A Shotgun Introduction to C

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C History

Developed between 1969 and 1973 along with Unix

Due mostly to Dennis Ritchie

Designed for systems programming

- Operating systems
- Utility programs
- Compilers
- Filters

Evolved from B, which evolved from BCPL
C History

Original machine, a DEC PDP-11, was very small:

24K bytes of memory, 12K used for operating system

Written when computers were big, capital equipment

Group would get one, develop new language, OS
Adding Two Numbers

```c
int add() /* Function that returns an integer */ {
    int x, y, z; /* Variables x, y, and z are integers */
    x = 38;     /* Set x to 38 */
    y = 4;      /* Set y to 4 */
    z = x + y;  /* Set z to the sum of x and y */
    return z;  /* Return z as the result of add() */
}
```

End statements with semicolons

Text between /* and */ is ignored (a comment)

Programs are mostly function definitions and global variables.
Variables

Names must start with a letter; may contain letters, numbers, and underscores.

```
a A a_variable aVariable a50 ex 12_ /* OK */
two-words 42_is_the_answer /* BAD */
```

Must be declared before they’re used

```
int a, b, c; /* 32-bit signed binary integers */
char c, d;  /* Single letter, digit, etc. */

a = 42;
b = 18;
f = 3;    /* BAD: f not declared */
c = 'o';  
d = '#';  
q = '4';  /* BAD: q not declared */
```
#define ROWS 10
#define COLUMNS 40

\[ \text{pos} = y \times \text{COLUMNS} + \text{rows}; \]

This turns into

\[ \text{pos} = y \times 40 + \text{rows}; \]

The “#” must be in the leftmost column.
int a, b, c;

a = b + c;  /* Addition */

a = b - c;  /* Subtraction */

a = -(b + c); /* Negation */

a = b * c;  /* Multiplication */

a = b / c;  /* Division (integer result) */

a = b % c;  /* Remainder (modulus) */

a = b < c;  /* a is non-zero if b is less than c */

a = b > c;  /* non-zero if b is greater than c */

a = b <= c; /* b less than or equal to c */

a = b >= c; /* b greater than or equal to c */

a = b == c; /* a is non-zero if b is equal to c */

a = b != c; /* a is non-zero if b different than c */
Assignment Operators

A convenient shorthand:

\[ a += 3; \quad /* \text{Increase } a \text{ by 3} */ \]
\[ a = a + 3; \quad /* \text{Equivalent} */ \]

\[ b *= 2; \quad /* \text{Double } b */ \]
\[ b = b \times 2; \quad /* \text{Equivalent} */ \]

Most operators have assignment variants.
Bitwise Operators

Internally, numbers represented in binary.

\[
\begin{align*}
10100101_2 &= 1 \times 2^7 + 0 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + \\
& \quad 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 \\
&= 128 + 32 + 4 + 1 \\
&= 165_{10}
\end{align*}
\]

Bitwise operators work directly on bits:

\[
\begin{array}{ccc}
10110 & & 10110 \\
\text{AND: } & \& & \text{OR: } \vert \\
10011 & & 10011 \\
\hline
\text{10010} & & \text{10111} \\
\text{XOR: } & \wedge & \text{10011} \\
\hline
& & \text{00101}
\end{array}
\]
Increment/Decrement Operators

\[
a = a + 1; /* Common operation */
\]

\[
a += 1; /* One shorthand */
\]

\[
a++; /* Even more succinct */
\]

\[
\text{for } (i = 0; i < 10; i++) \{ /* Very common idiom */
    /* i = 0, 1, 2, ..., 9 */
\}
\]

\[
a = 3;
b = a++; /* Postincrement: means b = 3; a = 4; */
\]

\[
b = ++a; /* Preincrement: means a = 5; b = 5; */
\]

\[
a = 3;
b = a--; /* Postdecrement: means b = 3; a = 2; */
\]

\[
b = --a; /* Predecrement: means a = 1; b = 1; */
\]
The If-Else Statement

```java
if (a == 3)
    c = 2;       // Runs if a is 3. One statement: braces optional */

if (b == 4 && c == 2) { /* && is logical AND */
    c = 5;       // Runs if b is 4 and c is 2 */
    a = a + 3;
} /* Two statements: braces mandatory */

if (a > b) {
    c = 1;       // Runs if a is greater than b */
} else {       // Runs if a is not greater than b */
    c = 5;
}

if (a > b || c == 3) { /* || is logical OR */
    c = 5;       // Runs if a is greater than b or c is 3 */
} else {       // Runs if a is greater than b or c is 3 */
    a = b + 2;
}
```
The Switch Statement: A Multiway Conditional

```c
switch (a + 1) {
    case 2:
        c = 8; /* Runs if a is 1 */
        b = 2;
        break;

    case 0:
    case 1: /* Multiple cases allowed */
        b = 3; /* Runs if a is -1 or 0 */
        break;

    case 42: /* Case labels need not be contiguous */
        c = 12;
        /* No break: falls through to next case! */

    case 4:
        c = 15; /* Runs if a is 3 or 41 */
        break;

    default: /* a default is optional */
        c = 0; /* Runs if no other case matches */
        break; /* Good style */
}
```
The While Statement

```c
int gcd(int a, int b)
{
    while (a != b) { /* Repeat while a and b are different */
        if (a > b)
            a -= b; /* a is larger; subtract b from it */
        else
            b -= a; /* b is larger; subtract a from it */
    }
    return a;
}
```
The For Statement

