Basic Refreshers

Number System

Advanced C

Number Systems

- A number is generally represented as
  - Decimal
  - Octal
  - Hexadecimal
  - Binary

Type	Dec	Oct	Hex	Bin			
Base	10	8	16	2			
	0	0	0	0	0	0	0
	1	1	1	0	0	0	1
	2	2	2	0	0	1	0
	3	3	3	0	0	1	1
	4	4	4	0	1	0	0
	5	5	5	0	1	0	1
	6	6	6	0	1	1	0
	7	7	7	0	1	1	1
	8	10	8	1	0	0	0
	9	11	9	1	0	0	1
	10	12	A	1	0	1	0
	11	13	B	1	0	1	1
	12	14	C	1	1	0	0
	13	15	D	1	1	0	1
	14	16	E	1	1	1	0
	15	17	F	1	1	1	1

Type	Range (8 Bits)
Decimal	0 - 255
Octal	000 - 0377
Hexadecimal	0x00 - 0xFF
Binary	0b00000000 - 0b11111111

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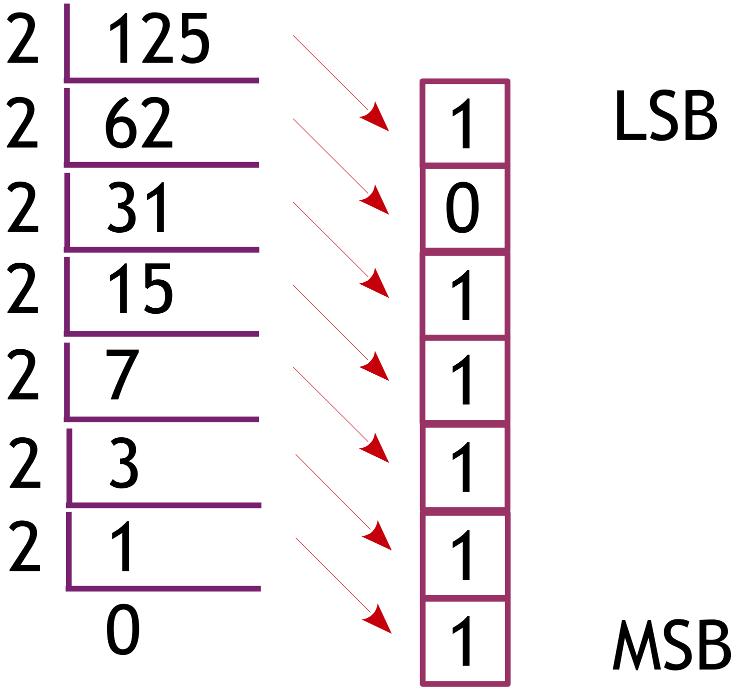
Number Systems – Decimal to Binary

- 125_{10} to Binary



2 | 125
2 | 62
2 | 31
2 | 15
2 | 7
2 | 3
2 | 1
0

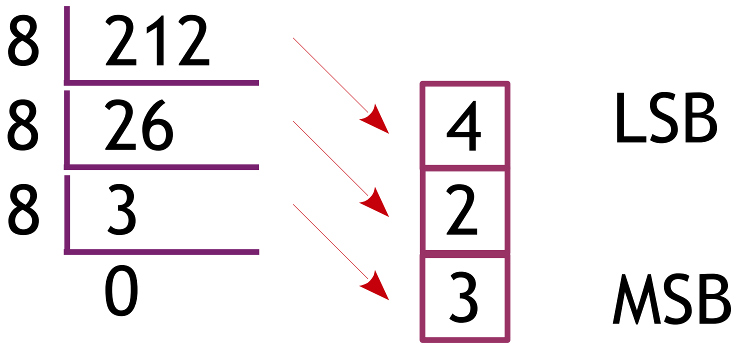
1 LSB
0
1
1
1
1
1 MSB

- So 125_{10} is 1111101_2

Advanced C

Number Systems – Decimal to Octal

- 212_{10} to Octal



8 | 212

8 | 26

8 | 3

0

4 LSB

2

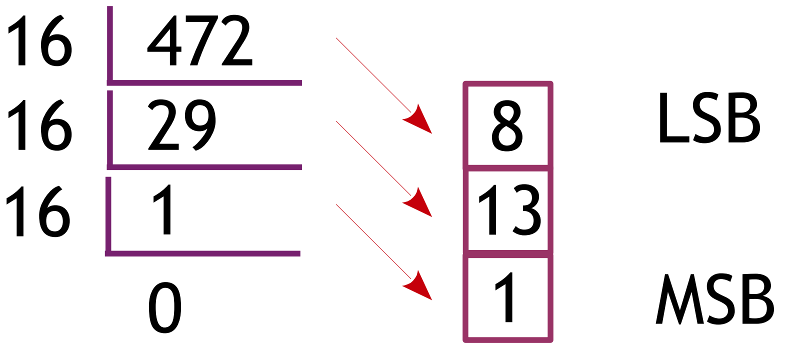
3 MSB

- So 212_{10} is 324_8

Advanced C

Number Systems – Decimal to Hexadecimal

- 472_{10} to Hexadecimal



16 | 472
16 | 29
16 | 1
0

8 LSB
13
1 MSB

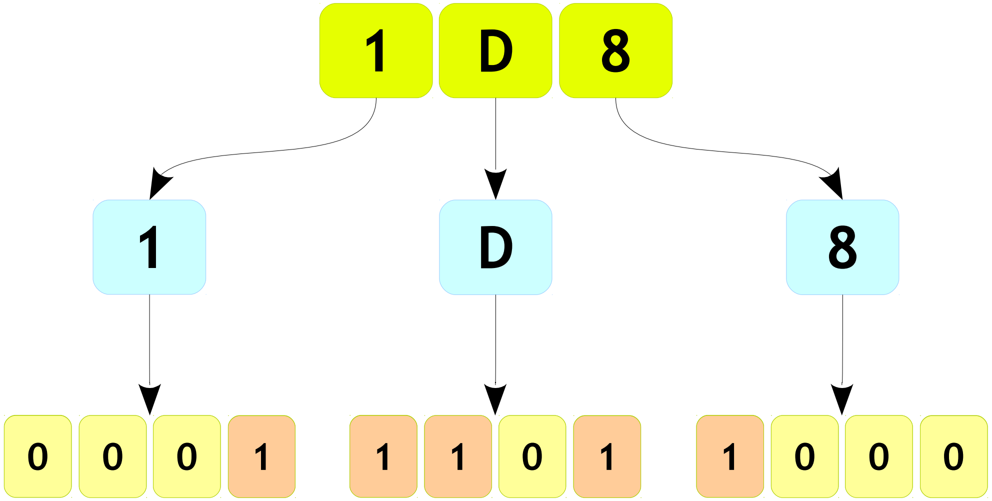
Representation	Substitutes															
Dec	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

- So 472_{10} is $1D8_{16}$

Advanced C

Number Systems – Hexadecimal to Binary

- $1D8_{16}$ to Binary

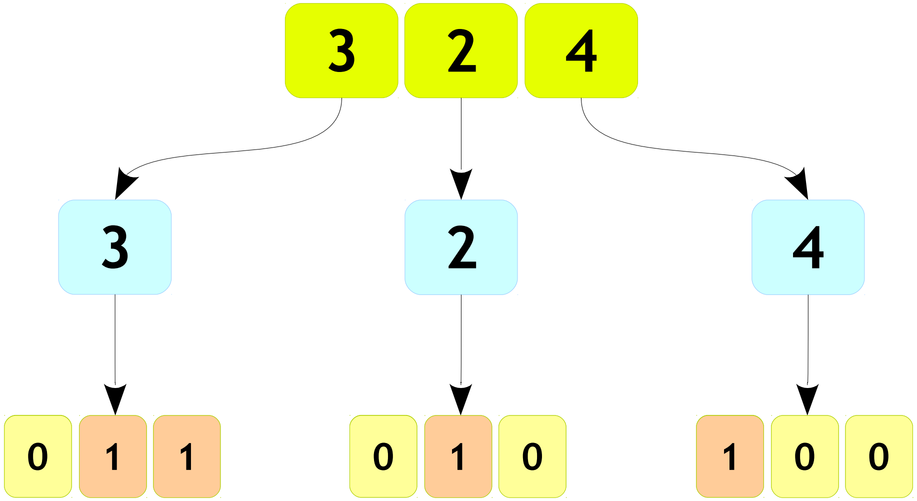


- So $1D8_{16}$ is 000111011000_2 which is nothing but 111011000_2

Advanced C

Number Systems – Octal to Binary

- 324_8 to Binary

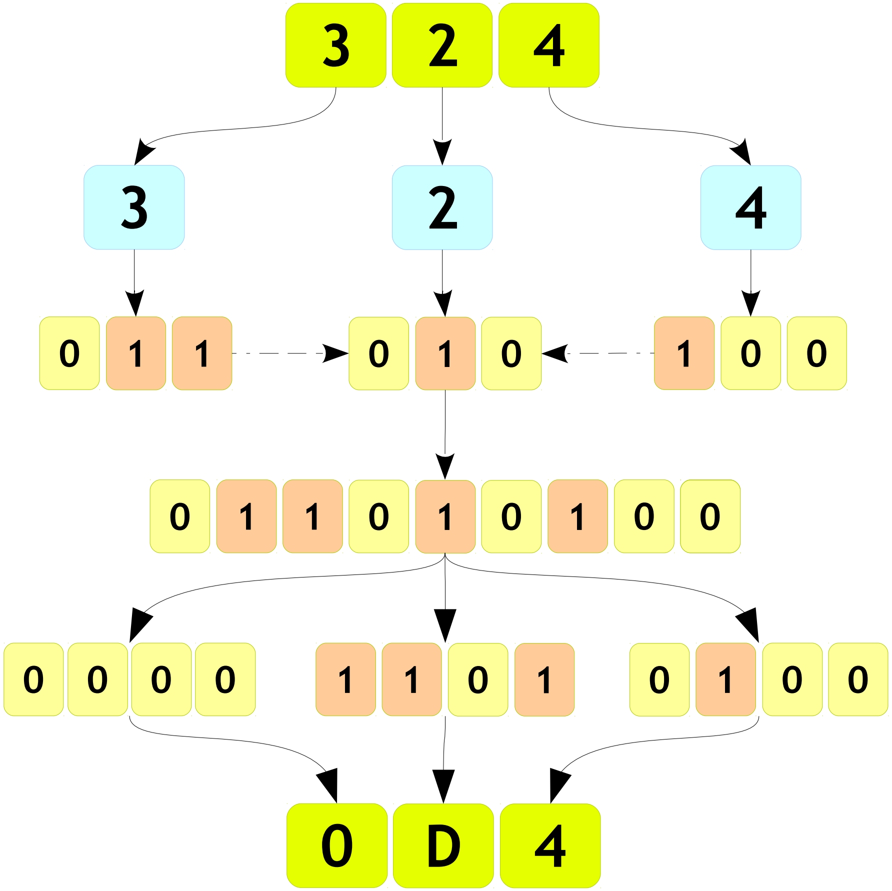


- So 324_8 is 011010100_2 which is nothing but 11010100_2

Advanced C

Number Systems – Octal to Hexadecimal

- 324_8 to Hexadecimal

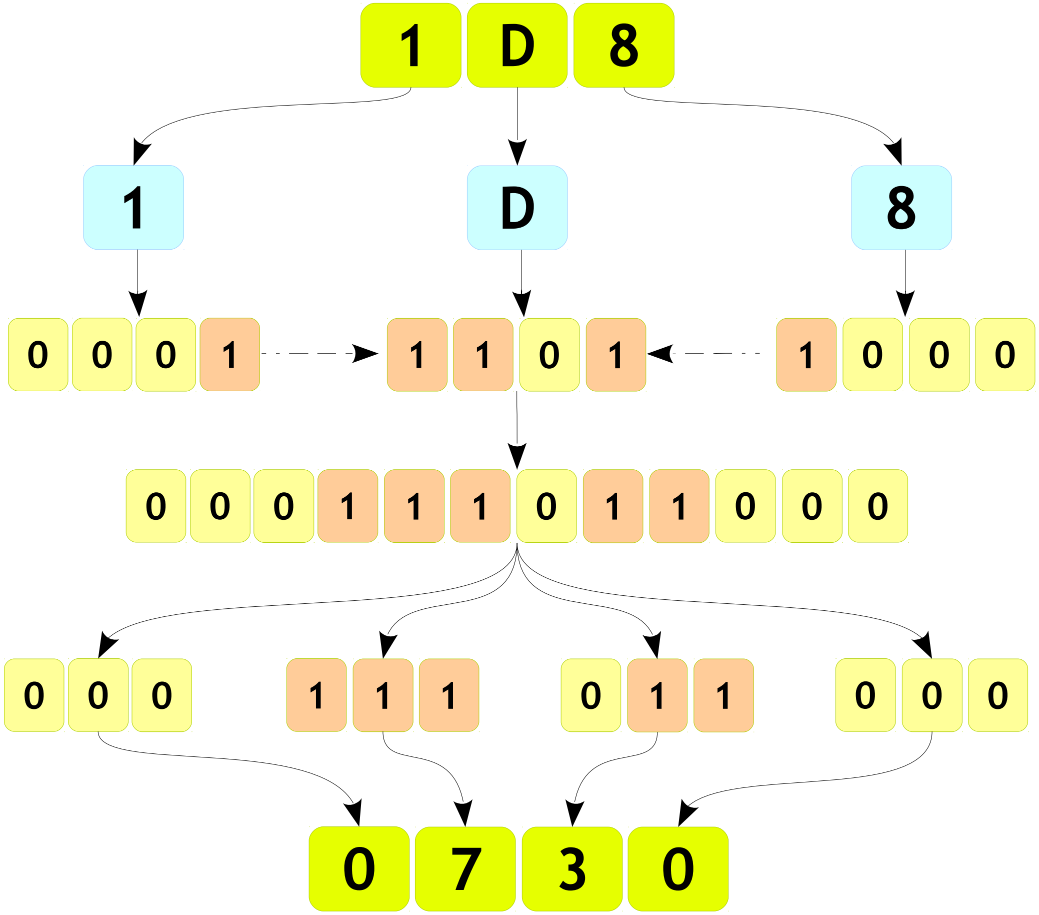


- So 324_8 is $0D4_{16}$ which is nothing but $D4_{16}$

Advanced C

Number Systems – Hexadecimal to Octal

- $1D8_{16}$ to Octal

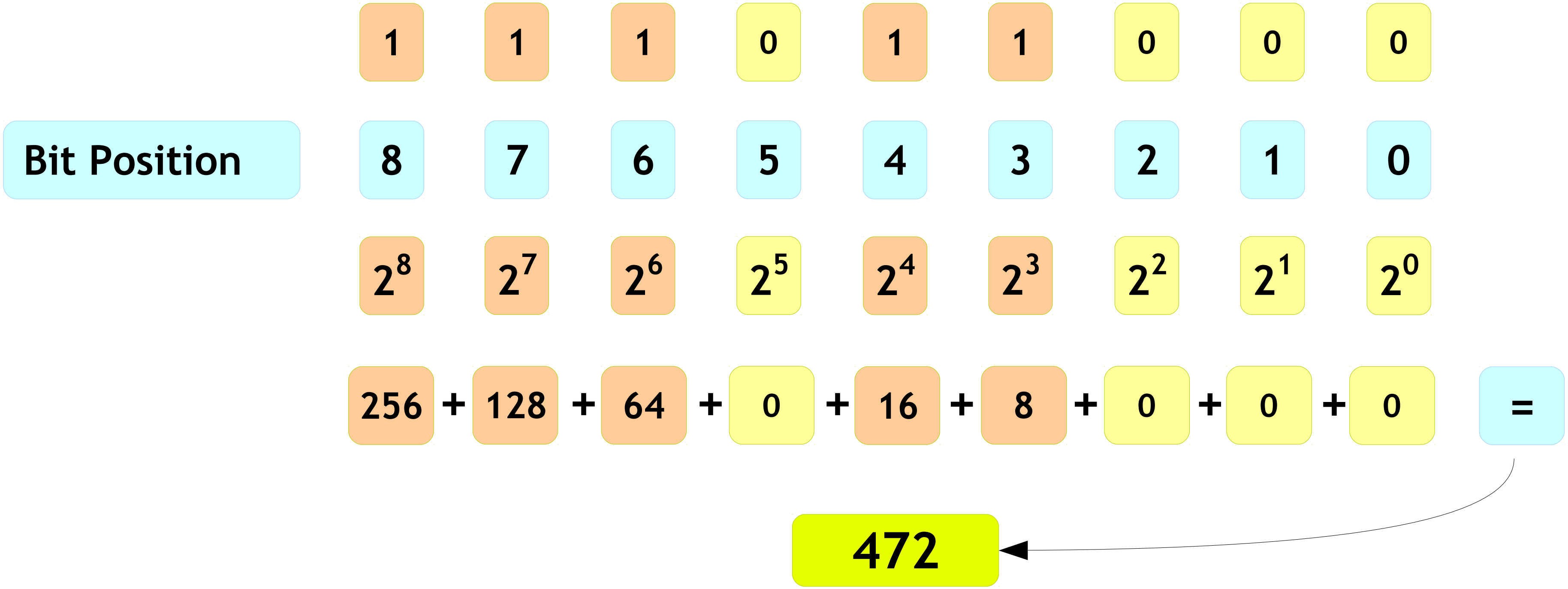


- So $1D8_{16}$ is 0730_8 which is nothing but 730_8

Advanced C

Number Systems – Binary to Decimal

- 111011000_2 to Decimal



	1	1	1	0	1	1	0	0	0
Bit Position	8	7	6	5	4	3	2	1	0
	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

$$256 + 128 + 64 + 0 + 16 + 8 + 0 + 0 + 0 =$$

472

- So 111011000_2 is 472_{10}

Data Representations

Advanced C

Data Representation - Bit

- Literally computer understand only two states HIGH and LOW making it a binary system
- These states are coded as 1 or 0 called binary digits
- "**Bi**nary Digi**t**" gave birth to the word "**Bit**"
- Bit is known a basic unit of information in computer and digital communication

