Computer Programming I

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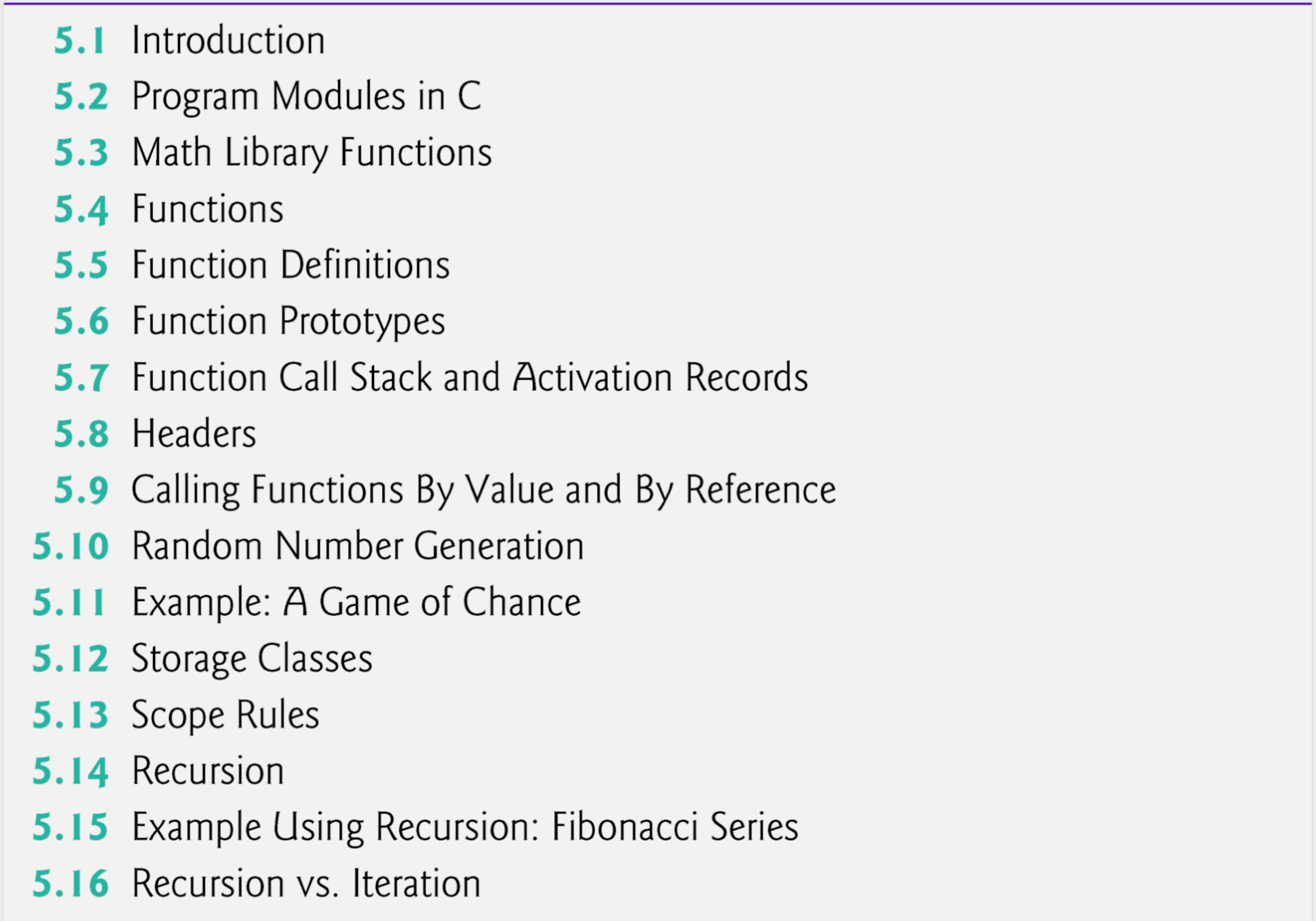
C Functions



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Call Functions By Value and By Reference

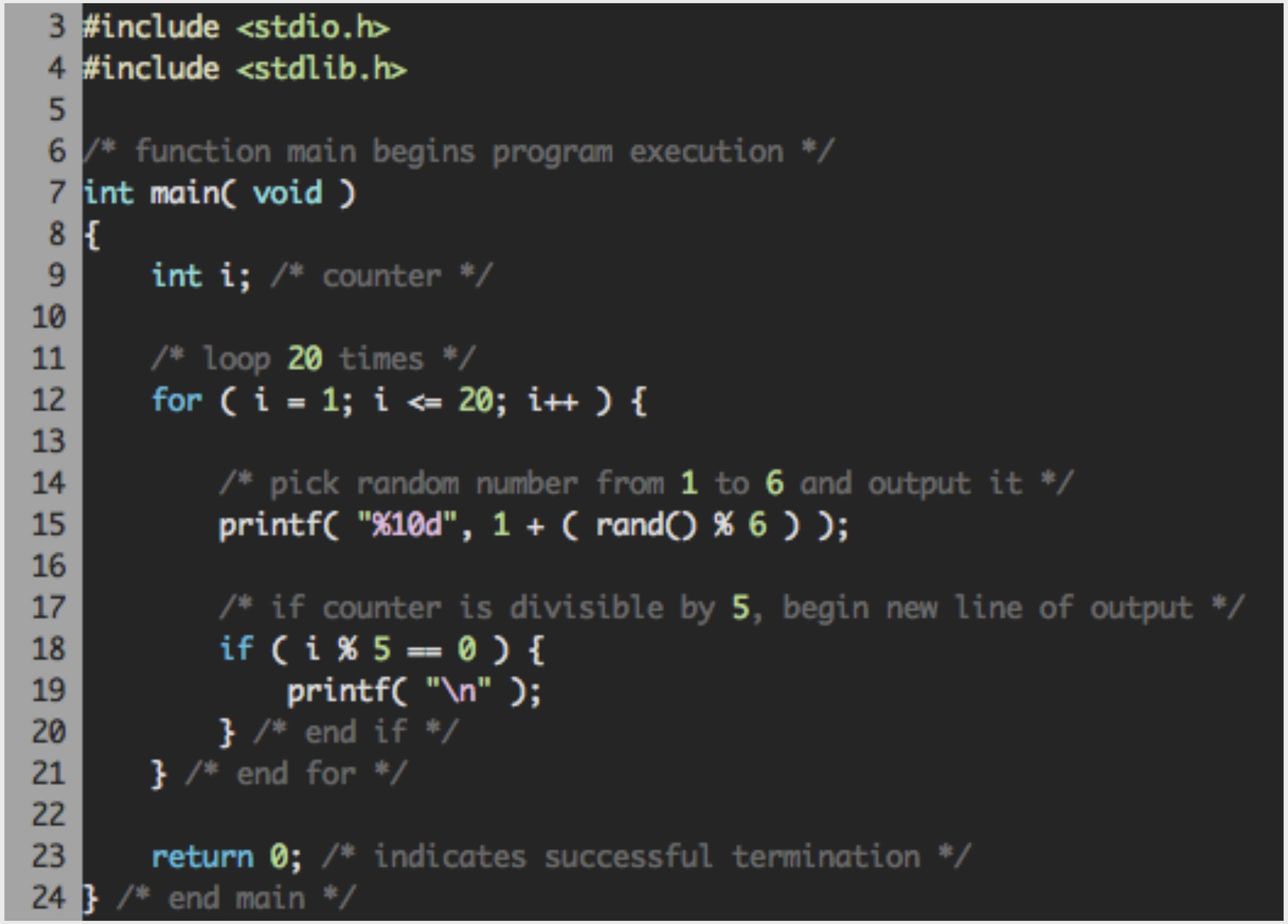
- There are two ways to invoke functions in many programming languages:
- **Call-by-Value**
  - A copy of the argument's value is made and passed to the called function
  - Changes to the copy do not affect an original variable's value in the caller.
- **Call-by-Reference**
  - The caller allows the called function to modify the original variable's value.

Call Functions By Value and By Reference (Cont.)

- We have to wait until Chapter 7 for a full understanding of the call-by-reference
- For now, we concentrate on call-by-value

Random Number Generation

- Example: fig05_07.c



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

/* function main begins program execution */
int main( void )
{
    int i; /* counter */

    /* loop 20 times */
    for ( i = 1; i <= 20; i++ ) {

        /* pick random number from 1 to 6 and output it */
        printf( "%10d", 1 + ( rand() % 6 ) );

        /* if counter is divisible by 5, begin new line of output */
        if ( i % 5 == 0 ) {
            printf( "\n" );
        } /* end if */
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

Random Number Generation

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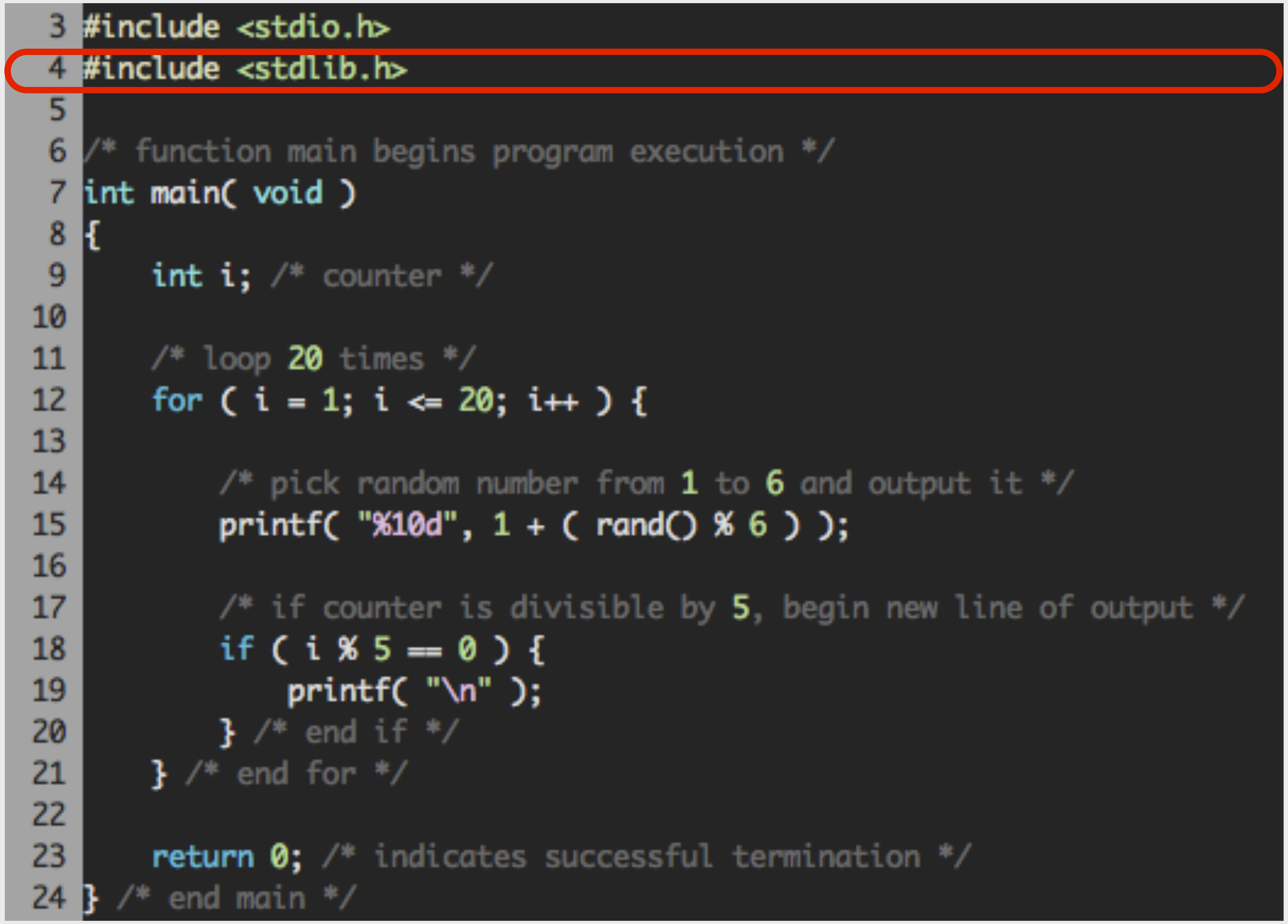

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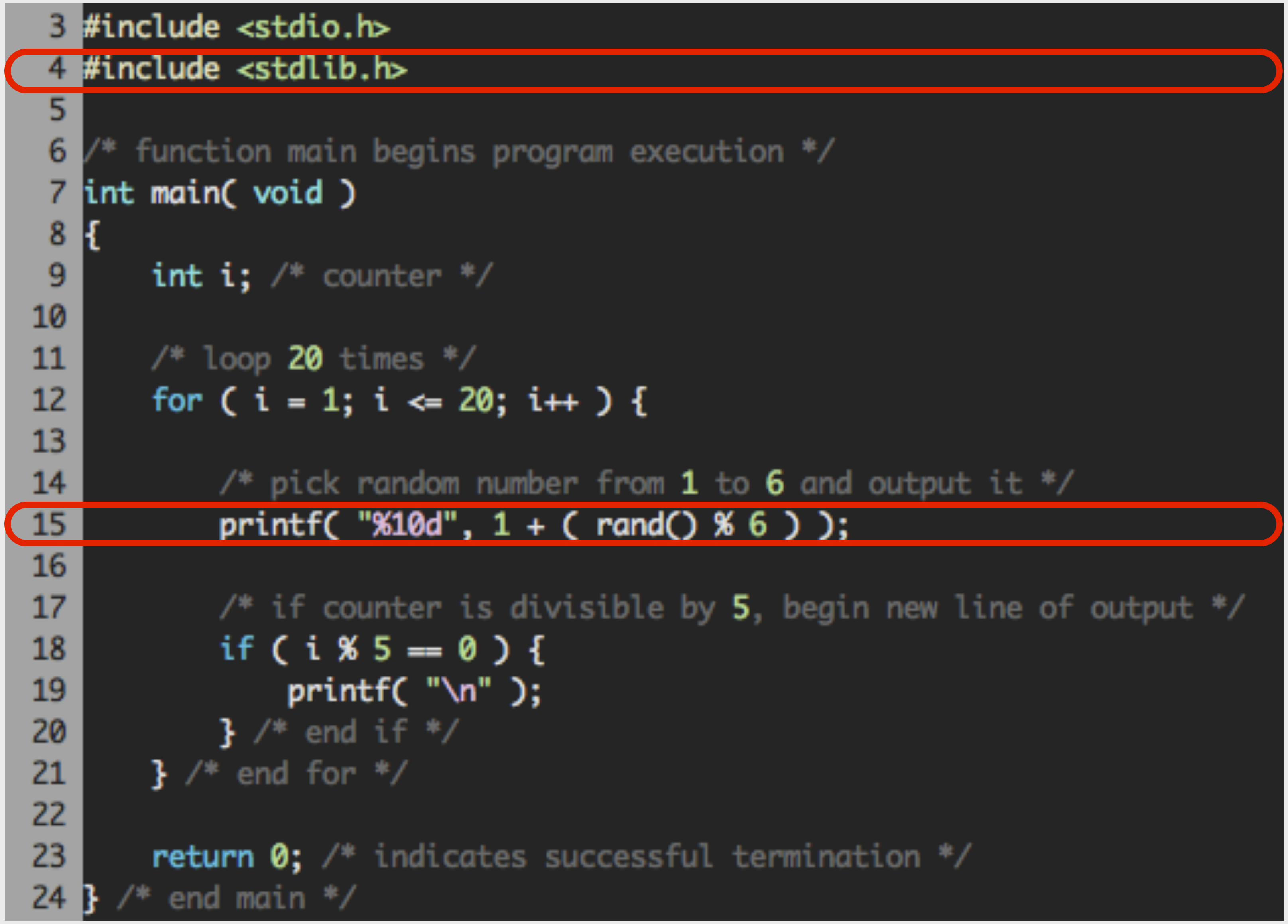

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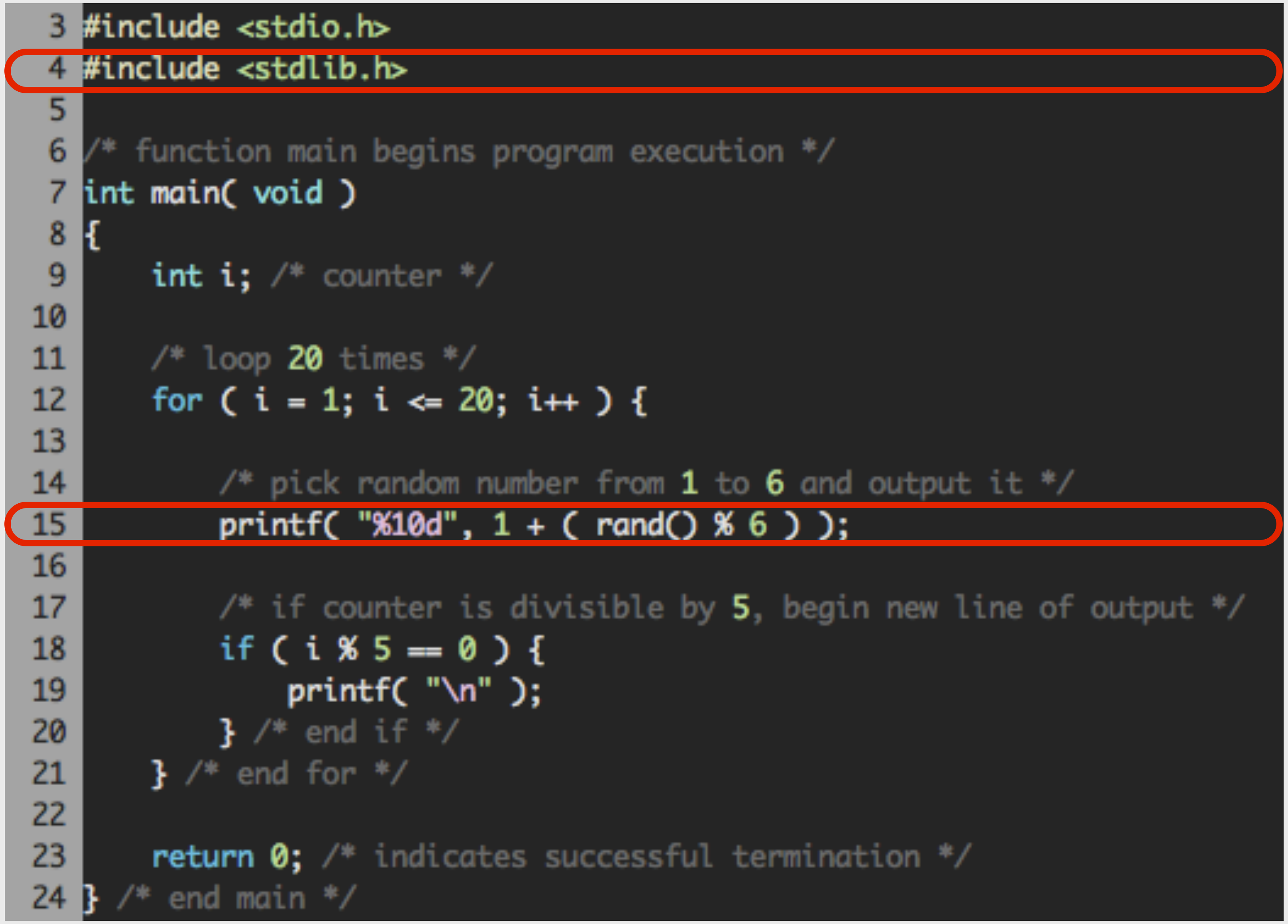

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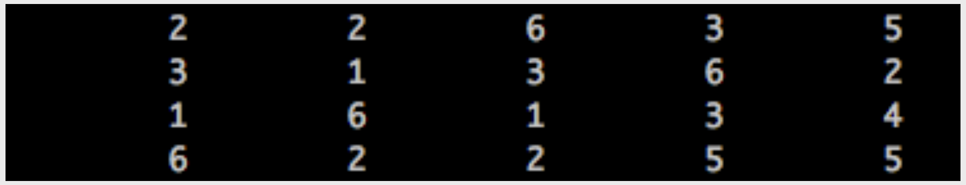


```
         2         2         6         3         5
         3         1         3         6         2
         1         6         1         3         4
         6         2         2         5         5
```

Random Number Generation (Cont.)

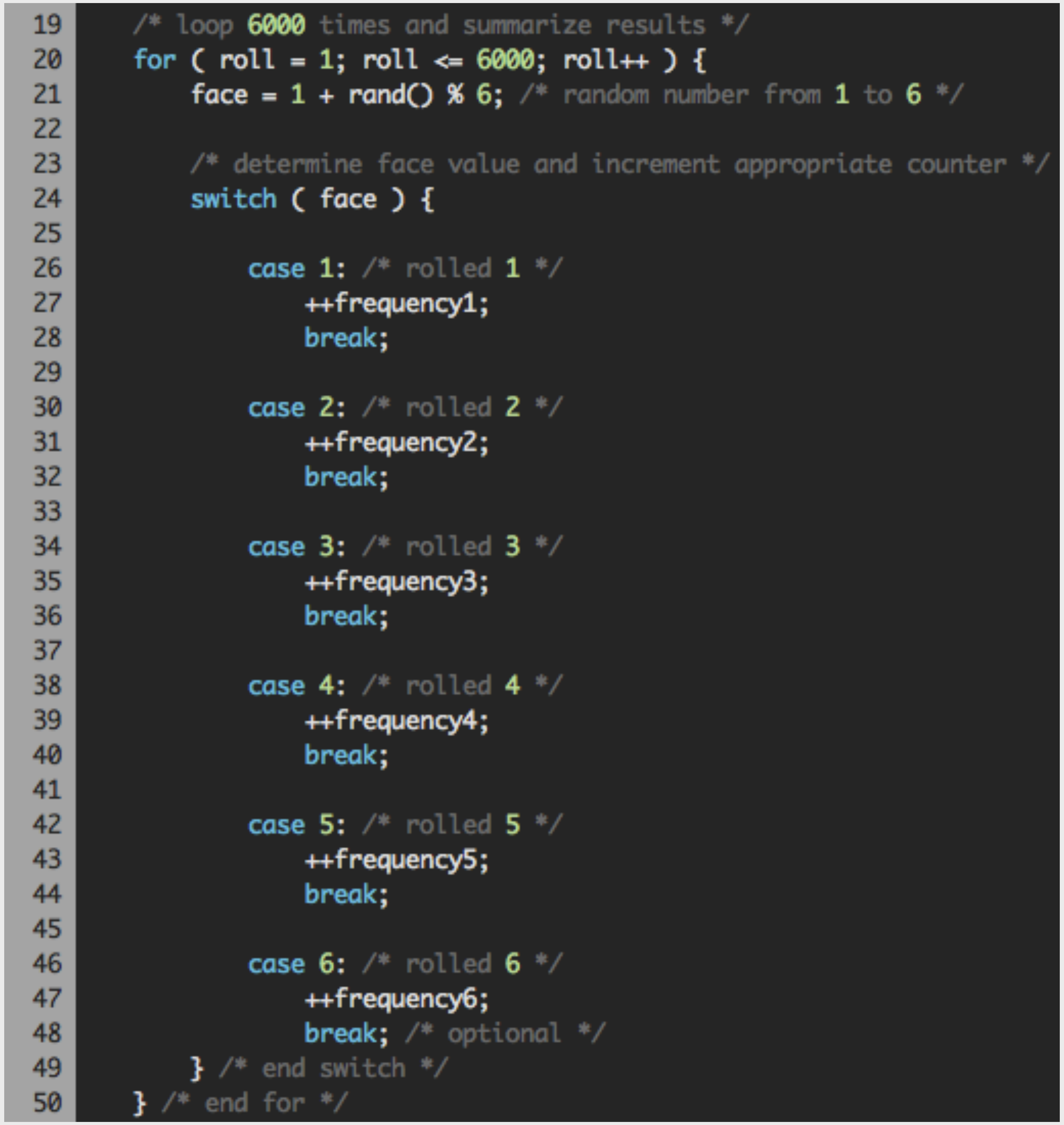
- The function prototype for function **`rand`** is in **`<stdlib.h>`**.
- The **`rand`** function generates an integer between **0 and `RAND_MAX`**
- We use the remainder operator (`%`) in conjunction with rand as follows

```
    rand() % 6
```

  - to produce integers in the **range 0 to 5**.
- This is called **scaling**.
- The number 6 is called the **scaling factor**.

