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THE C PROGRAMMING LANGUAGE

Contents

Character Counting

4a ⟨*wc.c* 4a⟩≡
This definition is continued in chunks 4 and 5.
Root chunk (not used in this document).

```
  ⟨Include the standard I/O functions. 19b⟩
  ⟨Include the boolean type and values. 19a⟩
```

4b ⟨*wc.c* 4a⟩+≡

```
  double char_count()
  {
      double nc;

      for (nc = 0; getchar() ≠ EOF; ++nc)
          ;

      return nc;
  }
```

Defines:
  `char_count`, never used.

Line Counting

4c ⟨*wc.c* 4a⟩+≡

```
  int line_count()
  {
      int c, nl;

      nl = 0;
      ⟨For each character c until EOF 19d⟩
          if (⟨the character is a newline 20c⟩)
              ++nl;

      return nl;
  }
```

Defines:
  `line_count`, never used.

Exercise 1-8

4d ⟨*wc.c* 4a⟩+≡

```
  bool is_whitespace(int c)
  {
      return (⟨the character is whitespace 20b⟩);
  }
```

Defines:
  `is_whitespace`, used in chunk 5a.
Uses `bool` 19a.

5a ⟨*wc.c* 4a⟩+≡
```
double ws_count()
{
    double ns = 0;
    int c = 0;

    ⟨For each character c until EOF 19d⟩
        if (is_whitespace(c))
            ++ns;

    return ns;
}
```
Defines:
  `ws_count`, never used.
Uses `is_whitespace` 4d.

Word Counting

5b ⟨*wc.c* 4a⟩+≡
```
#define IN  1
#define OUT 0
```
Defines:
  `IN`, used in chunks 5c, 12, and 16b.
  `OUT`, used in chunks 5c, 12, and 16b.

5c ⟨*wc.c* 4a⟩+≡
```
int main()
{
    int c, nl, nw, nc, state;

    state = OUT;
    nl = nw = nc = 0;
    ⟨For each character c until EOF 19d⟩ {
        ++nc;
        if (⟨the character is a newline 20c⟩)
            ++nl;
        if (⟨the character is whitespace 20b⟩)
            state = OUT;
        else if (state == OUT) {
          state = IN;
          ++nw;
        }
    }

    printf("%7d%8d%8d\n", nl, nw, nc);

    return 0;
}
```
Uses `IN` 5b, `OUT` 5b, and `printf` 19b.

Fahrenheit-Celsius table

Covers Exercises 1-3, 1-4, and 1-5.

6a ⟨*fahrcels.c* 6a⟩≡

This definition is continued in chunks 6 and 7.
Root chunk (not used in this document).

```
⟨Include the standard I/O functions. 19b⟩
⟨Include the standard string functions. 19c⟩
```

Declare some useful constants.

6b ⟨*fahrcels.c* 6a⟩+≡

```
#define LOWER 0
#define UPPER 300
#define STEP  20
```

Defines:
LOWER, used in chunks 6d and 7a.
STEP, used in chunks 6d and 7a.
UPPER, used in chunks 6d and 7a.

Exercise 1-3

6c ⟨*fahrcels.c* 6a⟩+≡

```
void print_header(char lhs[], char rhs[])
{
    printf("| %s | %s |\n", lhs, rhs);
    putchar('|');
    for (int i = -2; i < (int)strlen(lhs); ++i)
        putchar('-');
    putchar('+');
    for (int i = -2; i < (int)strlen(rhs); ++i)
        putchar('-');
    puts("|");
}
```

Defines:
print_header, used in chunks 6d and 7a.
Uses printf 19b, putchar 19b, puts 19b, and strlen 19c.

Exercise 1-4

6d ⟨*fahrcels.c* 6a⟩+≡

```
void celsfahr()
{
    print_header("Celsius", "Fahrenheit");
    for (int celsius = LOWER; celsius ≤ UPPER; celsius += STEP)
        printf("| %7d | %10.0f |\n", celsius, 32.0 + (9.0/5.0) * celsius);
}
```

Defines:
celsfahr, used in chunk 7b.
Uses LOWER 6b, print_header 6c, printf 19b, STEP 6b, and UPPER 6b.