Value	No of Bits
0	0
1	1

Advanced C

Data Representation - Byte

- A unit of digital information
- Commonly consist of 8 bits
- Considered smallest addressable unit of memory in computer

Value	No of Bits							
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1

Advanced C

Data Representation - Character

- One byte represents one unique character like 'A', 'b', '1', '$' ...
- Its possible to have 256 different combinations of 0s and 1s to form a individual character
- There are different types of character code representation like
  - ASCII → American Standard Code for Information Interchange – 7 Bits (Extended - 8 Bits)
  - EBCDIC → Extended BCD Interchange Code – 8 Bits
  - Unicode → Universal Code - 16 Bits and more

Advanced C

Data Representation - Character

- ASCII is the oldest representation
- Please try the following on command prompt to know the available codes

  ```
  $ man ascii
  ```

- Can be represented by char datatype

Value	No of Bits							
0	0	0	1	1	0	0	0	0
A	0	1	0	0	0	0	0	1

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Data Representation - word

- Amount of data that a machine can fetch and process at one time
- An integer number of bytes, for example, one, two, four, or eight
- General discussion on the bitness of the system is references to the word size of a system, i.e., a 32 bit chip has a 32 bit (4 Bytes) word size

Value	No of Bits																															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Advanced C

Integer Number - Positive

- Integers are like whole numbers, but allow negative numbers and no fraction
- An example of 13_{10} in 32 bit system would be

Bit	No of Bits																															
Position	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1

Advanced C

Integer Number - Negative

- Negative Integers represented with the 2's complement of the positive number
- An example of -13_{10} in 32 bit system would be

Bit	No of Bits																															
Position	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
1's Compli	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0
Add 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2's Compli	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1

- Mathematically : $-k \equiv 2^n - k$

Float Point Number

- A formulaic representation which approximates a real number
- Computers are integer machines and are capable of representing real numbers only by using complex codes
- The most popular code for representing real numbers is called the IEEE Floating-Point Standard

	Sign	Exponent	Mantissa
Float (32 bits) **Single Precision**	1 bit	8 bits	23 bits
Double (64 bits) **Double Precision**	1 bit	11 bits	52 bits

Advanced C

Float Point Number – Conversion Procedure

- STEP 1: Convert the absolute value of the number to binary, perhaps with a fractional part after the binary point. This can be done by -
  - Converting the integral part into binary format.
  - Converting the fractional part into binary format.

  The integral part is converted with the techniques examined previously.

  The fractional part can be converted by multiplying it with 2.

- STEP 2: Normalize the number. Move the binary point so that it is one bit from the left. Adjust the exponent of two so that the value does not change.

$$\text{Float} : V = (-1)^{s} * 2^{(E-127)} * 1.F$$

$$\text{Double} : V = (-1)^{s} * 2^{(E-1023)} * 1.F$$

Advanced C

Float Point Number – Conversion - Example 1

Convert 2.5 to IEEE 32-bit floating point format

Step 1:

0.5	× 2	1.0	1

$2.5_{10} = 10.1_2$

Step 2:

Normalize: $10.1_2 = 1.01_2 \times 2^1$

Mantissa is 01000000000000000000000
Exponent is $1 + 127 = 128 = 1000\ 0000_2$
Sign bit is 0

Bit	S	Exponent								Mantissa																						
Position	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Advanced C

Float Point Number – Conversion - Example 2

Convert 0.625 to IEEE 32-bit floating point format

Step 1:

0.625	× 2	1.25	1
0.25	× 2	0.5	0
0.5	× 2	1.0	1

$0.625_{10} = 0.101_2$

Step 2:

Normalize: $0.101_2 = 1.01_2 \times 2^{-1}$

Mantissa is 01000000000000000000000
Exponent is $-1 + 127 = 126 = 01111110_2$
Sign bit is 0

Bit	S	Exponent								Mantissa																						
Position	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	0	0	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Advanced C

Float Point Number – Conversion - Example 3

Convert 39887.5625 to IEEE 32-bit floating point format

Step 1:

0.5625	× 2 =	1.125	1
0.125	× 2 =	0.25	0
0.25	× 2 =	0.5	0
0.5	× 2 =	1.0	1

39887.5625_{10} =
1001101111001111.1001_2

Step 2:

Normalize:
1001101111001111.1001_2 =
$1.0011011110011111001_2 \times 2^{15}$

Mantissa is 00110111100111110010000
Exponent is 15 + 127 = 142 = 10001110_2
Sign bit is 0

Bit	S	Exponent								Mantissa																						
Position	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	0	1	0	0	0	1	1	1	0	0	0	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	1	0	0	0	0

Advanced C

Float Point Number – Conversion - Example 5

Convert -13.3125 to IEEE 32-bit floating point format

Step 1:

0.3125	× 2 =	0.625	0
0.625	× 2 =	1.25	1
0.25	× 2 =	0.5	0
0.5	× 2 =	1.0	1

$13.3125_{10} = 1101.0101_2$

Step 2:

Normalize:

$1101.0101_2 = 1.1010101_2 \times 2^3$

Mantissa is 10101010000000000000000
Exponent is $3 + 127 = 130 = 1000\ 0010_2$

Sign bit is 1

Bit	S	Exponent								Mantissa																						
Position	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	1	1	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Advanced C

Float Point Number – Conversion - Example 6

Convert 1.7 to IEEE 32-bit floating point format

Step 1:

0.7	× 2 =	1.4	1
0.4	× 2 =	0.8	0
0.8	× 2 =	1.6	1
0.6	× 2 =	1.2	1
0.2	x 2 =	0.4	0
0.4	× 2 =	0.8	0
0.8	× 2 =	1.6	1
0.6	× 2 =	1.2	1

$1.7_{10} = 1.1011001100110011001 1001_2$

Step 2:

Normalize:

$1.10110011001100110011001_2 =$

$1.10110011001100110011001_2 \times 2^0$

Mantissa is 10110011001100110011001

Exponent is 0 + 127 = 127 = 01111111_2

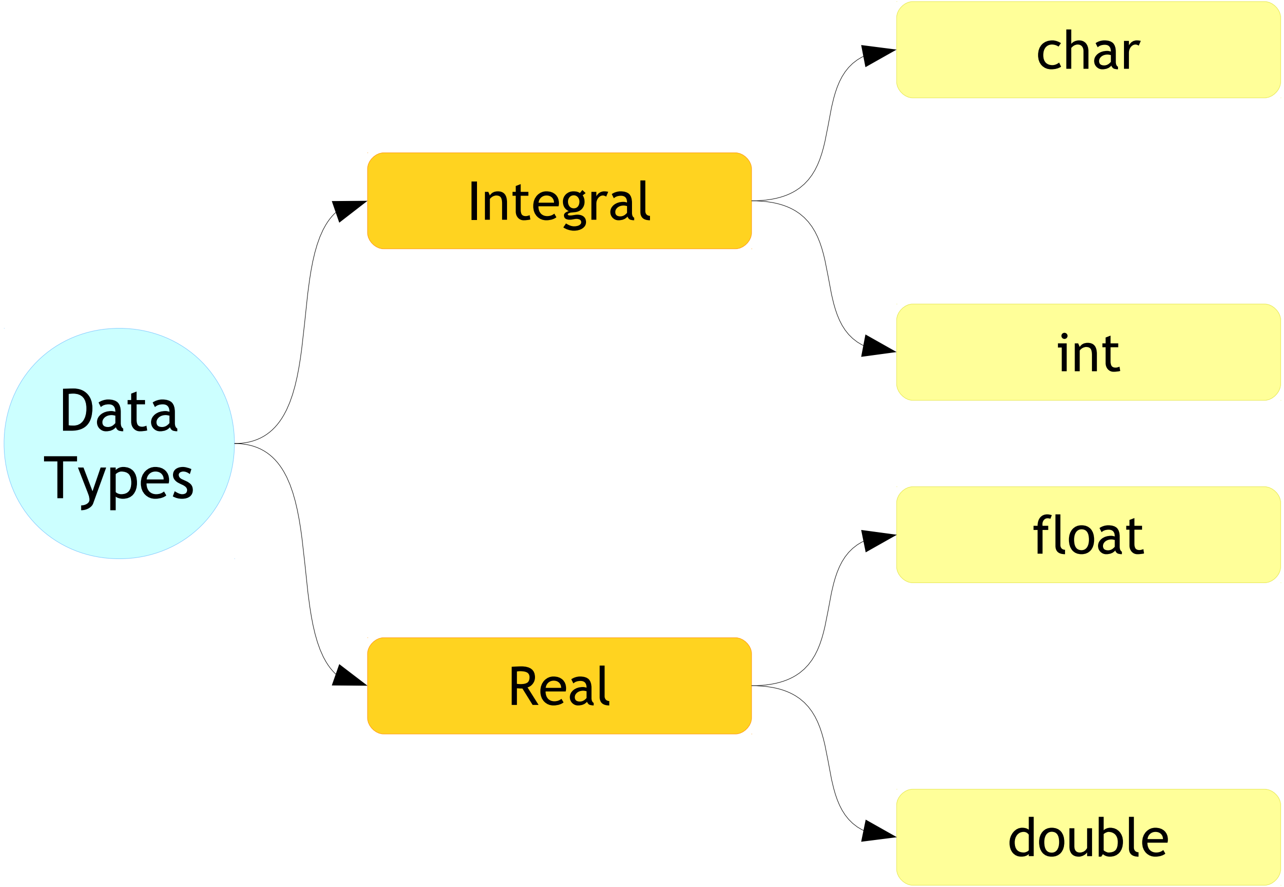
Sign bit is 1

Bit	S	Exponent								Mantissa																						
Position	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value	0	0	1	1	1	1	1	1	1	1	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1

Data Types

Advanced C

Data Types - Categories



Advanced C

Data Types - Usage

Syntax

```
data_type name_of_the_variable;
```

Example

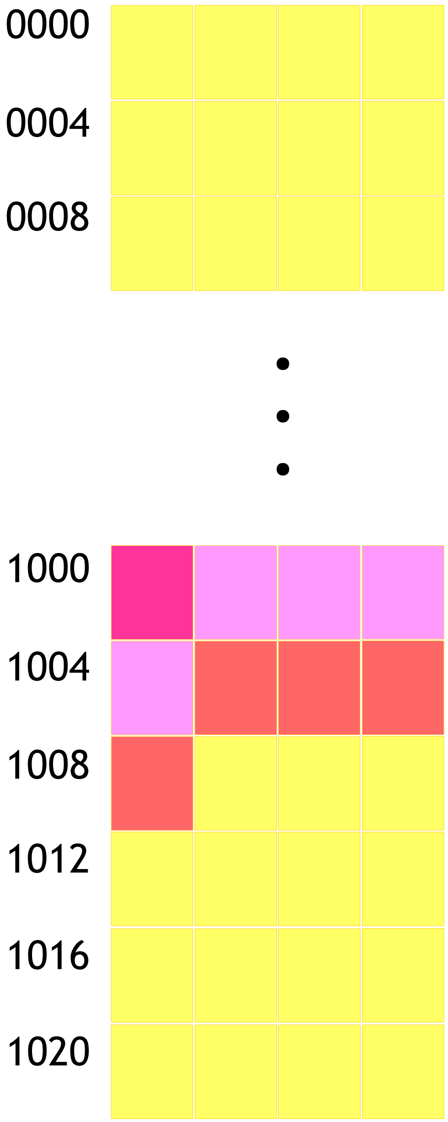
```
char option;
int age;
float height;
```

Advanced C

Data Types – Storage

Example

```c
char option;
int age;
float height;
```

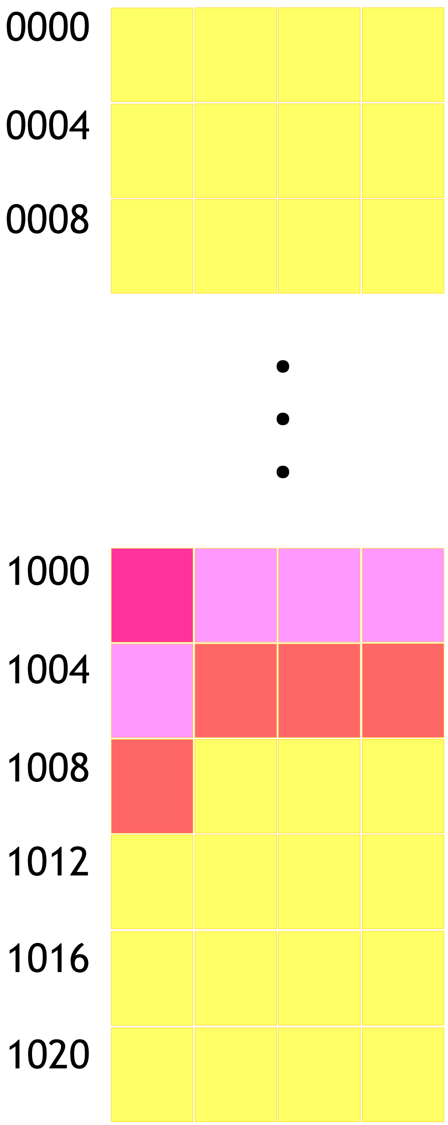


Advanced C

Data Types – Printing

001_example.c

```c
#include <stdio.h>

int main()
{
    char option;
    int age;
    float height;

    printf("The character is %c\n", option);
    printf("The integer is %d\n", age);
    printf("The float is %f\n", height);

    return 0;
}
```