Random Number Generation (Cont.)

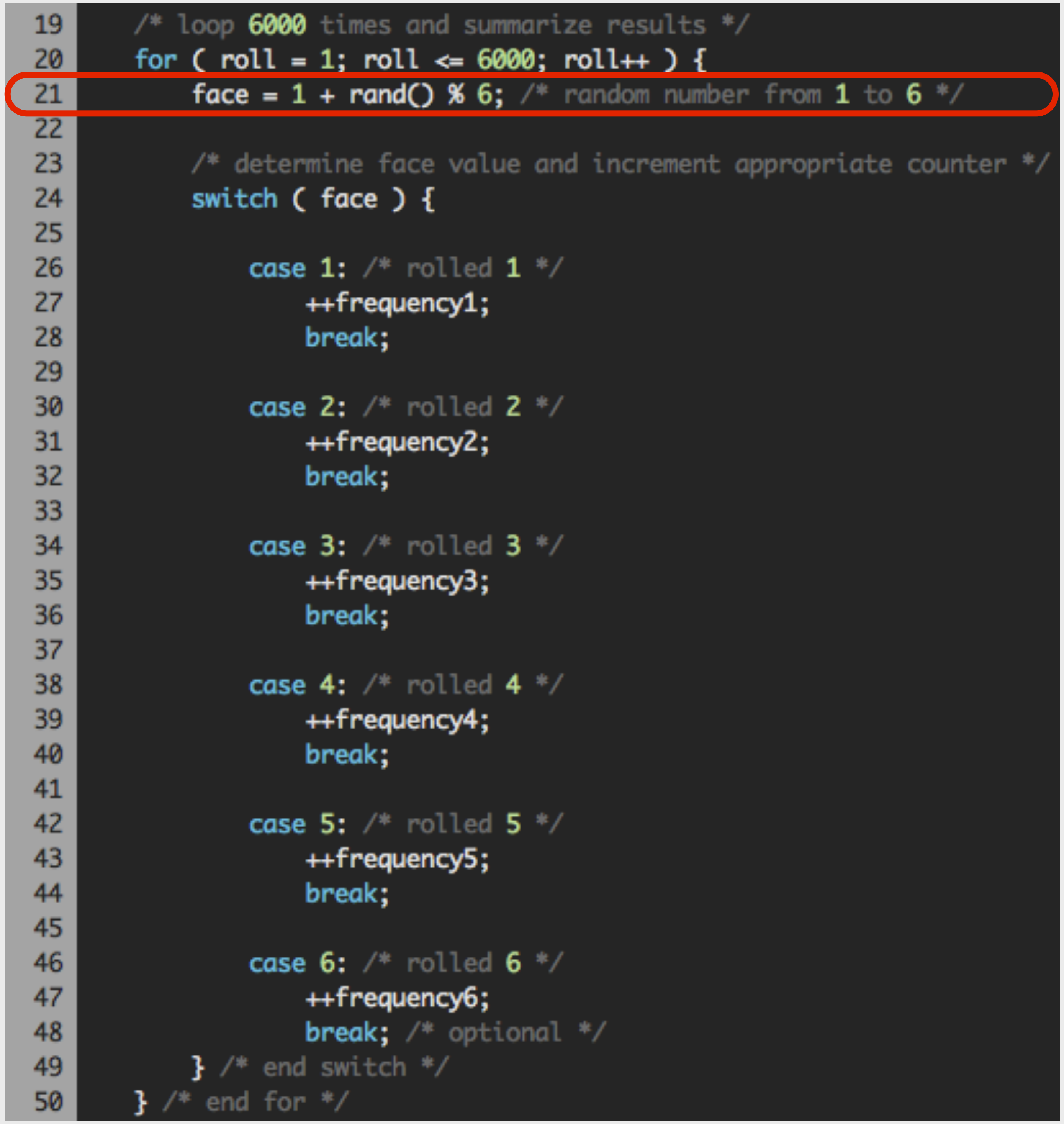
- Example: fig05_08.c



```c
    /* loop 6000 times and summarize results */
    for ( roll = 1; roll <= 6000; roll++ ) {
        face = 1 + rand() % 6; /* random number from 1 to 6 */

        /* determine face value and increment appropriate counter */
        switch ( face ) {

            case 1: /* rolled 1 */
                ++frequency1;
                break;

            case 2: /* rolled 2 */
                ++frequency2;
                break;

            case 3: /* rolled 3 */
                ++frequency3;
                break;

            case 4: /* rolled 4 */
                ++frequency4;
                break;

            case 5: /* rolled 5 */
                ++frequency5;
                break;

            case 6: /* rolled 6 */
                ++frequency6;
                break; /* optional */
        } /* end switch */
    } /* end for */
```

Random Number Generation (Cont.)

- Example: fig05_08.c



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    /* loop 6000 times and summarize results */
    for ( roll = 1; roll <= 6000; roll++ ) {
        face = 1 + rand() % 6; /* random number from 1 to 6 */

        /* determine face value and increment appropriate counter */
        switch ( face ) {

            case 1: /* rolled 1 */
                ++frequency1;
                break;

            case 2: /* rolled 2 */
                ++frequency2;
                break;

            case 3: /* rolled 3 */
                ++frequency3;
                break;

            case 4: /* rolled 4 */
                ++frequency4;
                break;

            case 5: /* rolled 5 */
                ++frequency5;
                break;

            case 6: /* rolled 6 */
                ++frequency6;
                break; /* optional */
        } /* end switch */
    } /* end for */
```

Random Number Generation (Cont.)

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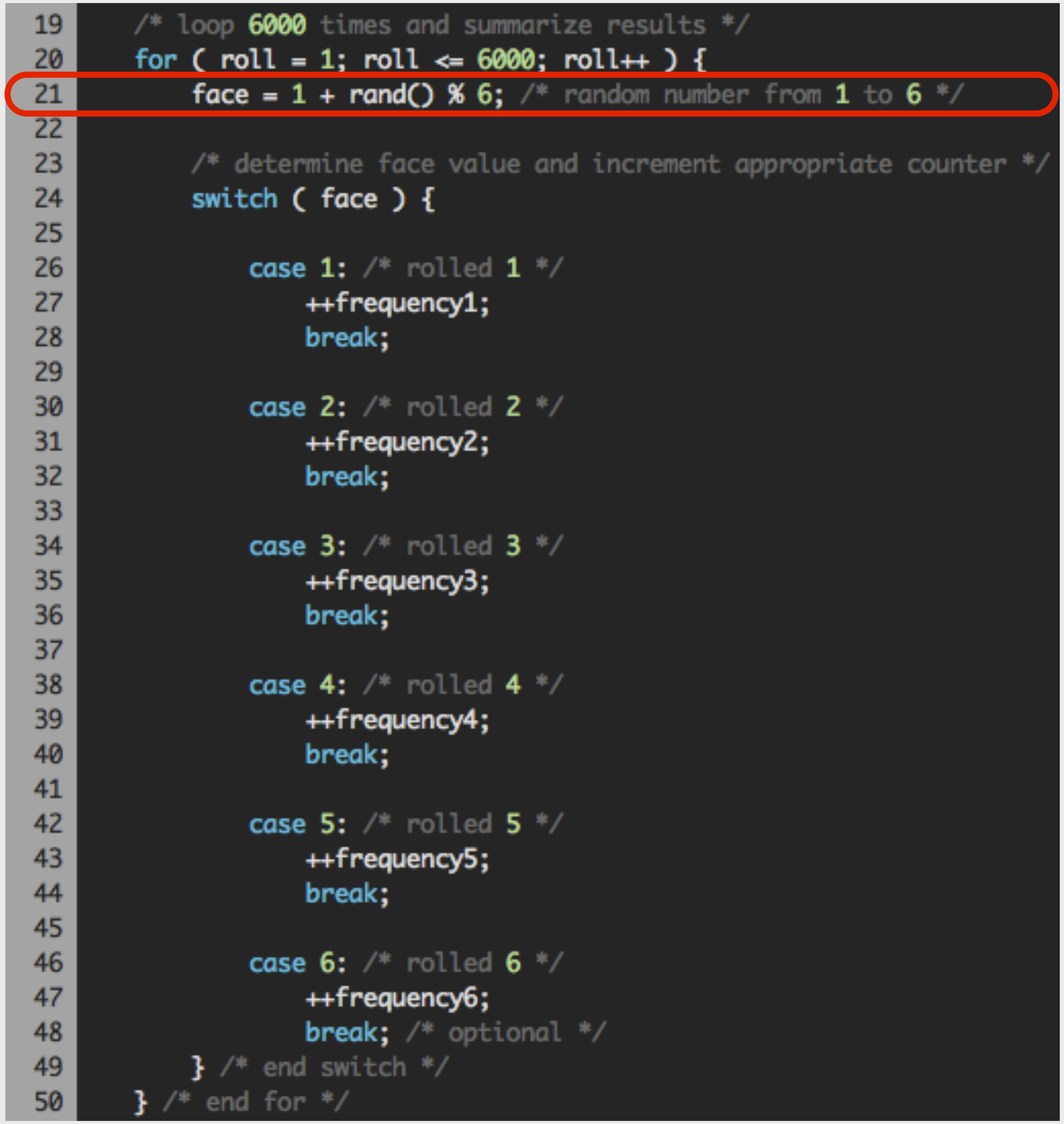

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        /* determine face value and increment appropriate counter */
        switch ( face ) {

            case 1: /* rolled 1 */
                ++frequency1;
                break;

            case 2: /* rolled 2 */
                ++frequency2;
                break;

            case 3: /* rolled 3 */
                ++frequency3;
                break;

            case 4: /* rolled 4 */
                ++frequency4;
                break;

            case 5: /* rolled 5 */
                ++frequency5;
                break;

            case 6: /* rolled 6 */
                ++frequency6;
                break; /* optional */
        } /* end switch */
    } /* end for */
```
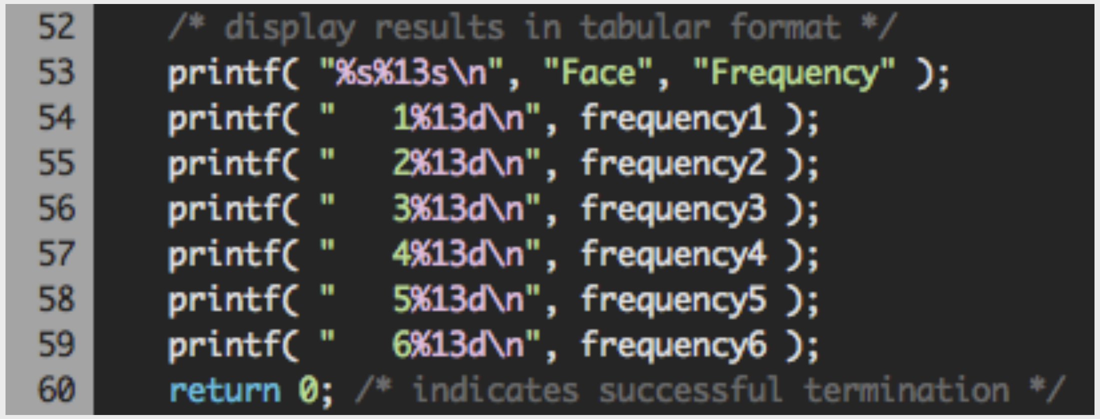



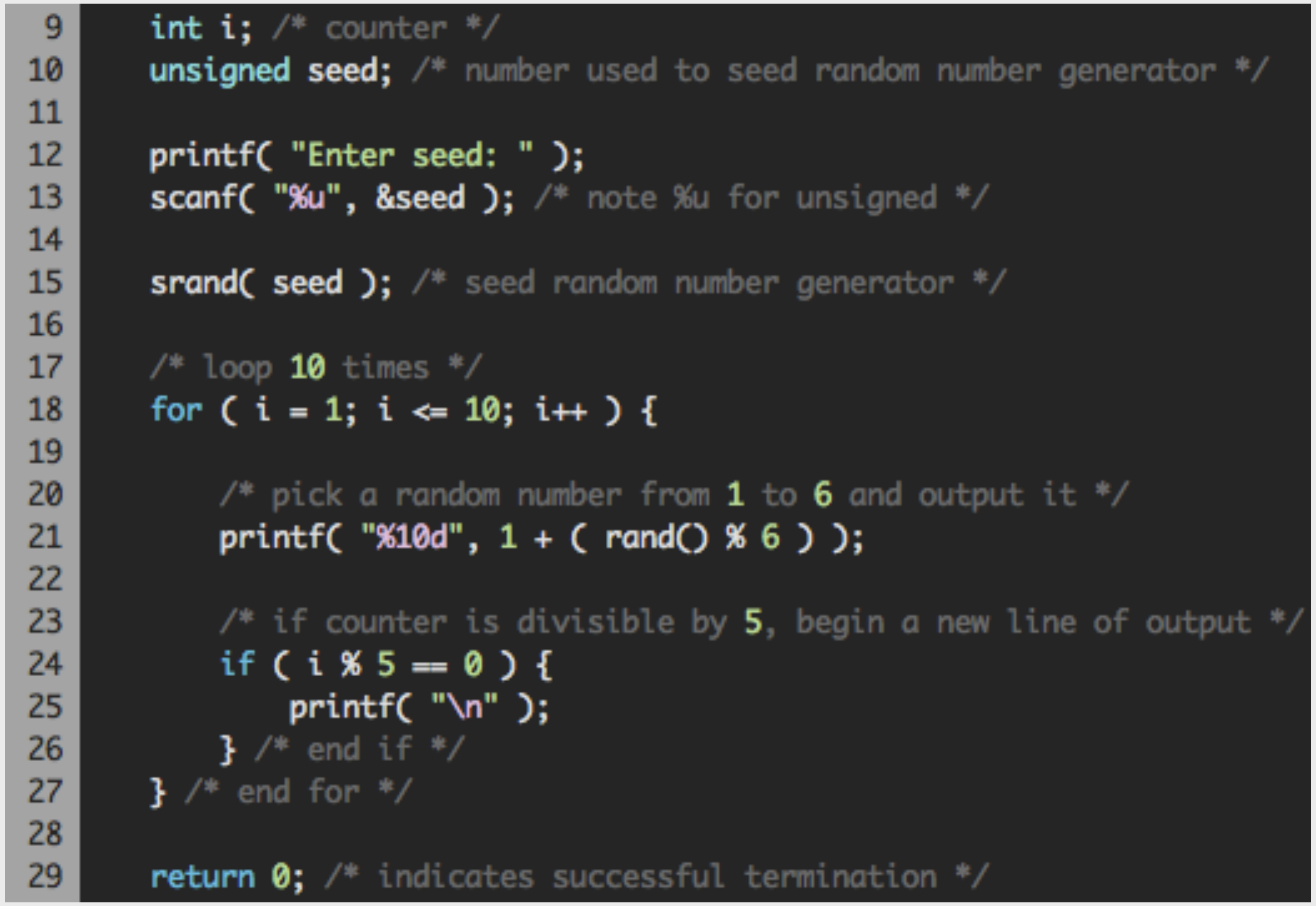
```c
    /* display results in tabular format */
    printf( "%s%13s\n", "Face", "Frequency" );
    printf( "   1%13d\n", frequency1 );
    printf( "   2%13d\n", frequency2 );
    printf( "   3%13d\n", frequency3 );
    printf( "   4%13d\n", frequency4 );
    printf( "   5%13d\n", frequency5 );
    printf( "   6%13d\n", frequency6 );
    return 0; /* indicates successful termination */
```

Random Number Generation (Cont.)

- Executing the program of fig05_07.c again produces **exactly** the same sequence of values.
- How can these be random numbers? Ironically, this repeatability is an important characteristic of function **`rand`**.
  - Calling **`rand`** repeatedly produces a sequence of numbers that appears to be random
- Another randomization is accomplished by **`srand`**

Random Number Generation (Cont.)

- Example: fig05_09.c



```c
    int i; /* counter */
    unsigned seed; /* number used to seed random number generator */

    printf( "Enter seed: " );
    scanf( "%u", &seed ); /* note %u for unsigned */

    srand( seed ); /* seed random number generator */

    /* loop 10 times */
    for ( i = 1; i <= 10; i++ ) {

        /* pick a random number from 1 to 6 and output it */
        printf( "%10d", 1 + ( rand() % 6 ) );

        /* if counter is divisible by 5, begin a new line of output */
        if ( i % 5 == 0 ) {
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        } /* end if */
    } /* end for */

    return 0; /* indicates successful termination */
```
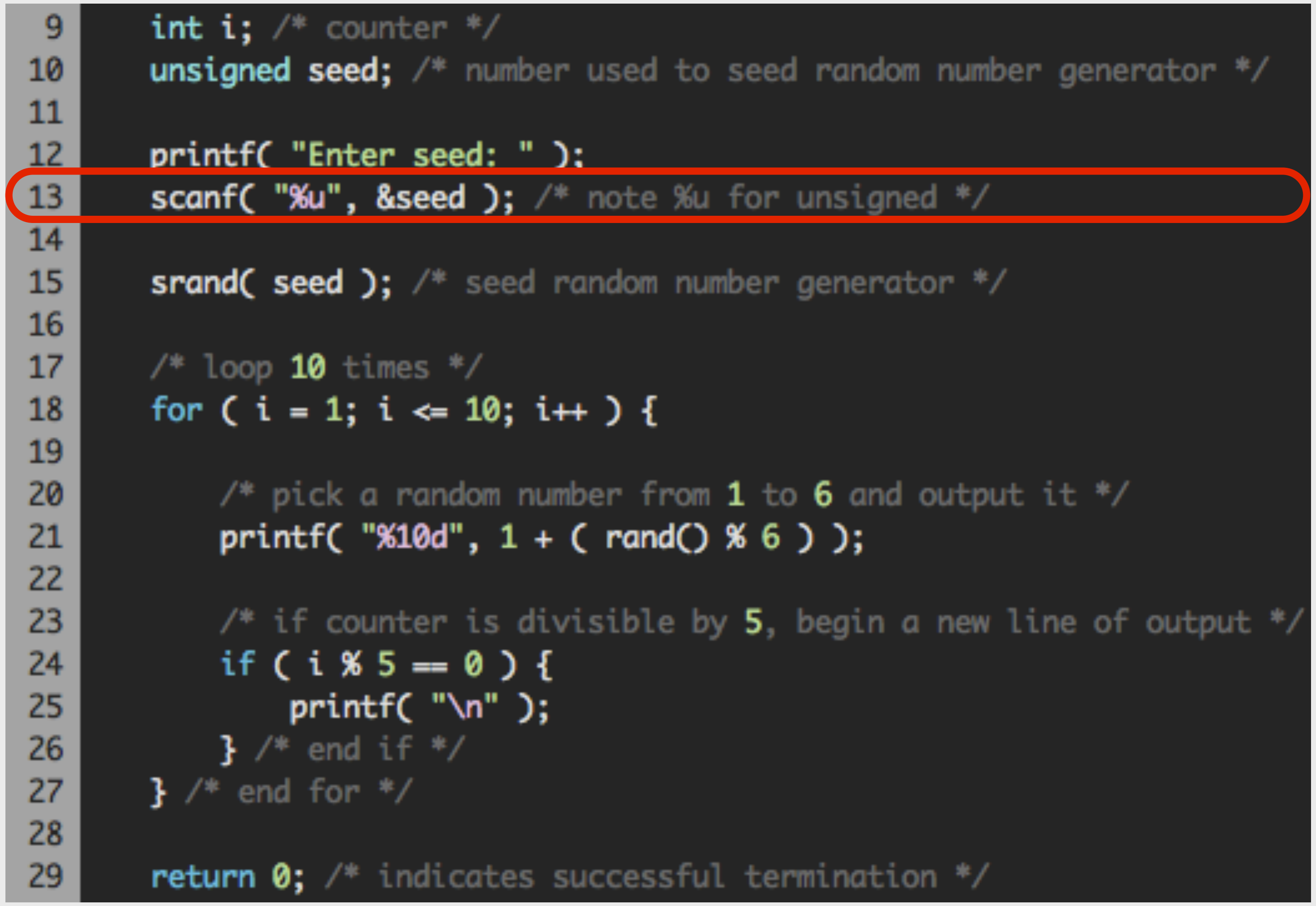

Random Number Generation (Cont.)