Exercise 1-5

7a ⟨*fahrcels.c* 6a⟩+≡
```
void fahrcels()
{
    print_header("Fahrenheit", "Celsius");
    for (int fahr = UPPER; fahr ≥ LOWER; fahr -= STEP)
        printf("| %10d | %7.1f |\n", fahr, (5.0/9.0) * (fahr-32.0));
}
```
Defines:
  `fahrcels`, used in chunk 7b.
Uses `LOWER` 6b, `print_header` 6c, `printf` 19b, `STEP` 6b, and `UPPER` 6b.

The `main` *function*

7b ⟨*fahrcels.c* 6a⟩+≡
```
int main()
{
    fahrcels();
    puts("\n");
    celsfahr();

    return 0;
}
```
Uses `celsfahr` 6d, `fahrcels` 7a, and `puts` 19b.

Functions

Exercise 1-16

7c ⟨*longestline.c* 7c⟩≡
This definition is continued in chunks 7–10.
Root chunk (not used in this document).

  ⟨*Include the standard I/O functions.* 19b⟩

```
#define MAXLINE 3
```

Defines:
  `MAXLINE`, used in chunk 8.

Declare a function `getline` that, given a character array and maximum line length to copy to it, returns the length of the longest line.

7d ⟨*longestline.c* 7c⟩+≡
```
int getline(char line[], int maxline);
```
Uses `getline` 9a.

8a ⟨*longestline.c* 7c⟩+≡
```
void copy(char to[], char from[]);


int main()
{
    int len, max;
    char line[MAXLINE], longest[MAXLINE];

    max = 0;
    while ((len = getline(line, MAXLINE)) > 0)
        if (len > max) {
            max = len;
            copy(longest, line);
        }

    if (max > 0) {
```
Uses `copy` 10, `getline` 9a, and `MAXLINE` 7c.

Print the length of the longest line, and as much of it as possible:

8b ⟨*longestline.c* 7c⟩+≡
```
        printf("The longest line had %d characters:\n%s", max, longest);
```
Uses `printf` 19b.

If the line was too long to print fully, print an ellipsis and a newline.

8c ⟨*longestline.c* 7c⟩+≡
```
        if (max ≥ MAXLINE && longest[MAXLINE-1] ≠ '\n')
            fputs("...\n", stdout);
```
Uses `fputs` 19b, `MAXLINE` 7c, and `stdout` 19b.

8d ⟨*longestline.c* 7c⟩+≡
```
    }


    return 0;
}
```

9a ⟨*longestline.c* 7c⟩+≡
```
/* getline: read a line into s, return length */
int getline(char s[], int lim)
{
    int c, i;

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

    if (c == '\n') {
        s[i] = c;
        ++i;
    }

    s[i] = '\0';
```

Defines:
`getline`, used in chunks 9a, 7d, and 8a.

If the last character read is a newline, return the number of characters in the line.

9b ⟨*longestline.c* 7c⟩+≡
```
    if (c == '\n')
        return i;
```

Otherwise, continue to count characters, until the end of the line or file.

9c ⟨*longestline.c* 7c⟩+≡
```

    while ((c = getchar()) != '\n' && c != EOF)
        ++i;
```

If we ended on a newline character, increment the count.

9d ⟨*longestline.c* 7c⟩+≡
```
    if (c == '\n')
        ++i;
```

Return the length of the longest line.

9e ⟨*longestline.c* 7c⟩+≡
```
    return i;
}
```

10 ⟨*longestline.c* 7c⟩+≡

```
/* copy: copy ‘from’ into ‘to’; assume ‘to’ is big enough */
void copy(char to[], char from[])
{
    int i;
    i = 0;
    while ((to[i] = from[i]) ≠ '\0')
        ++i;
}
```

Defines:
`copy`, used in chunk 8a.

Chapter One

Hello, world!

Covers Exercises 1-1 and 1-2.

Include the standard I/O functions, notably `printf`.

11a ⟨*hello.c* 11a⟩≡

This definition is continued in chunk 11b.
Root chunk (not used in this document).

```
  ⟨Include the standard I/O functions. 19b⟩
```

Define a `main` function that prints `Hello, world!`.