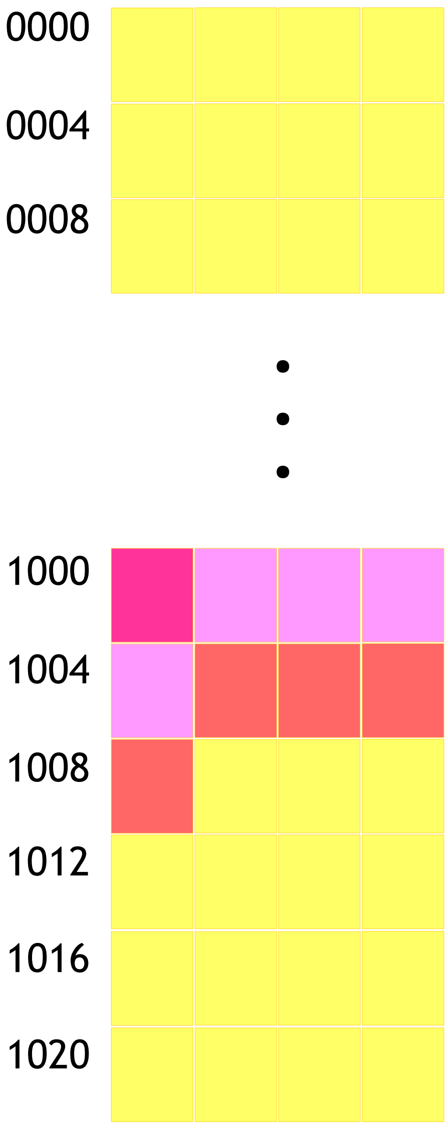


Advanced C

Data Types – Scaning

002_example.c

```
#include <stdio.h>

int main()
{
    char option;
    int age;
    float height;

    scanf(“%c”, &option);
    printf(“The character is %c\n”, option);
    scanf(“%d”, &age);
    printf(“The integer is %d\n”, age);
    scanf(“%f”, &height);
    printf(“The float is %f\n”, height);

    return 0;
}
```

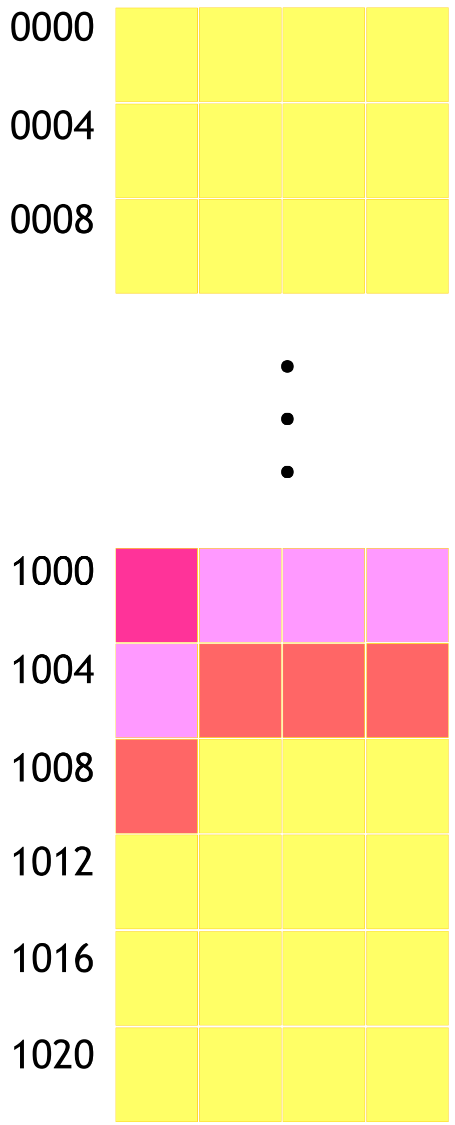


Advanced C

Data Types - Size

003_example.c

```
#include <stdio.h>

int main()
{
     char option;
     int age;
     float height;

     printf(“The size of char is %u\n”, sizeof(char));
     printf(“The size of int is %u\n”, sizeof(int));
     printf(“The float is %u\n”, sizeof(float));

     return 0;
}
```



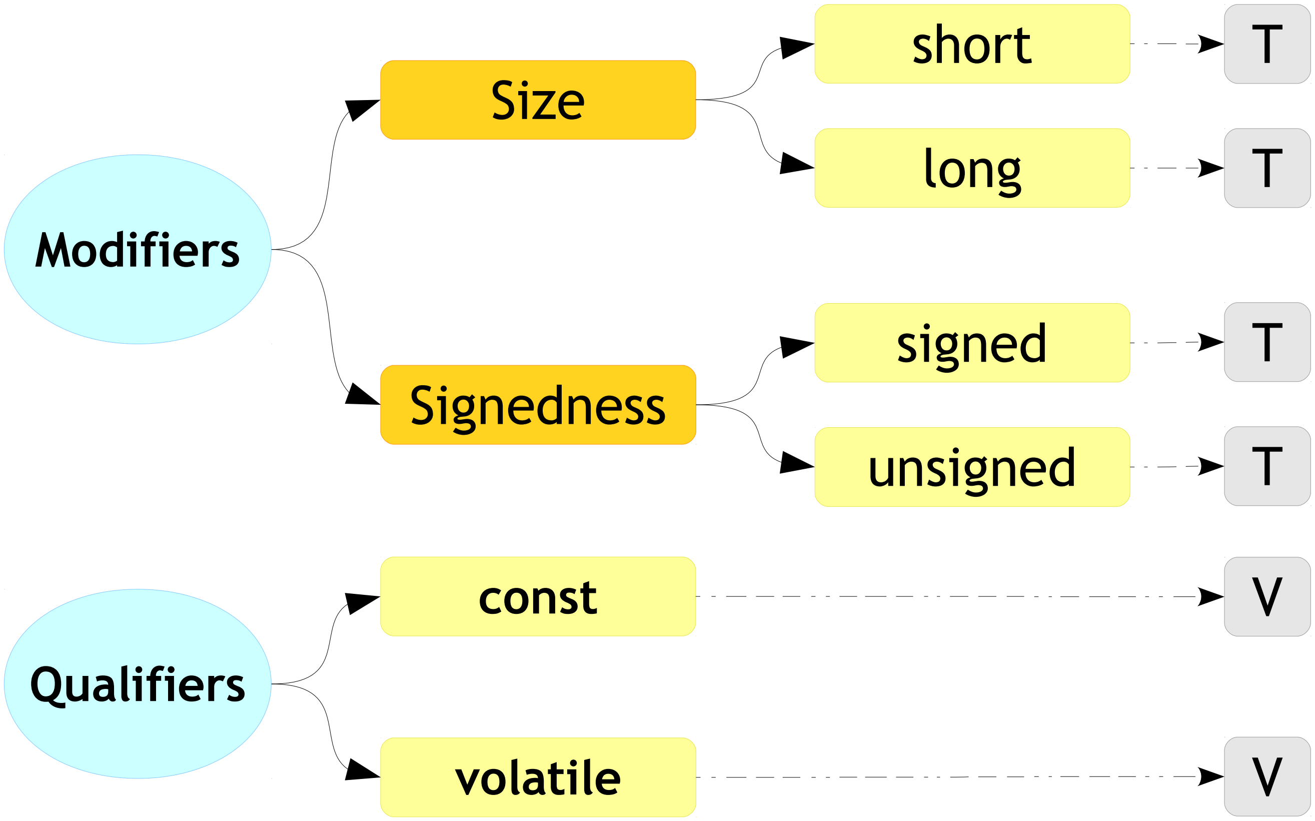
Advanced C

Data Types - Modifiers and Qualifiers

- These are some keywords which is used to tune the property of the data type like
  - Its width
  - Its sign
  - Its storage location in memory
  - Its access property
- The K & R C book mentions only two types of qualifiers (refer the next slide). The rest are sometimes interchangably called as specifers and modifiers and some people even call all as qualifiers!

Advanced C

Data Types - Modifiers and Qualifiers



V	Variables
T	Data Types
F	Functions

Note: Unsigned float in not supported

Advanced C

Data Types - Modifiers and Qualifiers - Usage

Syntax

```
<modifier> <qualifier> <data_type> name_of_the_variable;
```

Example

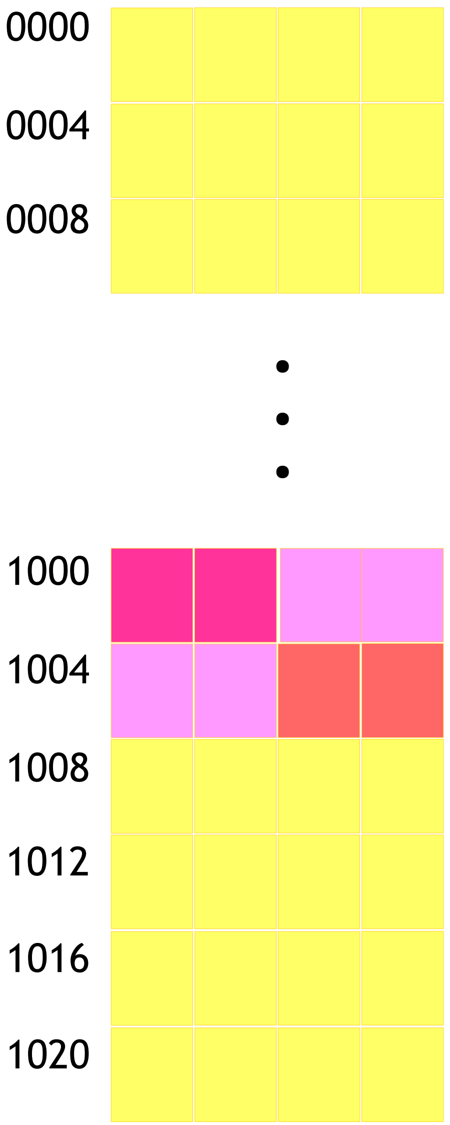
```
short int count1;
long int count2;
const int flag;
```

Advanced C

Data Types – Modifiers - Size

004_example.c

```
#include <stdio.h>

int main()
{
    short int count1;
    int long count2;
    short count3;

    printf(“short is %u bytes\n”, sizeof(short int));
    printf(“long int is %u bytes\n”, sizeof(int long));
    printf(“short is %u bytes\n”, sizeof(short));

    return 0;
}
```

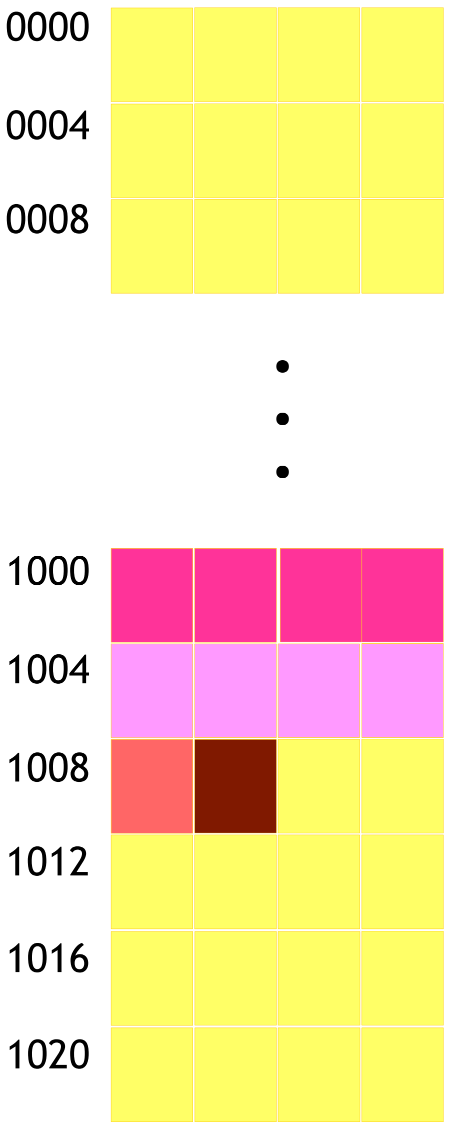


Advanced C

Data Types – Modifiers - Sign

005_example.c

```c
#include <stdio.h>

int main()
{
    unsigned int count1;
    signed int count2;
    unsigned char count3;
    signed char count4;

    printf(“count1 is %u bytes\n”, sizeof(unsigned int));
    printf(“count2 is %u bytes\n”, sizeof(signed int));
    printf(“count3 is %u bytes\n”, sizeof(unsigned char));
    printf(“count3 is %u bytes\n”, sizeof(signed char));

    return 0;
}
```

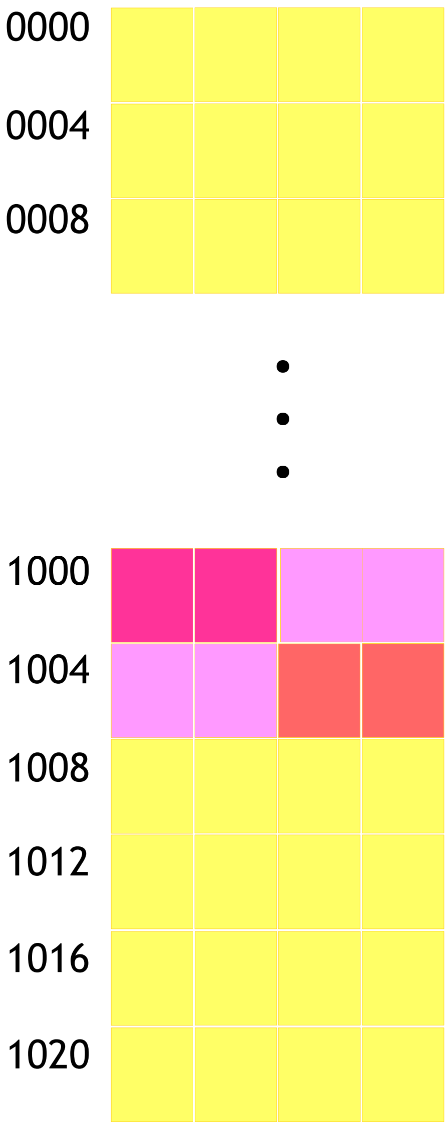


Advanced C

Data Types – Modifiers – Sign and Size

006_example.c

```
#include <stdio.h>

int main()
{
    unsigned short count1;
    signed long count2;
    short signed count3;

    printf(“count1 is %u bytes\n”, sizeof(count1));
    printf(“count2 is %u bytes\n”, sizeof(count2));
    printf(“count3 is %u bytes\n”, sizeof(count3));

    return 0;
}
```



Advanced C

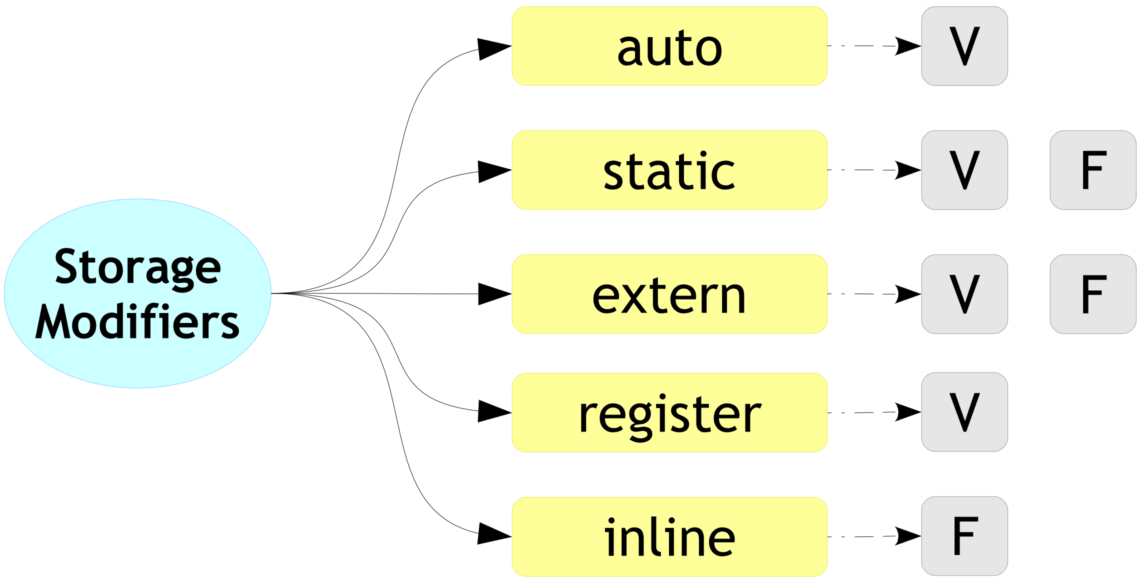
Data Types - Modifiers - Sign and Size

007_example.c

```
#include <stdio.h>

int main()
{
    unsigned int count1 = 10;
    signed int count2 = -1;

    if (count1 > count2)
    {
        printf(“Yes\n”);
    }
    else
    {
        printf(“No\n”);
    }

    return 0;
}
```

