf("\n Error! Type Y or N, please:\n\n");
        scanf(" %c",&answer);
    }
} while(toupper(answer)!='Y');
```

With for loops, we execute a loop for a certain number of times, and there are some differences in syntax:

3 sections separated by ;  
and enclosed in ()

No ; at the end

```
for (initialization statement; relational expression; increment expression)
{
    commands;
}
```

Let's look at an example:

- Write a program that uses a for loop to loop 5 times and print out the loop number

Let's look at an example:

- Write a program that uses a for loop to loop 5 times and print out the loop number

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

void main(void)
{
    int count;

    //For loop
    for (count = 1; count <= 5; count++)
    {
        printf("The counter = %d\n", count);
    }

    printf("\n");
}
```



# Here are some variations of the for loop expression:

**for (i = start; i < end; i = i + 1)**

i, start, end must be declared

**for (test = 10; test >= 1; test = test - 1)**

loop variable can start high to low

**for (k = 2; k < 100; k = k \* 2)**

loop variable can be incremented in any way

**for (j = 1; j <= finish; j++)**

increment expression can be written in short form:

j++ is same as j = j + 1

j-- is same as j = j - 1

j+=2 is same as j = j + 2

j\*=2 is same as j = j \* 2

# When using loops to access array elements, remember that the first array has index 0, not 1!

- So your control variable must start at 0

```
#include <stdio.h>
#include <stdlib.h>

int main(void)
{
    //Assign values to array a
    int i, a[5] = { 12, 24, 36, 48, 60 };

    //For loop to print elements
    for (i = 0; i < 5; i = i + 1)
    {
        printf("Array element[%d] equals %d\n\n", i, a[i]);
    }
}
```

```
Array element[0] equals 12
Array element[1] equals 24
Array element[2] equals 36
Array element[3] equals 48
Array element[4] equals 60
Press any key to continue . . . _
```

Note: You will need a nested for loop for a 2-dimensional array

Is your program not working well?  
Check these:

- Placement of semi-colons
- Appropriate libraries
- Consistent data types
- All variables declared
- Format for `scanf` for a `char` (remember the blank space or use `fflush`)
- Properties for `scanf` – remember the `&`

# Practice Problem

- Write a code to sum the first ***n*** digits ( $1+2+3+\dots+n$ )
- Ask the user to provide the value for *n*
- Calculate the sum for the *n* that was provided (use for loop)
- Print the final sum

Submit .cpp file called  
"Mena\_Time\_CForloopTeam#"  
("Mena\_10am\_CForloopL01") into Classwork folder

# Practice Problem

- Write a program asking the user to enter elements of a 2x2 matrix A
- Then display the elements (2 decimal places) as shown in the output
- Use for loops to get the inputs and then to print the values

```
Please enter the elements of Matrix a
Enter element in ROW=1, COL=1: 1
Enter element in ROW=1, COL=2: 2
Enter element in ROW=2, COL=1: 3
Enter element in ROW=2, COL=2: 4
-----
You have entered the following elements for Matrix a:
1.00
2.00
3.00
4.00
Press any key to continue . . .
```

Submit .cpp file called "Mena\_Time\_CMoreLoopsTeam#" ("Mena\_10am\_CMoreLoopsL01") into Classwork folder