Types, Operators and Expressions

CSE 2031

Fall 2010

Variable Names (2.1)

- Combinations of letters, numbers, and underscore character (_) that
  - do not start with a number;
  - are not a keyword.
- Upper and lower case letters are distinct (x ≠ X).
- Examples: Identify valid and invalid variable names
  `abc, aBc, abc5, aA3_ , char, _360degrees, 5sda, my_index, _temp, string, struct, pointer`

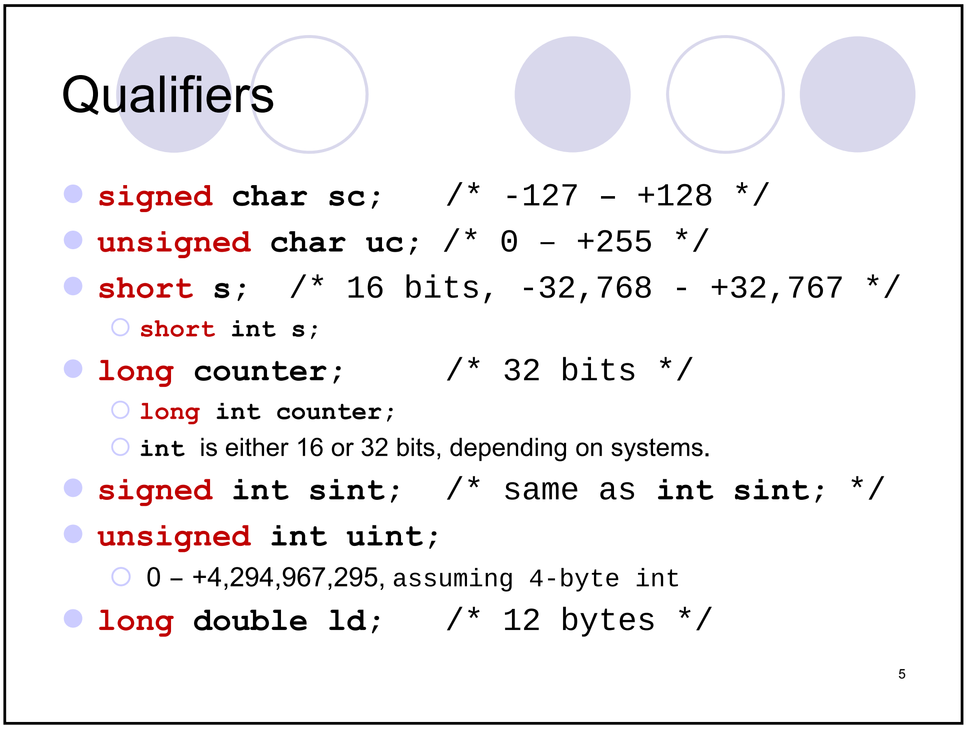
Variable Names: Recommendations

- Don’t begin variable names with underscore _
- Limit the length of a variable name to 31 characters or less.
- Function names, external variables: may be less than 31 characters allowed, depending on systems.
- Lower case for variable names.
- Upper case for symbolic constants
  - `#define MAX_SIZE 100`
- Use short names for local variables and long names for external variables.

Data Types and Sizes (2.2)

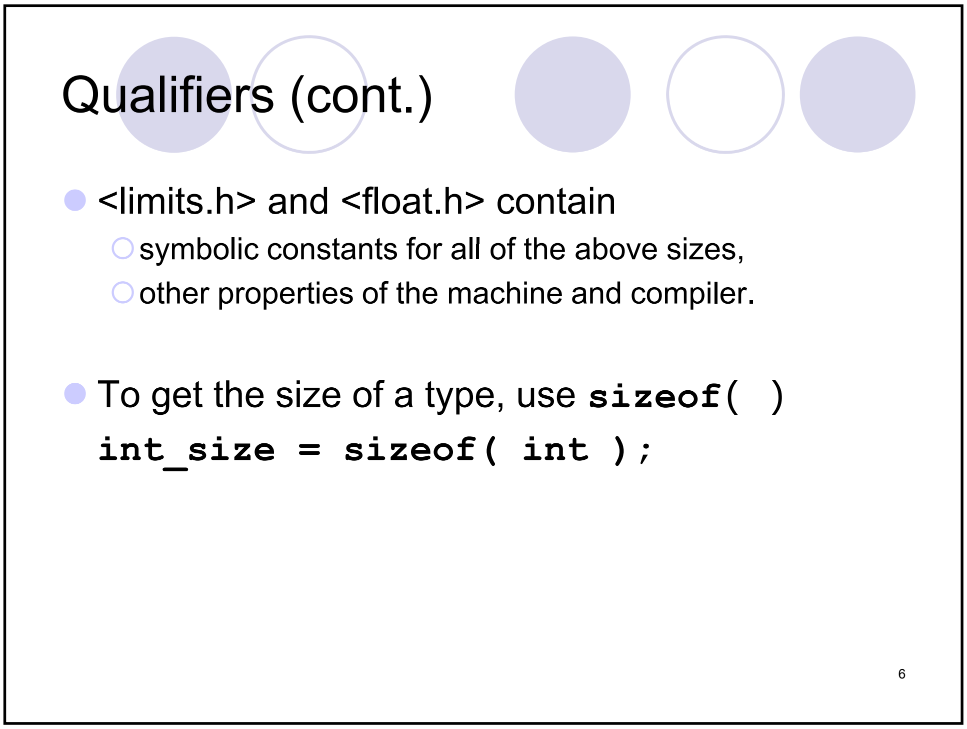
4 basic types in C

- **char** – characters (8 bits)
- **int** – integers (either 16 or 32 bits)
- **float** – single precision floating point numbers (4 bytes)
- **double** – double precision floating point numbers (8 bytes)



Qualifiers

- `signed char sc;    /* -127 – +128 */`
- `unsigned char uc; /* 0 – +255 */`
- `short s;  /* 16 bits, -32,768 - +32,767 */`
  - `short int s;`
- `long counter;      /* 32 bits */`
  - `long int counter;`
  - `int` is either 16 or 32 bits, depending on systems.
- `signed int sint;   /* same as int sint; */`
- `unsigned int uint;`
  - 0 – +4,294,967,295, `assuming 4-byte int`
- `long double ld;    /* 12 bytes */`



Qualifiers (cont.)

- <limits.h> and <float.h> contain
  - symbolic constants for all of the above sizes,
  - other properties of the machine and compiler.

- To get the size of a type, use `sizeof( )`

```
int_size = sizeof( int );
```

Characters

- 8 bits
- Included between 2 single quotes

  `char x =‘A’`
- Character string: enclosed between 2 double quotes

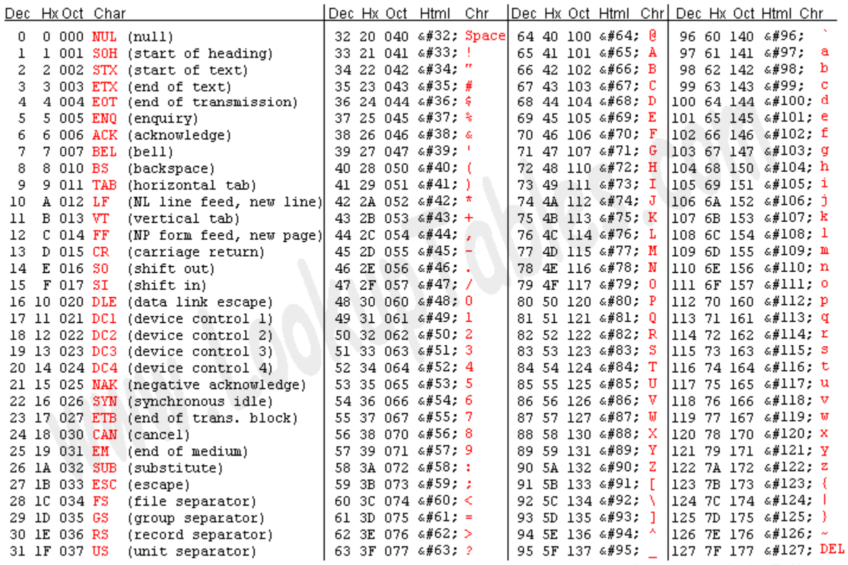
  `“This is a string”`
- Note: ‘A’ ≠ “A”

