Types

- The ***type*** of an object determines

  the ***values*** it can have and the ***operations*** that can be performed on it

- Basic types

`char`	a “character”; typically a “byte”
`int`	an integer; typically a “word”
`float`	single-precision floating point
`double`	double-precision floating point

- `int` qualifiers (optional)

`short int`	“smaller” `int`
`long int`	“bigger” `int`, but ***not*** double precision

- Unsigned integers: non-negative modulo 2^n where ***n*** is #bits/integer

  `unsigned int`   `unsigned short int`   `unsigned char`

- Is `char` signed or unsigned?

Type Sizes

	year	72–81	80–92	64–92	93–?
	computer	DEC-10	PCs	IBM360 VAX 68020 SPARC MIPS	R4000 DEC Alpha
type	`char`	7	8	8	8
	`short`	18	16	16	16,32
	`int`	36	16,32	32	32,64
	`long`	36	32	32	**64**
	`float`	36	32	32	32
	`double`	72	64	64	64
	pointer	18	**16, 32**	32	**64**

Note: C did not exist in 1964; this table just reflects typical sizes

Types of Constants

char	**'a'**	character constant (single quote)
	'\035'	character code **35** octal
	'\x29'	character code **29** hexadecimal
	'\t'	tab (**'\011'**, do “**man ascii**” for details)
	'\n'	newline (**'\012'**)
	'\\'	backslash
	'\''	single quote
	'\b'	backspace (**'\010'**)
	'\0'	null character
int	**156**	decimal constant
	0234	octal
	0x9c	hexadecimal
long	156L	
	156l	for sanity, use upper-case L
float	15.6f	
	1.56e1F	
double	15.6	“plain” floating point constants are **doubles**
	15.6L	
	15.6l	

Constant Expressions

- **Const** qualifier identifies ***read-only variables***

```
const double Pi = 3.14159;

const double TwoPi = 2*3.14159;
```

- ***Constant expressions*** are evaluated at ***compile time***

```
int p = 1 - 1;

int p = 1/0, x = 1 ? 0 : 1/0;
```

- Use constant expressions

  to reduce the number of **#define** constants

  to increase readability

  to improve changeability, e.g.

```
#define MAXLINE 120

...

char buf[2*MAXLINE + 1];
```

Arrays

- Array declarations specify the ***number*** of elements, not the upper bound

```
int digits[10];
```

`digits` is an array of 10 **`int`**s

```
digits[0], digits[1], ..., digits[9]
```

- Arrays may be indexed by any integer expression

```
digits[f(x)/2 + BASE]
```

- N***o bounds checking!***
- Multi-dimensional arrays

```
float matrix[3][4][5]
```

a 3-dimensional array with $3 \times 4 \times 5 = 60$ elements

- Arrays are stored in ***row-major order***; last subscript varies “fastest”

```
matrix[0][0][0], matrix[0][0][1], ...
```

Strings & Initialization

- “Strings” are arrays of characters

"**`hello\n`**"

'h'	**'e'**	**'l'**	**'l'**	**'o'**	**'\12'**	**'\0'**

the compiler always provides a terminating **`'\0'`**

- Array length can be ***derived*** from initialization

```
char hello[] = "hello\n";
```

is equivalent to

```
char hello[7] = "hello\n";
char hello[7] = { 'h', 'e', 'l', 'l', 'o', '\n', '\0' }
```

- Ditto for arrays

```
int x[] = { 1, 2, 3 };
int y[][3] = {
    { 1, 3, 5 },
    { 2, 4, 6 },
    { 3, 5, 7 },
    { 4, 6, 8 }
};
```

will be 4 — number of 3-element rows

these braces can be omitted

Enumerations

- ***Enumerations*** associate constant values with identifiers

```
enum boolean { NO, YES };
enum color { RED, GREEN, BLUE };
```

- Values are generated and may be printed symbolically by debuggers
- Values can be given and unspecified ones automatically continue

```
enum escapes { BELL='\a', BACKSPACE='\b', TAB='\t'};
enum months { Jan=1, Feb, Mar, Apr, May, Jun, Jul,
    Aug, Sep, Oct, Nov, Dec };
```

- **`enum`** identifiers are **`int`** constants, but enumeration type may take less space

`sizeof NO`	is 4 bytes
`enum boolean flag;`	may occupy 1–4 bytes

- **`enum`** identifiers should have no ***conflicts***
- What is the difference between **`enum`** and #define?