- Example: fig05_09.c



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    int i; /* counter */
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    printf( "Enter seed: " );
    scanf( "%u", &seed ); /* note %u for unsigned */

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    /* loop 10 times */
    for ( i = 1; i <= 10; i++ ) {

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        if ( i % 5 == 0 ) {
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        } /* end if */
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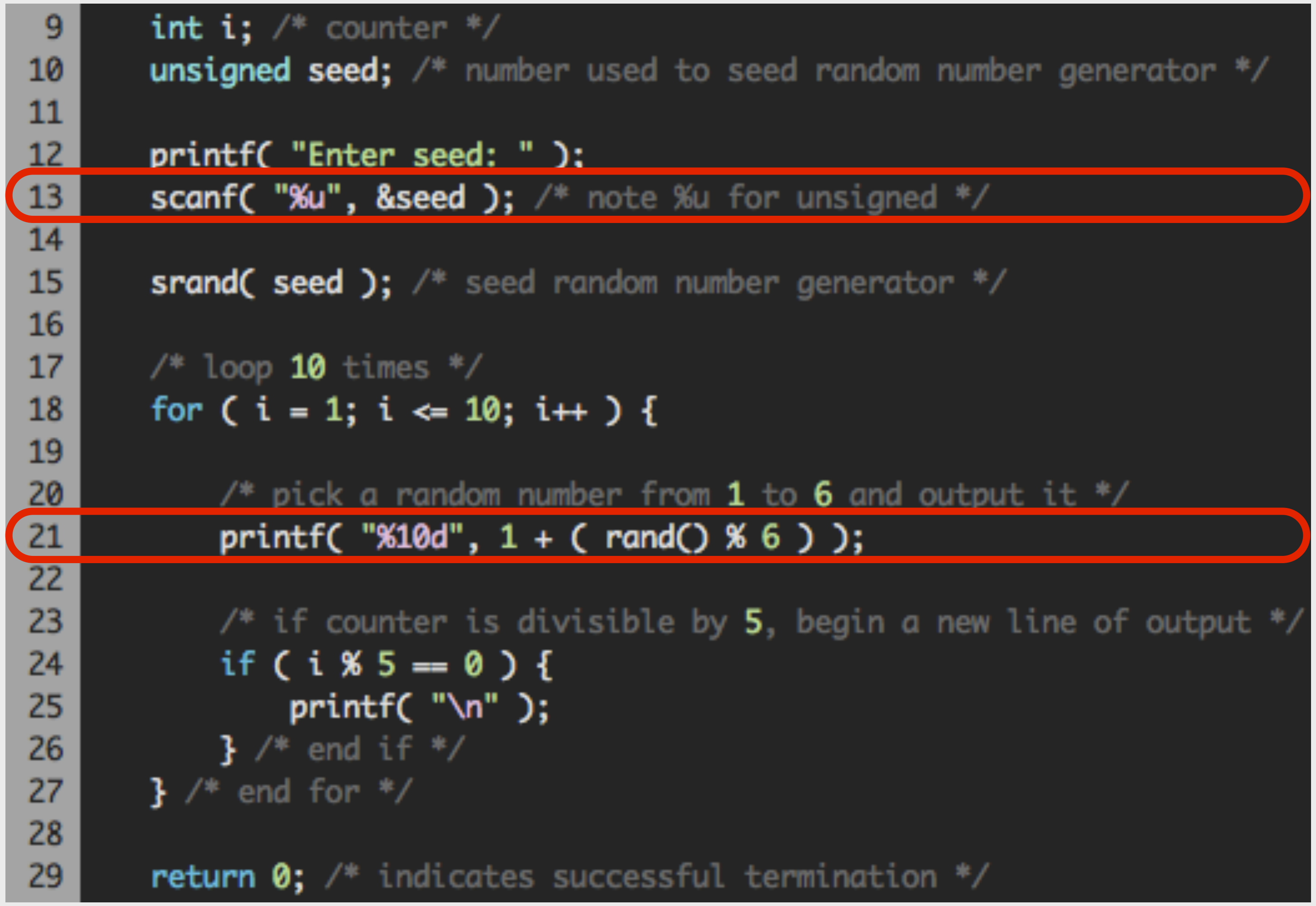
    return 0; /* indicates successful termination */
```

Random Number Generation (Cont.)

- Example: fig05_09.c



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      printf( "%10d", 1 + ( rand() % 6 ) );

      /* if counter is divisible by 5, begin a new line of output */
      if ( i % 5 == 0 ) {
         printf( "\n" );
      } /* end if */
   } /* end for */

   return 0; /* indicates successful termination */
```
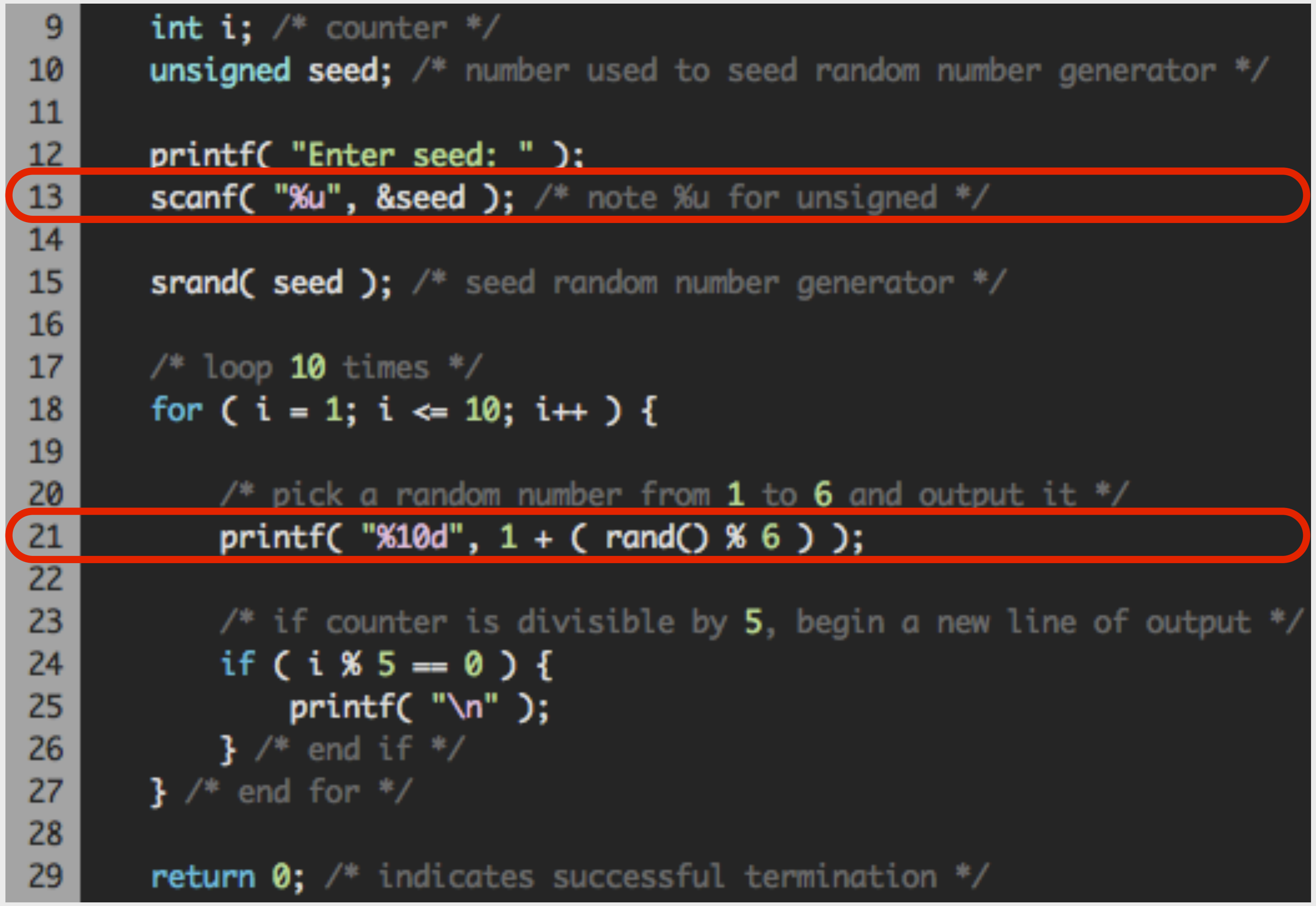

Random Number Generation (Cont.)

- Example: fig05_09.c



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    srand( seed ); /* seed random number generator */

    /* loop 10 times */
    for ( i = 1; i <= 10; i++ ) {

        /* pick a random number from 1 to 6 and output it */
        printf( "%10d", 1 + ( rand() % 6 ) );

        /* if counter is divisible by 5, begin a new line of output */
        if ( i % 5 == 0 ) {
            printf( "\n" );
        } /* end if */
    } /* end for */

    return 0; /* indicates successful termination */
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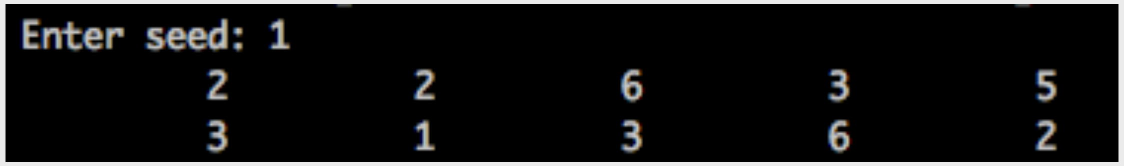
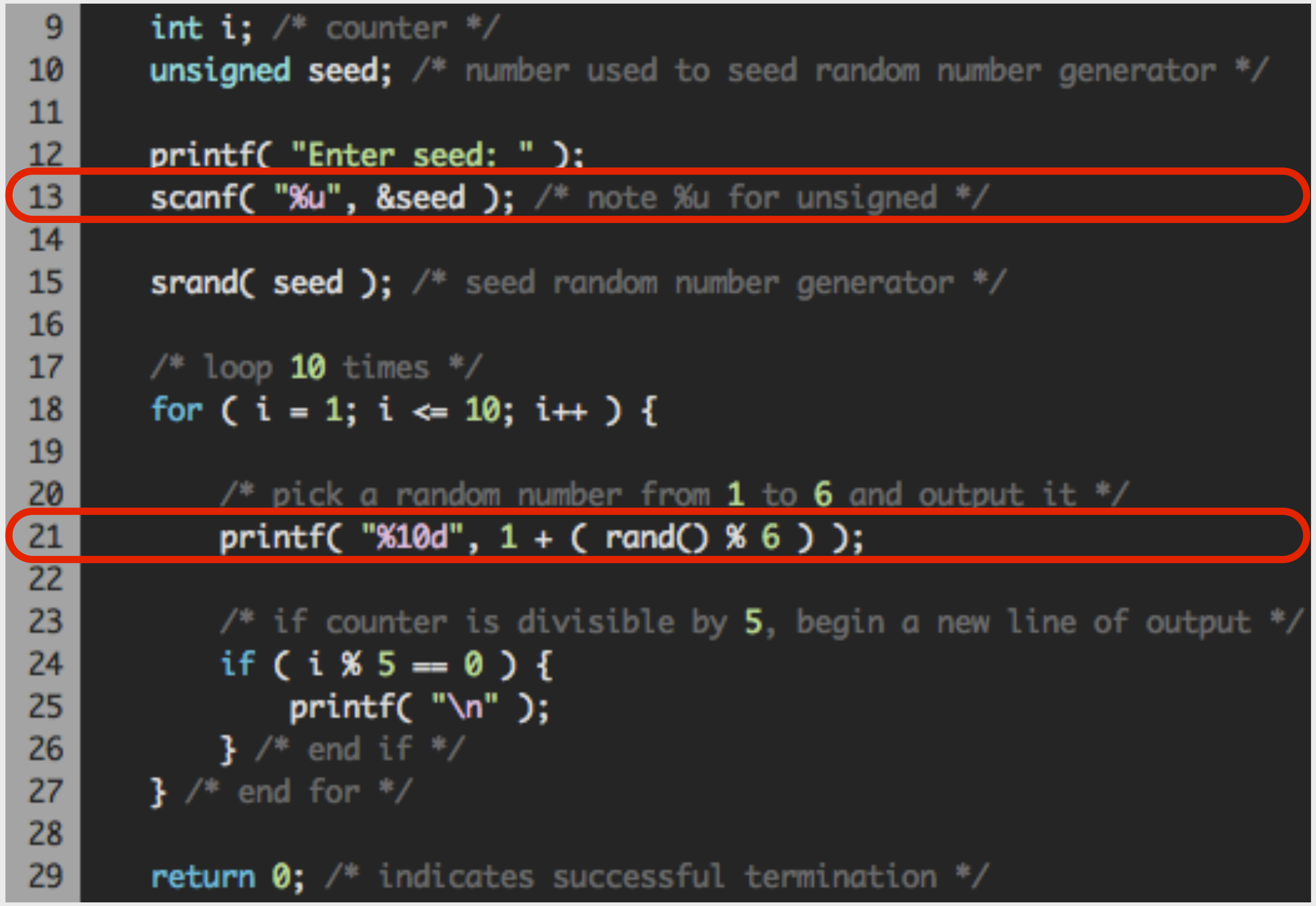


```
Enter seed: 1
         2         2         6         3         5
         3         1         3         6         2
```

Random Number Generation (Cont.)

- Example: fig05_09.c



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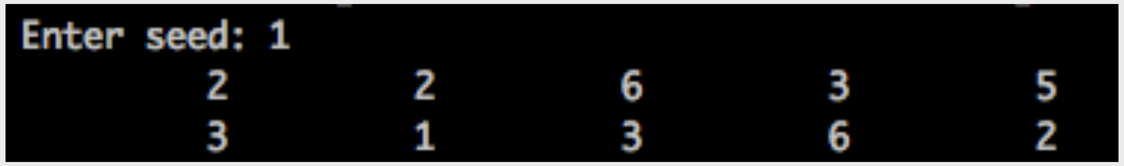

```
Enter seed: 1
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         3         1         3         6         2
```
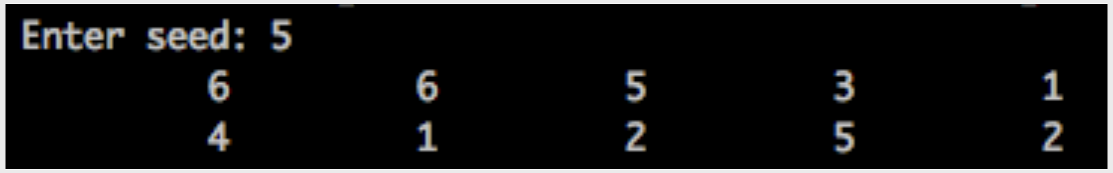



```
Enter seed: 5
         6         6         5         3         1
         4         1         2         5         2
```

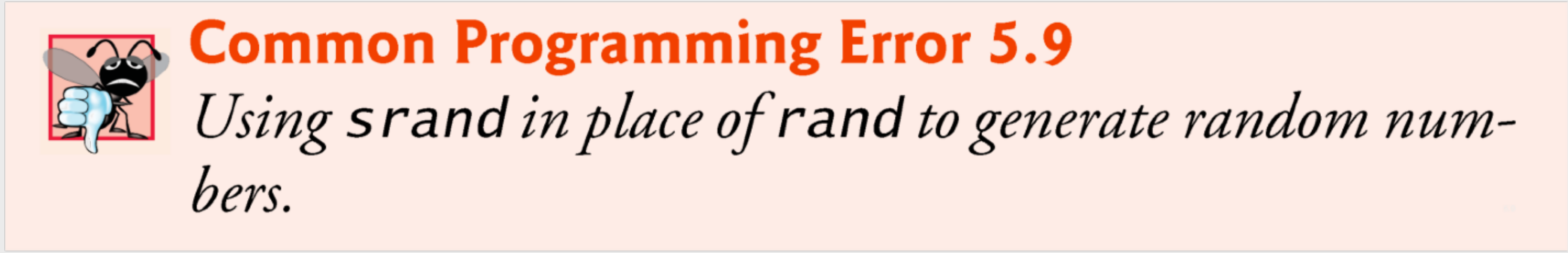
Random Number Generation (Cont.)

- To randomize without entering a seed each time, use a statement like

```
srand( time( NULL ) );
```

  - This causes the computer to read its clock to obtain the value for the seed automatically.
  - Function time takes **`NULL`** as an argument (time is capable of providing you with a string representing the value it returns; **`NULL`** disables this capability for a specific call to time).
  - The function prototype for time is in **`<time.h>`**.

Random Number Generation (Cont.)



Common Programming Error 5.9

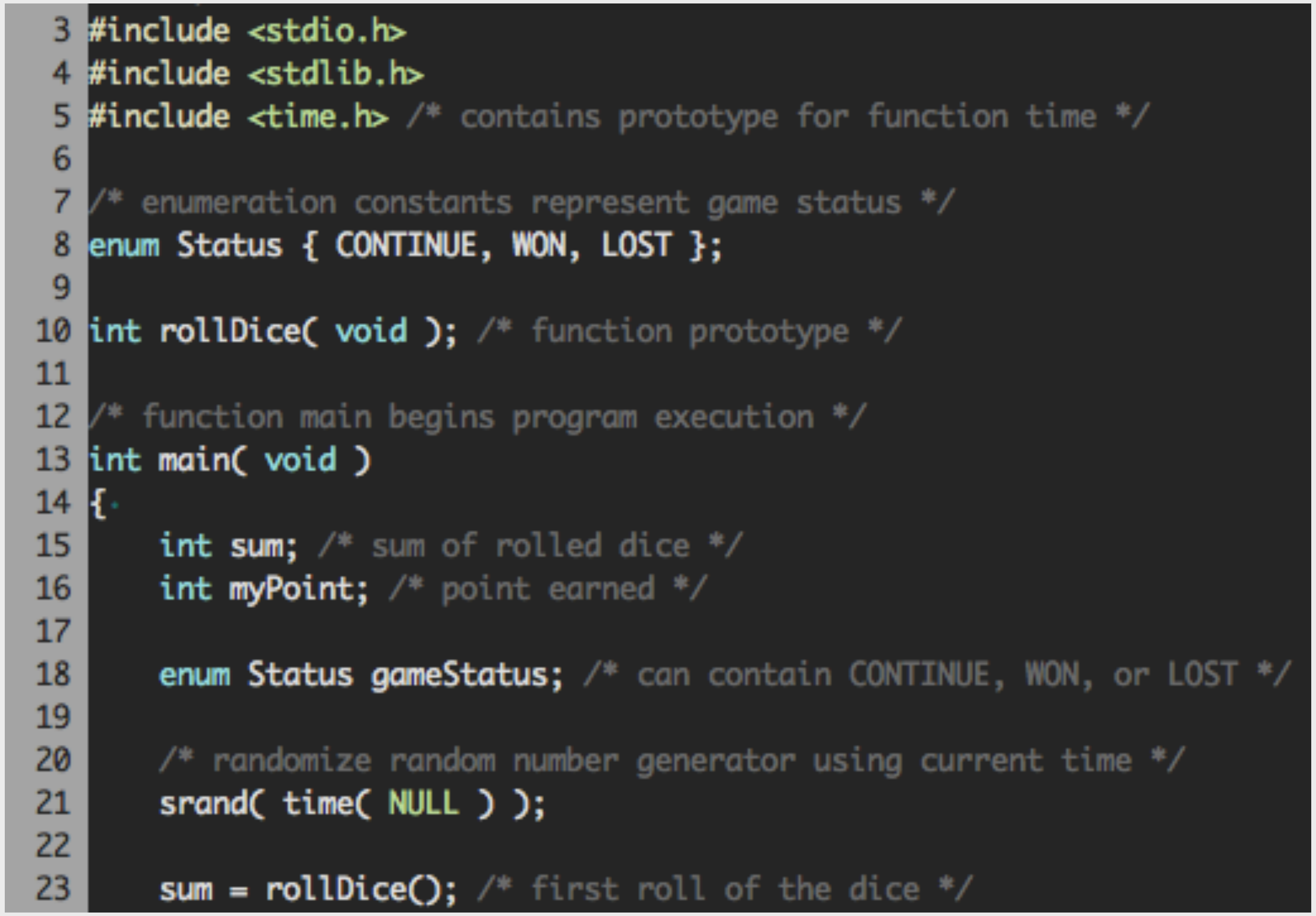
Using `srand` *in place of* `rand` *to generate random numbers.*

Example: A Game of Chance

- One of the most popular games of chance is a dice game known as "**craps**." The rules of the game are simple.
  - A player rolls two dice. Each die has six faces. These faces contain 1, 2, 3, 4, 5, and 6 spots.
  - If the sum is **7 or 11 on the first throw**, the player **wins**.
  - If the sum is **2, 3, or 12 on the first throw**, the player **loses**.
  - If the sum is **4, 5, 6, 8, 9, or 10 on the first throw**, then that sum becomes the player's "point."
    - To **win**, you must continue rolling the dice until you "**make your point**." The player **loses by rolling a 7** before making the point.

Example: A Game of Chance (Cont.)

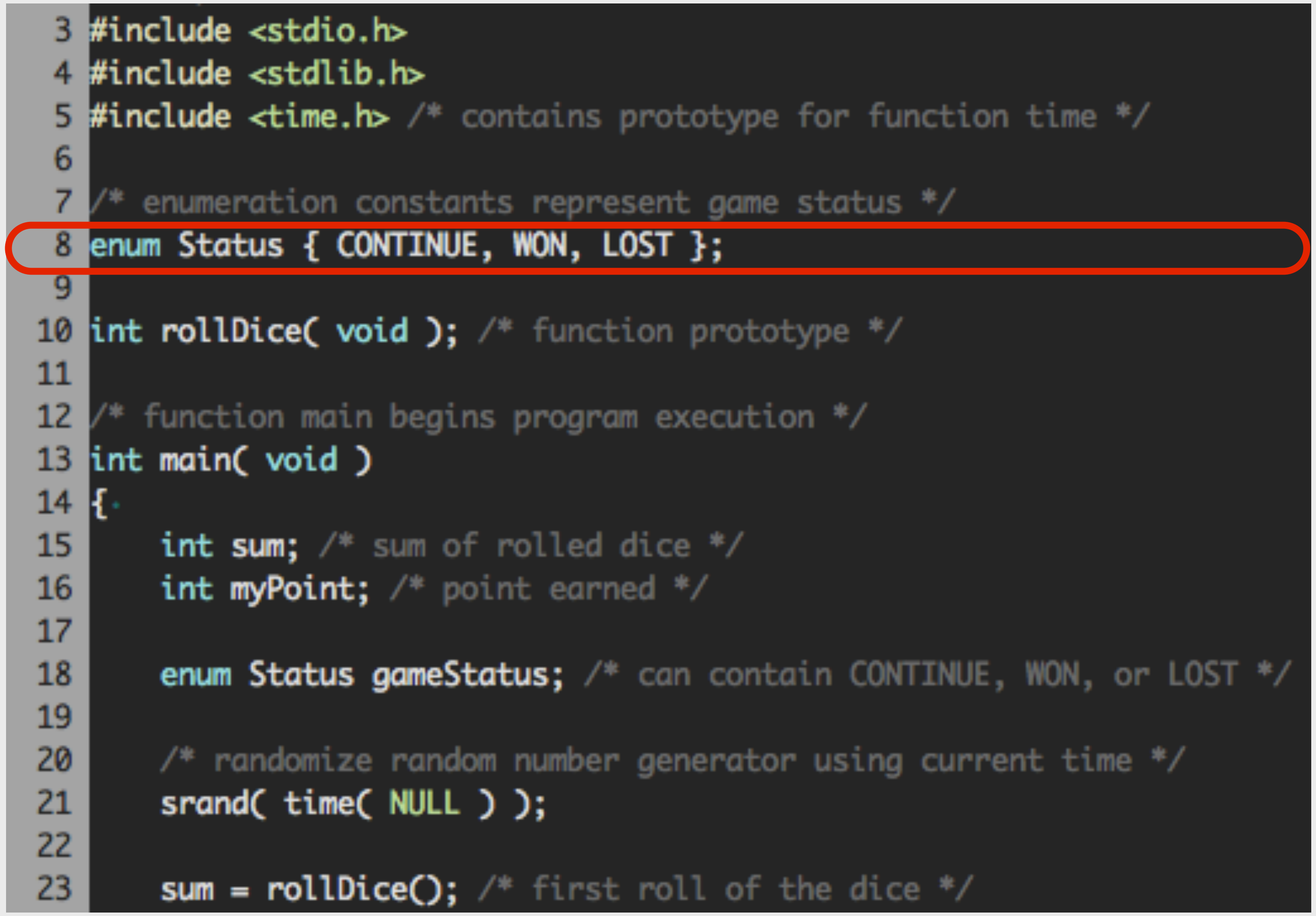
- Example: fig05_10.c



```
#include <stdio.h>
#include <stdlib.h>
#include <time.h> /* contains prototype for function time */

/* enumeration constants represent game status */
enum Status { CONTINUE, WON, LOST };

int rollDice( void ); /* function prototype */

/* function main begins program execution */
int main( void )
{
    int sum; /* sum of rolled dice */
    int myPoint; /* point earned */

    enum Status gameStatus; /* can contain CONTINUE, WON, or LOST */

    /* randomize random number generator using current time */
    srand( time( NULL ) );

    sum = rollDice(); /* first roll of the dice */
```

Example: A Game of Chance (Cont.)