A

A	\0

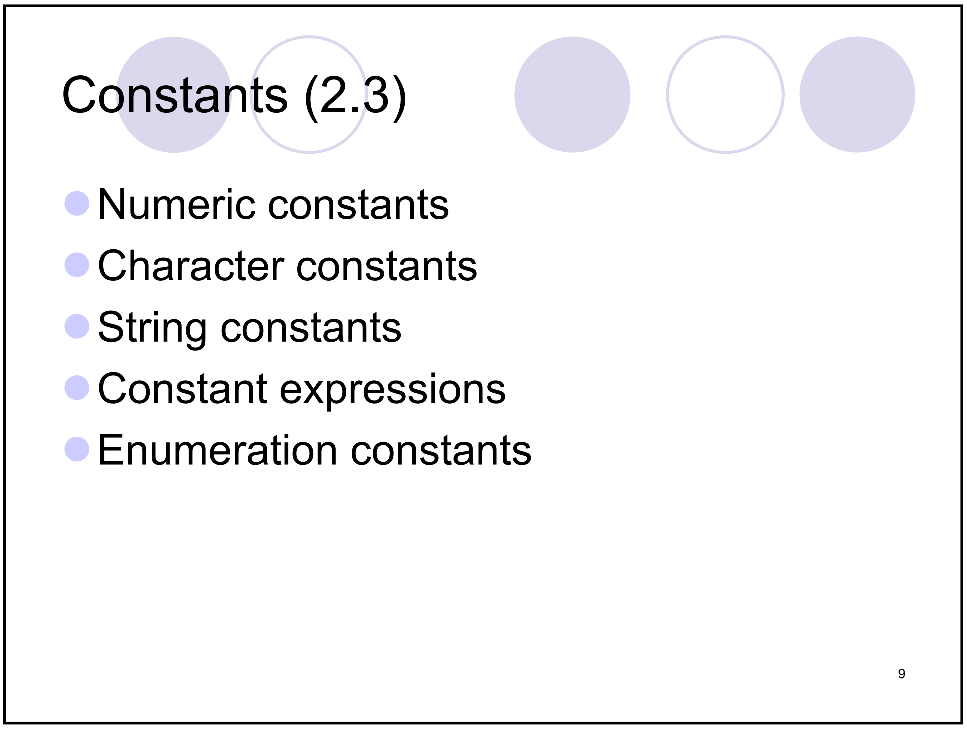
- **`c =‘\012’`** /* 10 decimal; new line character */

Characters



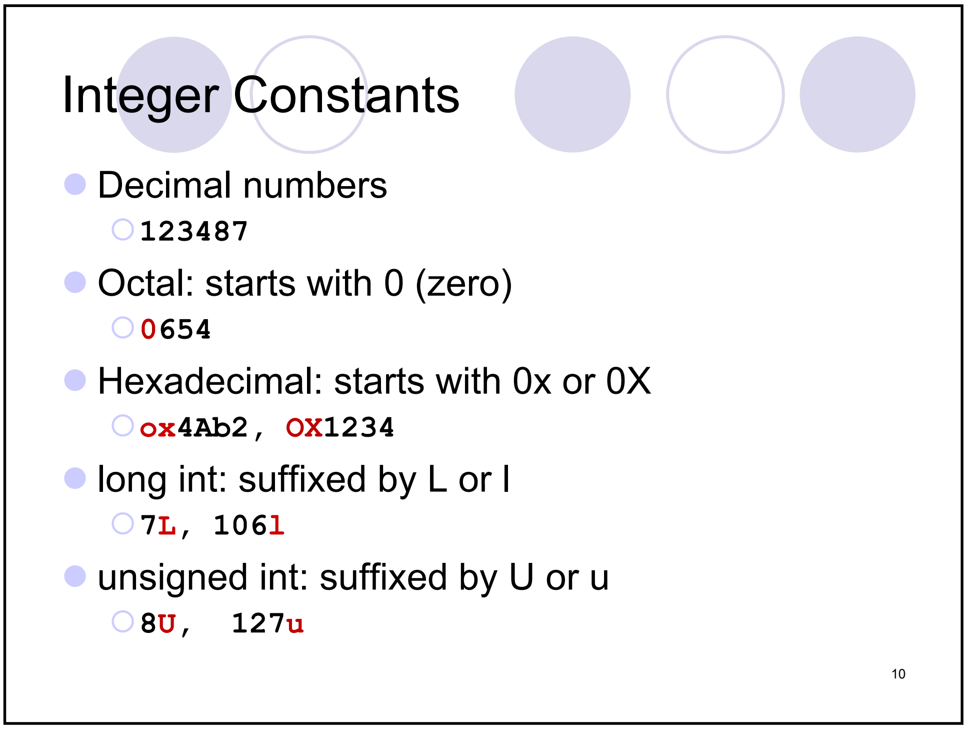
Dec	Hx	Oct	Char		Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL	(null)	32	20	040	&#32;	Space	64	40	100	&#64;	@	96	60	140	&#96;	`
1	1	001	SOH	(start of heading)	33	21	041	&#33;	!	65	41	101	&#65;	A	97	61	141	&#97;	a
2	2	002	STX	(start of text)	34	22	042	&#34;	"	66	42	102	&#66;	B	98	62	142	&#98;	b
3	3	003	ETX	(end of text)	35	23	043	&#35;	#	67	43	103	&#67;	C	99	63	143	&#99;	c
4	4	004	EOT	(end of transmission)	36	24	044	&#36;	$	68	44	104	&#68;	D	100	64	144	&#100;	d
5	5	005	ENQ	(enquiry)	37	25	045	&#37;	%	69	45	105	&#69;	E	101	65	145	&#101;	e
6	6	006	ACK	(acknowledge)	38	26	046	&#38;	&	70	46	106	&#70;	F	102	66	146	&#102;	f
7	7	007	BEL	(bell)	39	27	047	&#39;	'	71	47	107	&#71;	G	103	67	147	&#103;	g
8	8	010	BS	(backspace)	40	28	050	&#40;	(	72	48	110	&#72;	H	104	68	150	&#104;	h
9	9	011	TAB	(horizontal tab)	41	29	051	&#41;	)	73	49	111	&#73;	I	105	69	151	&#105;	i
10	A	012	LF	(NL line feed, new line)	42	2A	052	&#42;	*	74	4A	112	&#74;	J	106	6A	152	&#106;	j
11	B	013	VT	(vertical tab)	43	2B	053	&#43;	+	75	4B	113	&#75;	K	107	6B	153	&#107;	k
12	C	014	FF	(NP form feed, new page)	44	2C	054	&#44;	,	76	4C	114	&#76;	L	108	6C	154	&#108;	l
13	D	015	CR	(carriage return)	45	2D	055	&#45;	-	77	4D	115	&#77;	M	109	6D	155	&#109;	m
14	E	016	SO	(shift out)	46	2E	056	&#46;	.	78	4E	116	&#78;	N	110	6E	156	&#110;	n
15	F	017	SI	(shift in)	47	2F	057	&#47;	/	79	4F	117	&#79;	O	111	6F	157	&#111;	o
16	10	020	DLE	(data link escape)	48	30	060	&#48;	0	80	50	120	&#80;	P	112	70	160	&#112;	p
17	11	021	DC1	(device control 1)	49	31	061	&#49;	1	81	51	121	&#81;	Q	113	71	161	&#113;	q
18	12	022	DC2	(device control 2)	50	32	062	&#50;	2	82	52	122	&#82;	R	114	72	162	&#114;	r
19	13	023	DC3	(device control 3)	51	33	063	&#51;	3	83	53	123	&#83;	S	115	73	163	&#115;	s
20	14	024	DC4	(device control 4)	52	34	064	4	4	84	54	124	&#84;	T	116	74	164	&#116;	t
21	15	025	NAK	(negative acknowledge)	53	35	065	&#53;	5	85	55	125	&#85;	U	117	75	165	&#117;	u
22	16	026	SYN	(synchronous idle)	54	36	066	&#54;	6	86	56	126	&#86;	V	118	76	166	&#118;	v
23	17	027	ETB	(end of trans. block)	55	37	067	7	7	87	57	127	&#87;	W	119	77	167	&#119;	w
24	18	030	CAN	(cancel)	56	38	070	8	8	88	58	130	&#88;	X	120	78	170	&#120;	x
25	19	031	EM	(end of medium)	57	39	071	&#57;	9	89	59	131	&#89;	Y	121	79	171	&#121;	y
26	1A	032	SUB	(substitute)	58	3A	072	&#58;	:	90	5A	132	&#90;	Z	122	7A	172	&#122;	z
27	1B	033	ESC	(escape)	59	3B	073	&#59;	;	91	5B	133	&#91;	[	123	7B	173	&#123;	{
28	1C	034	FS	(file separator)	60	3C	074	&#60;	<	92	5C	134	&#92;	\	124	7C	174	&#124;	|
29	1D	035	GS	(group separator)	61	3D	075	&#61;	=	93	5D	135	&#93;	]	125	7D	175	&#125;	}
30	1E	036	RS	(record separator)	62	3E	076	&#62;	>	94	5E	136	&#94;	^	126	7E	176	&#126;	~
31	1F	037	US	(unit separator)	63	3F	077	&#63;	?	95	5F	137	&#95;	_	127	7F	177	&#127;	DEL