Advanced C

Data Types and Function - Storage Modifiers

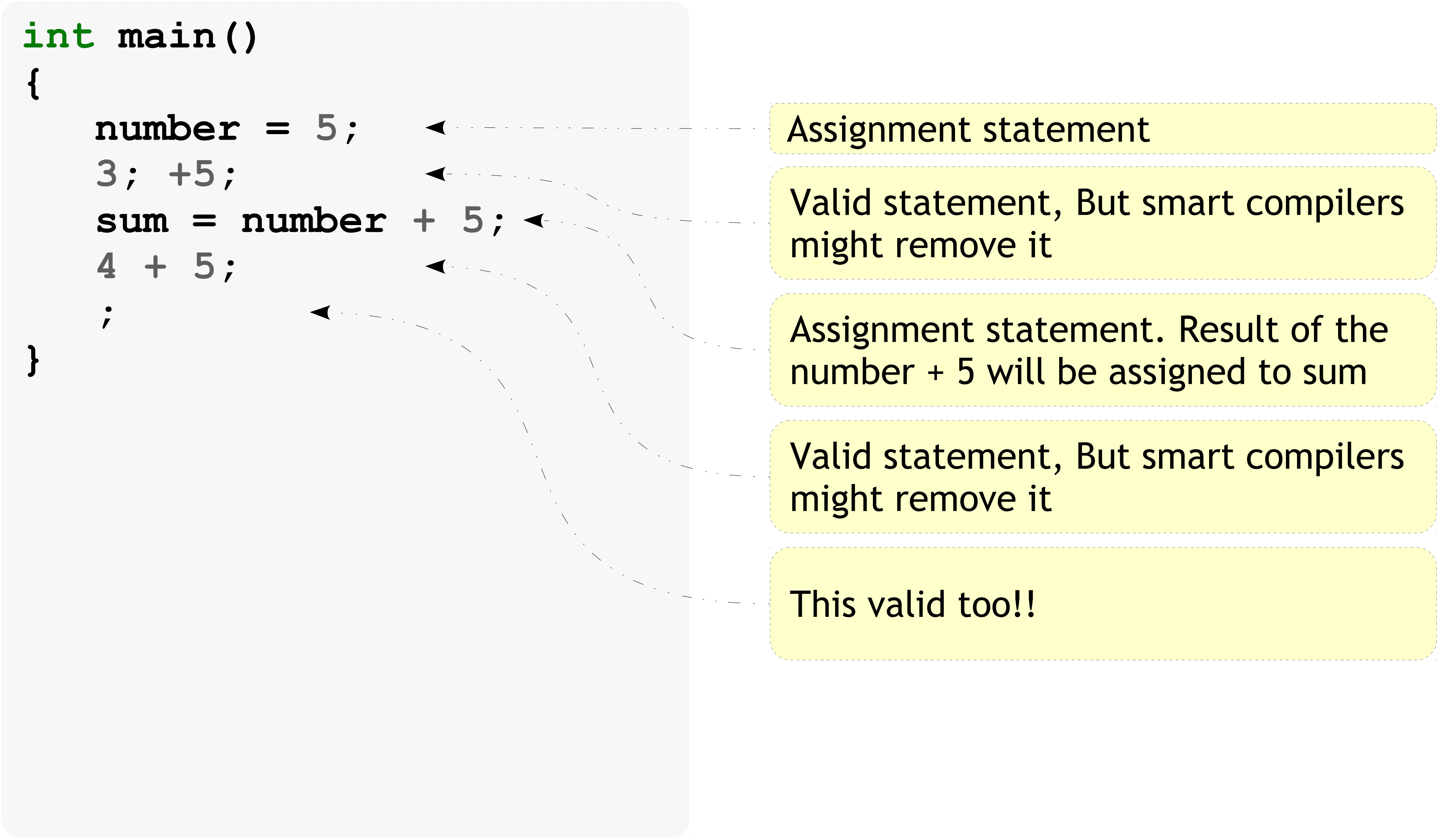


V	Variables
T	Data Types
F	Functions

Statements

Advanced C

Code Statements - Simple



```
int main()
{
    number = 5;
    3; +5;
    sum = number + 5;
    4 + 5;
    ;
}
```

Assignment statement

Valid statement, But smart compilers might remove it

Assignment statement. Result of the number + 5 will be assigned to sum

Valid statement, But smart compilers might remove it

This valid too!!

Advanced C

Code Statements - Compound

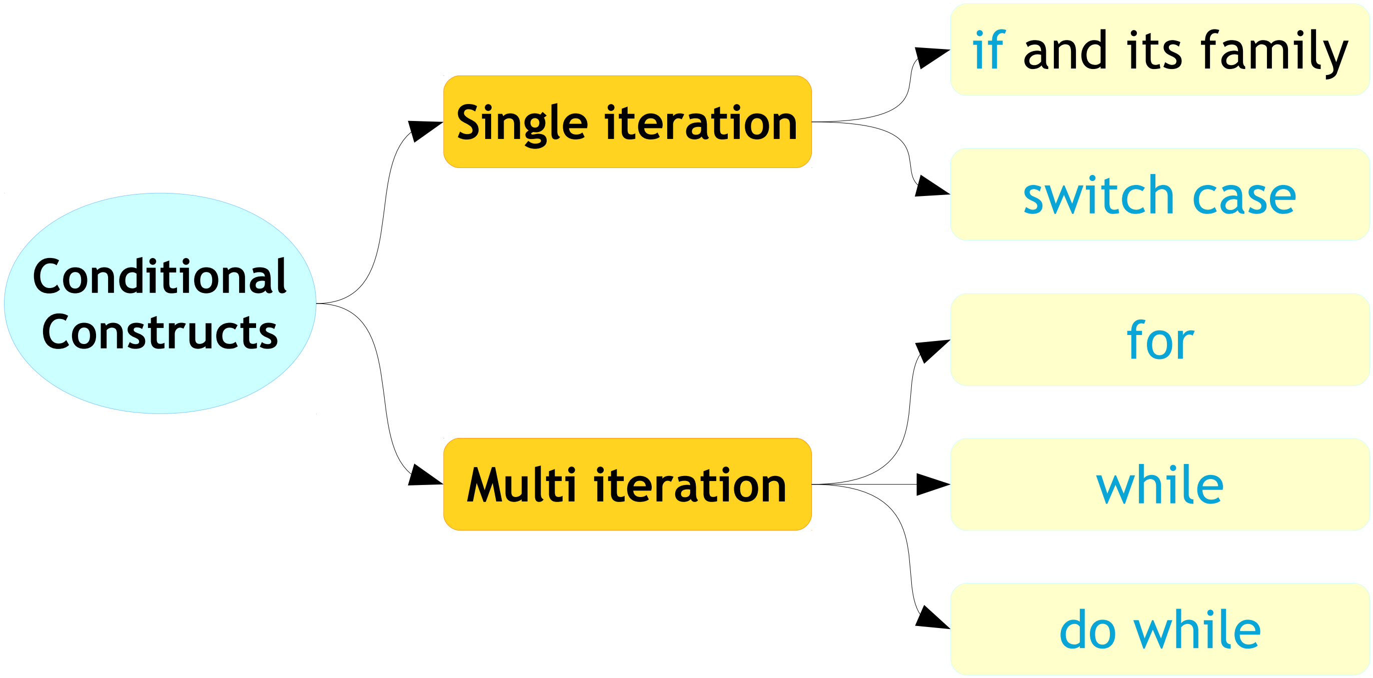
```
int main()
{
    ...
    if (num1 > num2)
    {
        if (num1 > num3)
        {
            printf(“Hello”);
        }
        else
        {
            printf(“World”);
        }
    }
    ...
}
```

If conditional statement

Nested if statement

Conditional Constructs

Conditional Constructs



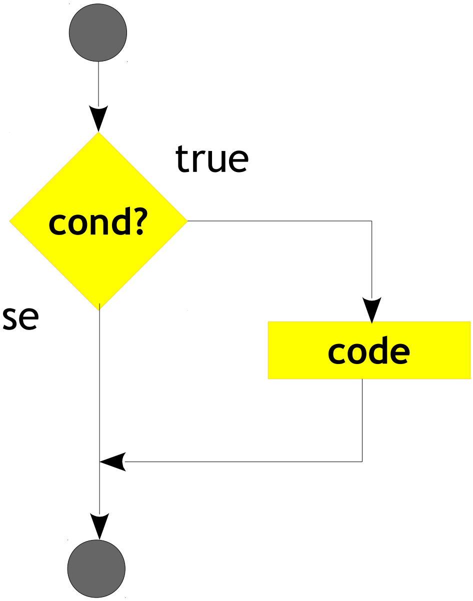
Advanced C

Conditional Constructs - if

Syntax

```
if (condition)
{
    statement(s);
}
```

Flow



008_example.c

```
#include <stdio.h>

int main()
{
    int num = 2;

    if (num < 5)
    {
        printf(“num < 5\n”);
    }
    printf(“num is %d\n”, num);

    return 0;
}
```

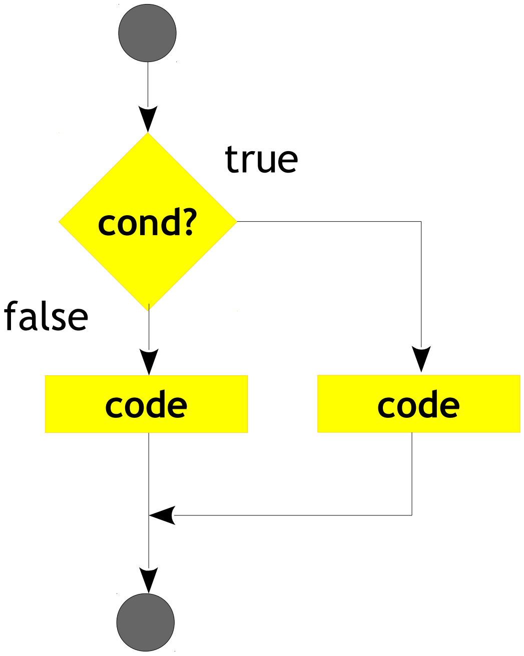
Advanced C

Conditional Constructs – if else

Syntax

```
if (condition)
{
    statement(s);
}
else
{
    statement(s);
}
```

Flow



Conditional Constructs – if else

009_example.c

```
#include <stdio.h>

int main()
{
    int num = 10;

    if (num < 5)
    {
        printf(“num is smaller than 5\n”);
    }
    else
    {
        printf(“num is greater than 5\n”);
    }

    return 0;
}
```

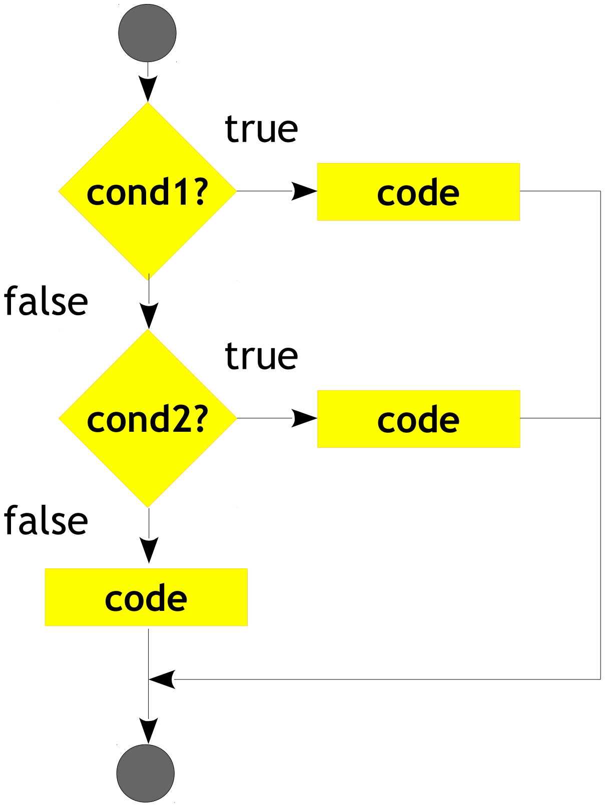
Advanced C

Conditional Constructs – if else if

Syntax

```
if (condition1)
{
    statement(s);
}
else if (condition2)
{
    statement(s);
}
else
{
    statement(s);
}
```

Flow



Advanced C

Conditional Constructs – if else if

009_example.c

```c
#include <stdio.h>

int main()
{
    int num = 10;

    if (num < 5)
    {
        printf(“num is smaller than 5\n”);
    }
    else if (num > 5)
    {
        printf(“num is greater than 5\n”);
    }
    else
    {
        printf(“num is equal to 5\n”);
    }


    return 0;
}
```

Conditional Constructs – Exercise

- WAP to find the max of two numbers
- WAP to print the grade for a given percentage
- WAP to find the greatest of given 3 numbers
- WAP to check whether character is
  - Upper case
  - Lower case
  - Digit
  - No of the above
- WAP to find the middle number (by value) of given 3 numbers

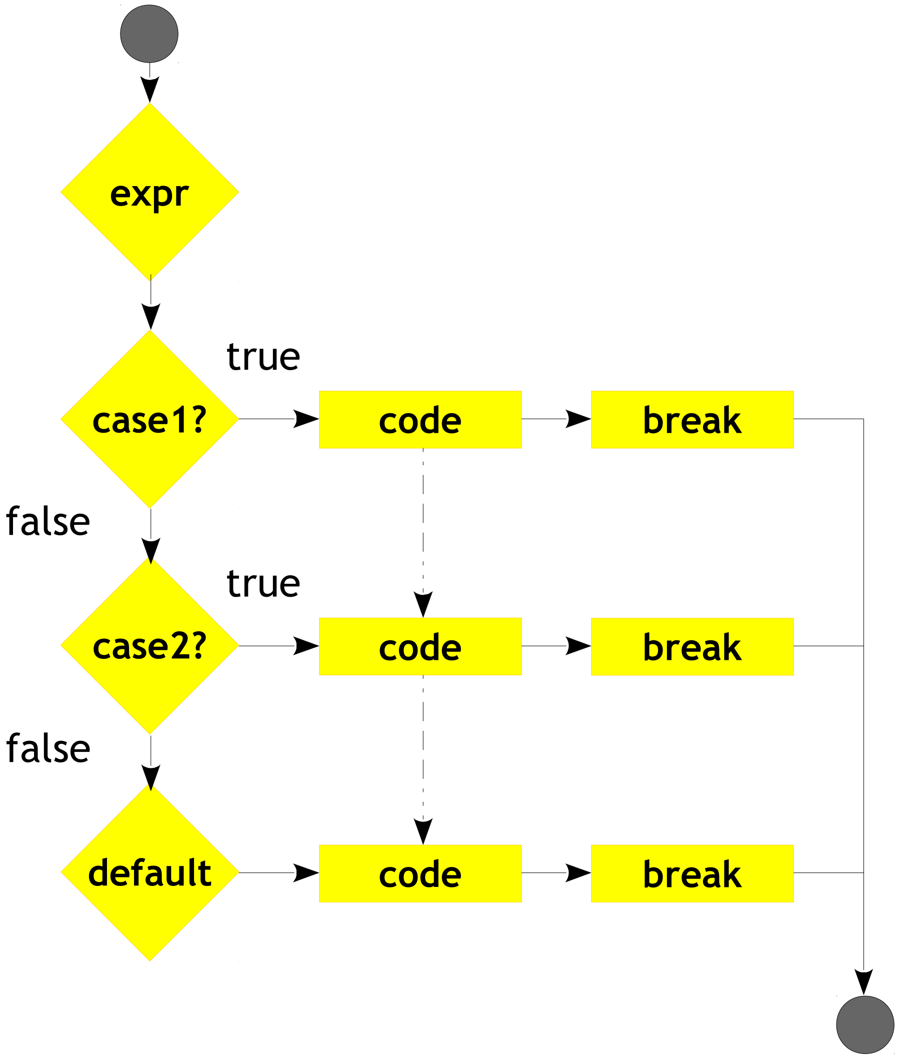
Advanced C

Conditional Constructs – switch

Syntax

```
switch (expression)
{
    case constant:
        statement(s);
        break;
    case constant:
        statement(s);
        break;
    case constant:
        statement(s);
        break;
    default:
        statement(s);
}
```