- Example: fig05_10.c



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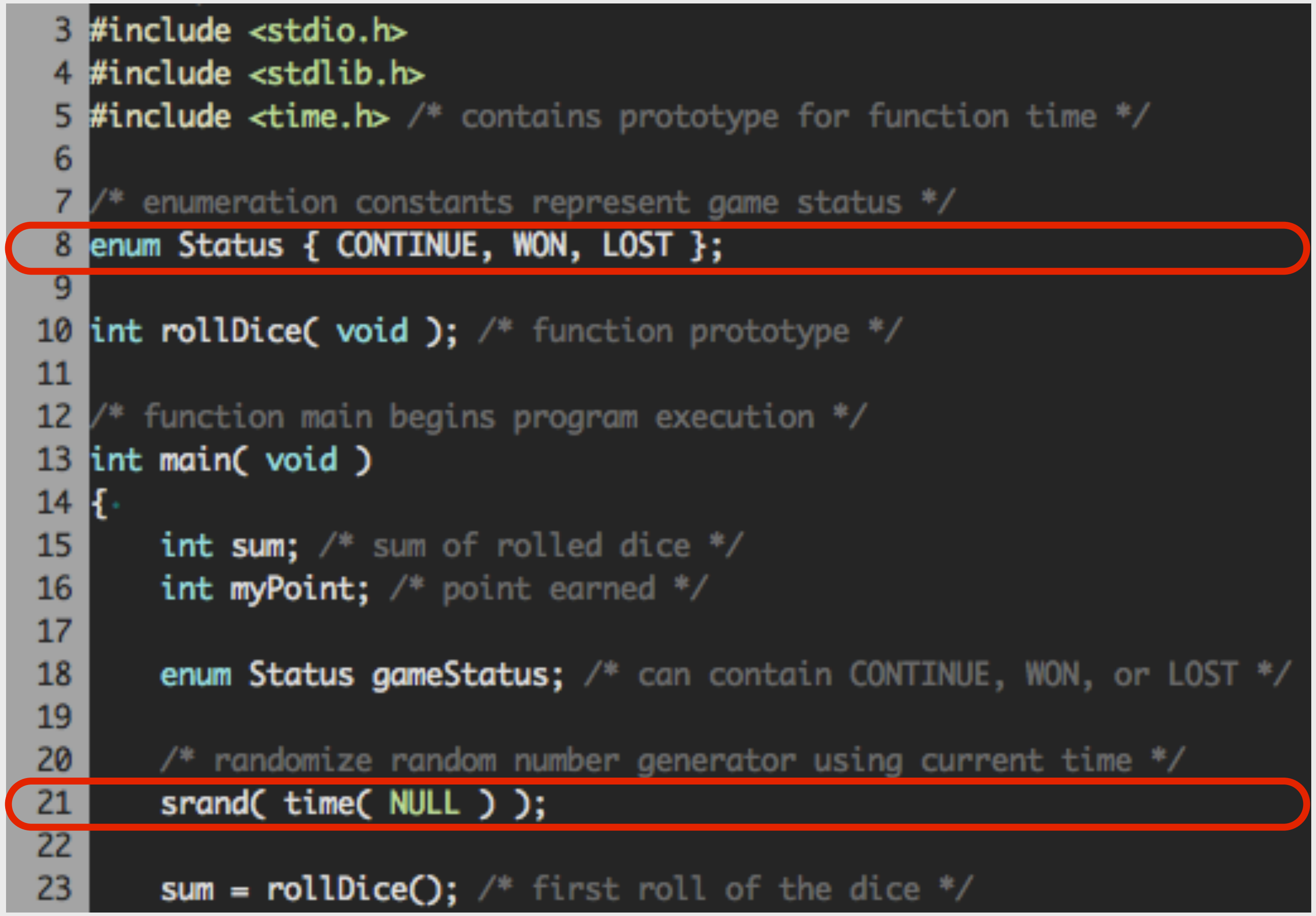

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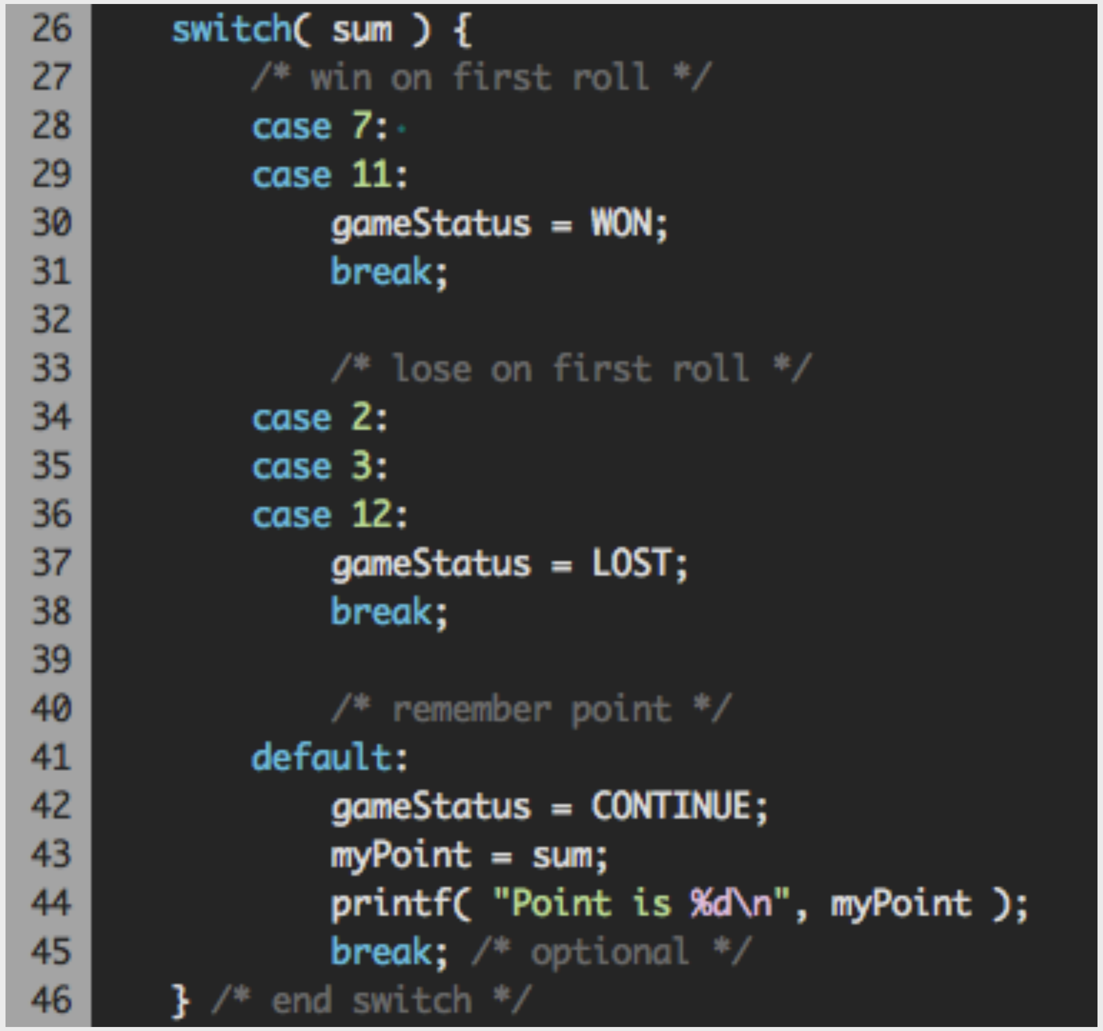
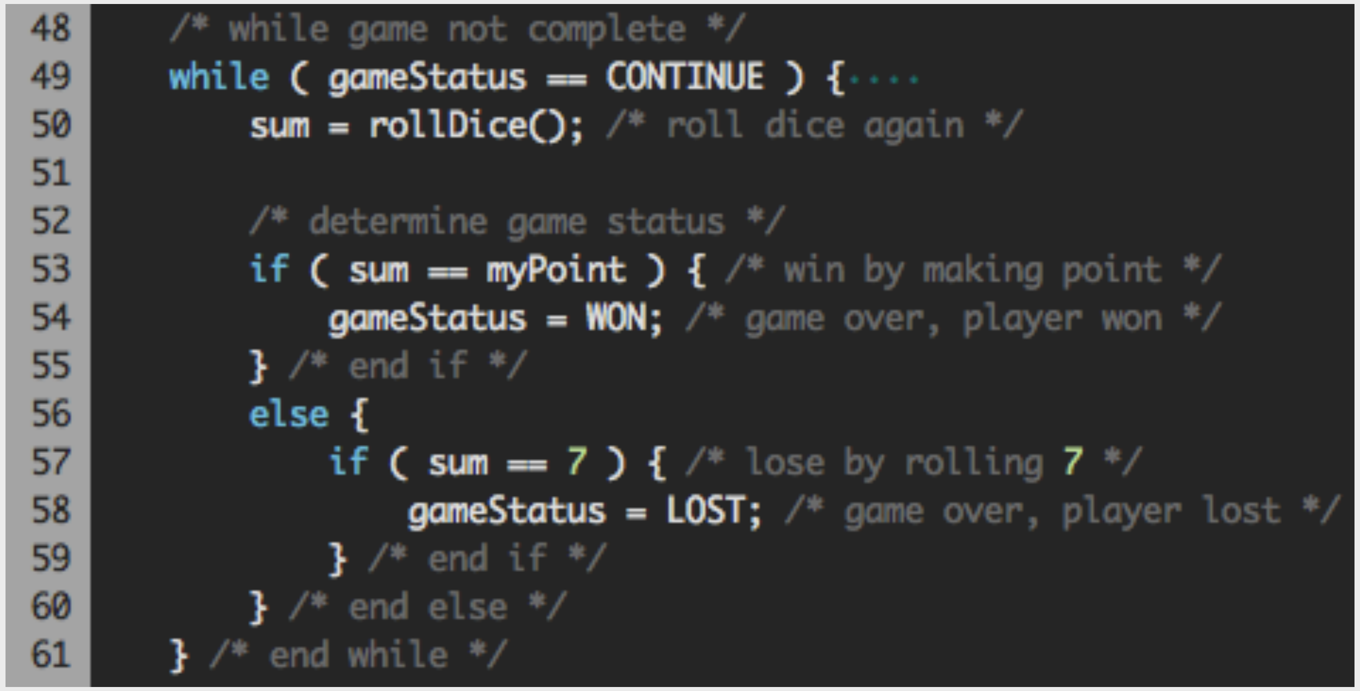


```c
    switch( sum ) {
        /* win on first roll */
        case 7:
        case 11:
            gameStatus = WON;
            break;

            /* lose on first roll */
        case 2:
        case 3:
        case 12:
            gameStatus = LOST;
            break;

            /* remember point */
        default:
            gameStatus = CONTINUE;
            myPoint = sum;
            printf( "Point is %d\n", myPoint );
            break; /* optional */
    } /* end switch */
```

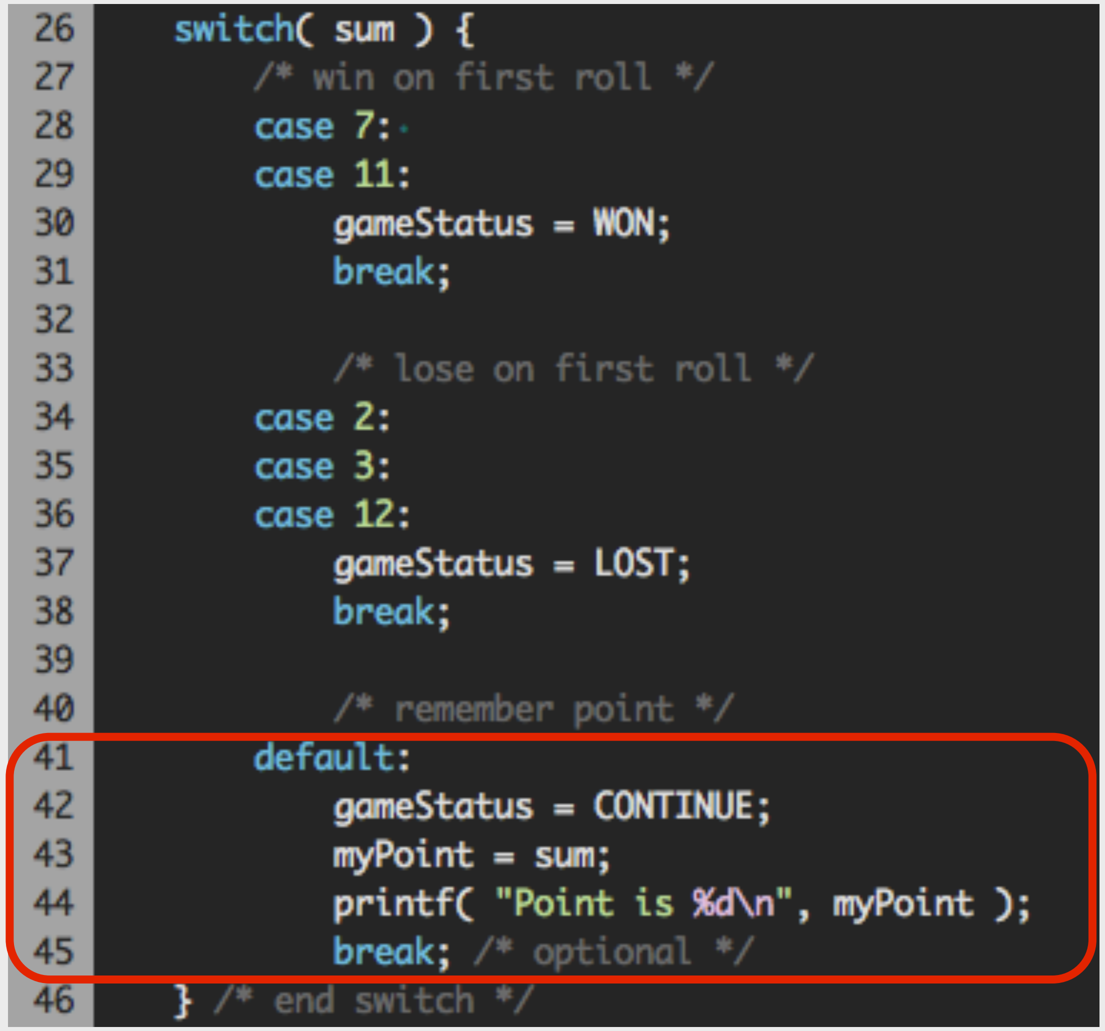


```c
    /* while game not complete */
    while ( gameStatus == CONTINUE ) {
        sum = rollDice(); /* roll dice again */

        /* determine game status */
        if ( sum == myPoint ) { /* win by making point */
            gameStatus = WON; /* game over, player won */
        } /* end if */
        else {
            if ( sum == 7 ) { /* lose by rolling 7 */
                gameStatus = LOST; /* game over, player lost */
            } /* end if */
        } /* end else */
    } /* end while */
```

Example: A Game of Chance (Cont.)

- Example: fig05_10.c



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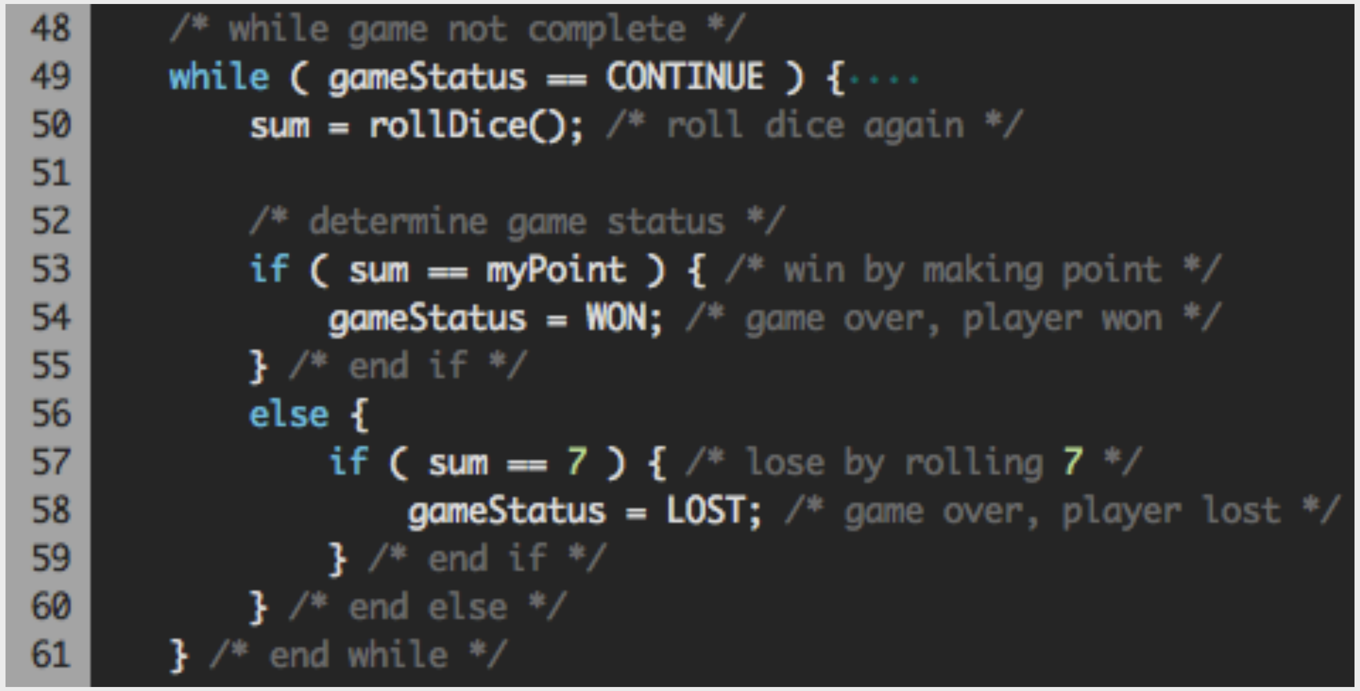

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        if ( sum == myPoint ) { /* win by making point */
            gameStatus = WON; /* game over, player won */
        } /* end if */
        else {
            if ( sum == 7 ) { /* lose by rolling 7 */
                gameStatus = LOST; /* game over, player lost */
            } /* end if */
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Example: A Game of Chance (Cont.)