/* Sum the numbers from 1 to n */
int sumup(int n)
{
    int i, s;
    i = 0;
    s = 0;
    while (i <= n) {
        s += i;
        i += 1;
    }
    return s;
}
Arrays

```c
int i;
int a[10]; /* Array of 10 integers */
int b[] = { 2,3,7,6 }; /* Initial values */

a[0] = 3;
a[2] = 5;
a[9] = 18;
a[10] = 42; /* BAD: only a[0] ... a[9] */
a[-1] = 2; /* BAD: positive indexes only */

a[1] = b[0]; /* a[0] = 2 */
b[3] = 42;

i = 5;
a[i] = 42; /* a[5] = 42 */
i = 4;
a[i] = 10; /* a[4] = 10 */
```
Strings

/* Strings are null-terminated arrays of characters */

char name1[] = "Stephen";
/* is equivalent to */
char name2[] = {'S', 't', 'e', 'p', 'h', 'e', 'n', 0};

name1[5] = 'a';

/* name1 now "Stephan" */
struct point { /* Define an aggregate type "struct point" */
    int x;
    int y;
};

struct point p; /* Declare a new point */
p.x = 10; /* Set its coordinates */
p.y = 15;

printf("(%d,%d)\n", p.x, p.y);

struct point q = { 320, 200 }; /* Initialize contents */
p = q; /* Copy one point to another */

struct rect {
    struct point southwest;
    struct point northeast;
};

struct rect r;
r.southwest.x = 10;
r.southwest.y = 5;
r.northeast.x = 125;
r.northeast.y = 200;
```c
int num_calls = 0; /* global variable */

int power(int base, int n)
{
    int p; /* Different than main’s p */

    for ( p = 1 ; n > 0 ; --n )
        p *= base;

    num_calls++;

    return p;
}

int main() /* main function always runs first */
{
    int n, p;

    n = power(2, 5); /* n = 32 */
    p = power(3, 3); /* p = 27 */

    p = num_calls; /* p = 2 */
}
```
Pointers

\[
\begin{array}{ccc}
\text{x=1} & \text{y=2} & \text{ip} \\
\end{array}
\]

```c
int x = 1, y = 2;
int *ip;
```

```c
ip = &x;
y = *ip;
*ip = 0;
```
Pointers

```c
int x = 1, y = 2;
int *ip;

ip = &x;
```
Pointers

```
int x = 1, y = 2;
int *ip;

ip = &x;
y = *ip;
```
Pointers

```
int x = 1, y = 2;
int *ip;
ip = &x;
y = *ip;
*ip = 0;
```
Pointers

```c
void swap(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}
```

Does this work?
void swap(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}

Does this work?
Nope.

void swap(int *px, int *py)
{
    int temp;

    temp = *px; /* get data at px */
    *px = *py; /* get data at py */
    *py = temp; /* write data at py */
}

void main()
{
    int a = 1, b = 2;

    /* Pass addresses of a and b */
    swap(&a, &b);

    /* a = 2 and b = 1 */
}
Arrays and Pointers

int a[10];
Arrays and Pointers

```c
int a[10];
int *pa = &a[0];
```
int a[10];
int *pa = &a[0];
pa = pa + 1;
Arrays and Pointers

```c
int a[10];
int *pa = &a[0];
pa = pa + 1;
pa = &a[1];
```
Pointers and Structs

```c
struct point {
    int x;
    int y;
};

struct point p, *pp;

p.x = 100;
p.y = 200;

pp = &p;       /* pp now points to p */

(*pp).x = 50;  /* Assign to x field of p */
pp->x = 50;    /* Equivalent */
pp->y = 42;
```
Strlen: An Example

```c
int strlen(const char *s)
{
    int n;

    for (n = 0 ; *s != '\0' ; s++)
        n++;

    return n;
}

void main()
{
    char ste[] = "Stephen"
    int l = strlen(ste);
}
```
Separate Compilation

`file1.c`

```c
extern void bar();
char a[] = "Hello";

int main() {
    bar();
}

void baz(char *s) {
    printf("\%\%s", s);
}
```

`file2.c`

```c
extern char a[];
extern void baz(char *);

static char b[6];

void bar() {
    strcpy(b, a);
    baz(b);
}
```
Better Style: Header Files

```c
#include "myfiles.h"

char a[] = "Hello";

int main() {
    bar();
}

void baz(char *s) {
    printf("%\%%s", s);
}
```

```c
#include "myfiles.h"

static char b[6];

void bar() {
    strcpy(b, a);
    baz(b);
}
```

```c
#ifndef _MYFILES_H
#define _MYFILES_H

/* in file1.c */
extern void bar();
extern char a[];

/* in file2.c */
extern void baz(char *);

#endif
```