Flow



Advanced C

Conditional Constructs - switch

010_example.c

```
#include <stdio.h>

int main()
{
    int option;
    printf(“Enter the value\n”);
    scanf(“%d”, &option);

    switch (option)
    {
        case 10:
            printf(“You entered 10\n”);
            break;
        case 20:
            printf(“You entered 20\n”);
            break;
        default:
            printf(“Try again\n”);
    }

    return 0;
}
```

Advanced C

Conditional Constructs – switch - DIY

- W.A.P to check whether character is
  - Upper case
  - Lower case
  - Digit
  - None of the above
- W.A.P for simple calculator

Advanced C

Conditional Constructs - while

Syntax

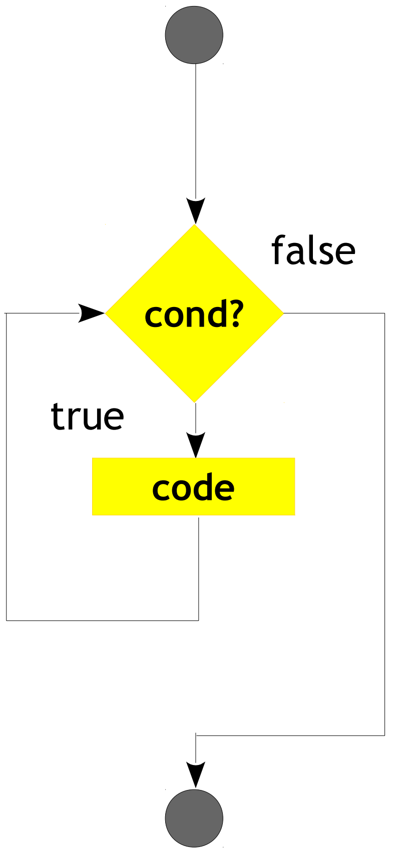
```
while (condition)
{
    statement(s);
}
```

- **Controls** the loop.
- Evaluated **before** each execution of loop body

011_example.c

```
#include <stdio.h>

int main()
{
    int iter;

    iter = 0;
    while (iter < 5)
    {
        printf(“Looped %d times\n”, iter);
        iter++;
    }

    return 0;
}
```

Flow



Advanced C

Conditional Constructs – do while

Syntax

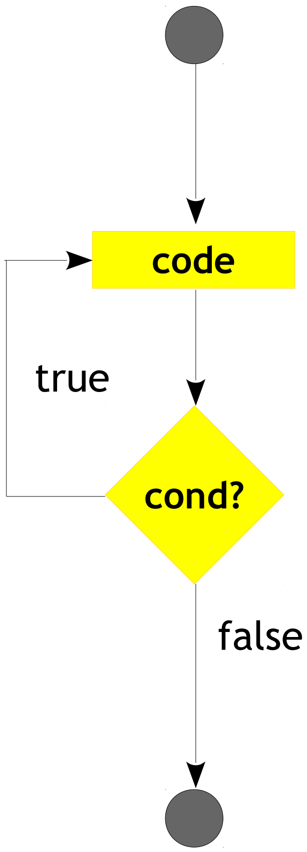
```
do
{
    statement(s);
} while (condition);
```

- **Controls** the loop.
- Evaluated **after** each execution of loop body

012_example.c

```
#include <stdio.h>

int main()
{
    int iter;

    iter = 0;
    do
    {
        printf(“Looped %d times\n”, iter);
        iter++;
    } while (iter < 10);

    return 0;
}
```

Flow



Advanced C

Conditional Constructs - for

Syntax

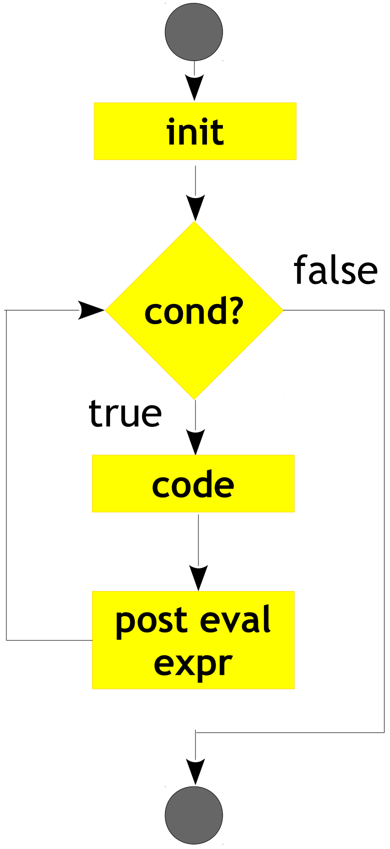
```
for (init; condition; post evaluation expr)
{
    statement(s);
}
```

- **Controls** the loop.
- Evaluated **before** each execution of loop body

013_example.c

```
#include <stdio.h>

int main()
{
    int iter;

    for (iter = 0; iter < 10; iter++)
    {
        printf("Looped %d times\n", iter);
    }

    return 0;
}
```

Flow



Advanced C

Conditional Constructs - Classwork

- W.A.P to print the power of two series using for loop
  - $2^1, 2^2, 2^3, 2^4, 2^5 \ldots$
- W.A.P to print the power of N series using Loops
  - $N^1, N^2, N^3, N^4, N^5 \ldots$
- W.A.P to multiply 2 nos without multiplication operator
- W.A.P to check whether a number is palindrome or not

Advanced C

Conditional Constructs – for – DIY

- WAP to print line pattern
  - Read total (n) number of pattern chars in a line (number should be “odd”)
  - Read number (m) of pattern char to be printed in the middle of line (“odd” number)
  - Print the line with two different pattern chars
  - Example – Let's say two types of pattern chars '$' and '*' to be printed in a line. Total number of chars to be printed in a line are 9. Three '*' to be printed in middle of line.
    - Output ==> $$$* * *$$$

Advanced C

Conditional Constructs – for – DIY

- Based on previous example print following pyramid

```
      *
    * * *
  * * * * *
* * * * * * *
```

Advanced C

Conditional Constructs – for – DIY

- Print rhombus using for loops

```
      *
    * * *
  * * * * *
* * * * * * *
  * * * * *
    * * *
      *
```

Advanced C

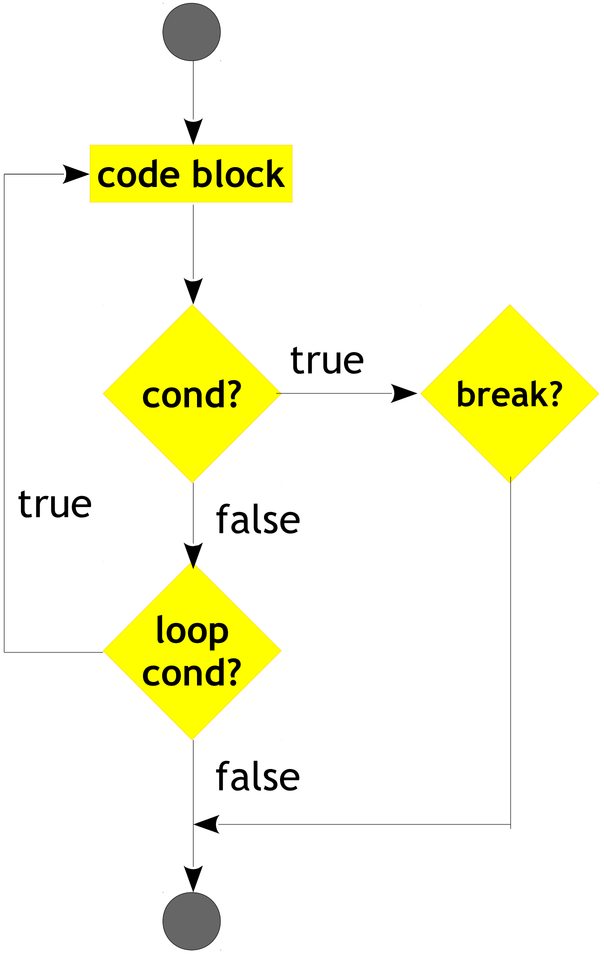
Conditional Constructs – break

- A break statement shall appear only in “switch body” or “loop body”
- “*break*” is used to exit the loop, the statements appearing after break in the loop will be skipped

Syntax

```
do
{
    conditional statement
        break;
} while (condition);
```

Flow



Advanced C

Conditional Constructs - break

014_example.c

```
#include <stdio.h>

int main()
{
    int iter;

    for (iter = 0; iter < 10; iter++)
    {
        if (iter == 5)
        {
            break;
        }
        printf(“%d\n”, iter);
    }

    return 0;
}
```

Advanced C

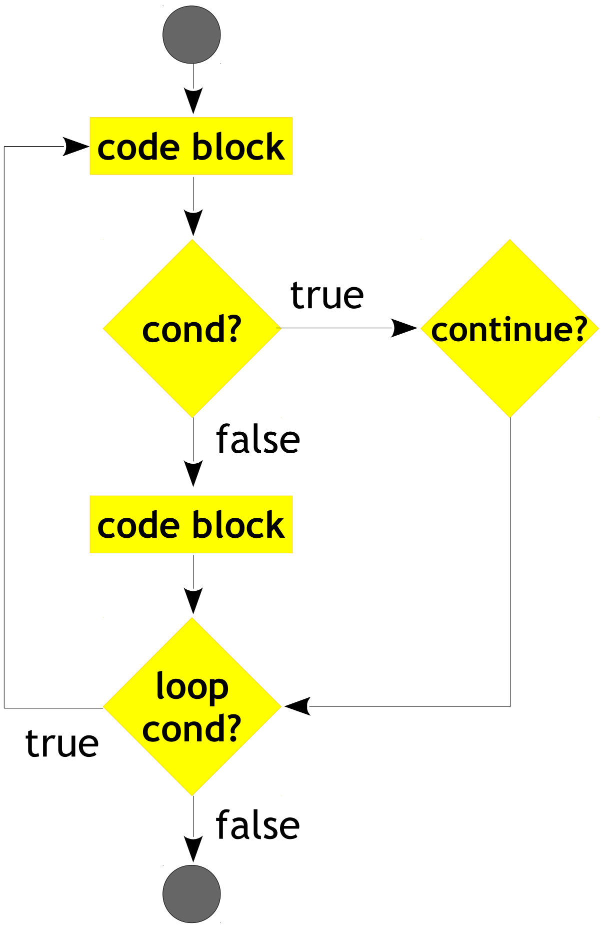
Conditional Constructs – continue

- A *continue* statement causes a jump to the loop-continuation portion, that is, to the end of the loop body
- The execution of code appearing after the continue will be skipped
- Can be used in any type of multi iteration loop

Syntax

```
do
{
    conditional statement
        continue;
} while (condition);
```

Flow



Advanced C

Conditional Constructs – continue

015_example.c

```
#include <stdio.h>

int main()
{
    int iter;

    for (iter = 0; iter < 10; iter++)
    {
        if (iter == 5)
        {
            continue;
        }
        printf(“%d\n”, iter);
    }

    return 0;
}
```

Advanced C

Conditional Constructs – goto

- A *goto* statement causes a unconditional jump to a labeled statement
- Generally avoided in general programming, since it sometimes becomes tough to trace the flow of the code

Syntax

```
goto label;
…
…
label:
…
```

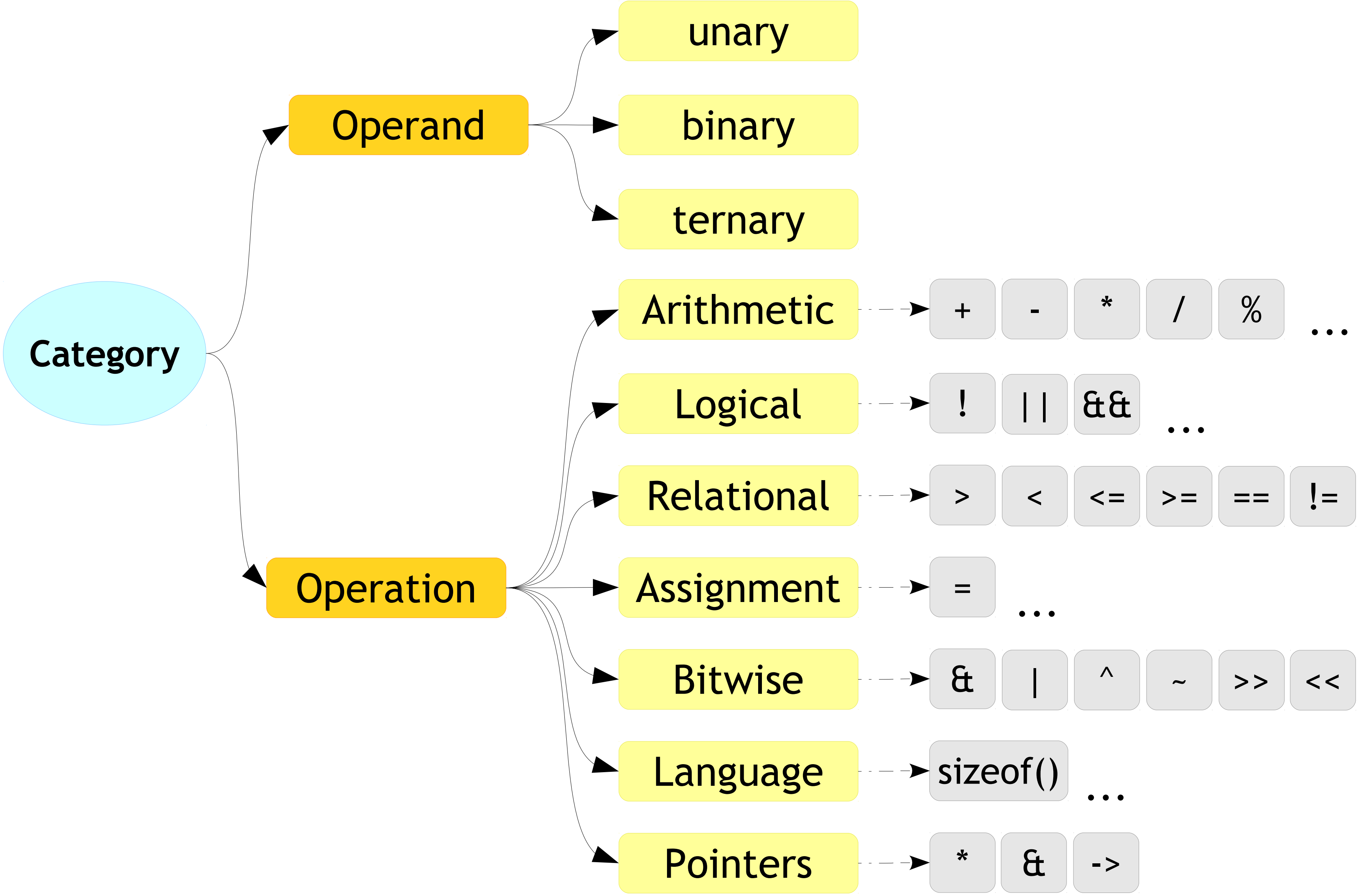
Operators

Advanced C

Operators

- Symbols that instructs the compiler to perform specific arithmetic or logical operation on operands
- All C operators do 2 things
  - Operates on its operands
  - Returns a value

Operators



- Category
  - Operand
    - unary
    - binary
    - ternary
  - Operation
    - Arithmetic
      - + - * / % ...
    - Logical
      - ! || && ...
    - Relational
      - > < <= >= == !=
    - Assignment
      - = ...
    - Bitwise
      - & | ^ ~ >> <<
    - Language
      - sizeof() ...
    - Pointers
      - * & ->

Advanced C

Operators – Precedence and Associativity

Operators	Associativity	Precedence
() [] -> .	L - R	HIGH
! ~ ++ -- - + * & (type) sizeof	R - L	
/ % *	L - R	
+ -	L - R	
<< >>	L - R	
< <= > >=	L - R	
== !=	L - R	
&	L - R	
^	L - R	
|	L - R	
&&	L - R	
||	L - R	
?:	R - L	
= += -= *= /= %= &= ^= |= <<= >>=	R - L	
,	L - R	LOW

Note:

post ++ and -- operators have higher precedence than pre ++ and -- operators

(Rel-99 spec)

Advanced C

Operators - Arithmetic

Operator	Description	Associativity
/	Division	L to R
*	Multiplication	
%	Modulo	
+	Addition	
-	Subtraction	

016_example.c

```c
#include <stdio.h>

int main()
{
    int num;

    num = 7 - 4 * 3 / 2 + 5;

    printf(“Result is %d\n”, num);

    return 0;
}
```

What will be the output?