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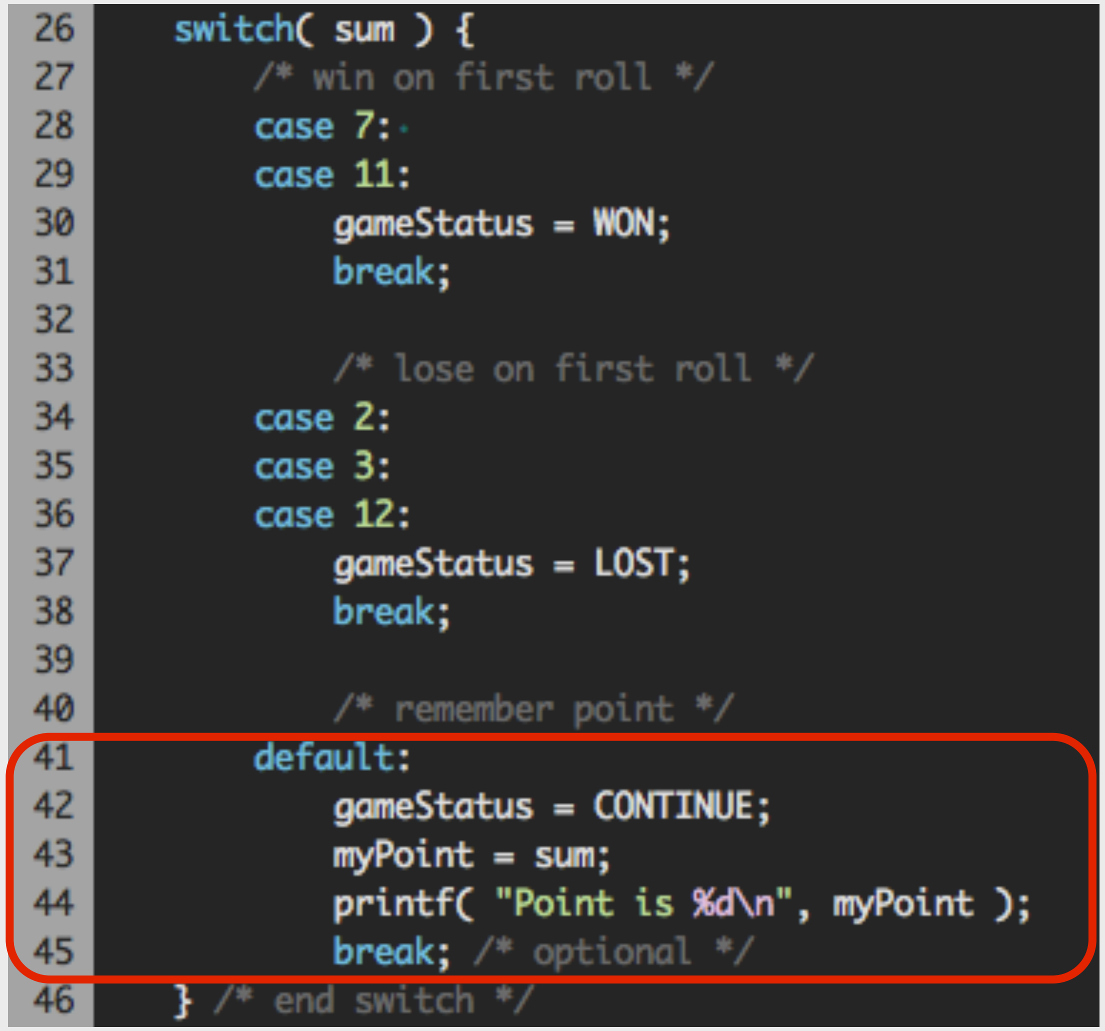

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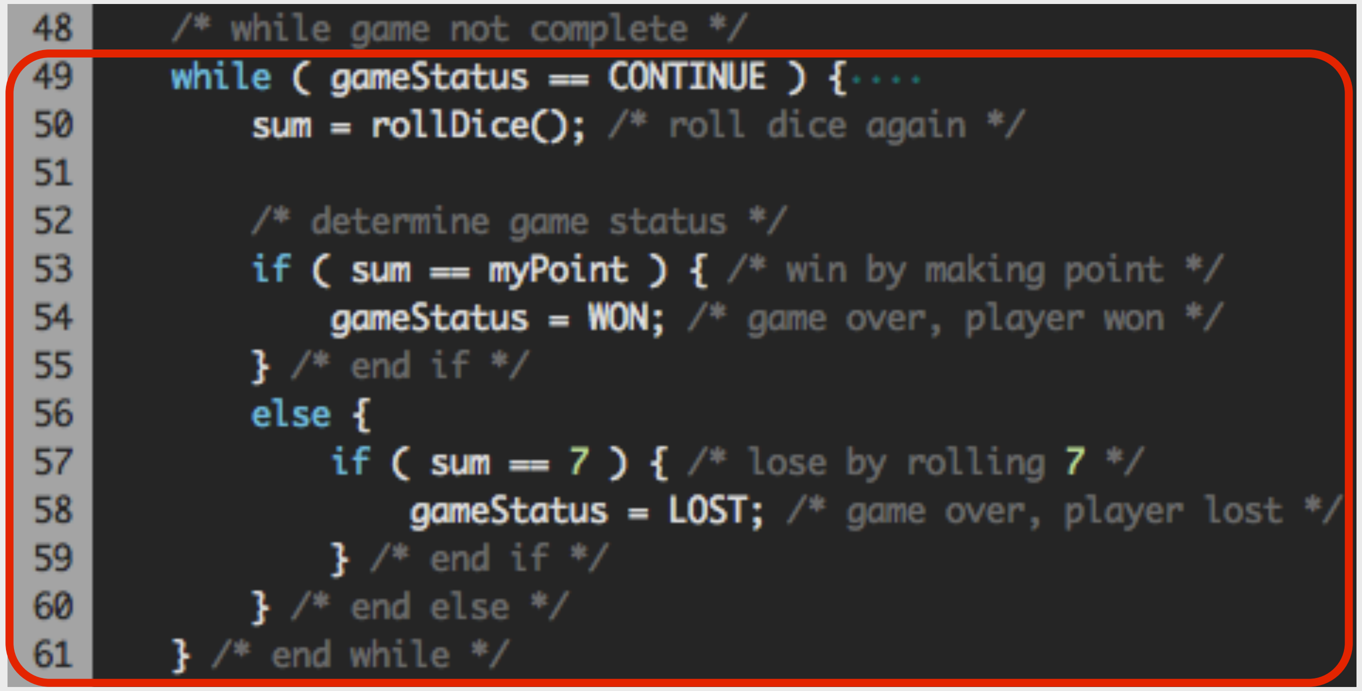
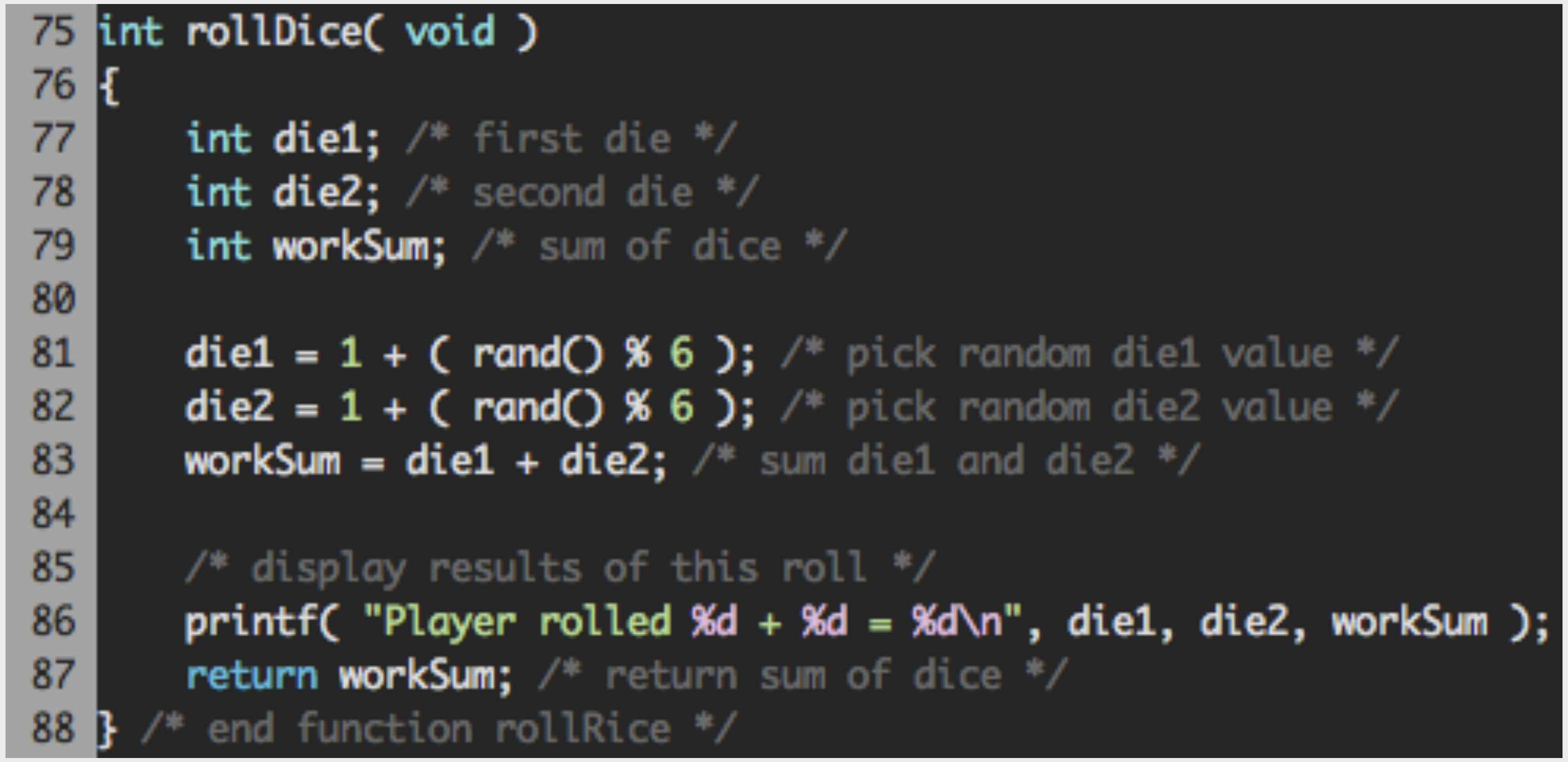
    } /* end switch */
```



```c
    /* while game not complete */
    while ( gameStatus == CONTINUE ) {
        sum = rollDice(); /* roll dice again */

        /* determine game status */
        if ( sum == myPoint ) { /* win by making point */
            gameStatus = WON; /* game over, player won */
        } /* end if */
        else {
            if ( sum == 7 ) { /* lose by rolling 7 */
                gameStatus = LOST; /* game over, player lost */
            } /* end if */
        } /* end else */
    } /* end while */
```

Example: A Game of Chance (Cont.)

- Example: fig05_10.c



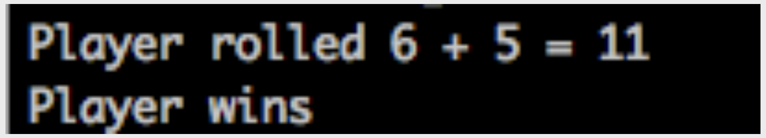
```c
int rollDice( void )
{
    int die1; /* first die */
    int die2; /* second die */
    int workSum; /* sum of dice */

    die1 = 1 + ( rand() % 6 ); /* pick random die1 value */
    die2 = 1 + ( rand() % 6 ); /* pick random die2 value */
    workSum = die1 + die2; /* sum die1 and die2 */

    /* display results of this roll */
    printf( "Player rolled %d + %d = %d\n", die1, die2, workSum );
    return workSum; /* return sum of dice */
} /* end function rollRice */
```

Example: A Game of Chance (Cont.)

- Example: fig05_10.c

Example: A Game of Chance (Cont.)

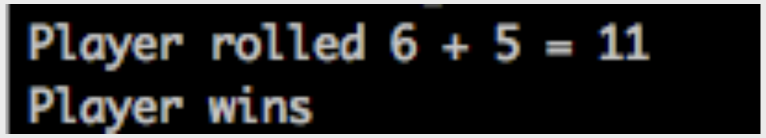
- Example: fig05_10.c



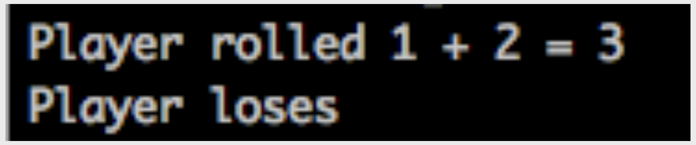
```
Player rolled 6 + 5 = 11
Player wins
```

Example: A Game of Chance (Cont.)

- Example: fig05_10.c



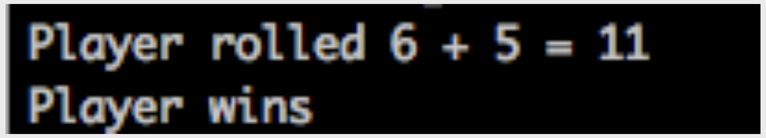
```
Player rolled 6 + 5 = 11
Player wins
```



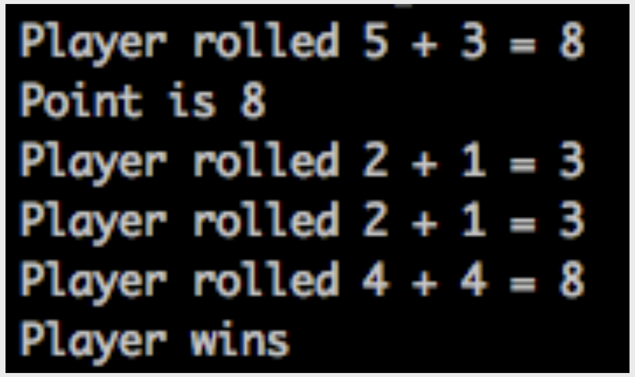
```
Player rolled 1 + 2 = 3
Player loses
```

Example: A Game of Chance (Cont.)

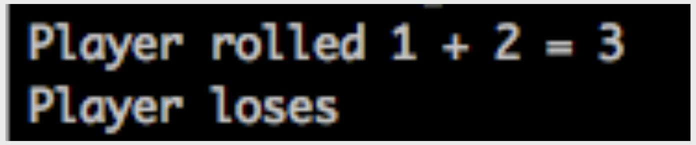
- Example: fig05_10.c



```
Player rolled 6 + 5 = 11
Player wins
```



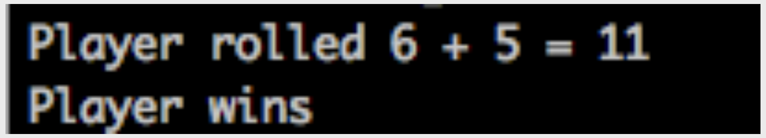
```
Player rolled 5 + 3 = 8
Point is 8
Player rolled 2 + 1 = 3
Player rolled 2 + 1 = 3
Player rolled 4 + 4 = 8
Player wins
```



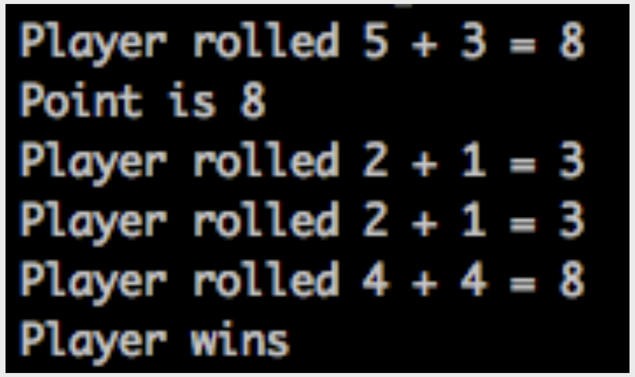
```
Player rolled 1 + 2 = 3
Player loses
```

Example: A Game of Chance (Cont.)

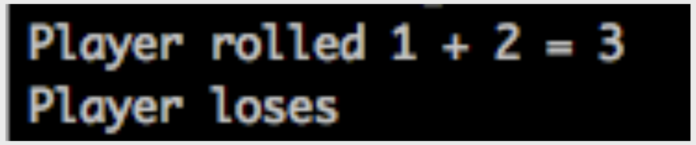
- Example: fig05_10.c



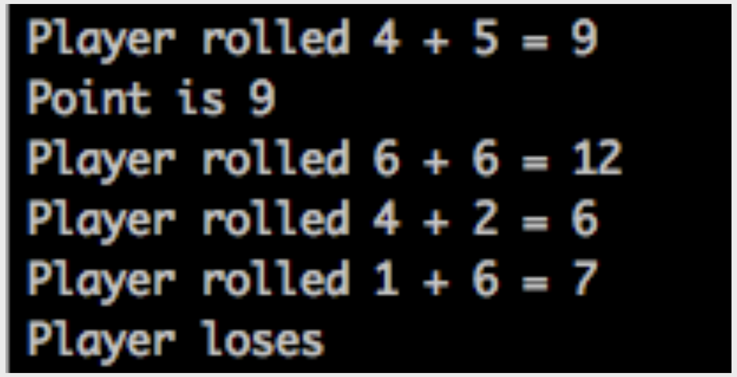
```
Player rolled 6 + 5 = 11
Player wins
```



```
Player rolled 5 + 3 = 8
Point is 8
Player rolled 2 + 1 = 3
Player rolled 2 + 1 = 3
Player rolled 4 + 4 = 8
Player wins
```



```
Player rolled 1 + 2 = 3
Player loses
```



```
Player rolled 4 + 5 = 9
Point is 9
Player rolled 6 + 6 = 12
Player rolled 4 + 2 = 6
Player rolled 1 + 6 = 7
Player loses
```

Example: A Game of Chance (Cont.)

- An enumeration, introduced by the keyword **`enum`**, is a set of integer constants represented by identifiers.
    - Enumeration constants are sometimes called **symbolic constants**.
    - The constant **`CONTINUE`** has the value 0, **`WON`** has the value 1 and **`LOST`** has the value 2.
    - It’s also possible to assign an integer value to each identifier in an enum (see Chapter 10).

Storage Classes

- Actually, each identifier in a program has other attributes, including **storage class**, **storage duration**, **scope** and **linkage**.
  - **storage class** determines its storage duration, scope and linkage.
  - **storage duration** is the period during which the identifier exists in memory.
  - **scope** is where the identifier can be referenced in a program.
  - **linkage** determines for a multiple-source-file program

Storage Classes (Cont.)

- An identifier’s **scope** is where the identifier can be referenced in a program.
- An identifier’s **linkage** determines for a **multiple-source-file program**
- This section discusses **storage classes** and **storage duration**. (Chap 5.12)

Storage Classes (Cont.)

- The four storage-class specifiers can be split into two storage durations: **automatic storage duration** and **static storage duration**.

- Keywords **auto** and **register** are used to declare variables of **automatic storage duration**.

Storage Classes (Cont.)

- A function's **local variables** (those declared in the parameter list or function body) normally have **automatic** storage duration.
- Local variables have automatic storage duration **by default**, so keyword **auto** is rarely used.
- For example

  auto double x, y;

Storage Classes (Cont.)

- **register** variables
  - Loaded into registers for calculations and other processing.
  - The following declaration suggests that the integer variable counter be placed in one of the computer's registers and initialized to 1:

    register int counter = 1;

Storage Classes (Cont.)

- Keywords **extern** and **static** are used in the declarations of identifiers for variables and functions of **static storage duration.**
  - Identifiers of static storage duration exist from the time at which the program begins execution.
  - For static variables, storage is allocated and initialized once, when the program begins execution. For example:

    static int count = 1;
- In Chapter 14 we discuss the explicit use of **extern** and **static** with **external identifiers** and **multiple-source-file programs**.

Scope Rules

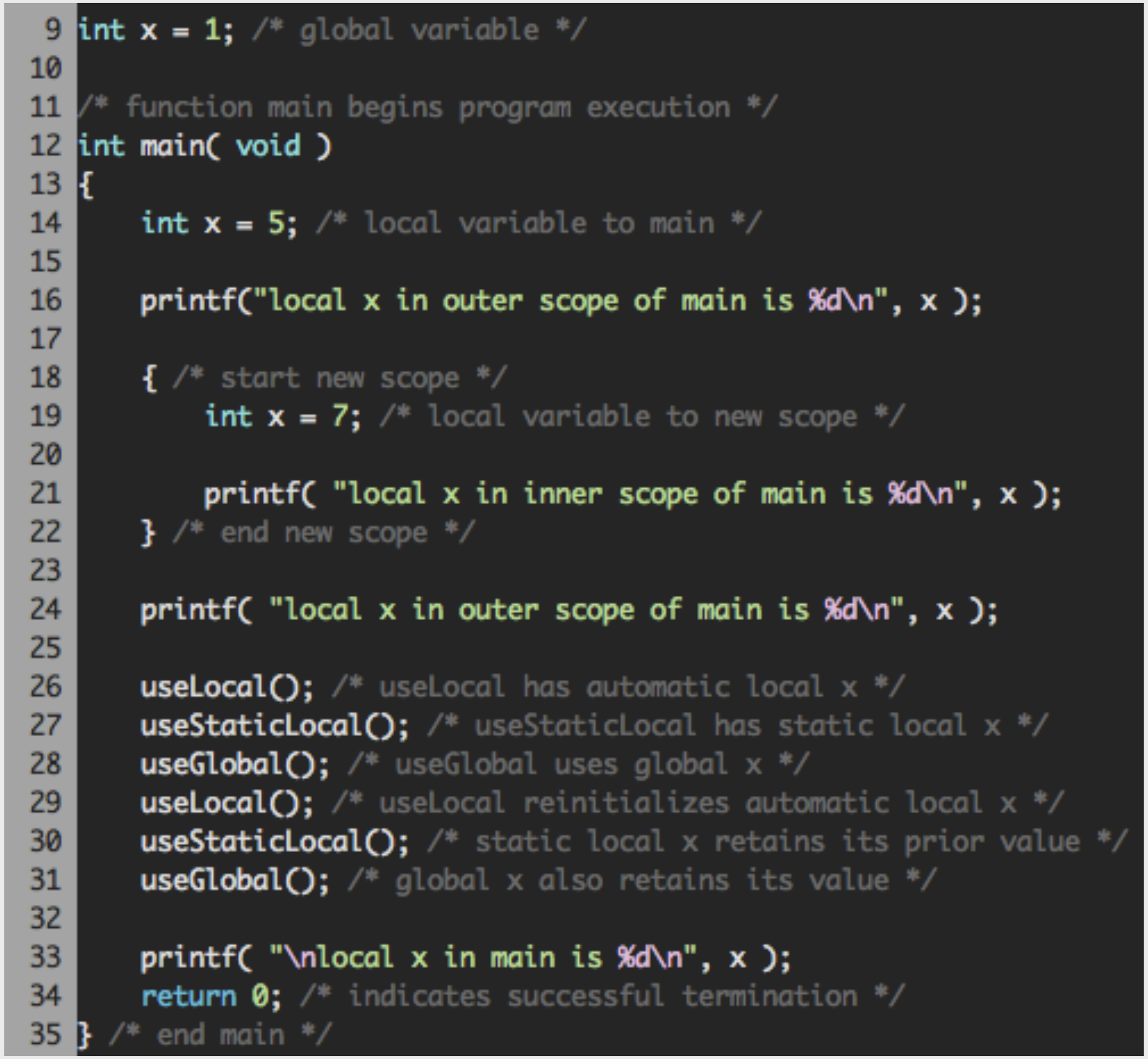
- The four identifier scopes are
  - function scope
  - file scope
  - block scope
  - function-prototype scope

Scope Rules (Cont.)

- Labels (an identifier followed by a colon such as **start:**) are the only identifiers with **function scope**.
- An identifier declared outside any function has **file scope**.
- Identifiers defined inside a block ({}) have **block scope**.
- The only identifiers with **function-prototype scope** are those used in the parameter list of a function prototype.

Scope Rules (Cont.)

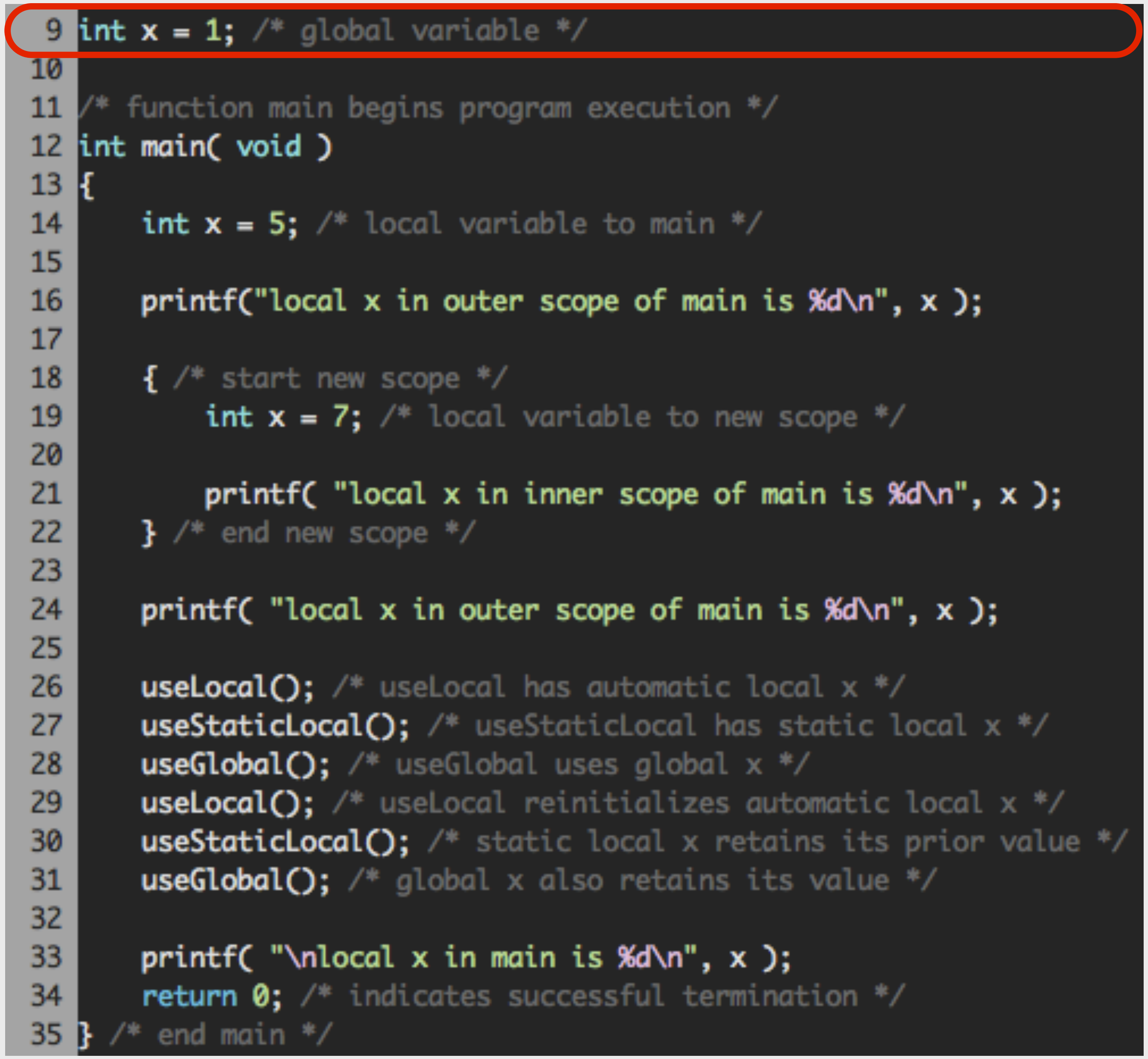
- Example: fig05_12.c