11b ⟨*hello.c* 11a⟩+≡

```
  int main()
  {
      printf("Hello, world!\n");
  }
```

Uses `printf` 19b.

Arrays

Exercise 1-13

Vertical histogram

12 ⟨*wordlength.c* 12⟩≡
Root chunk (not used in this document).

```
⟨Include the standard I/O functions. 19b⟩


#define IN    1
#define OUT   0

#define MAX_WORD_LENGTH 10
#define TERM_WIDTH 80


int main()
{
    int c, state, wl;
    int length[MAX_WORD_LENGTH+1];

    for (int i = 0; i ≤ MAX_WORD_LENGTH; ++i)
        length[i] = 0;

    state = OUT;
    wl = 0;
    ⟨For each character c until EOF 19d⟩ {
        if (⟨the character is whitespace 20b⟩) {
            if (state == IN) {
                state = OUT;
                ++length[wl ≤ MAX_WORD_LENGTH ? wl-1 : MAX_WORD_LENGTH];
            }
        } else {
            if (state == OUT) {
                state = IN;
                wl = 0;
            }
            ++wl;
        }
    }

    for (int j = 0; j ≤ MAX_WORD_LENGTH; ++j) {
        if (j == MAX_WORD_LENGTH)
            printf(">%d: ", MAX_WORD_LENGTH);
        else
            printf(" %2d: ", j+1);

        for (int k = 0; k < length[j]; ++k)
            putchar('#');
        putchar('\n');
    }


    return 0;
}
```

Uses IN 5b, OUT 5b, printf 19b, and putchar 19b.

Exercise 1-9

13a ⟨*catblanks.c* 13a⟩≡

This definition is continued in chunk 13b.
Root chunk (not used in this document).

```
    ⟨Include the standard I/O functions. 19b⟩
    ⟨Include the boolean type and values. 19a⟩
```

13b ⟨*catblanks.c* 13a⟩+≡

```
    int main()
    {
        int c;
        bool prev_blank = false;

        ⟨For each character c until EOF 19d⟩ {
            if (!(prev_blank && c == ' '))
                ⟨Print the character. 20a⟩
            prev_blank = (c == ' ');
        }


        return 0;
    }
```

Uses bool 19a.

Exercise 1-14

13c ⟨*charfreq.c* 13c⟩≡

This definition is continued in chunk 14.
Root chunk (not used in this document).

```
    ⟨Include the standard I/O functions. 19b⟩


    #define MIN_ASCII 0
    #define MAX_ASCII 0177
```

14a ⟨*charfreq.c* 13c⟩+≡
```
void prchar(int c)
{
    switch (c) {
        case ' ':
            printf("%11s", "<space>");
            break;
        case '\b':
            printf("%11s", "<backspace>");
            break;
        case '\n':
            printf("%11s", "<newline>");
            break;
        case '\t':
            printf("%11s", "<tab>");
            break;
        default:
            /* FIXME: why can't I return this? */
            /* return ((char[2]) { (char) c, '\0' }); */
            printf("%11c", c);
            break;
    }
}
```

Defines:
`prchar`, used in chunk 14b.
Uses `printf` 19b.

14b ⟨*charfreq.c* 13c⟩+≡
```
int main()
{
    int c;
    int freq[MAX_ASCII+1] = {0};

    ⟨For each character c until EOF 19d⟩
        ++freq[c];

    for (int i = 0; i ≤ MAX_ASCII; ++i) {
        if (!freq[i]) continue;

        prchar(i);
        fputs(": ", stdout);
        for (int j = 0; j < freq[i]; ++j)
            putchar('#');
        putchar('\n');
    }


    return 0;
}
```
Uses `fputs` 19b, `prchar` 14a, `putchar` 19b, and `stdout` 19b.

15a ⟨*unambiguous.c* 15a⟩≡

This definition is continued in chunks 15 and 16a.
Root chunk (not used in this document).

```
  ⟨Include the standard I/O functions. 19b⟩


  int main()
  {
```

Exercise 1-10

Process each character `c`.

15b ⟨*unambiguous.c* 15a⟩+≡

```
  int c;

      ⟨For each character c until EOF 19d⟩ {
```

Replace each tab by `\t`.