Advanced C

Operators – Language - sizeof()

017_example.c

```
#include <stdio.h>

int main()
{
    int num = 5;

    printf(“%u:%u:%u\n”, sizeof(int), sizeof num, sizeof 5);

    return 0;
}
```

018_example.c

```
#include <stdio.h>

int main()
{
    int num1 = 5;
    int num2 = sizeof(++num1);

    printf(“num1 is %d and num2 is %d\n”, num1, num2);

    return 0;
}
```

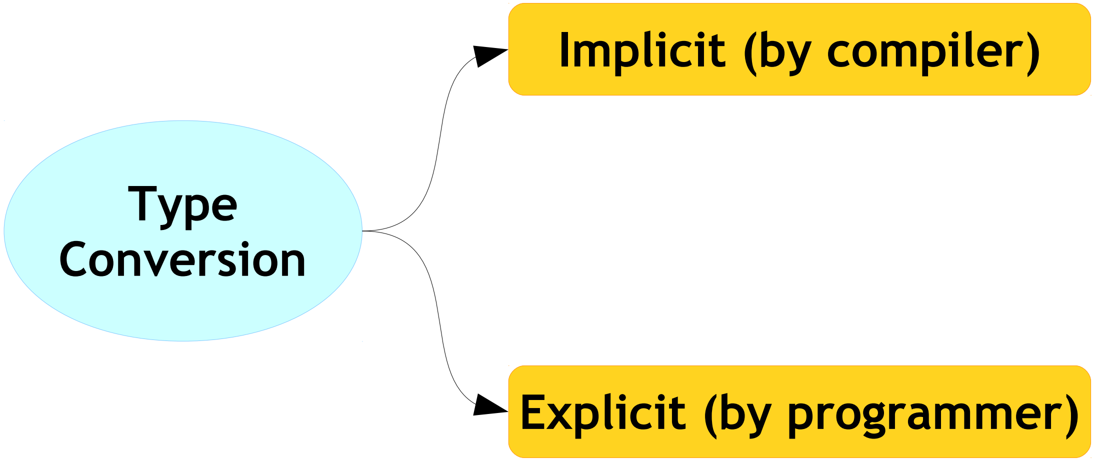
Advanced C

Operators – Language - sizeof()

- 3 reasons for why sizeof is not a function
  - Any type of operands
  - Type as an operand
  - No brackets needed across operands

Advanced C

Type Conversion

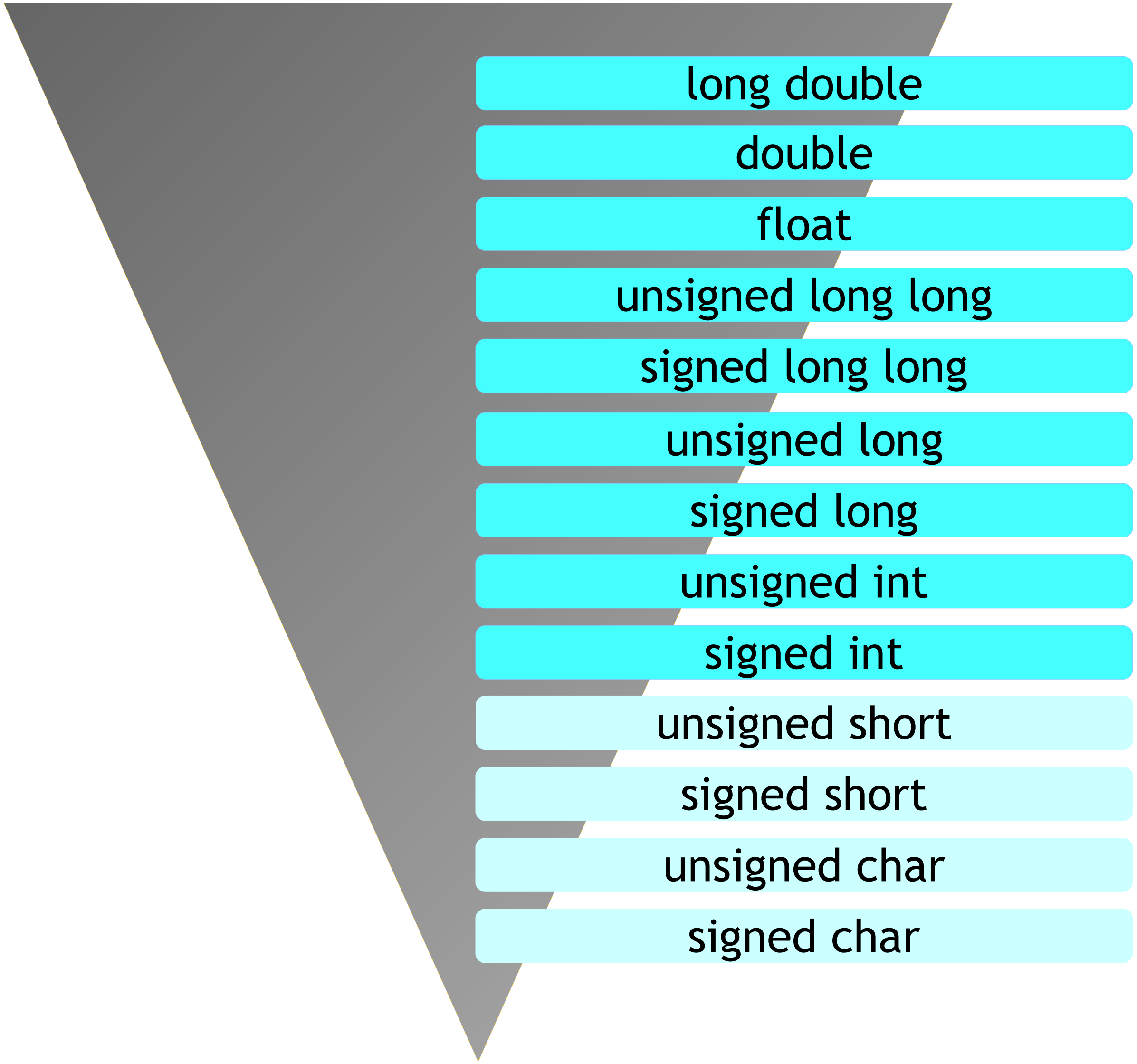


Type Conversion

Implicit (by compiler)

Explicit (by programmer)

Type Conversion Hierarchy



long double

double

float

unsigned long long

signed long long

unsigned long

signed long

unsigned int

signed int

unsigned short

signed short

unsigned char

signed char

Advanced C

Type Conversion - Implicit

- Automatic Unary conversions
  - The result of + and - are promoted to int if operands are char and short
  - The result of ~ and ! is integer
- Automatic Binary conversions
  - If one operand is of LOWER RANK (LR) data type & other is of HIGHER RANK (HR) data type then LOWER RANK will be converted to HIGHER RANK while evaluating the expression.
  - Example: LR + HR → LR converted to HR

Advanced C

Type Conversion - Implicit

- Type promotion
  - LHS type is HR and RHS type is LR → int = char → LR is promoted to HR while assigning
- Type demotion
  - LHS is LR and RHS is HR → int = float → HR rank will be demoted to LR. Truncated

Advanced C

Type Conversion – Explicit (Type Casting)

Syntax

```
(data_type) expression
```

019_example.c

```
#include <stdio.h>

int main()
{
    int num1 = 5, num2 = 3;

    float num3 = (float) num1 / num2;

    printf(“nun3 is %f\n”, num3);

    return 0;
}
```

Advanced C

Operators - Logical

Operator	Description	Associativity
!	Logical NOT	R to L
&&	Logical AND	L to R
||	Logical OR	L to R

020_example.c

```c
#include <stdio.h>

int main()
{
    int num1 = 1, num2 = 0;

    if (++num1 || num2++)
    {
        printf(“num1 is %d num2 is %d\n”, num1, num2);
    }
    num1 = 1, num2 = 0;
    if (num1++ && ++num2)
    {
        printf(“num1 is %d num2 is %d\n”, num1, num2);
    }
    else
    {
        printf(“num1 is %d num2 is %d\n”, num1, num2);
    }
    return 0;
}
```

What will be the output?

Advanced C

Operators – Circuit Logical

- Have the ability to “short circuit” a calculation if the result is definitely known, this can improve efficiency
  - Logical AND operator (**&&**)
    - If one operand is false, the result is false.
  - Logical OR operator (||)
    - If one operand is true, the result is true.

Operators - Relational

Operator	Description	Associativity
>	Greater than	L to R
<	Lesser than	
>=	Greater than or equal	
<=	Lesser than or equal	
==	Equal to	
!=	Not Equal to	

021_example.c

```
#include <stdio.h>

int main()
{
    float num1 = 0.7;

    if (num1 == 0.7)
    {
        printf(“Yes, it is equal\n”);
    }
    else
    {
        printf(“No, it is not equal\n”);
    }

    return 0;
}
```

What will be the output?

Advanced C

Operators - Assignment

022_example.c

```c
#include <stdio.h>

int main()
{
    int num1 = 1, num2 = 1;
    float num3 = 1.7, num4 = 1.5;

    num1 += num2 += num3 += num4;

    printf(“num1 is %d\n”, num1);

    return 0;
}
```

023_example.c

```c
#include <stdio.h>

int main()
{
    float num1 = 1;

    if (num1 = 1)
    {
        printf(“Yes, it is equal!!\n”);
    }
    else
    {
        printf(“No, it is not equal\n”);
    }

    return 0;
}
```

Advanced C

Operators - Bitwise

- Bitwise operators perform operations on bits
- The operand type shall be integral
- Return type is integral value

Advanced C

Operators - Bitwise

&	**Bitwise AND**	Bitwise ANDing of all the bits in two operands

Operand	Value								
A	0x61	0	1	1	0	0	0	0	1
B	0x13	0	0	0	1	0	0	1	1
A & B	0x01	0	0	0	0	0	0	0	1

|	**Bitwise OR**	Bitwise ORing of all the bits in two operands

Operand	Value								
A	0x61	0	1	1	0	0	0	0	1
B	0x13	0	0	0	1	0	0	1	1
A | B	0x73	0	1	1	1	0	0	1	1

Advanced C

Operators - Bitwise

^	**Bitwise XOR**	Bitwise XORing of all the bits in two operands

Operand	Value								
A	0x61	0	1	1	0	0	0	0	1
B	0x13	0	0	0	1	0	0	1	1
A ^ B	0x72	0	1	1	1	0	0	1	0

~	**Compliment**	Complimenting all the bits of the operand

Operand	Value								
A	0x61	0	1	1	0	0	0	0	1
~A	0x9E	1	0	0	1	1	1	1	0

Advanced C

Operators – Bitwise – Shift

Syntax

Left Shift :

shift-expression* << *additive-expression

(left operand) **(right operand)**

Right Shift :

shift-expression* >> *additive-expression

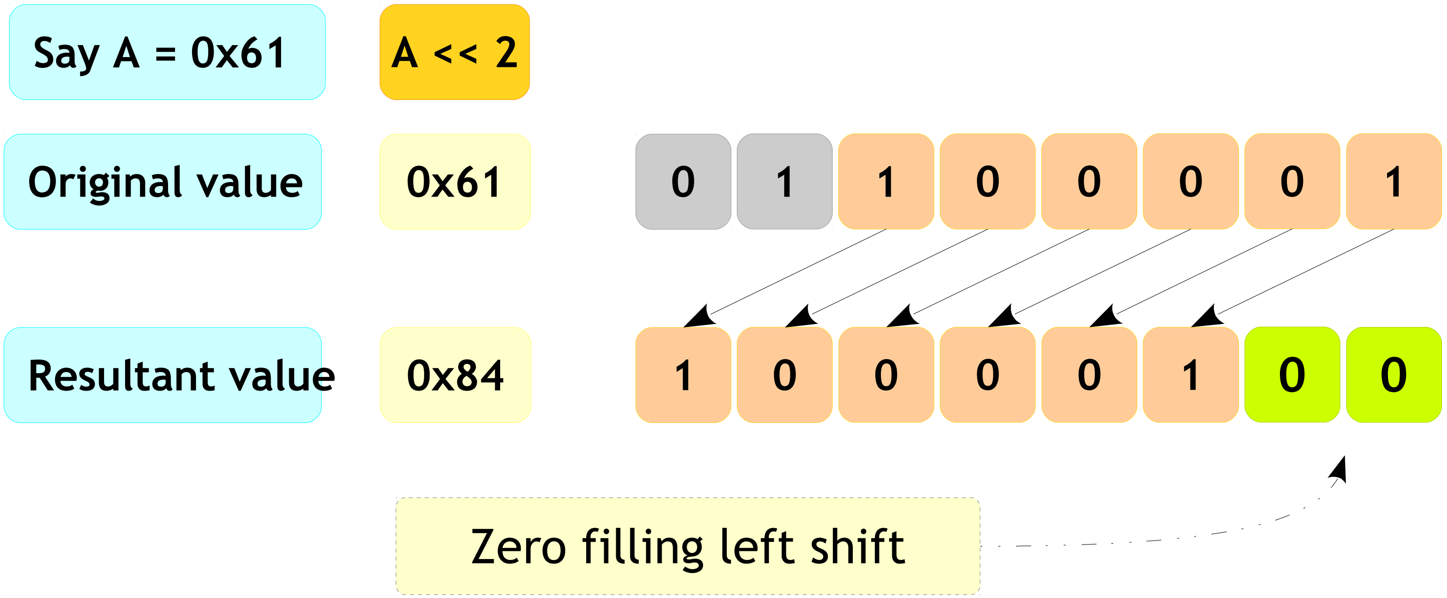
(left operand) **(right operand)**

Advanced C

Operators – Bitwise – Left Shift

'Value' << 'Bits Count'

- Value : Is shift operand on which bit shifting effect to be applied
- Bits count : By how many bit(s) the given “Value” to be shifted



Say A = 0x61	A << 2								
Original value	0x61	0	1	1	0	0	0	0	1
Resultant value	0x84	1	0	0	0	0	1	0	0