Source: www.LookupTables.com



Constants (2.3)

- Numeric constants
- Character constants
- String constants
- Constant expressions
- Enumeration constants



Integer Constants

- Decimal numbers
  - `123487`
- Octal: starts with 0 (zero)
  - `0654`
- Hexadecimal: starts with 0x or 0X
  - `ox4Ab2, OX1234`
- long int: suffixed by L or l
  - `7L, 106l`
- unsigned int: suffixed by U or u
  - `8U,  127u`

Floating-point Constants

```
15.75
1.575E1      /* = 15.75 */
1575e-2      /* = 15.75 */
-2.5e-3       /* = -0.0025 */
25E-4        /* = 0.0025 */
```

- If there is no suffix, the type is considered **double** (8 bytes).
- To specify **float** (4 bytes), use suffix F or f.
- To specify **long double** (12 bytes), use suffix L or l.

```
100L  /* long double */
100F  /* float */
```

- You can omit the integer portion of the floating-point constant.

```
.0075e2
0.075e1
.075e1
75e-2
```

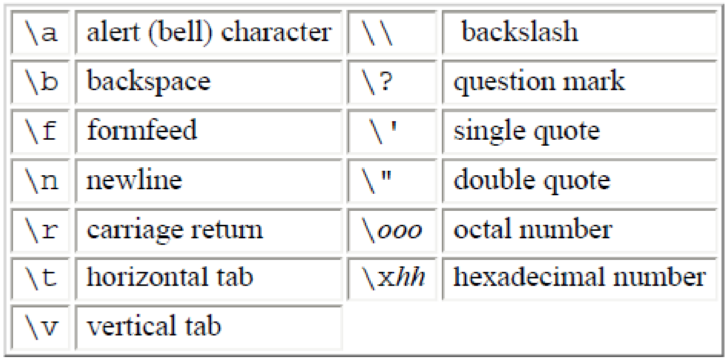
Numeric Constants

`2010`	int
`100000`	will be taken as long
`729L or 729l`	long (int)
`2010U or 2010u`	unsigned
`20628UL or 20628ul`	unsigned long
`24.7 or 1e-2`	double
`24.7F or 24.7f`	float
`24.7L or 24.7l`	long double
`037`	octal (= 31 decimal)
`0x1f, 0X1f, 0x1F`	hexadecimal (= 31)
`OXFUL`	What is this?

Character Constants

'x'	
'2'	numeric value 50
'\0'	NULL char, value 0
#define NEW_LINE '\012'	octal, 10 in decimal
#define SPACE '\x20'	hex, 32 in decimal

Escape Sequences



\a	alert (bell) character	\\	backslash
\b	backspace	\?	question mark
\f	formfeed	\'	single quote
\n	newline	\"	double quote
\r	carriage return	\ooo	octal number
\t	horizontal tab	\x*hh*	hexadecimal number
\v	vertical tab		

String Constants

```
“hello, world\n”

“”  /* empty string */

\”  /* double quote character */
```

“hello,” “ world” same as **“hello, world”**

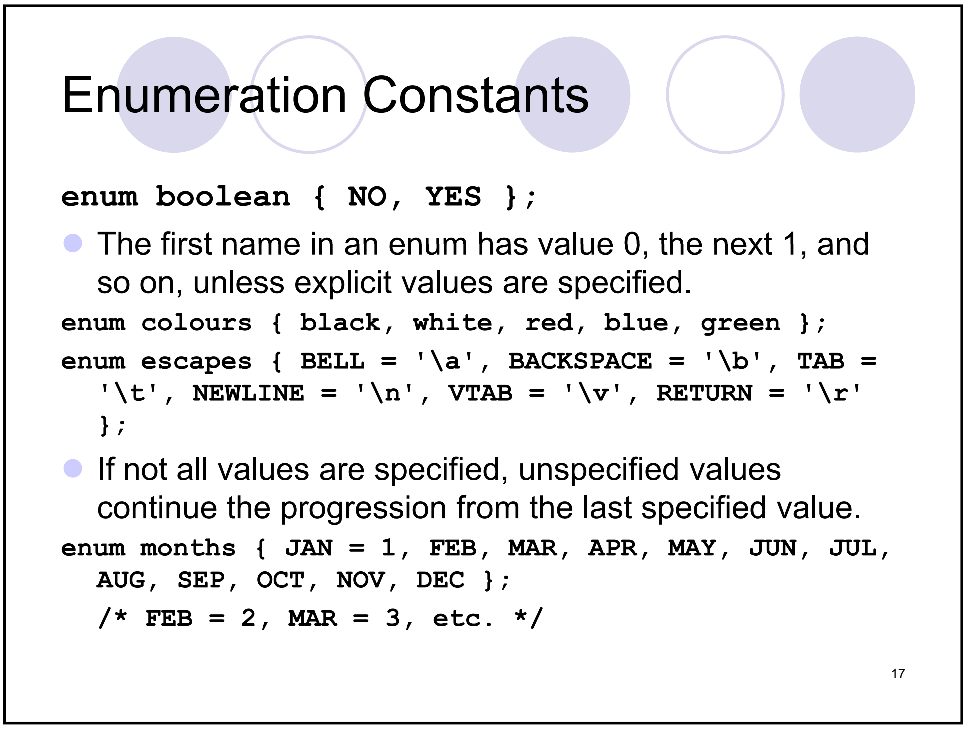
- concatenated at compile time
- useful for splitting up long strings across several source lines.

Constant Expressions

- Expressions that involve only constants.
- Evaluated during compilation.

```
#define MAXLINE 1000
char line[MAXLINE+1];

#define LEAP 1 /* in leap years */
int days[31+28+LEAP+31+30+31+30+31+31+30+31+30+31];
```



Enumeration Constants

```
enum boolean { NO, YES };
```

- The first name in an enum has value 0, the next 1, and so on, unless explicit values are specified.

```
enum colours { black, white, red, blue, green };
enum escapes { BELL = '\a', BACKSPACE = '\b', TAB =
  '\t', NEWLINE = '\n', VTAB = '\v', RETURN = '\r'
  };
```

- If not all values are specified, unspecified values continue the progression from the last specified value.

```
enum months { JAN = 1, FEB, MAR, APR, MAY, JUN, JUL,
  AUG, SEP, OCT, NOV, DEC };
  /* FEB = 2, MAR = 3, etc. */
```

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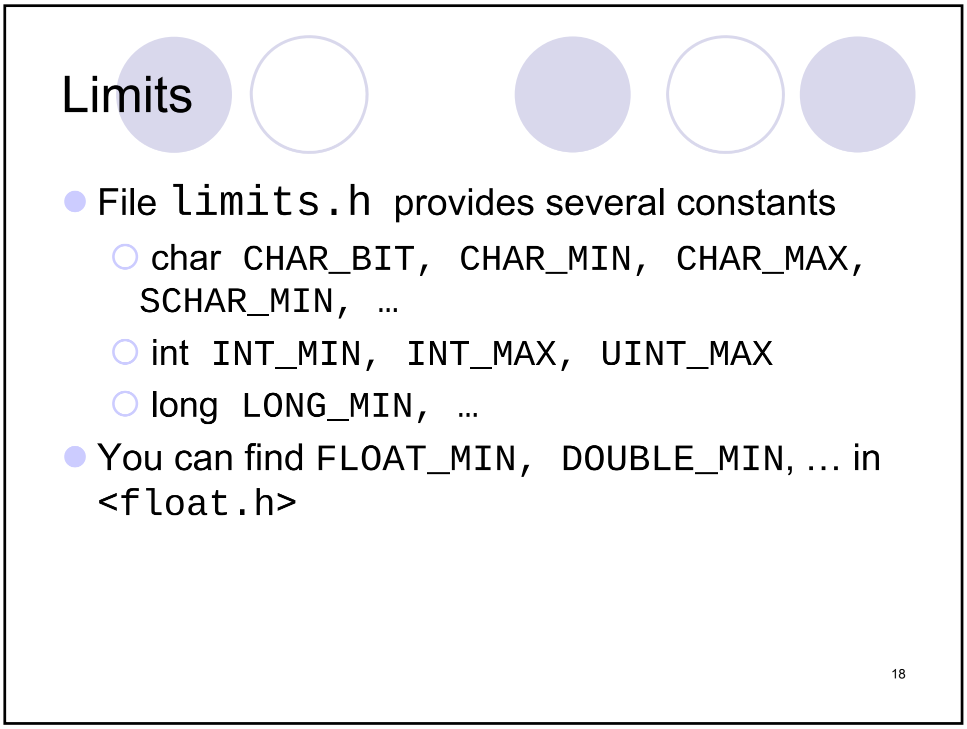