```c
int x = 1; /* global variable */

/* function main begins program execution */
int main( void )
{
    int x = 5; /* local variable to main */

    printf("local x in outer scope of main is %d\n", x );

    { /* start new scope */
        int x = 7; /* local variable to new scope */

        printf( "local x in inner scope of main is %d\n", x );
    } /* end new scope */

    printf( "local x in outer scope of main is %d\n", x );

    useLocal(); /* useLocal has automatic local x */
    useStaticLocal(); /* useStaticLocal has static local x */
    useGlobal(); /* useGlobal uses global x */
    useLocal(); /* useLocal reinitializes automatic local x */
    useStaticLocal(); /* static local x retains its prior value */
    useGlobal(); /* global x also retains its value */

    printf( "\nlocal x in main is %d\n", x );
    return 0; /* indicates successful termination */
} /* end main */
```

Scope Rules (Cont.)

- Example: fig05_12.c



```c
int x = 1; /* global variable */

/* function main begins program execution */
int main( void )
{
    int x = 5; /* local variable to main */

    printf("local x in outer scope of main is %d\n", x );

    { /* start new scope */
        int x = 7; /* local variable to new scope */

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    printf( "\nlocal x in main is %d\n", x );
    return 0; /* indicates successful termination */
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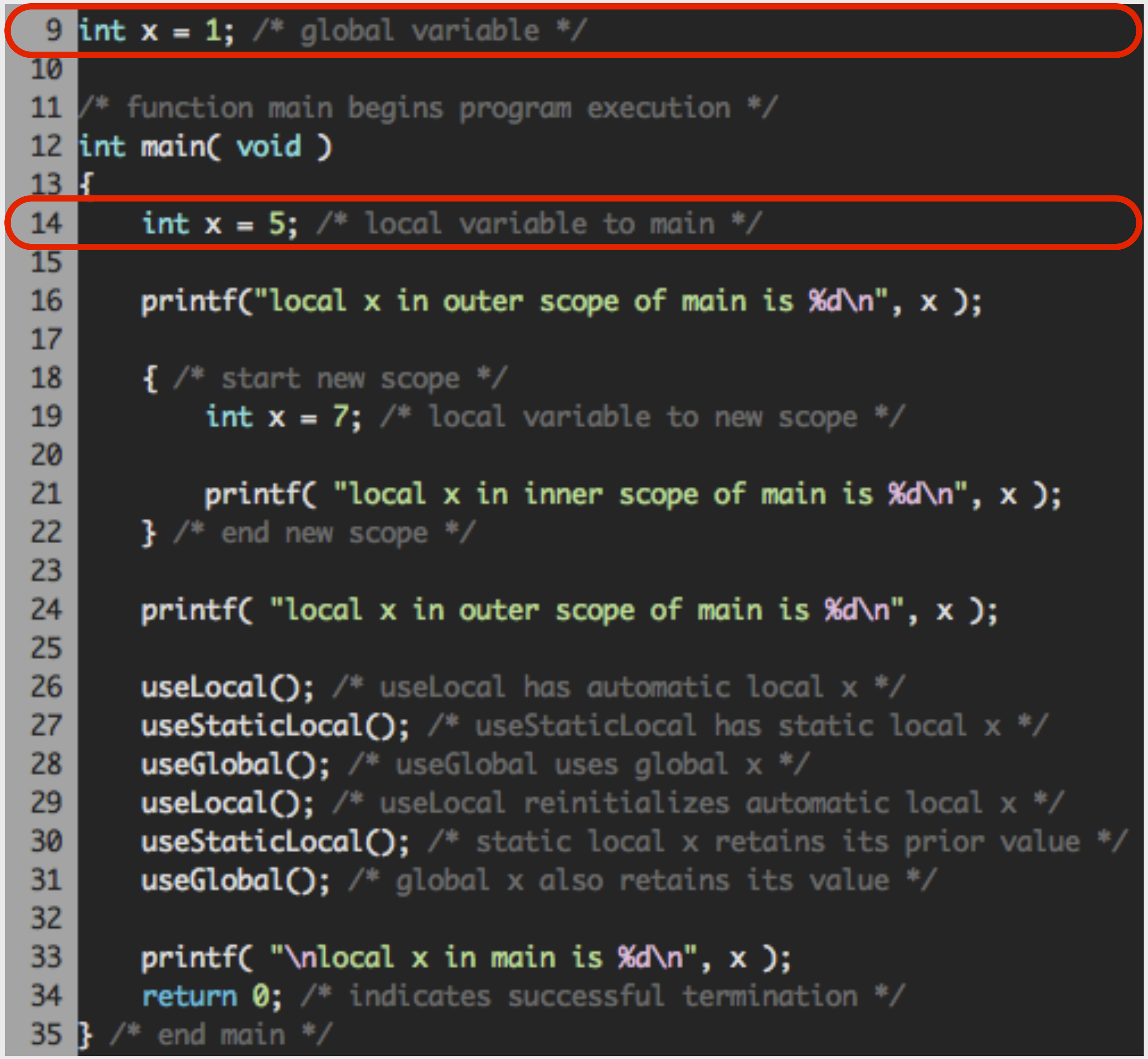
```

Scope Rules (Cont.)

- Example: fig05_12.c



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/* function main begins program execution */
int main( void )
{
    int x = 5; /* local variable to main */

    printf("local x in outer scope of main is %d\n", x );

    { /* start new scope */
        int x = 7; /* local variable to new scope */

        printf( "local x in inner scope of main is %d\n", x );
    } /* end new scope */

    printf( "local x in outer scope of main is %d\n", x );

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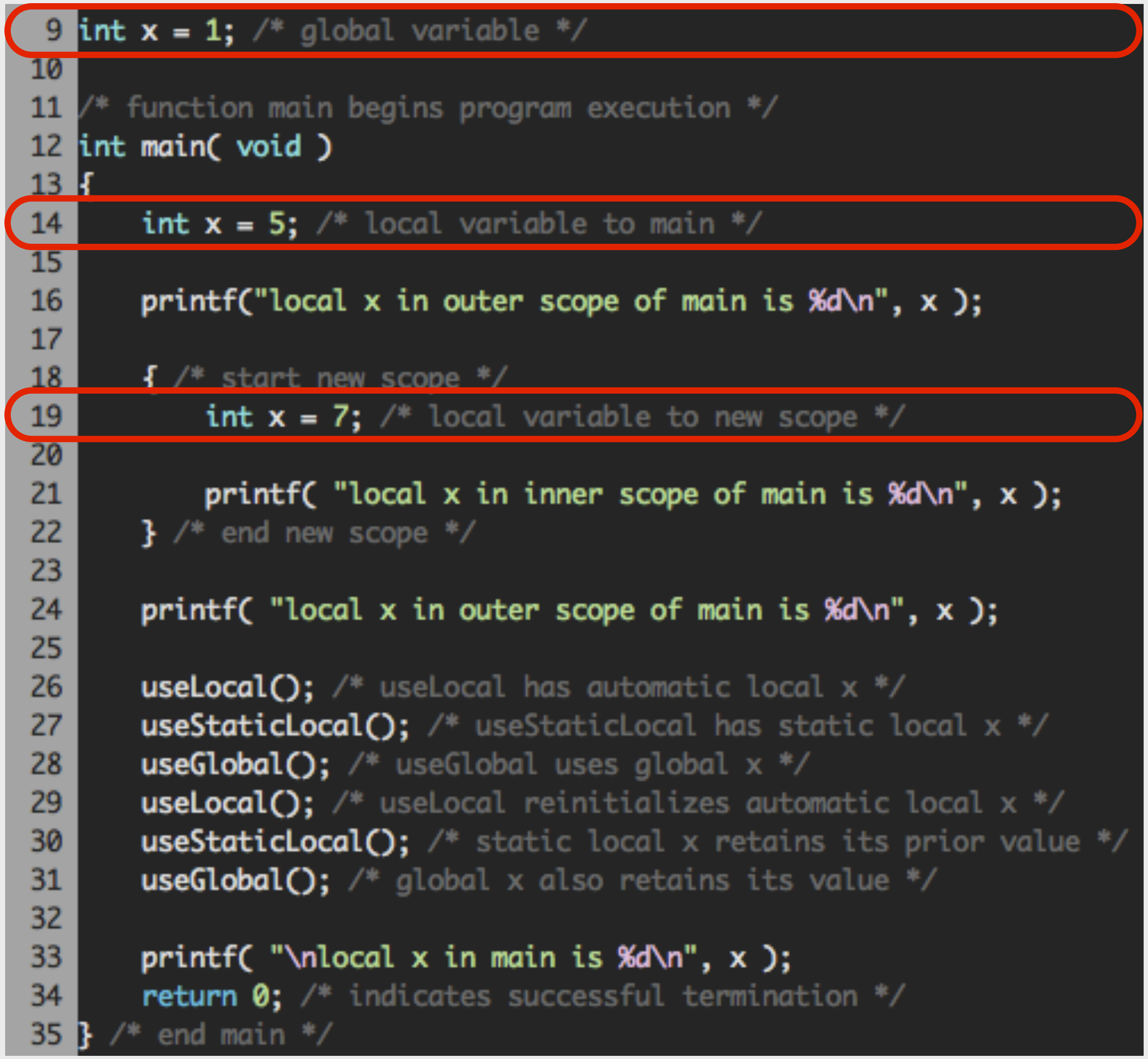
    printf( "\nlocal x in main is %d\n", x );
    return 0; /* indicates successful termination */
} /* end main */
```

Scope Rules (Cont.)

- Example: fig05_12.c



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{
    int x = 5; /* local variable to main */

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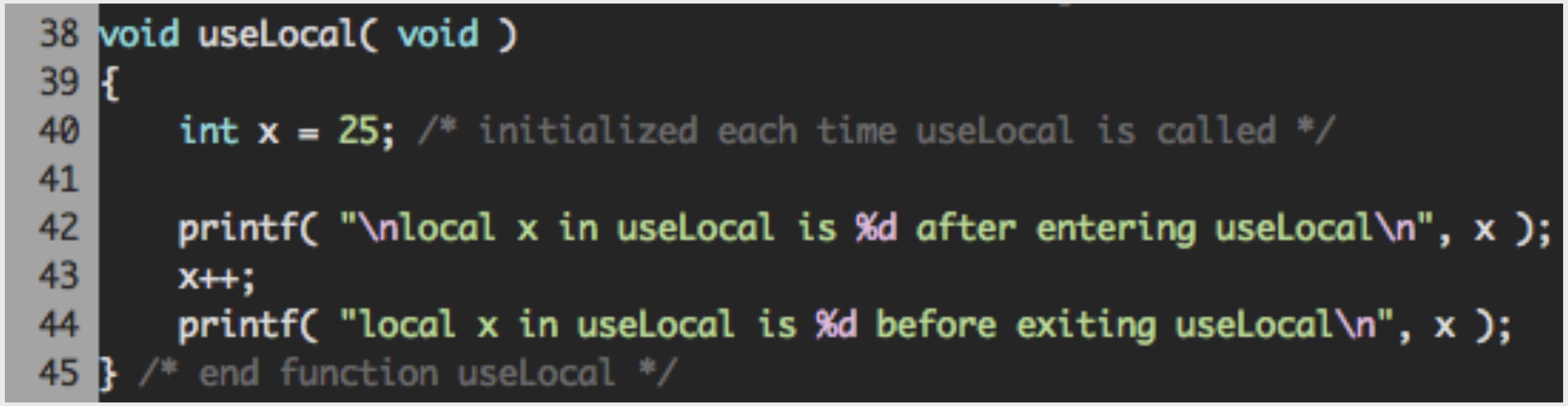
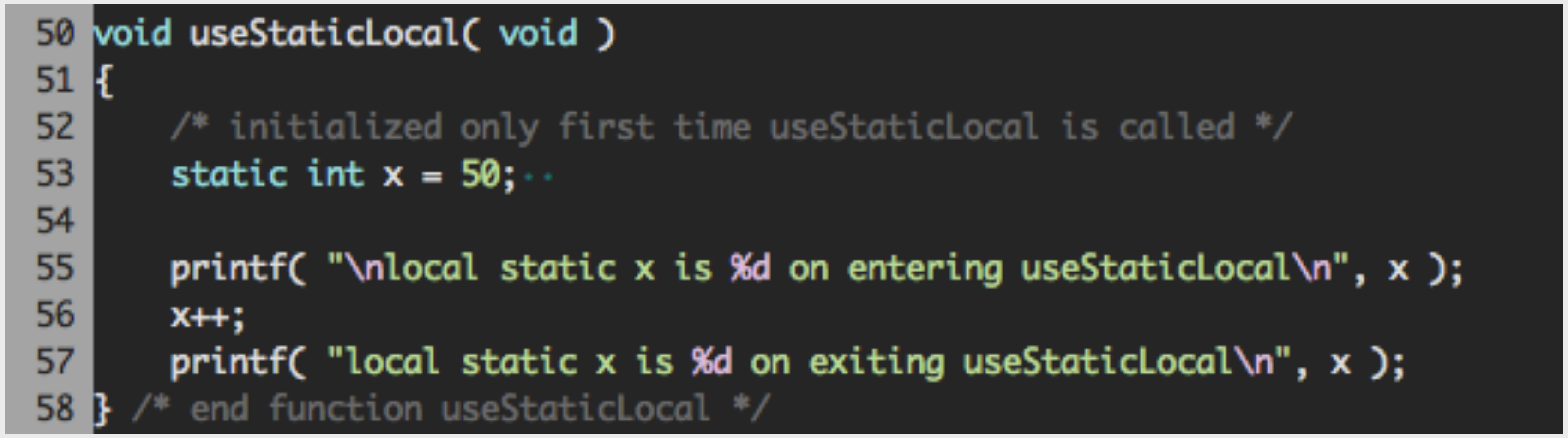
Scope Rules (Cont.)

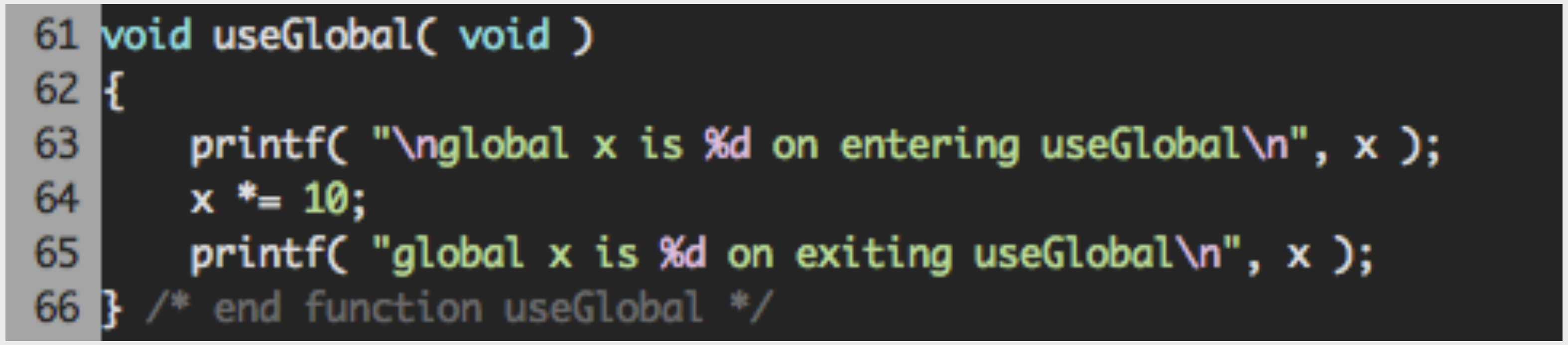
- Example: fig05_12.c



```c
void useLocal( void )
{
    int x = 25; /* initialized each time useLocal is called */

    printf( "\nlocal x in useLocal is %d after entering useLocal\n", x );
    x++;
    printf( "local x in useLocal is %d before exiting useLocal\n", x );
} /* end function useLocal */
```



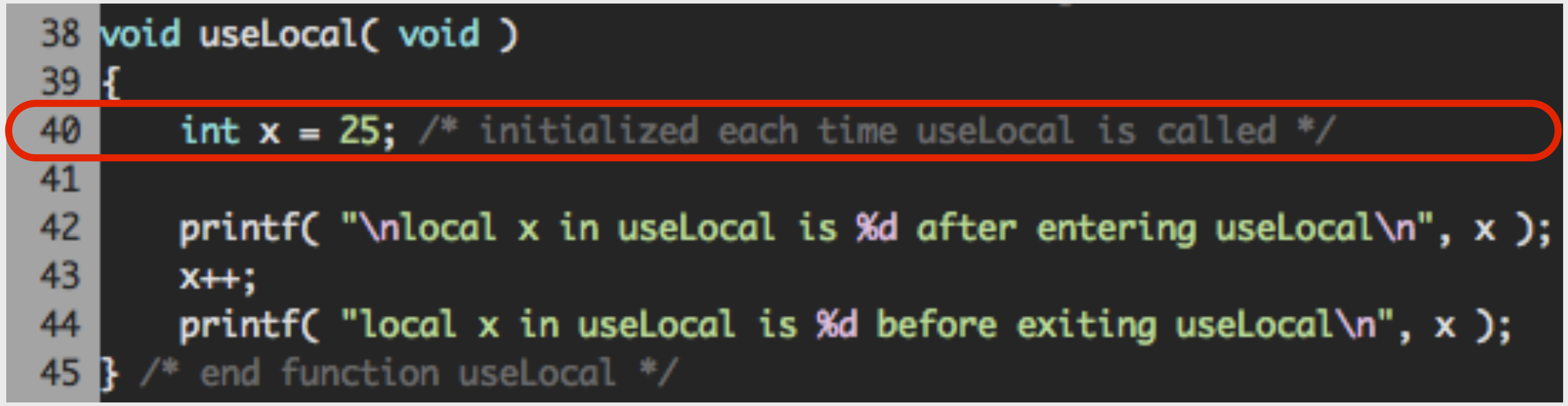
```c
void useStaticLocal( void )
{
    /* initialized only first time useStaticLocal is called */
    static int x = 50;

    printf( "\nlocal static x is %d on entering useStaticLocal\n", x );
    x++;
    printf( "local static x is %d on exiting useStaticLocal\n", x );
} /* end function useStaticLocal */
```



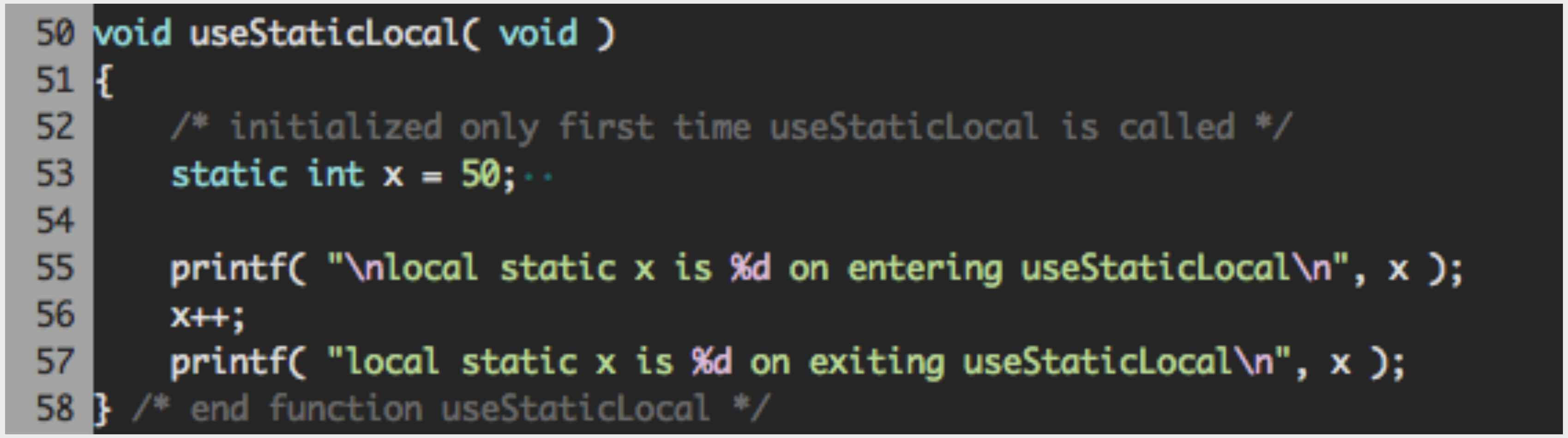
```c
void useGlobal( void )
{
    printf( "\nglobal x is %d on entering useGlobal\n", x );
    x *= 10;
    printf( "global x is %d on exiting useGlobal\n", x );
} /* end function useGlobal */
```

Scope Rules (Cont.)