15c ⟨*unambiguous.c* 15a⟩+≡

```
          if (⟨the character is a tab 20d⟩)
              fputs("\\t", stdout);
```

Uses `fputs` 19b and `stdout` 19b.

Replace each backspace by `\b`.

15d ⟨*unambiguous.c* 15a⟩+≡

```
          else if (⟨the character is a backspace 20e⟩)
              fputs("\\b", stdout);
```

Uses `fputs` 19b and `stdout` 19b.

Replace each backslash by `\\`.

15e ⟨*unambiguous.c* 15a⟩+≡

```
          else if (⟨the character is a backslash 20f⟩)
              fputs("\\\\", stdout);
```

Uses `fputs` 19b and `stdout` 19b.

Otherwise print the character unchanged.

15f ⟨*unambiguous.c* 15a⟩+≡

```
          else
              ⟨Print the character. 20a⟩
```

Finally, close the **while** loop and exit.

16a ⟨*unambiguous.c* 15a⟩+≡
```
    }

    return 0;
}
```

Exercise 1-12

16b ⟨*words.c* 16b⟩≡
Root chunk (not used in this document).

```
⟨Include the standard I/O functions. 19b⟩


#define IN    1
#define OUT   0


int main()
{
    int c, state;

    state = OUT;
    ⟨For each character c until EOF 19d⟩ {
        if (⟨the character is whitespace 20b⟩) {
            if (state == IN)
                putchar('\n');
            state = OUT;
        } else {
            state = IN;
        }

        if (state == IN)
            putchar(c);
    }


    return 0;
}
```
Uses IN 5b, OUT 5b, and putchar 19b.

Copy

Covers Exercises 1-6 and 1-7.

16c ⟨*copy.c* 16c⟩≡
This definition is continued in chunk 17.
Root chunk (not used in this document).

```
⟨Include the standard I/O functions. 19b⟩
```

17 ⟨*copy.c* 16c⟩+≡

```
int main()
{
    int c;
    ⟨For each character c until EOF 19d⟩
        ⟨Print the character. 20a⟩

    return 0;
}
```

Common

Headers

19a ⟨*Include the boolean type and values.* 19a⟩≡

This code is used in chunks 4a and 13a.

```
#include <stdbool.h>
```

Defines:
`bool`, used in chunks 4d and 13b.

19b ⟨*Include the standard I/O functions.* 19b⟩≡

This code is used in chunks 4a, 6a, 7c, 11–13, 15, and 16.

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

Defines:
`fputs`, used in chunks 8c, 14, and 15.
`printf`, used in chunks 5–8, 19b, 11b, 12, and 14a.
`putchar`, used in chunks 6c, 12, 14b, 16b, and 20a.
`puts`, used in chunks 6c and 7b.
`stdout`, used in chunks 8c, 14, and 15.

19c ⟨*Include the standard string functions.* 19c⟩≡

This code is used in chunk 6a.

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

Defines:
`strlen`, used in chunk 6c.

Patterns

Control

19d ⟨*For each character* `c` *until* `EOF` 19d⟩≡

This code is used in chunks 4, 5, and 12–17.

```
while ((c = getchar()) ≠ EOF)
```

I/O

20a ⟨*Print the character.* 20a⟩≡
This code is used in chunks 13b, 15f, and 17.

```
putchar(c);
```

Uses `putchar` 19b.

Predicates

For our purposes, whitespace is a space, tab, or newline.

20b ⟨*the character is whitespace* 20b⟩≡
This code is used in chunks 4d, 5c, 12, and 16b.

```
c == ' ' || ⟨the character is a newline 20c⟩ || ⟨the character is a tab 20d⟩
```

20c ⟨*the character is a newline* 20c⟩≡
This code is used in chunks 4c, 5c, and 20b.

```
c == '\n'
```

20d ⟨*the character is a tab* 20d⟩≡
This code is used in chunks 15c and 20b.

```
c == '\t'
```

20e ⟨*the character is a backspace* 20e⟩≡
This code is used in chunk 15d.

```
c == '\b'
```

20f ⟨*the character is a backslash* 20f⟩≡
This code is used in chunk 15e.

```
c == '\\'
```

Chunks

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