Limits

- File `limits.h` provides several constants
  - ○ char `CHAR_BIT, CHAR_MIN, CHAR_MAX, SCHAR_MIN,` …
  - ○ int `INT_MIN, INT_MAX, UINT_MAX`
  - ○ long `LONG_MIN,` …
- You can find `FLOAT_MIN, DOUBLE_MIN`, … in `<float.h>`

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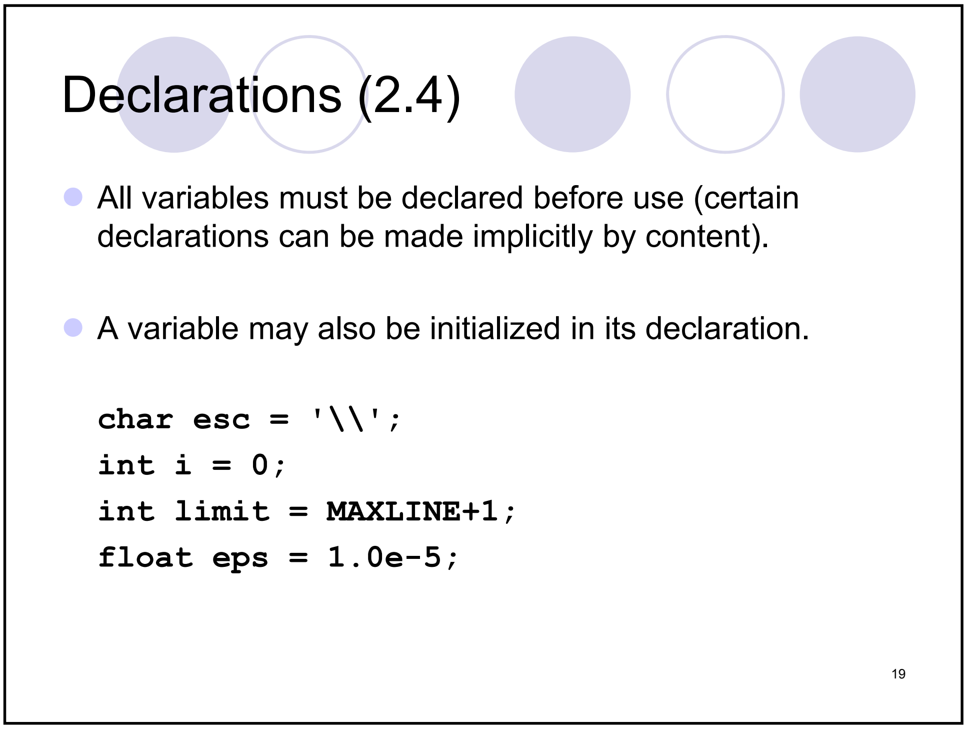
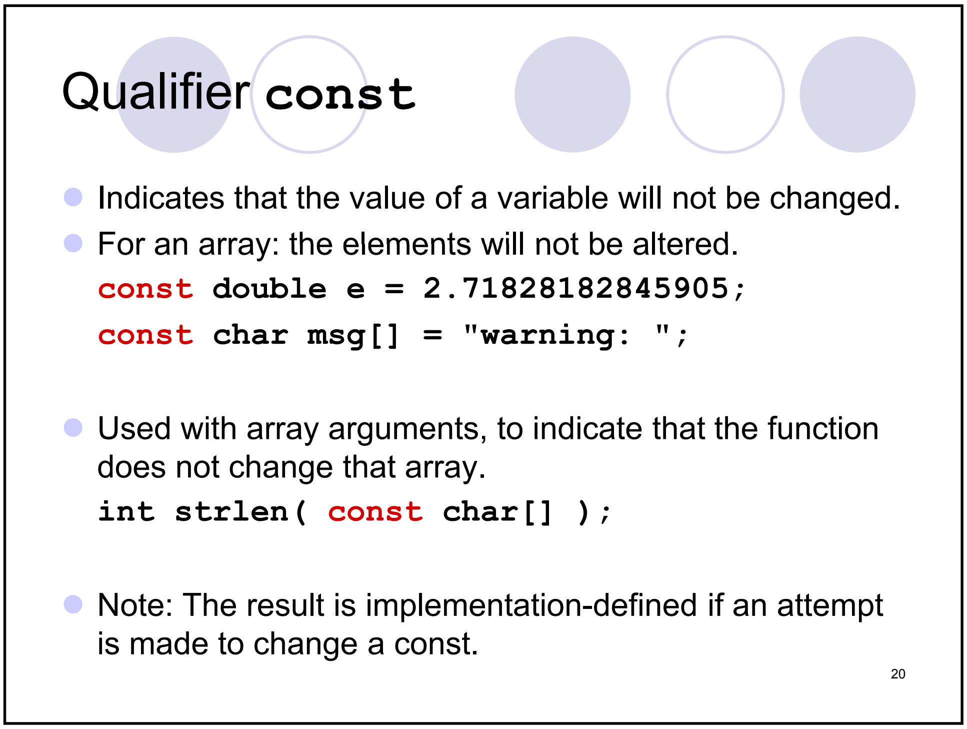


Declarations (2.4)

- All variables must be declared before use (certain declarations can be made implicitly by content).
- A variable may also be initialized in its declaration.

```
char esc = '\\';
int i = 0;
int limit = MAXLINE+1;
float eps = 1.0e-5;
```



Qualifier `const`

- Indicates that the value of a variable will not be changed.
- For an array: the elements will not be altered.

```
const double e = 2.71828182845905;
const char msg[] = "warning: ";
```

- Used with array arguments, to indicate that the function does not change that array.

```
int strlen( const char[] );
```

- Note: The result is implementation-defined if an attempt is made to change a const.

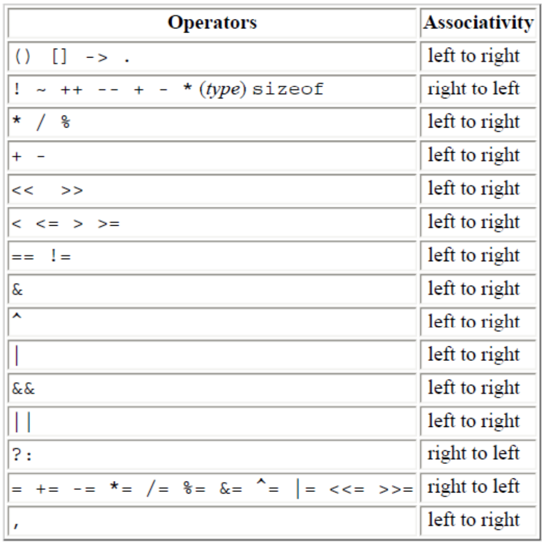
Arithmetic Operators (2.5)

```
+ – * / %
```

Examples:

```
abc = x + y * z;
j = a % i;
++x;
x++;
x += 5;   /* x = x + 5; */
y /= z;   /* y = y / z */
What is x *= y + 1 ?
```

Precedence and Associativity



Operators	Associativity
`()  []  ->  .`	left to right
`!  ~  ++  --  +  -  *` (*type*) `sizeof`	right to left
`*  /  %`	left to right
`+  -`	left to right
`<<   >>`	left to right
`<  <=  >  >=`	left to right
`==  !=`	left to right
`&`	left to right
`^`	left to right
`|`	left to right
`&&`	left to right
`||`	left to right
`?:`	right to left
`=  +=  -=  *=  /=  %=  &=  ^=  |=  <<=  >>=`	right to left
`,`	left to right

Type Conversion (2.7)

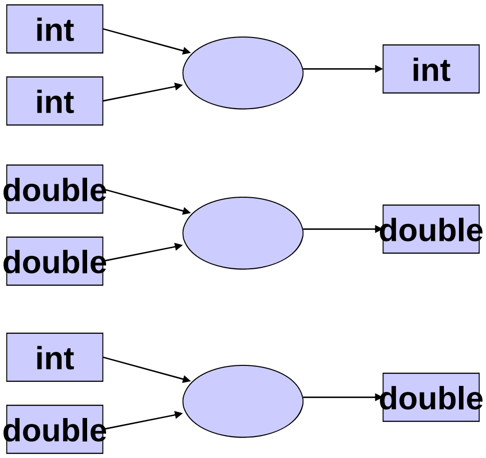
- **`float f; int i;`** What is the type of **`f+i`** ?
- General rule: convert a “narrower” operand into a “wider” one without losing information.
- So **`i`** is converted to float before the addition.
- **`char`** may be freely used in arithmetic expressions.

```
/* lower: convert c to lower case; ASCII only */
int lower(int c)
{
   if (c >= 'A' && c <= 'Z')
      return c – 'A' + 'a';
   else return c;
}
```

Arithmetic Conversion

- When a binary operator has operands of different types, the “lower” type is *promoted* to the “higher” type before the operation proceeds.
- If either operand is long double, convert the other to long double.
- Otherwise, if either operand is double, convert the other to double.
- Otherwise, if either operand is float, convert the other to float.
- Otherwise, convert char and short to int.
- Then, if either operand is long, convert the other to long.