- Example: fig05_12.c



```
void useLocal( void )
{
    int x = 25; /* initialized each time useLocal is called */

    printf( "\nlocal x in useLocal is %d after entering useLocal\n", x );
    x++;
    printf( "local x in useLocal is %d before exiting useLocal\n", x );
} /* end function useLocal */
```



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{
    /* initialized only first time useStaticLocal is called */
    static int x = 50;

    printf( "\nlocal static x is %d on entering useStaticLocal\n", x );
    x++;
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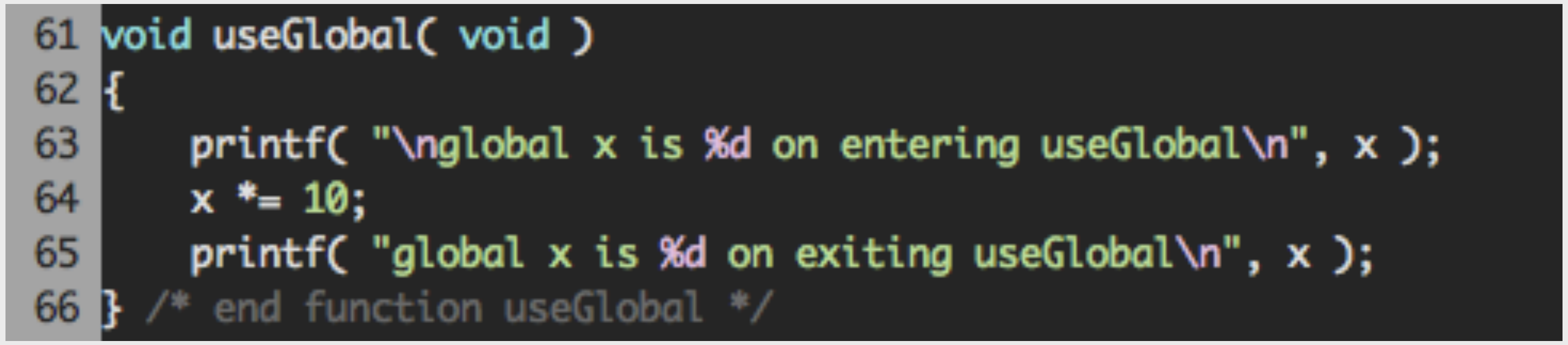
} /* end function useStaticLocal */
```



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void useGlobal( void )
{
    printf( "\nglobal x is %d on entering useGlobal\n", x );
    x *= 10;
    printf( "global x is %d on exiting useGlobal\n", x );
} /* end function useGlobal */
```
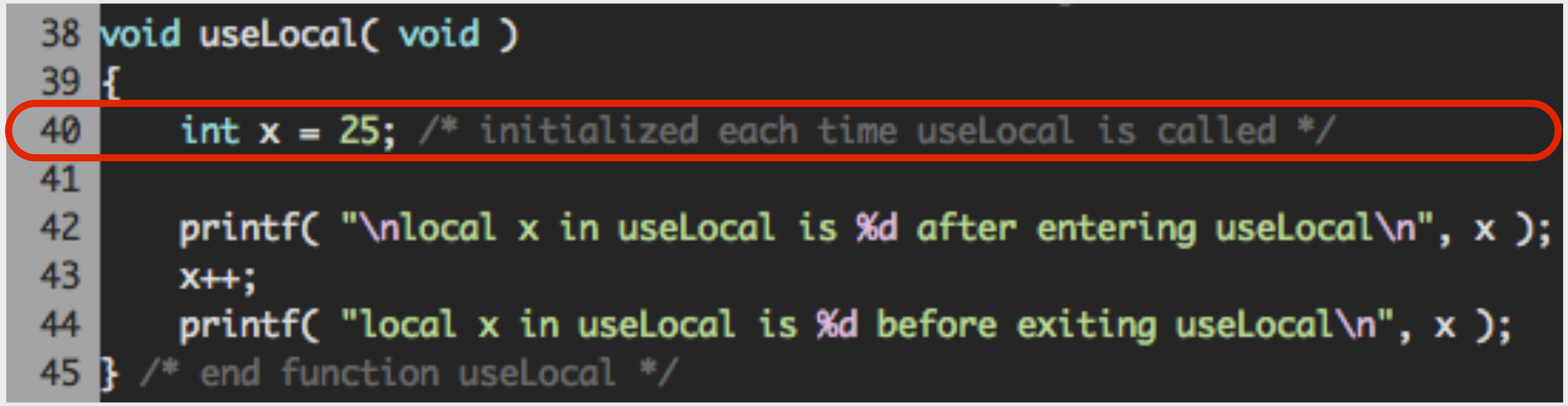

Scope Rules (Cont.)

- Example: fig05_12.c



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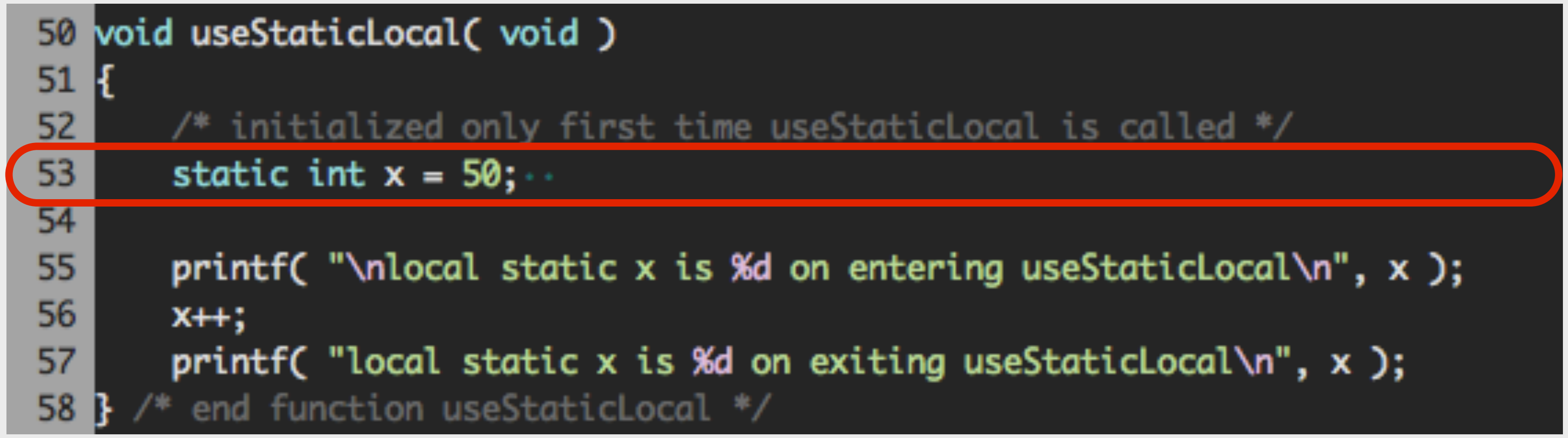

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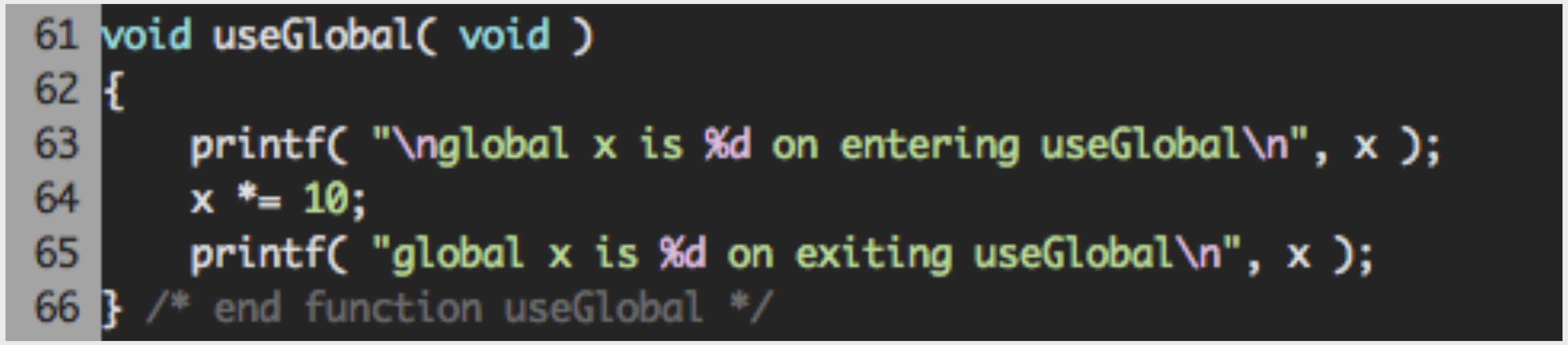

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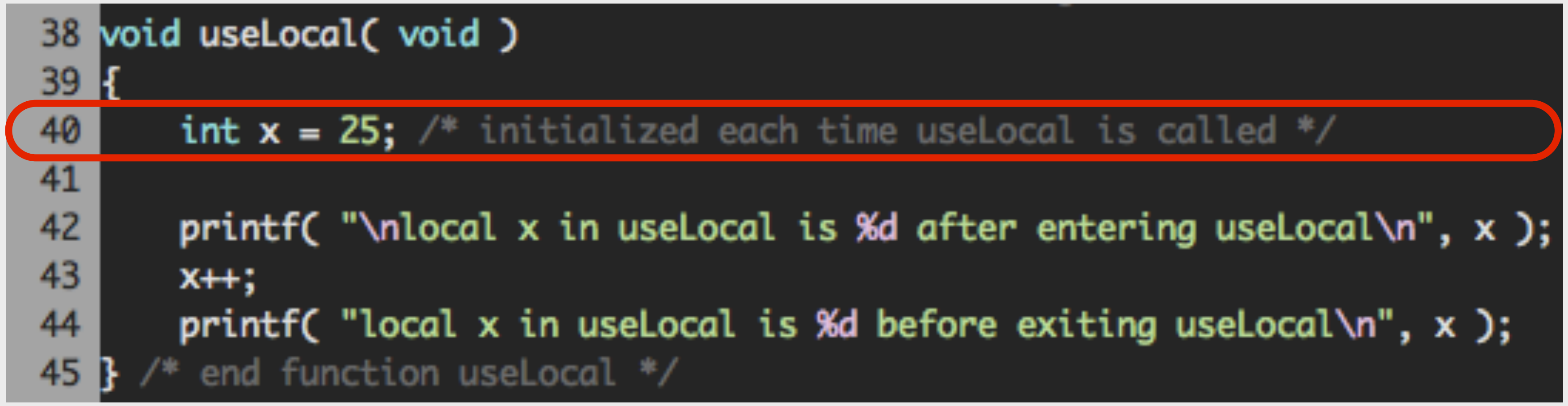
} /* end function useGlobal */
```

Scope Rules (Cont.)

- Example: fig05_12.c



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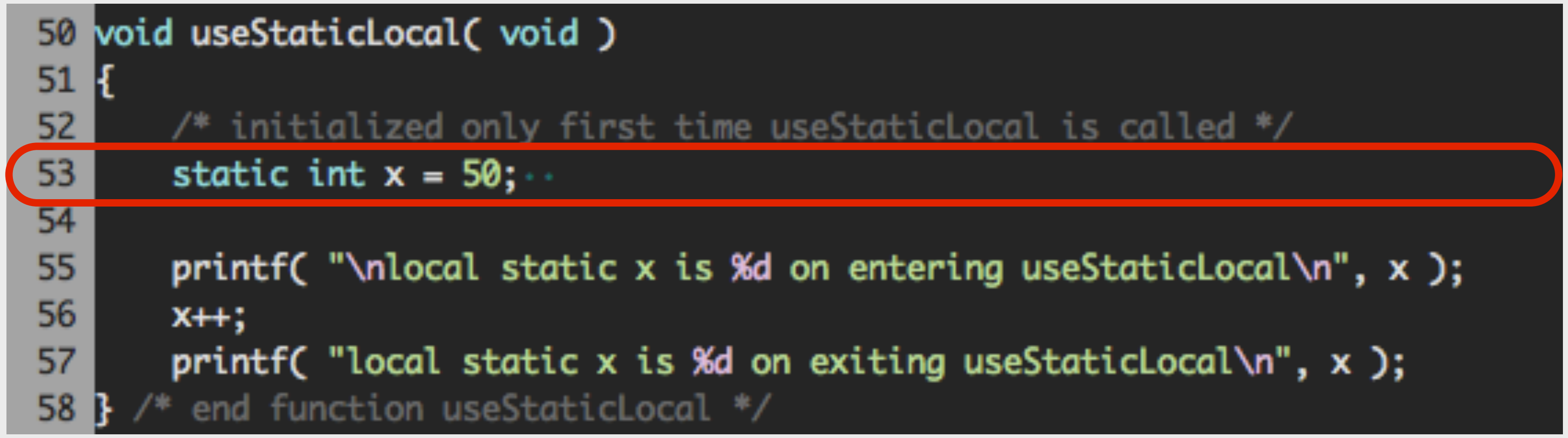

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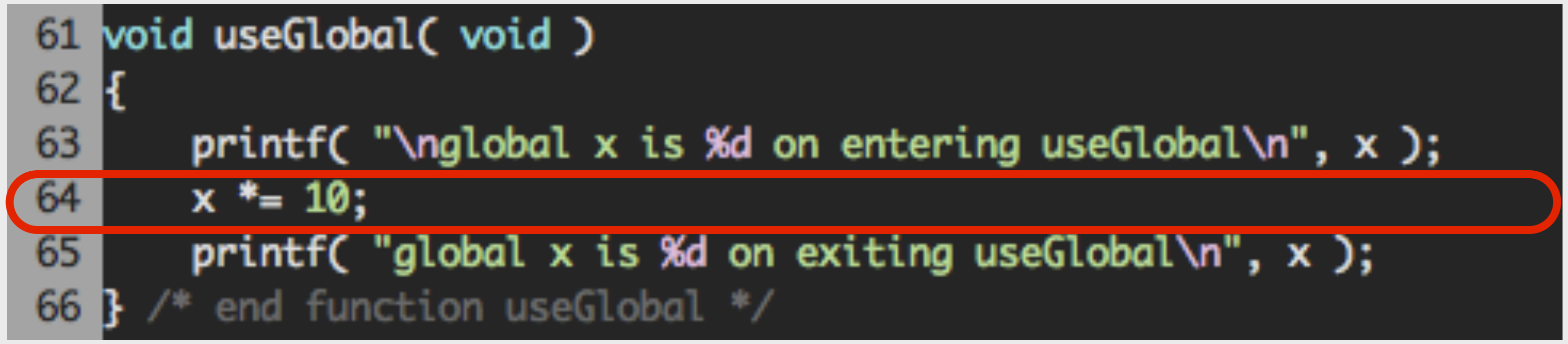

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   x *= 10;
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} /* end function useGlobal */
```
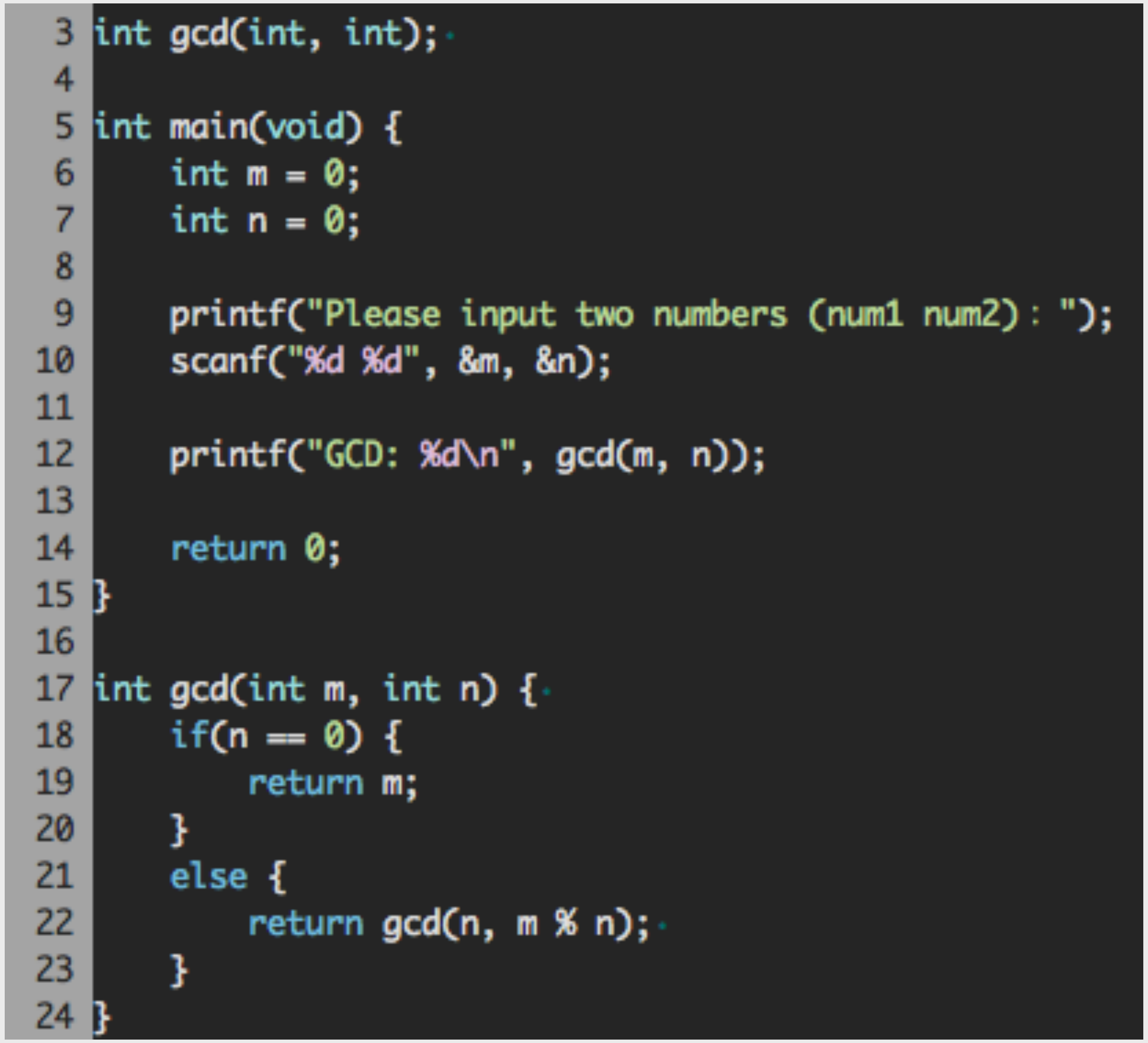

Recursion vs. Iteration

- Each **recursive** call causes another copy of the function (actually only the function’s variables) to be created; this can consume considerable memory.
- **Iteration** normally occurs within a function, so the overhead of repeated function calls and extra memory assignment is omitted.
- So why choose recursion?

Greatest common divisor

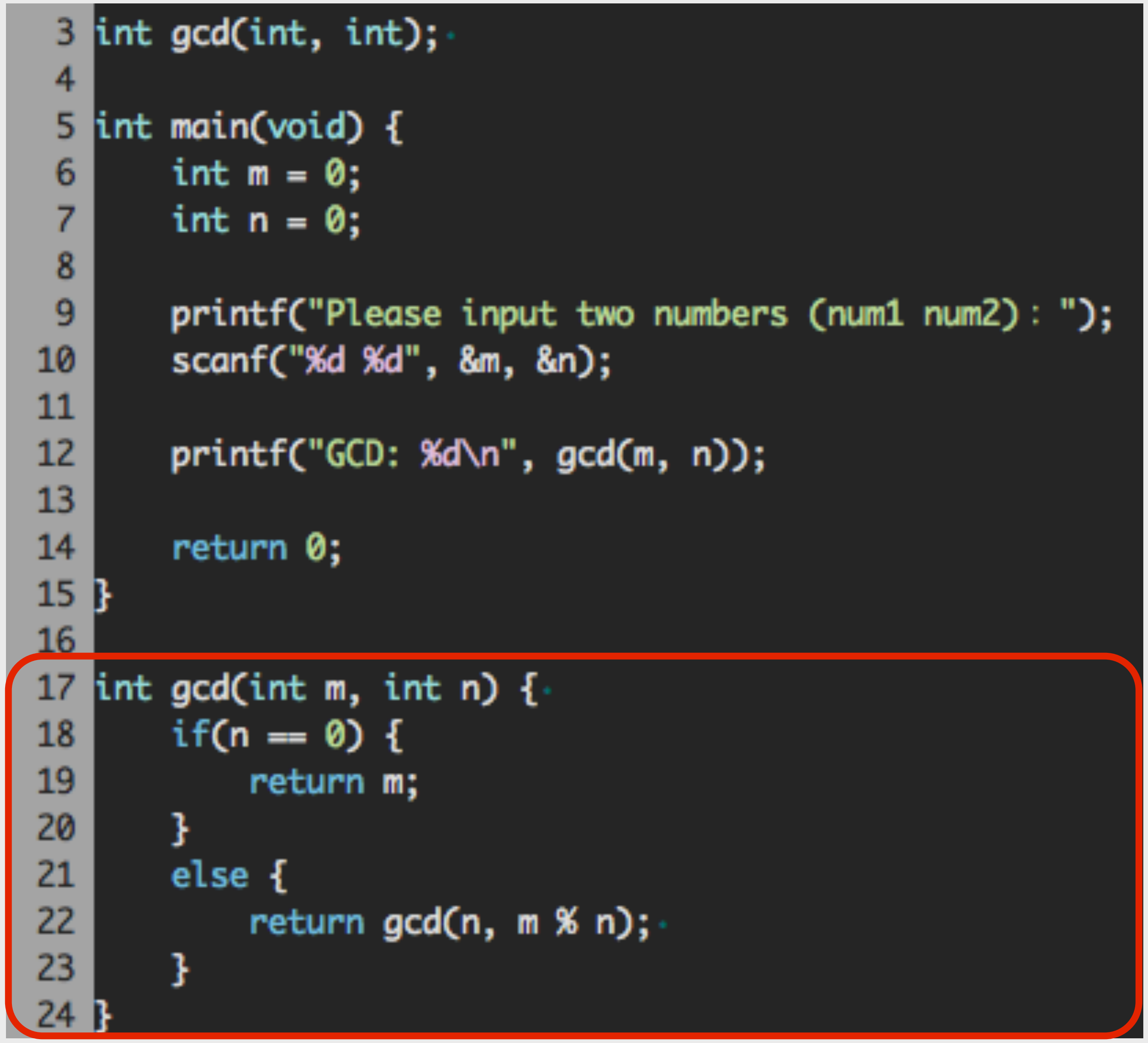
- Example: fig05_16-1.c



```c
int gcd(int, int);

int main(void) {
    int m = 0;
    int n = 0;

    printf("Please input two numbers (num1 num2): ");
    scanf("%d %d", &m, &n);

    printf("GCD: %d\n", gcd(m, n));

    return 0;
}

int gcd(int m, int n) {
    if(n == 0) {
        return m;
    }
    else {
        return gcd(n, m % n);
    }
}
```