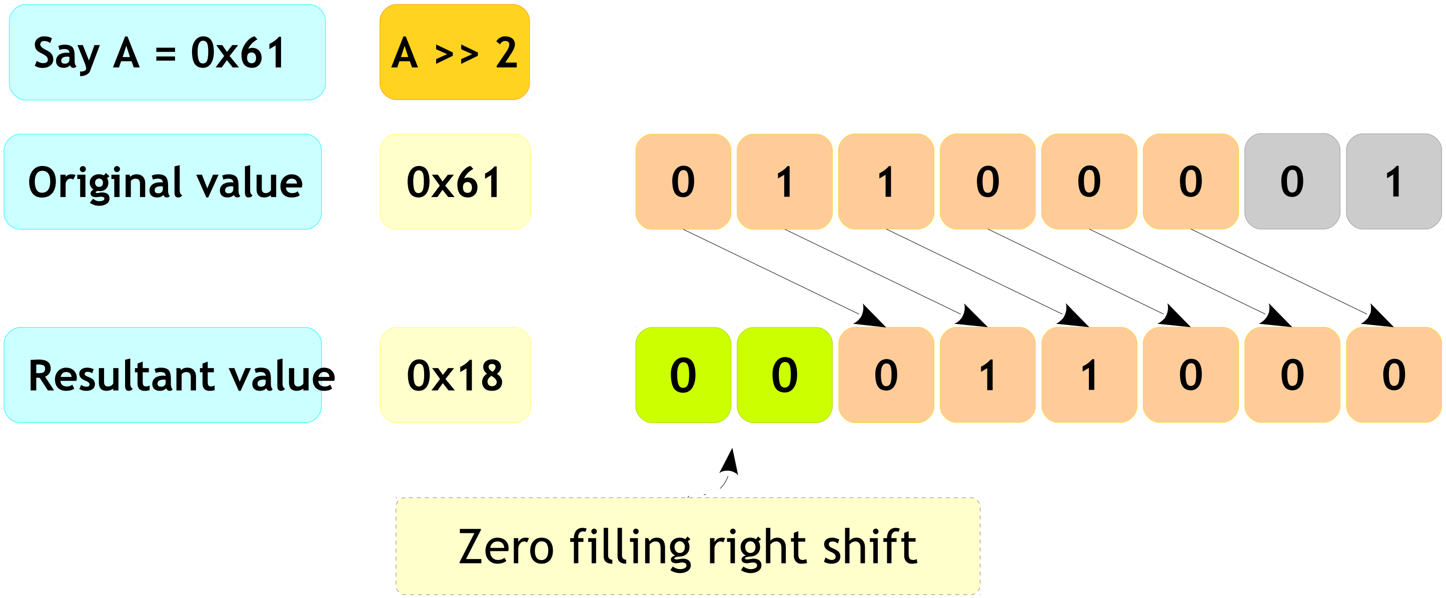
Zero filling left shift

Advanced C

Operators – Bitwise – Right Shift

'Value' >> 'Bits Count'

- Value : Is shift operand on which bit shifting effect to be applied
- Bits count : By how many bit(s) the given “Value” to be shifted



Say A = 0x61

A >> 2

Original value | 0x61 | 0 1 1 0 0 0 0 1

Resultant value | 0x18 | 0 0 0 1 1 0 0 0

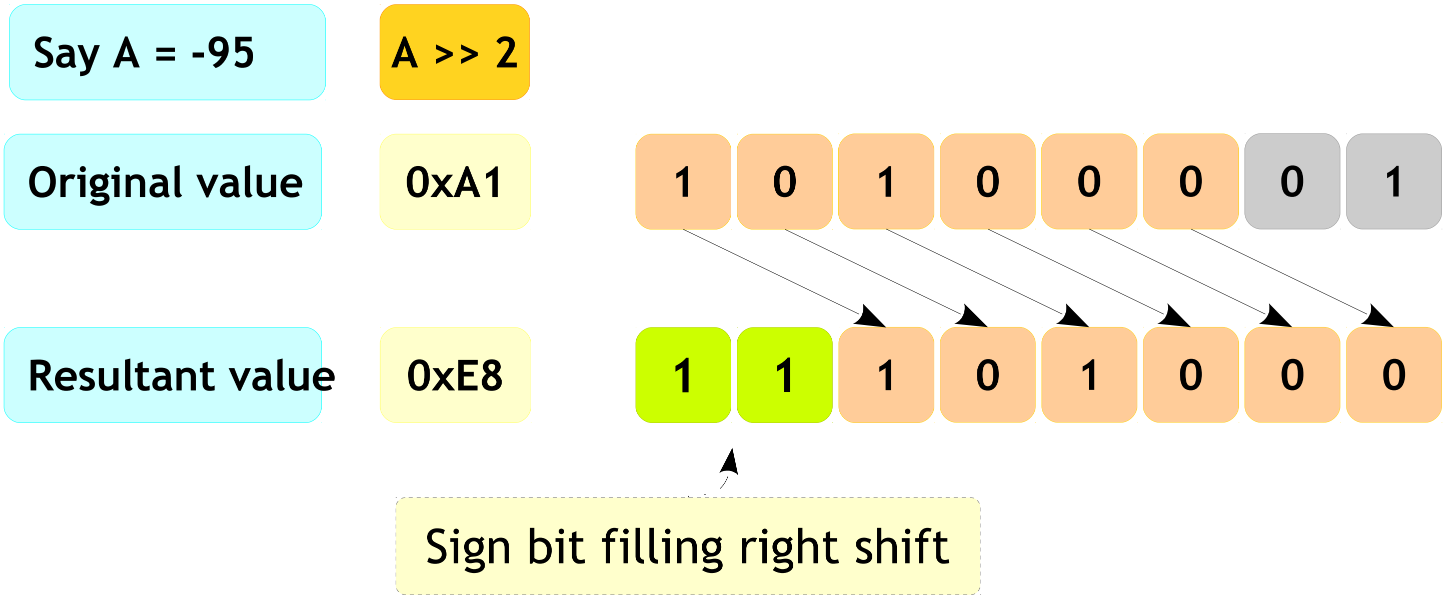
Zero filling right shift

Advanced C

Operators - Bitwise - Right Shift - Signed Valued

“Signed Value' >> 'Bits Count'

- Same operation as mentioned in previous slide.
- But the sign bits gets propagated.



Say A = -95

A >> 2

Original value 0xA1 1 0 1 0 0 0 0 1

Resultant value 0xE8 1 1 1 0 1 0 0 0

Sign bit filling right shift

Advanced C

Operators - Bitwise

024_example.c

```
#include <stdio.h>

int main()
{
     int count;
     unsigned char iter = 0xFF;

     for (count = 0; iter != 0; iter >>= 1)
     {
          if (iter & 01)
          {
               count++;
          }
     }

     printf(“count is %d\n”, count);

     return 0;
}
```

Advanced C

Operators – Bitwise – Shift

- Each of the operands shall have integer type
- The integer promotions are performed on each of the operands
- If the value of the right operand is negative or is greater than or equal to the width of the promoted left operand, the behavior is undefined
- Left shift (<<) operator : If left operand has a signed type and nonnegative value, and (left_operand * (2^n)) is representable in the result type, then that is the resulting value; otherwise, the behavior is undefined

Advanced C

Operators – Bitwise - Shift

- The below example has undefined behaviour

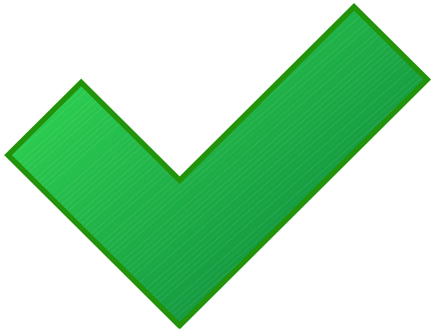
025_example.c

```
#include <stdio.h>

int main()
{
    int x = 7, y = 7;

    x = 7 << 32;
    printf(“x is %x\n”, x);

    x = y << 32;
    printf(“x is %x\n”, x);

    return 0;
}
```

Advanced C

Operators – Bitwise - Mask

- If you want to create the below art assuming your are not a good painter, What would you do?



Advanced C

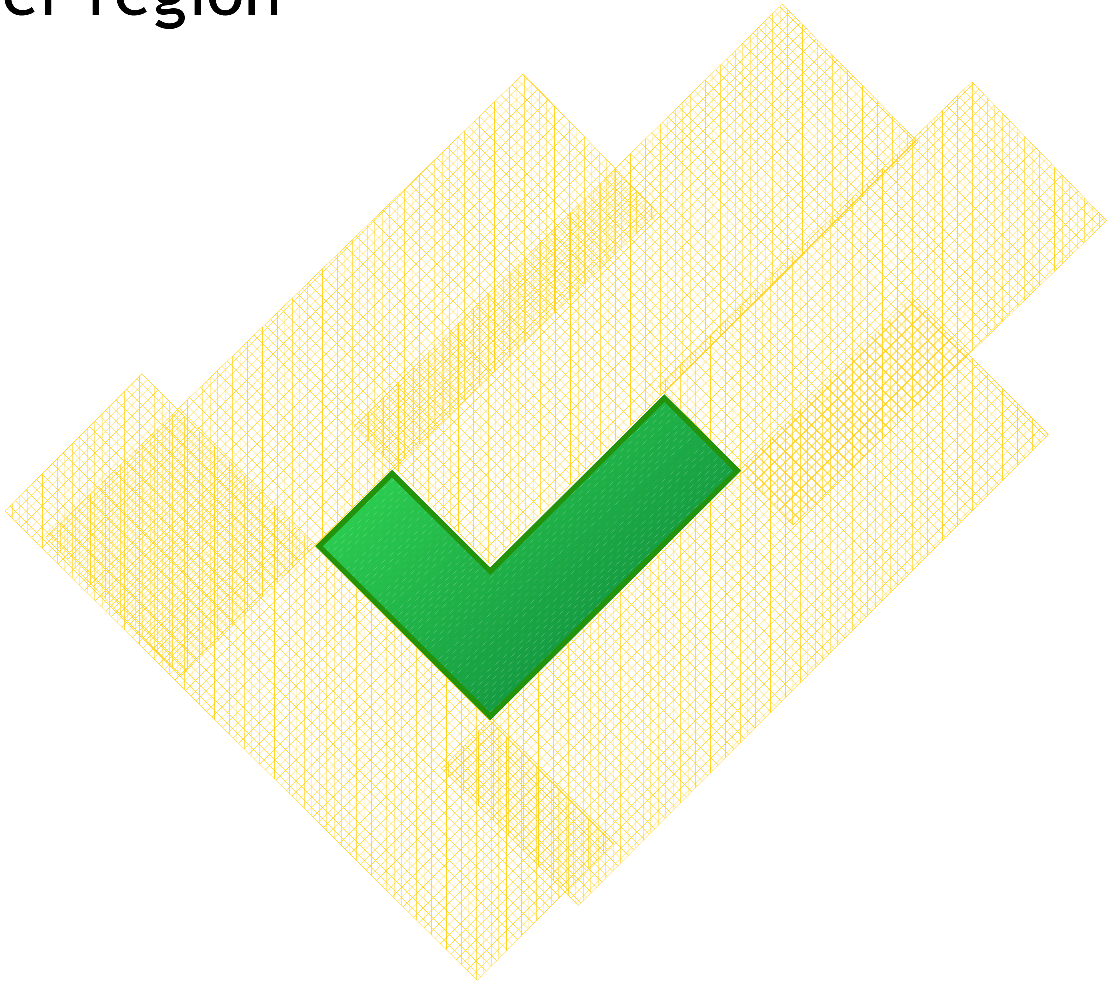
Operators – Bitwise - Mask

- Mask the area as shown, and use a brush or a spray paint to fill the required area!

Advanced C

Operators – Bitwise - Mask

- Fill the inner region



Advanced C

Operators – Bitwise - Mask

- Remove the mask tape

✓

Operators – Bitwise - Mask

- So masking, technically means unprotecting the required bits of register and perform the actions like
  - Set Bit
  - Clear Bit
  - Get Bit

  etc,..

Advanced C

Operators – Bitwise - Mask

	7	6	5	4	3	2	1	0	Bit Position
& Operator	0	1	1	0	0	0	0	1	The register to be modified
	1	1	0	1	1	1	1	1	Mask to **CLEAR 5th bit** position
	0	1	0	0	0	0	0	1	The result
| Operator	0	1	0	0	0	0	0	1	The register to be modified
	0	0	1	0	0	0	0	0	Mask to **SET 5th bit** position
	0	1	1	0	0	0	0	1	The result

Advanced C

Operators – Bitwise - Shift

- W.A.P to count set bits in a given number
- W.A.P to print bits of given number
- W.A.P to swap nibbles of given number

Advanced C

Operators - Ternary

Syntax

```
Condition ? Expression 1 : Expression 2;
```

025_example.c

```c
#include <stdio.h>

int main()
{
    int num1 = 10;
    int num2 = 20;
    int num3;

    if (num1 > num2)
    {
        num3 = num1;
    }
    else
    {
        num3 = num2;
    }
    printf(“%d\n”, num3);

    return 0;
}
```

```c
#include <stdio.h>

int main()
{
    int num1 = 10;
    int num2 = 20;
    int num3;

    num3 = num1 > num2 ? num1 : num2;
    printf(“Greater num is %d\n”, num3);

    return 0;
}
```

Advanced C

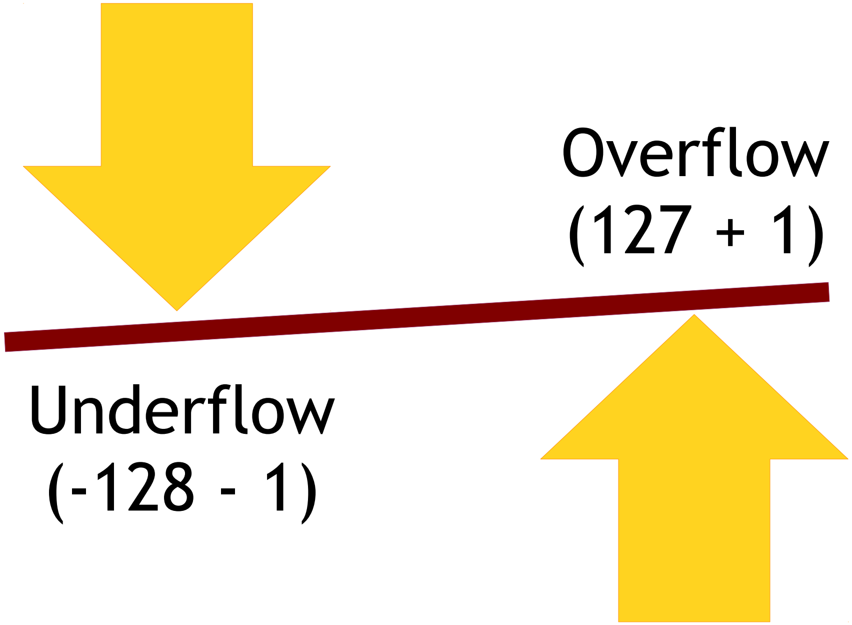
Operators – Comma

- The left operand of a comma operator is evaluated as a void expression (result discarded)
- Then the right operand is evaluated; the result has its type and value
- Comma acts as separator (not an operator) in following cases -
  - Arguments to function
  - Lists of initializers (variable declarations)
- But, can be used with parentheses as function arguments such as -
  - foo ((x = 2, x + 3)); // final value of argument is 5

Advanced C

Over and Underflow

- 8-bit Integral types can hold certain ranges of values
- So what happens when we try to traverse this boundary?