Arithmetic Conversion: Examples

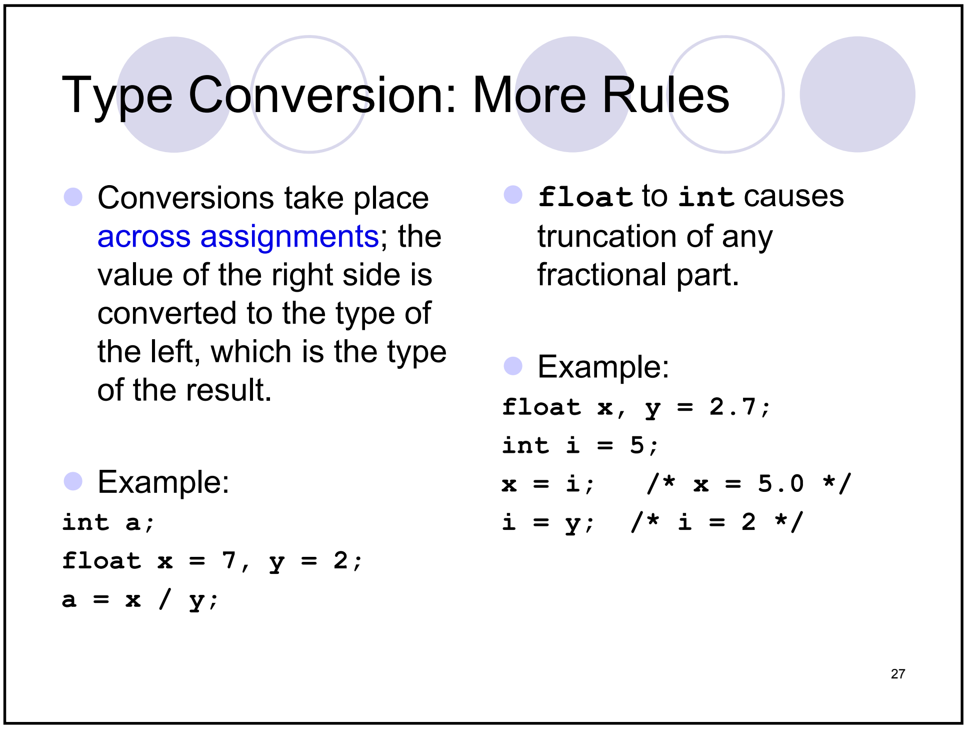


```
int a=5, b=2, c;
double x, y = 2;

x = a/b;
          // x = 2.0
c = a/b;
          // c = 2
x = a/y;
         // x = 2.5
c = a/y;
         // c = 2
```

More Examples

- 17 / 5
  - 3
- 17.0 / 5
  - 3.4
- 9 / 2 / 3.0 / 4
  - 9 / 2 = 4
  - 4 / 3.0 = 1.333
  - 1.333 / 4 = 0.333



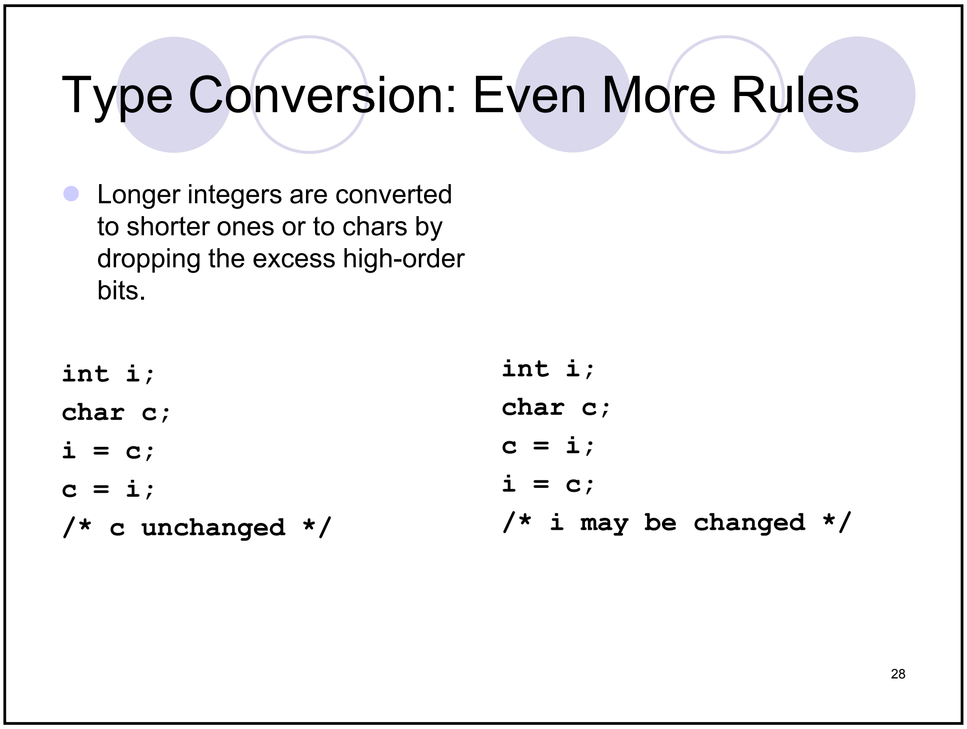
Type Conversion: More Rules

- Conversions take place across assignments; the value of the right side is converted to the type of the left, which is the type of the result.
- Example:

```
int a;
float x = 7, y = 2;
a = x / y;
```

- **`float`** to **`int`** causes truncation of any fractional part.
- Example:

```
float x, y = 2.7;
int i = 5;
x = i;   /* x = 5.0 */
i = y;  /* i = 2 */
```

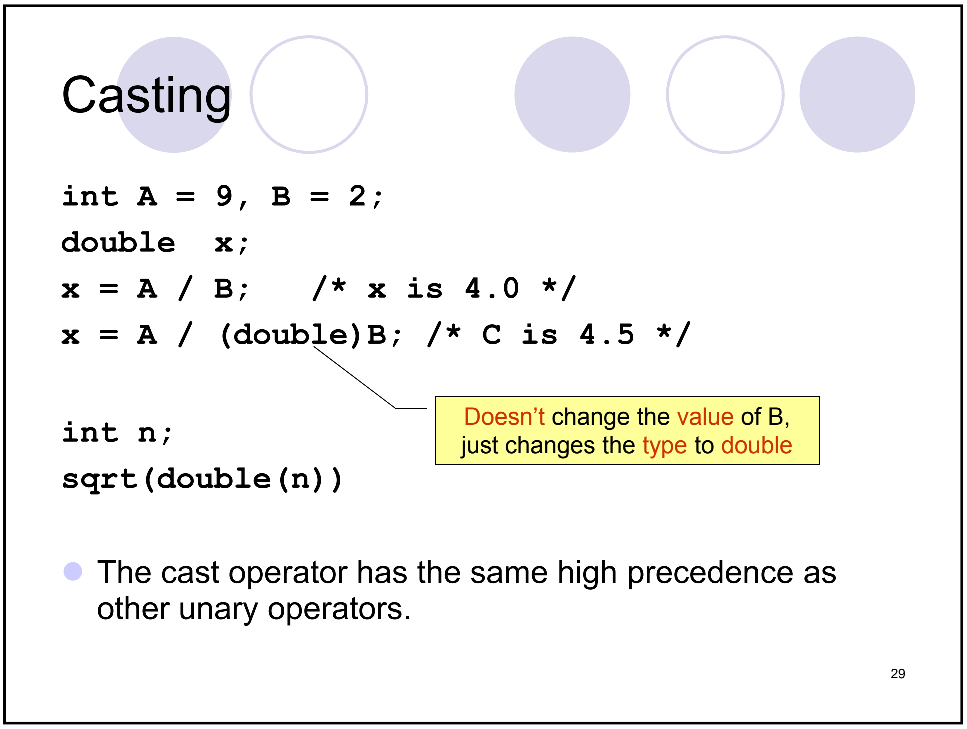


Type Conversion: Even More Rules

- Longer integers are converted to shorter ones or to chars by dropping the excess high-order bits.

```
int i;
char c;
i = c;
c = i;
/* c unchanged */
```

```
int i;
char c;
c = i;
i = c;
/* i may be changed */
```



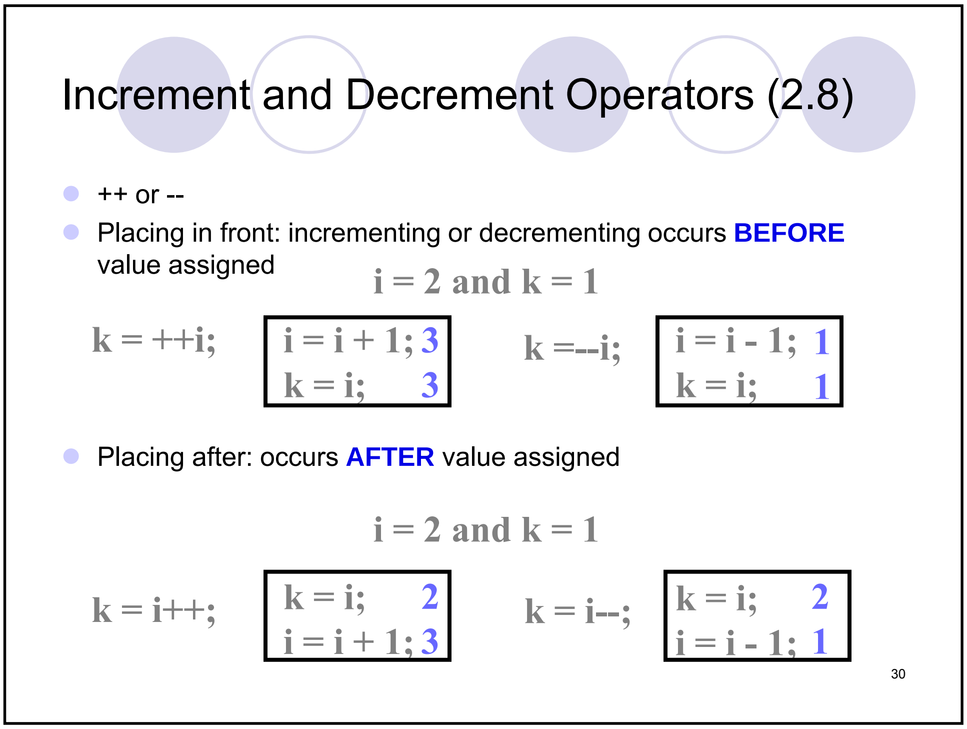
Casting

```
int A = 9, B = 2;
double  x;
x = A / B;   /* x is 4.0 */
x = A / (double)B; /* C is 4.5 */

int n;
sqrt(double(n))
```

Doesn't change the value of B, just changes the type to double

- The cast operator has the same high precedence as other unary operators.



Increment and Decrement Operators (2.8)

- ++ or --
- Placing in front: incrementing or decrementing occurs **BEFORE** value assigned

i = 2 and k = 1

k = ++i;

i = i + 1; 3
k = i; 3

k =--i;

i = i - 1; 1
k = i; 1

- Placing after: occurs **AFTER** value assigned

i = 2 and k = 1

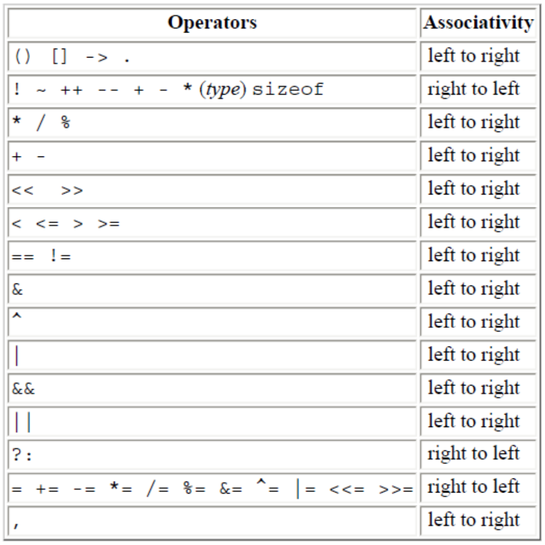
k = i++;

k = i; 2
i = i + 1; 3

k = i--;

k = i; 2
i = i - 1; 1

Precedence and Associativity



Operators	Associativity
() [] -> .	left to right
! ~ ++ -- + - * (*type*) sizeof	right to left
* / %	left to right
+ -	left to right
<< >>	left to right
< <= > >=	left to right
== !=	left to right
&	left to right
^	left to right
|	left to right
&&	left to right
||	left to right
?:	right to left
= += -= *= /= %= &= ^= |= <<= >>=	right to left
,	left to right

Examples

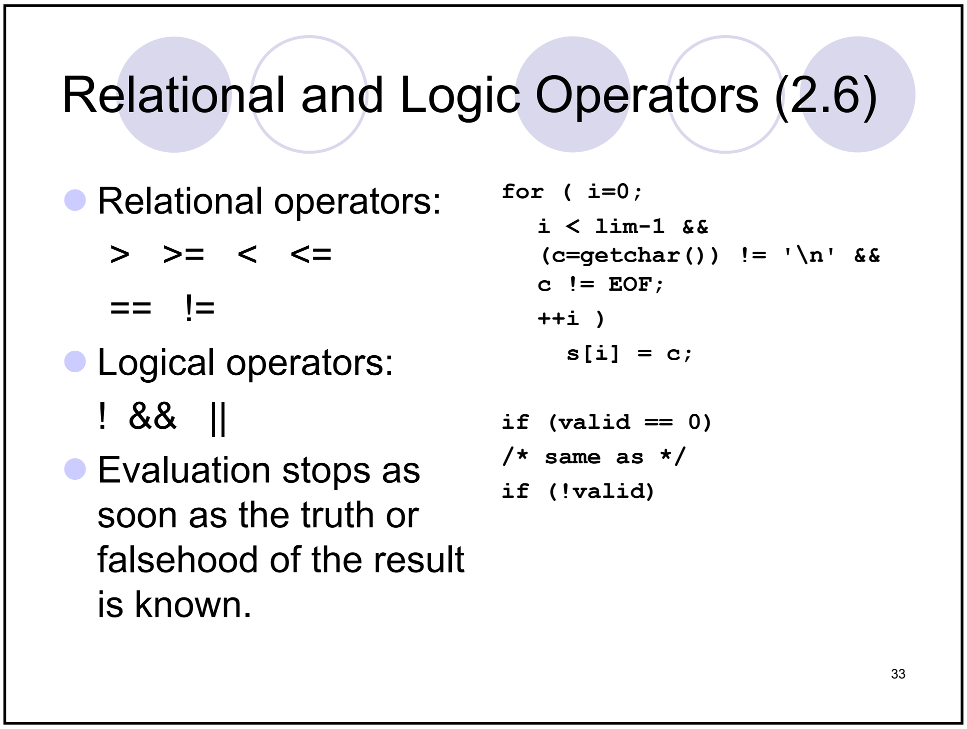
int a=2, b=3; c=5, d=7, e=11, f=3;

f += a/b/c; 3

d -= 7+c*--d/e; -3

d = 2*a%b+c+1; 7

a += b +=c += 1+2; 13



Relational and Logic Operators (2.6)

- Relational operators:

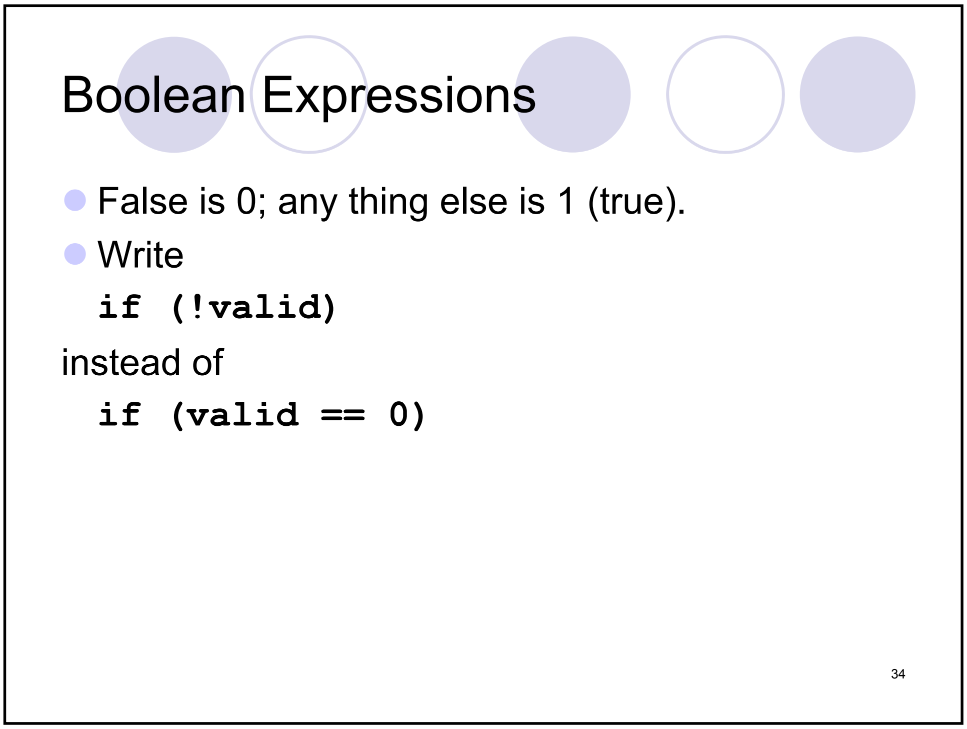
  `>  >=  <  <=`

  `==  !=`
- Logical operators:

  `!  &&  ||`
- Evaluation stops as soon as the truth or falsehood of the result is known.

```
for ( i=0;
   i < lim-1 &&
   (c=getchar()) != '\n' &&
   c != EOF;
   ++i )
     s[i] = c;

if (valid == 0)
/* same as */
if (!valid)
```



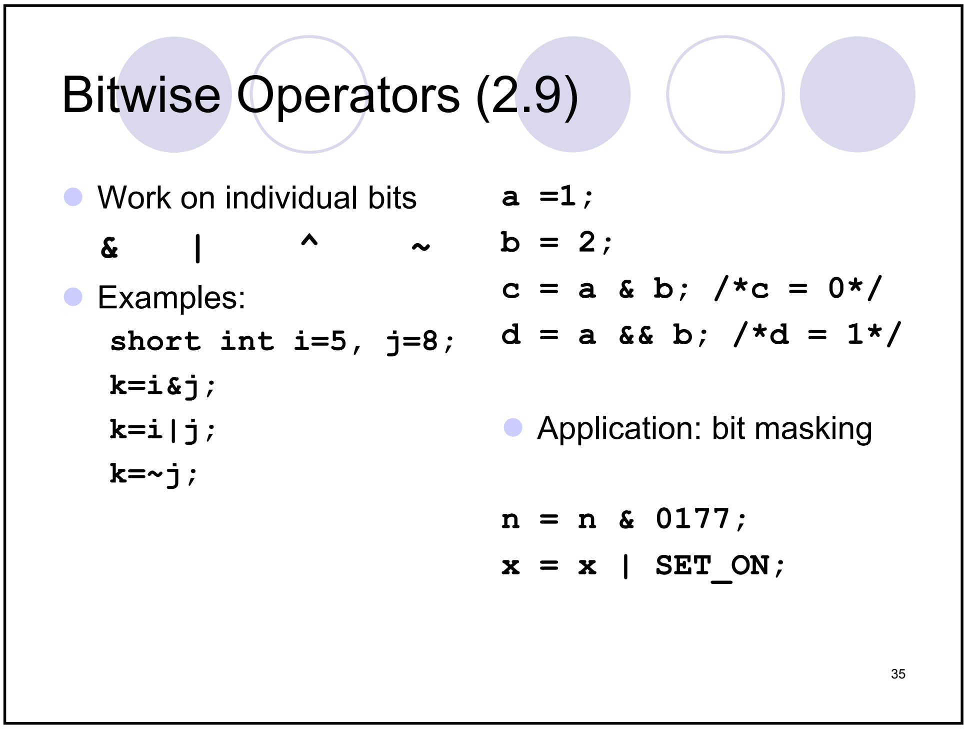
Boolean Expressions

- False is 0; any thing else is 1 (true).
- Write

```
  if (!valid)
```

instead of

```
  if (valid == 0)
```



Bitwise Operators (2.9)

- Work on individual bits

```
&    |    ^    ~
```

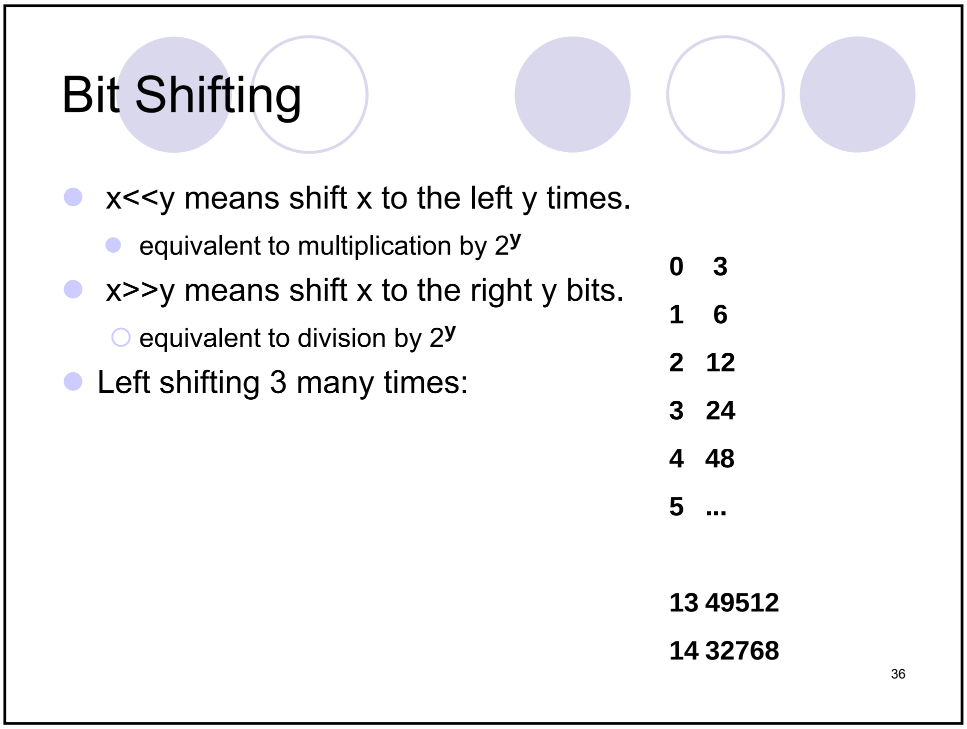
- Examples:

```
short int i=5, j=8;
k=i&j;
k=i|j;
k=~j;
```

```
a =1;
b = 2;
c = a & b; /*c = 0*/
d = a && b; /*d = 1*/
```

- Application: bit masking

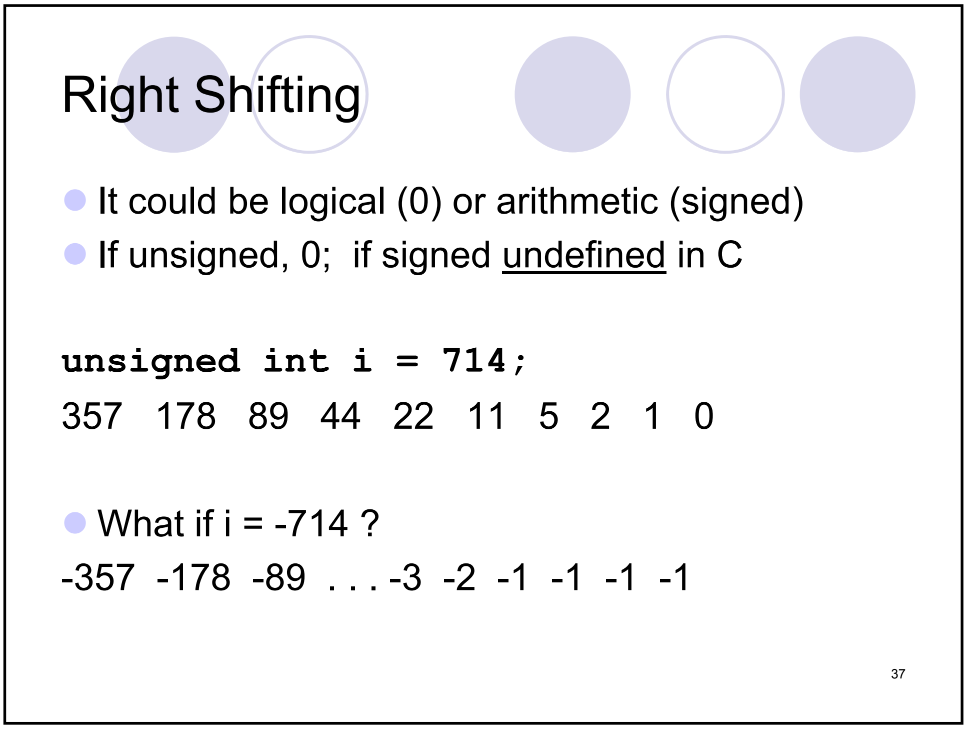
```
n = n & 0177;
x = x | SET_ON;
```



Bit Shifting

- x<<y means shift x to the left y times.
  - equivalent to multiplication by 2^y
- x>>y means shift x to the right y bits.
  - equivalent to division by 2^y
- Left shifting 3 many times:

0	3
1	6
2	12
3	24
4	48
5	...
13	49512
14	32768



Right Shifting

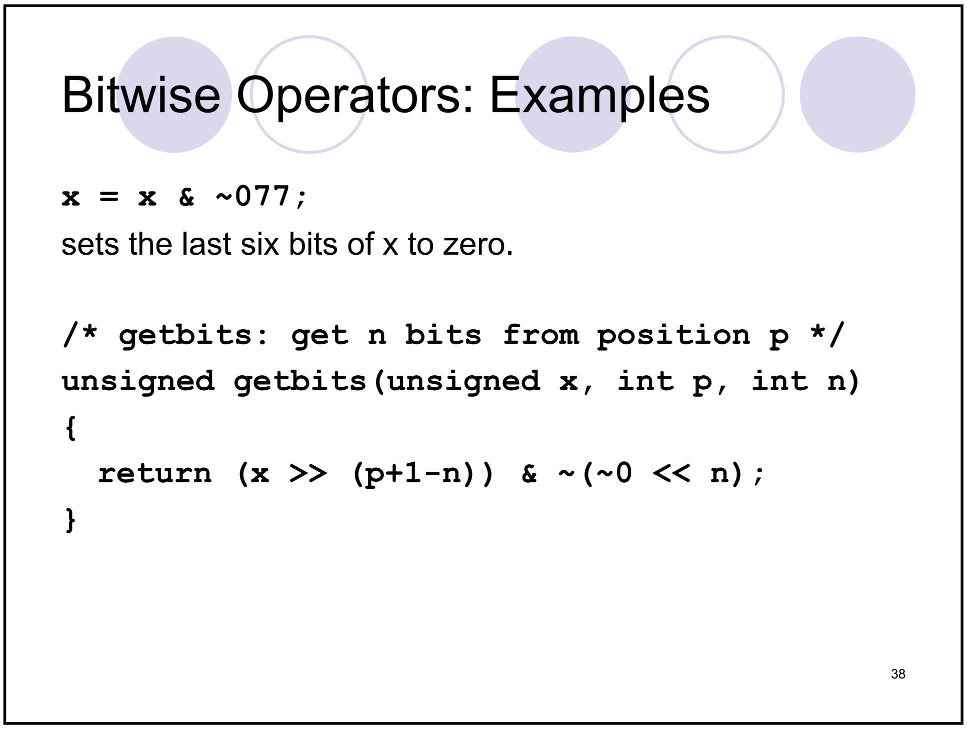
- It could be logical (0) or arithmetic (signed)
- If unsigned, 0; if signed undefined in C

```
unsigned int i = 714;
```

357   178   89   44   22   11   5   2   1   0

- What if i = -714 ?

-357 -178 -89 . . . -3 -2 -1 -1 -1 -1



Bitwise Operators: Examples

```
x = x & ~077;
```

sets the last six bits of x to zero.

```
/* getbits: get n bits from position p */
unsigned getbits(unsigned x, int p, int n)
{
  return (x >> (p+1-n)) & ~(~0 << n);
}
```

Assignment Operators / Expressions (2.10)

- A *= B;   // equivalent to
- A = (A) * (B);   // note the parentheses
- Can be used with: **+ – * / % << >> & ^ |**

```
yyval[yypv[p3+p4] + yypv[p1]] += 2

/* bitcount: count 1 bits in x */
int bitcount(unsigned x) {
   int b;
   for ( b = 0; x != 0; x >>= 1 )
        if ( x & 01 )
                b++;
   return b;
}
```

Conditional Expressions (2.11)

```
exp1 ? exp2 : exp3
```

- If exp1 is true, the value of the conditional expression is exp2; otherwise, exp3.

```
z = (a > b)? a : b; /* z = max (a, b)*/
```

- If **expr2** and **expr3** are of different types, the type of the result is determined by the conversion rules discussed earlier.

```
int n; float f;
(n > 0) ? f : n
/* result of type float in either case */
```

Conditional Expressions: Advantage

- Succinct code

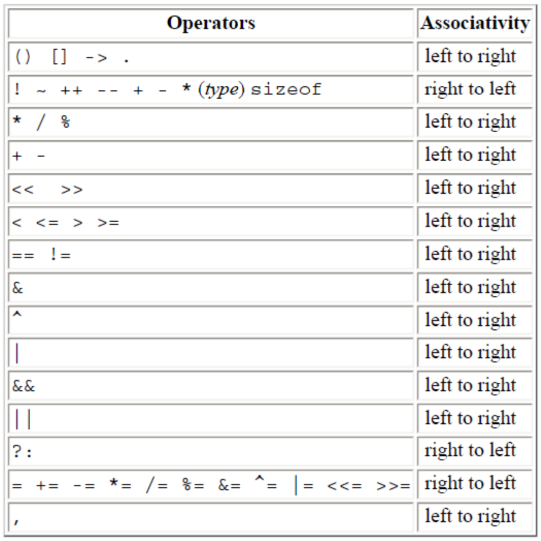
- Example 1:

```
for (i = 0; i < n; i++)
  printf("%6d%c", a[i],
      (i%10==9 || i==n-1) ? '\n' : ' ');
```

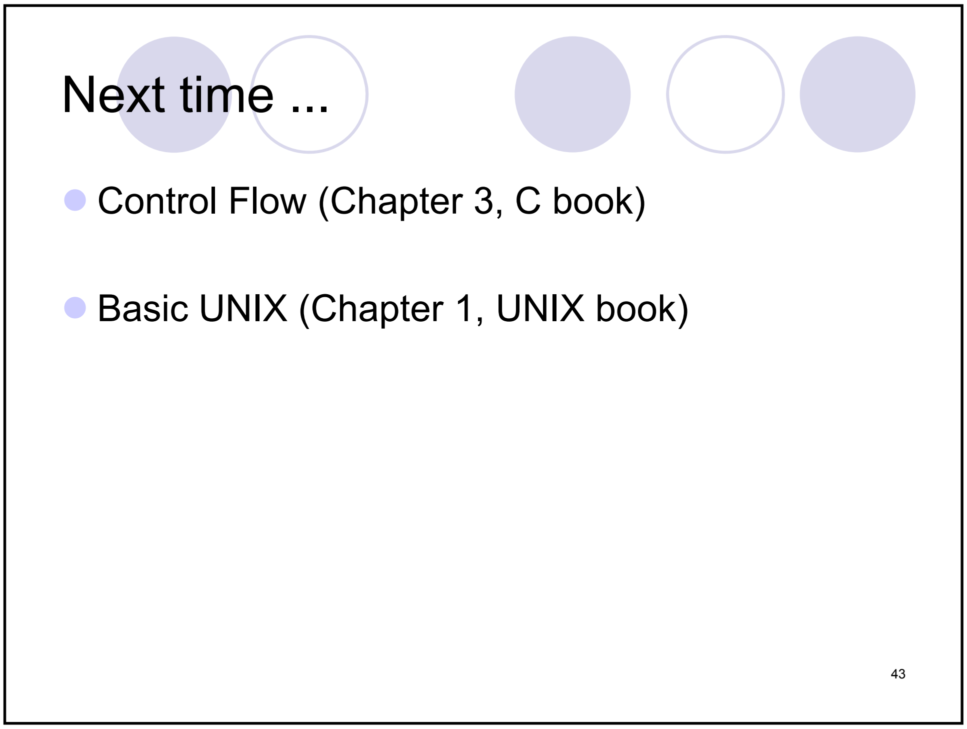
- Example 2:

```
printf("You have %d item%s.\n", n,
  n==1 ? "" : "s");
```

Precedence and Order of Evaluation (2.12)



Operators	Associativity
() [] -> .	left to right
! ~ ++ -- + - * (*type*) sizeof	right to left
* / %	left to right
+ -	left to right
<< >>	left to right
< <= > >=	left to right
== !=	left to right
&	left to right
^	left to right
|	left to right
&&	left to right
||	left to right
?:	right to left
= += -= *= /= %= &= ^= |= <<= >>=	right to left
,	left to right



Next time ...

- Control Flow (Chapter 3, C book)
- Basic UNIX (Chapter 1, UNIX book)