Overflow
(127 + 1)

Underflow
(-128 - 1)

Advanced C

Overflow – Signed Numbers

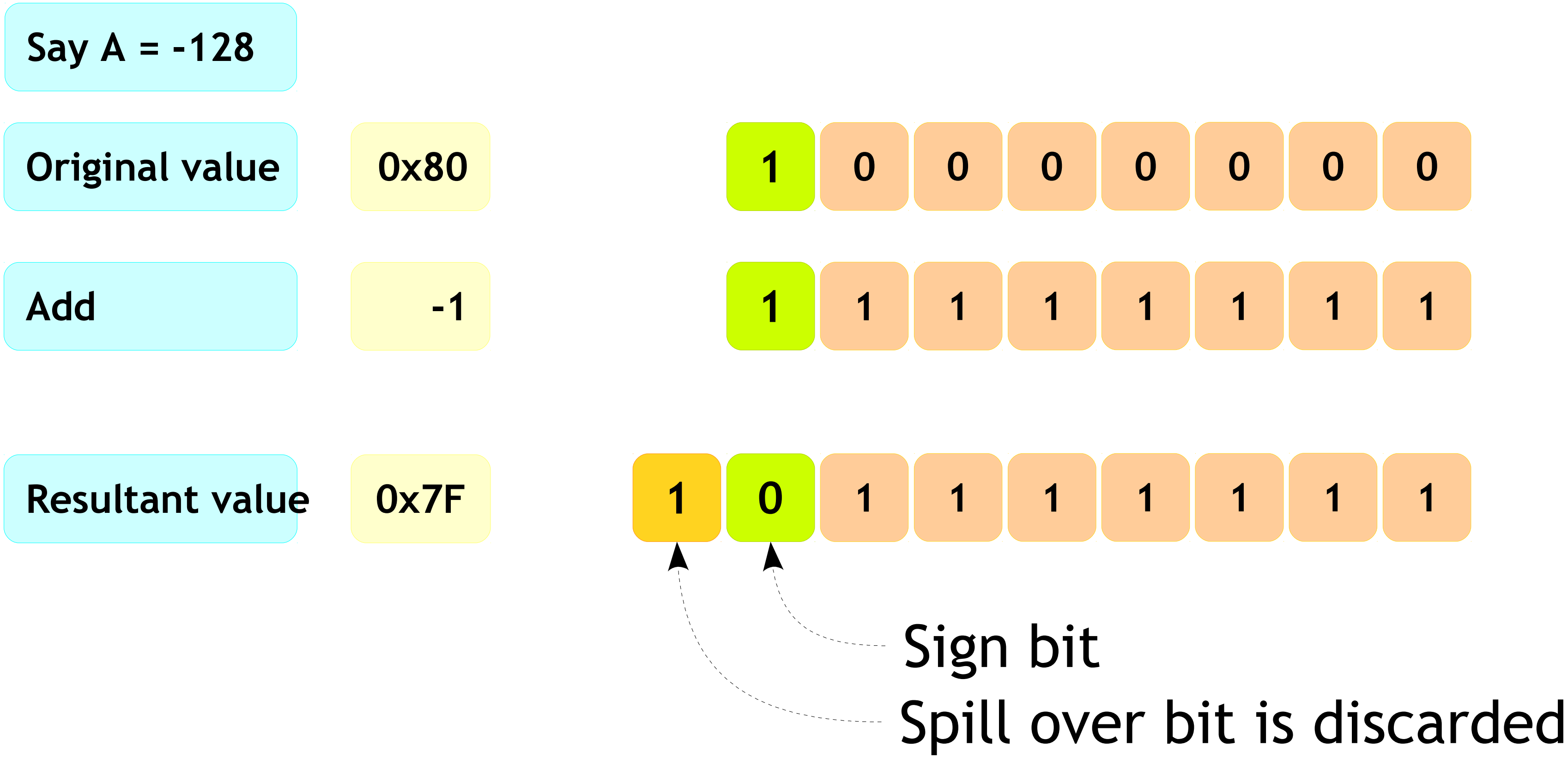
Say A = +127

Original value	0x7F	0	1	1	1	1	1	1	1
Add	1	0	0	0	0	0	0	0	1
Resultant value	0x80	1	0	0	0	0	0	0	0

Sign bit

Advanced C

Underflow – Signed Numbers



Say A = -128

Original value	0x80		1	0	0	0	0	0	0	0
Add	-1		1	1	1	1	1	1	1	1
Resultant value	0x7F	1	0	1	1	1	1	1	1	1

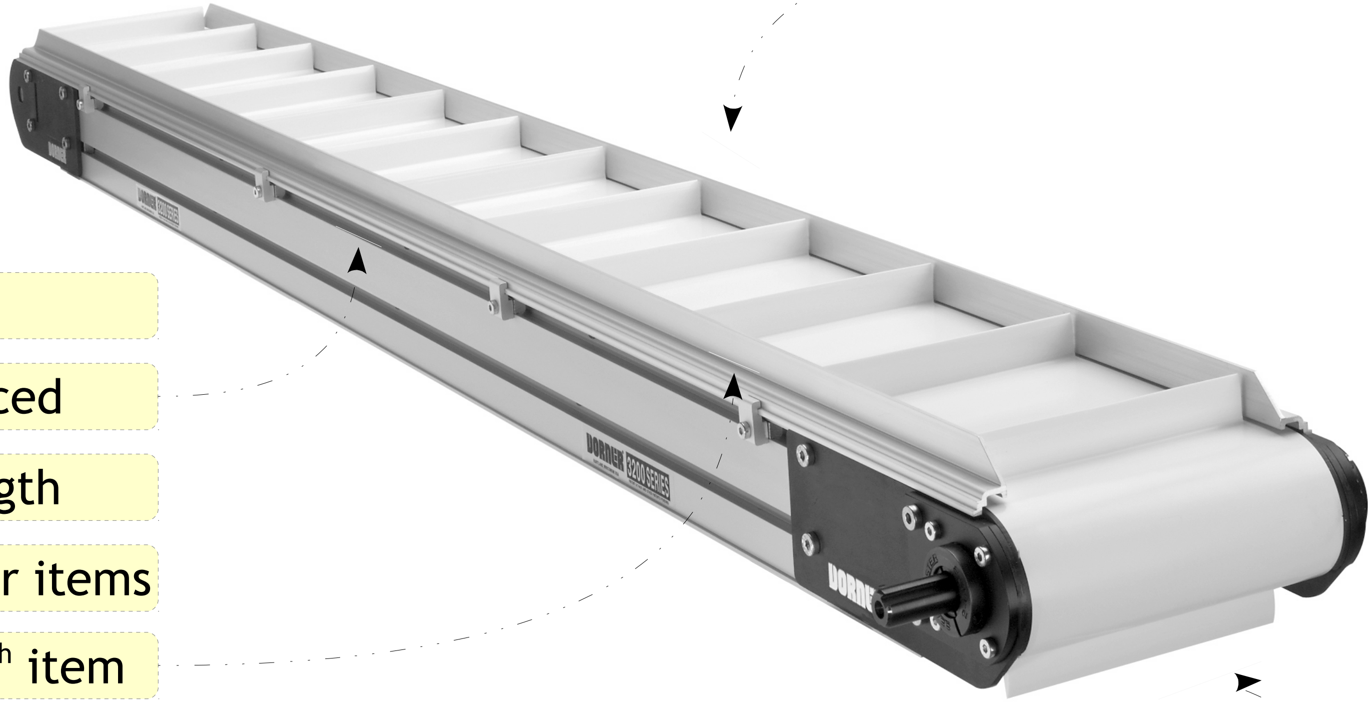
Sign bit

Spill over bit is discarded

Arrays

Advanced C

Arrays – Know the Concept



A conveyor belt

Starts here

Equally spaced

Defined length

Carry similar items

Index as 10th item

Ends here

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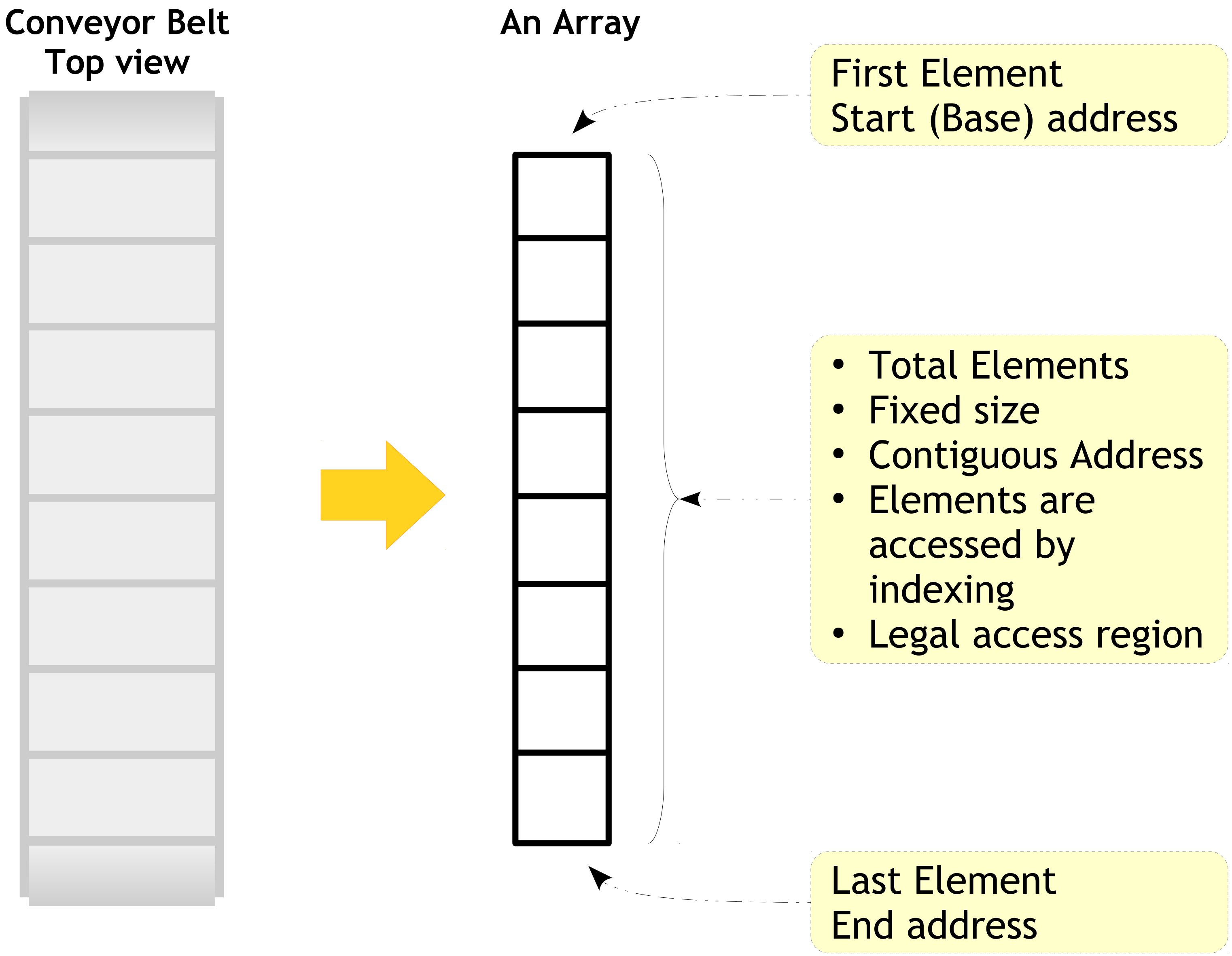
Arrays – Know the Concept



First Element
Start (Base) address

- Total Elements
- Fixed size
- Contiguous Address
- Elements are accessed by indexing
- Legal access region

Last Element
End address

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Arrays

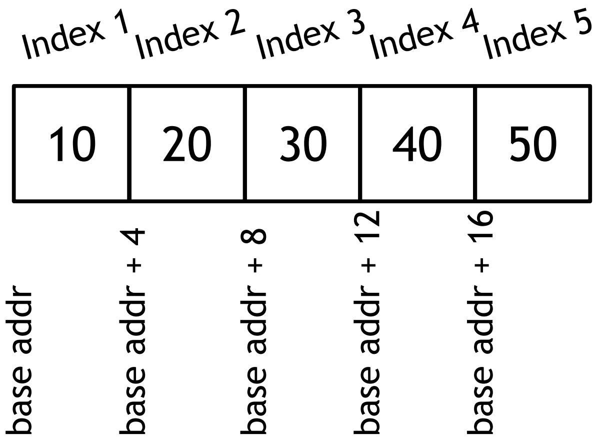
Syntax

```
data_type name[SIZE];

Where SIZE represents number of elements
Memory occupied by array = (number of elements * size of an element)
                         = (SIZE * <size of data_type>)
```

Example

```
int age[5] = {10, 20, 30, 40, 50};
```



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Arrays – Points to be noted

- An array is a collection of similar data type
- Elements occupy consecutive memory locations (addresses)
- First element with lowest address and the last element with highest address
- Elements are indexed from 0 to SIZE – 1. Example : 5 elements array (say array[5]) will be indexed from 0 to 4
- Accessing out of range array elements would be “illegal access”
  - Example : Do not access elements array[-1] and array[SIZE]
- Array size can't be altered at run time

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Arrays - Why?

027_example.c

```c
#include <stdio.h>

int main()
{
    int num1 = 10;
    int num2 = 20;
    int num3 = 30;
    int num4 = 40;
    int num5 = 50;

    printf(“%d\n”, num1);
    printf(“%d\n”, num2);
    printf(“%d\n”, num3);
    printf(“%d\n”, num4);
    printf(“%d\n”, num5);

    return 0;
}
```

```c
#include <stdio.h>

int main()
{
    int num_array[5] = {10, 20, 30, 40, 50};
    int index;

    for (index = 0; index < 5; index++)
    {
        printf(“%d\n”, num_array[index]);
    }

    return 0;
}
```

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Arrays - Reading

028_example.c

```c
#include <stdio.h>

int main()
{
    int num_array[5] = {1, 2, 3, 4, 5};
    int index;

    index = 0;
    do
    {
        printf(“Index %d has Element %d\n”, index, num_array[index]);
        index++;
    } while (index < 5);

    return 0;
}
```

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Arrays - Storing

029_example.c

```
#include <stdio.h>

int main()
{
    int num_array[5];
    int index;

    for (index = 0; index < 5; index++)
    {
        scanf(“%d”, &num_array[index]);
    }

    return 0;
}
```

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Arrays - Initializing

030_example.c

```
#include <stdio.h>

int main()
{
    int array1[5] = {1, 2, 3, 4, 5};
    int array2[5] = {1, 2};
    int array3[] = {1, 2};
    int array4[]; /* Invalid */

    printf(“%u\n”, sizeof(array1));
    printf(“%u\n”, sizeof(array2));
    printf(“%u\n”, sizeof(array3));

    return 0;
}
```

Arrays – Copying

- Can we copy 2 arrays? If yes how?

031_example.c

```
#include <stdio.h>

int main()
{
    int array_org[5] = {1, 2, 3, 4, 5};
    int array_bak[5];
    int index;

    array_bak = array_org;

    if (array_bak == array_org)
    {
        printf(“Copied\n”);
    }

    return 0;
}
```

Waow!! so simple?
But can I do this

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Arrays – Copying

- No!! its not so simple to copy two arrays as put in the previous slide. C doesn't support it!
- Then how to copy an array?
- It has to be copied element by element

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Arrays – DIY

- W.A.P to find the average of elements stored in a array.
  - Read value of elements from user
  - For given set of values : { 13, 5, -1, 8, 17 }
  - Average Result = 8.4
- W.A.P to find the largest array element
  - Example 100 is the largest in {5, 100, -2, 75, 42}

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Arrays – DIY

- W.A.P to compare two arrays (element by element).
  - Take equal size arrays
  - Arrays shall have unique values stored in random order
  - Array elements shall be entered by user
  - Arrays are compared “EQUAL” if there is one to one mapping of array elements value
  - Print final result “EQUAL” or “NOT EQUAL”

Example of Equal Arrays :

- A[3] = {2, -50, 17}
- B[3] = {17, 2, -50}

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Arrays – Oops!! what is this now?