Greatest common divisor

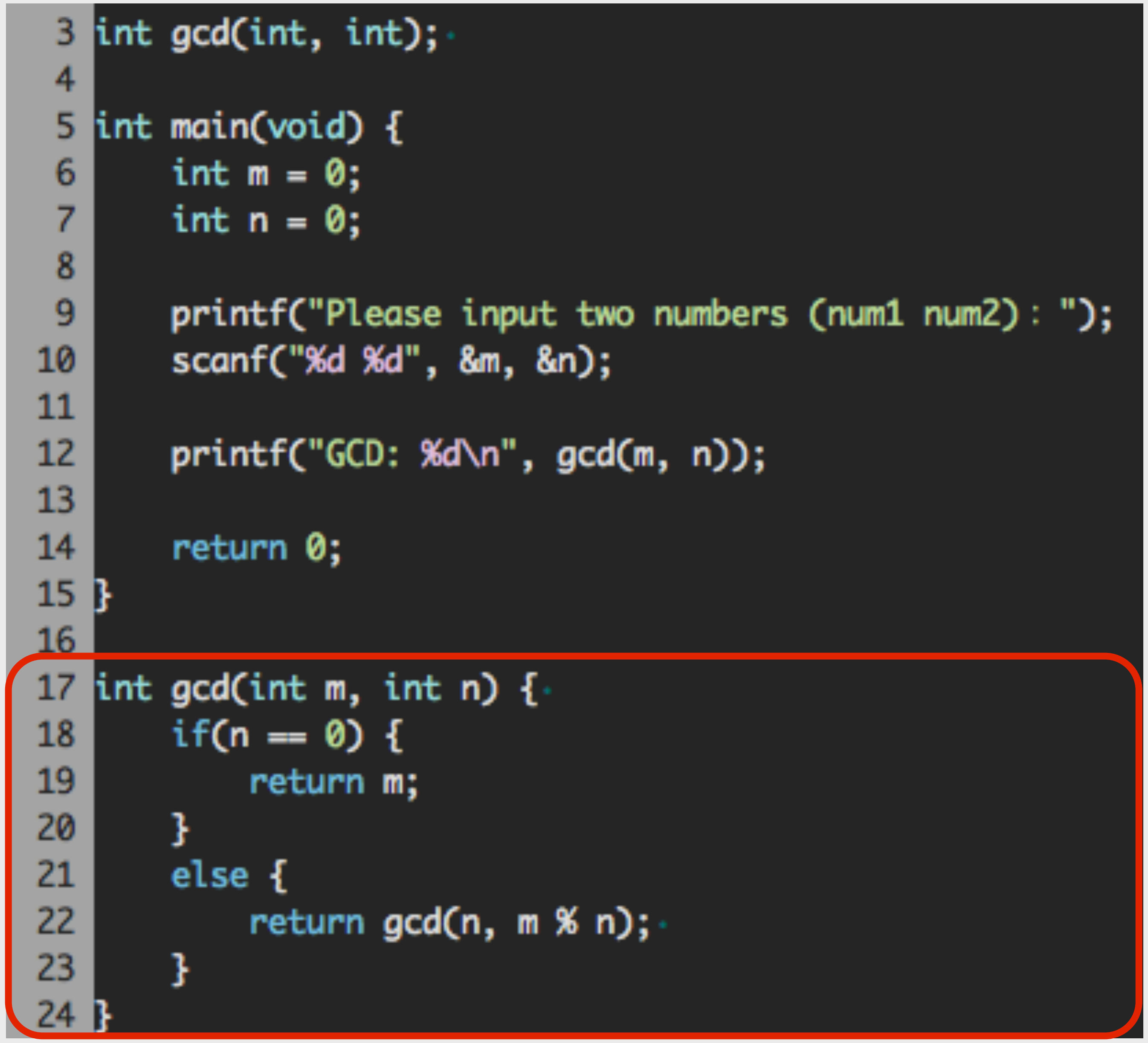
- Example: fig05_16-1.c



```c
int gcd(int, int);

int main(void) {
    int m = 0;
    int n = 0;

    printf("Please input two numbers (num1 num2): ");
    scanf("%d %d", &m, &n);

    printf("GCD: %d\n", gcd(m, n));

    return 0;
}

int gcd(int m, int n) {
    if(n == 0) {
        return m;
    }
    else {
        return gcd(n, m % n);
    }
}
```

Greatest common divisor

- Example: fig05_16-1.c



```c
int gcd(int, int);

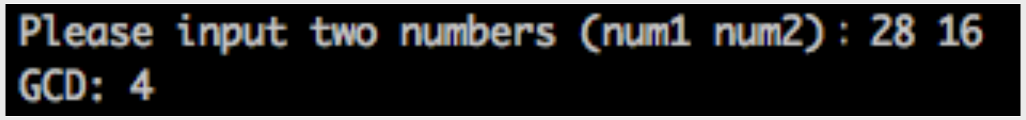
int main(void) {
    int m = 0;
    int n = 0;

    printf("Please input two numbers (num1 num2): ");
    scanf("%d %d", &m, &n);

    printf("GCD: %d\n", gcd(m, n));

    return 0;
}

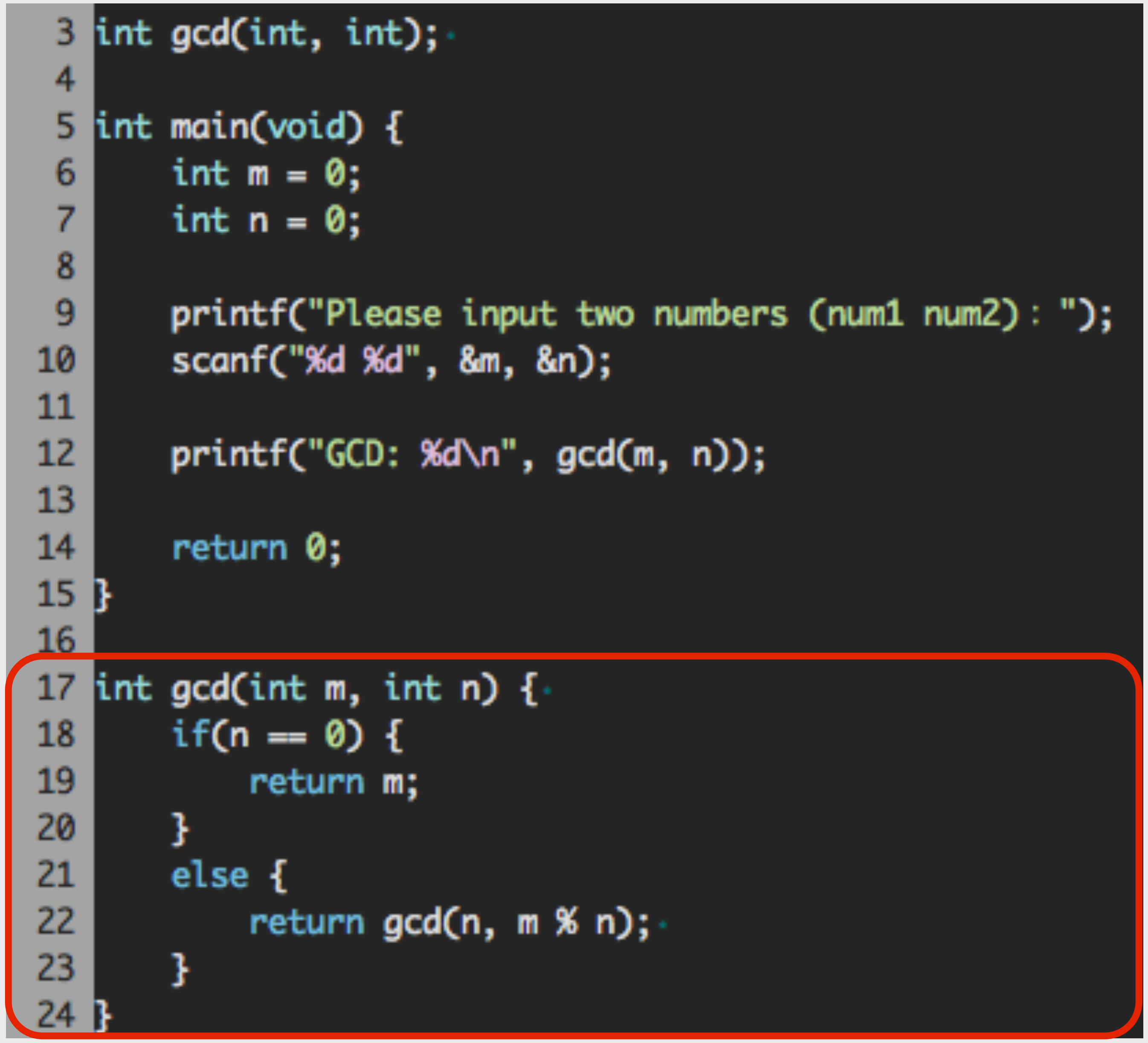
int gcd(int m, int n) {
    if(n == 0) {
        return m;
    }
    else {
        return gcd(n, m % n);
    }
}
```



```
Please input two numbers (num1 num2): 28 16
GCD: 4
```

Greatest common divisor

- Example: fig05_16-1.c



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    int n = 0;

    printf("Please input two numbers (num1 num2): ");
    scanf("%d %d", &m, &n);

    printf("GCD: %d\n", gcd(m, n));

    return 0;
}

int gcd(int m, int n) {
    if(n == 0) {
        return m;
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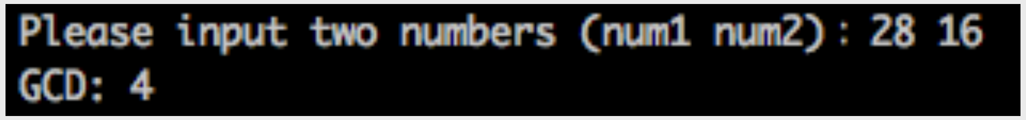
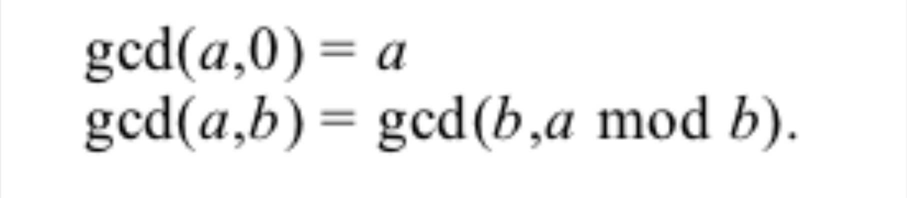
    else {
        return gcd(n, m % n);
    }
}
```



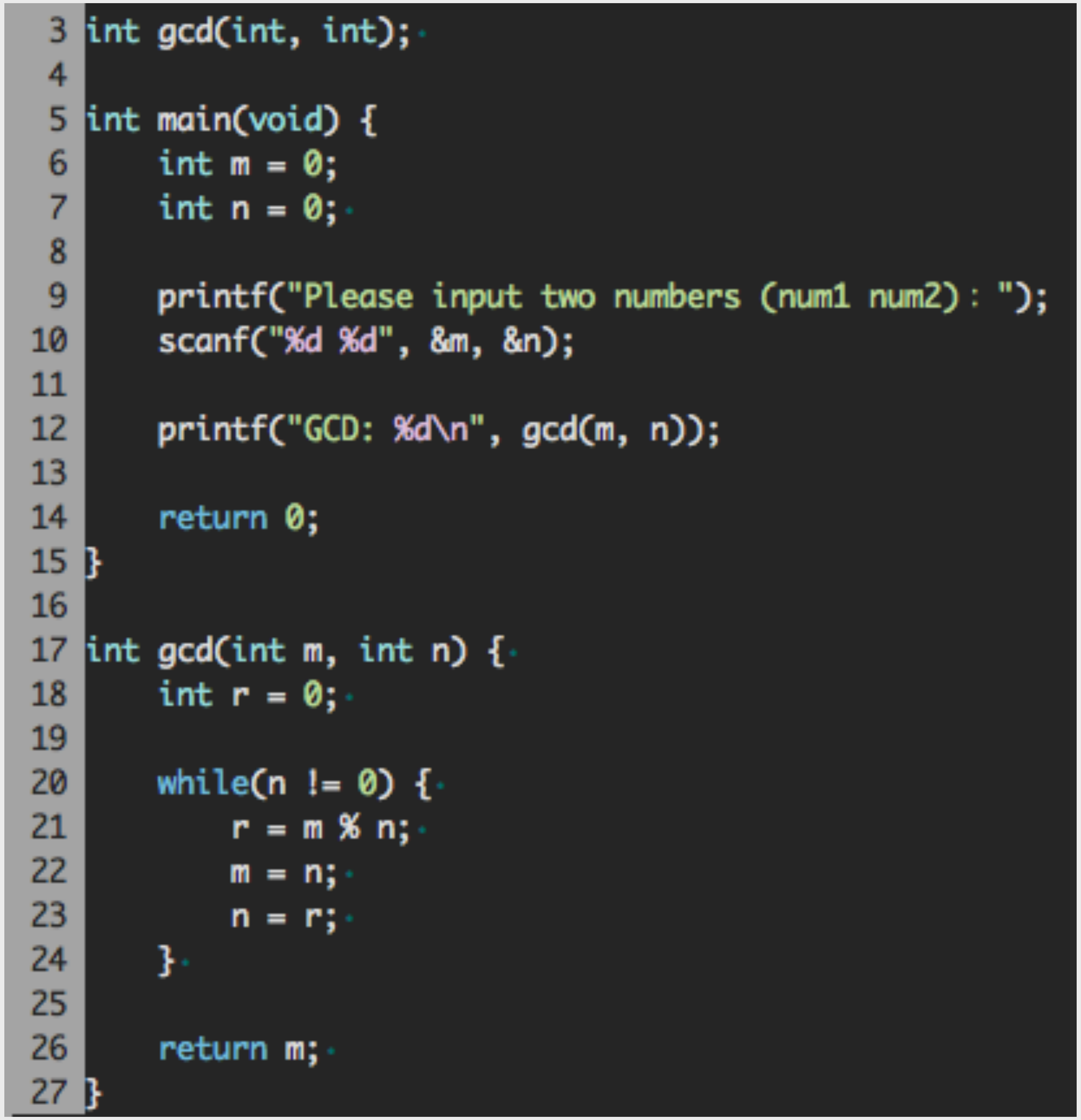
```
Please input two numbers (num1 num2): 28 16
GCD: 4
```



$$\gcd(a,0) = a$$
$$\gcd(a,b) = \gcd(b, a \bmod b).$$

Greatest common divisor

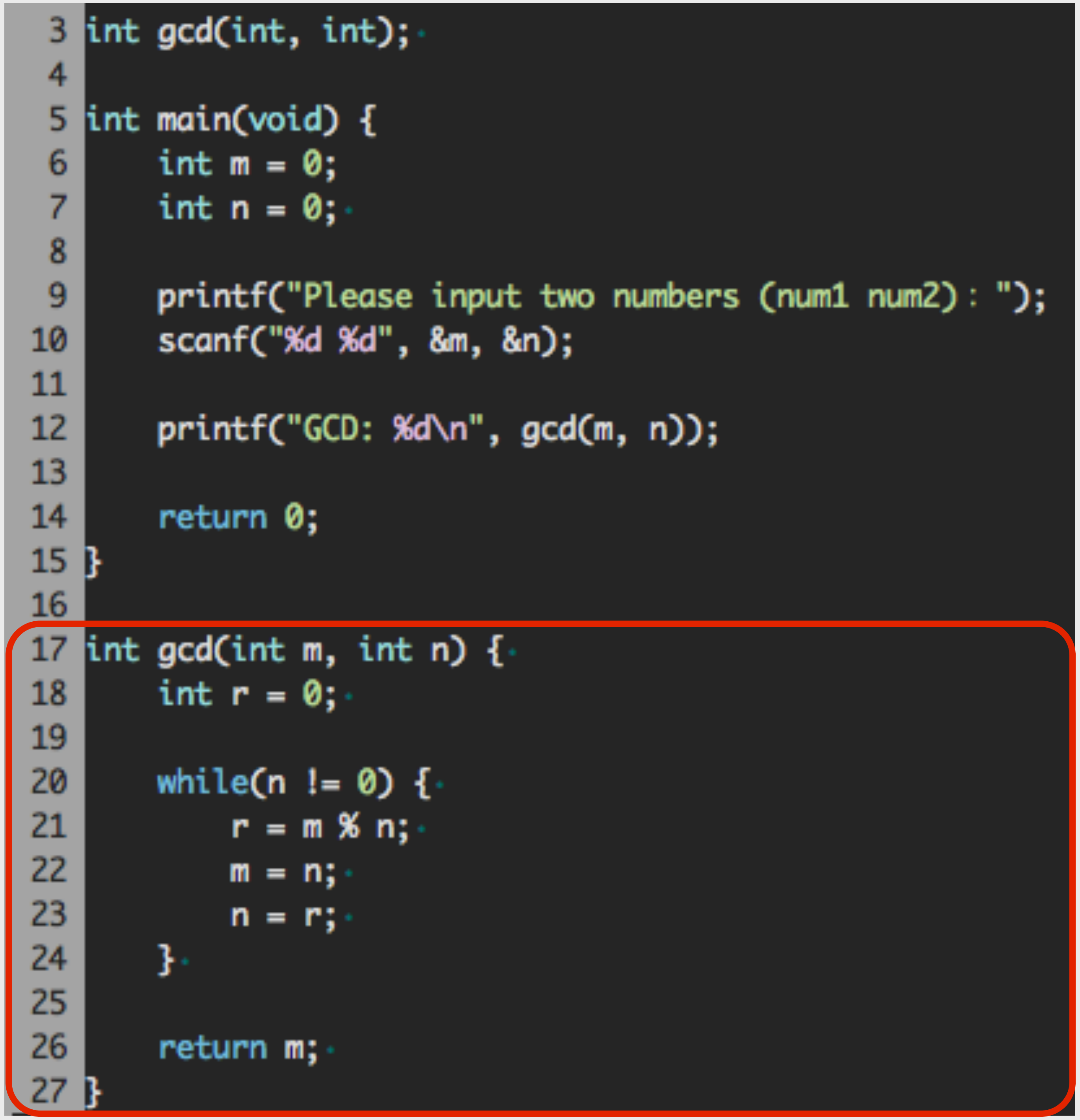
- Example: fig05_16-2.c



```c
int gcd(int, int);

int main(void) {
    int m = 0;
    int n = 0;

    printf("Please input two numbers (num1 num2)： ");
    scanf("%d %d", &m, &n);

    printf("GCD: %d\n", gcd(m, n));

    return 0;
}

int gcd(int m, int n) {
    int r = 0;

    while(n != 0) {
        r = m % n;
        m = n;
        n = r;
    }

    return m;
}
```

Greatest common divisor

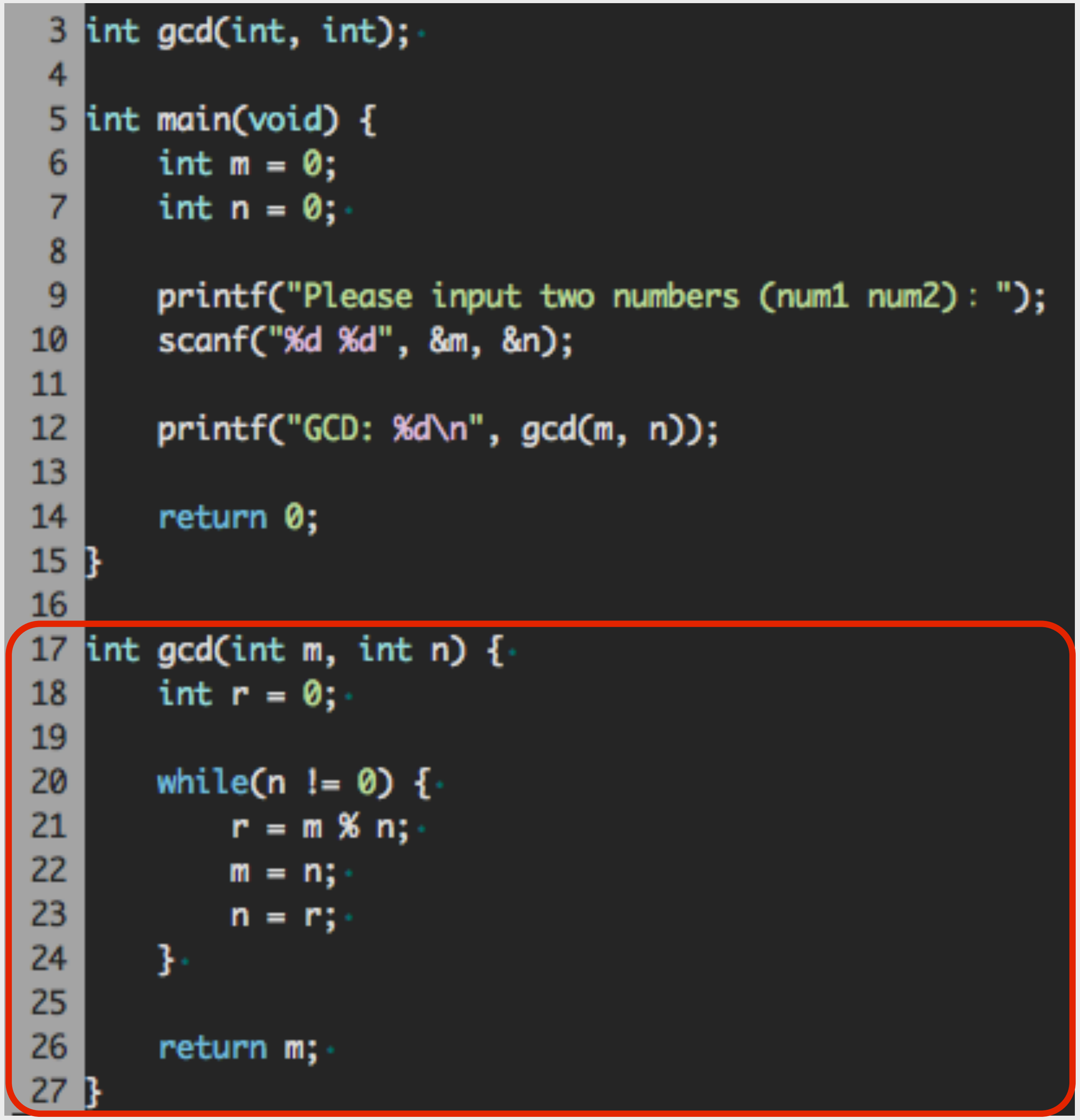
- Example: fig05_16-2.c



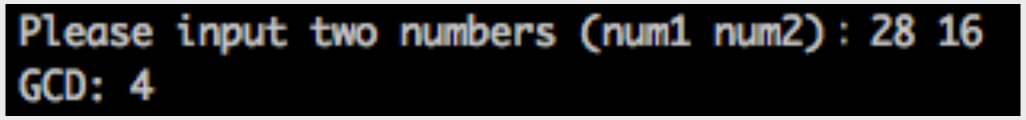
```c
int gcd(int, int);

int main(void) {
    int m = 0;
    int n = 0;

    printf("Please input two numbers (num1 num2): ");
    scanf("%d %d", &m, &n);

    printf("GCD: %d\n", gcd(m, n));

    return 0;
}

int gcd(int m, int n) {
    int r = 0;

    while(n != 0) {
        r = m % n;
        m = n;
        n = r;
    }

    return m;
}
```

Greatest common divisor

- Example: fig05_16-2.c

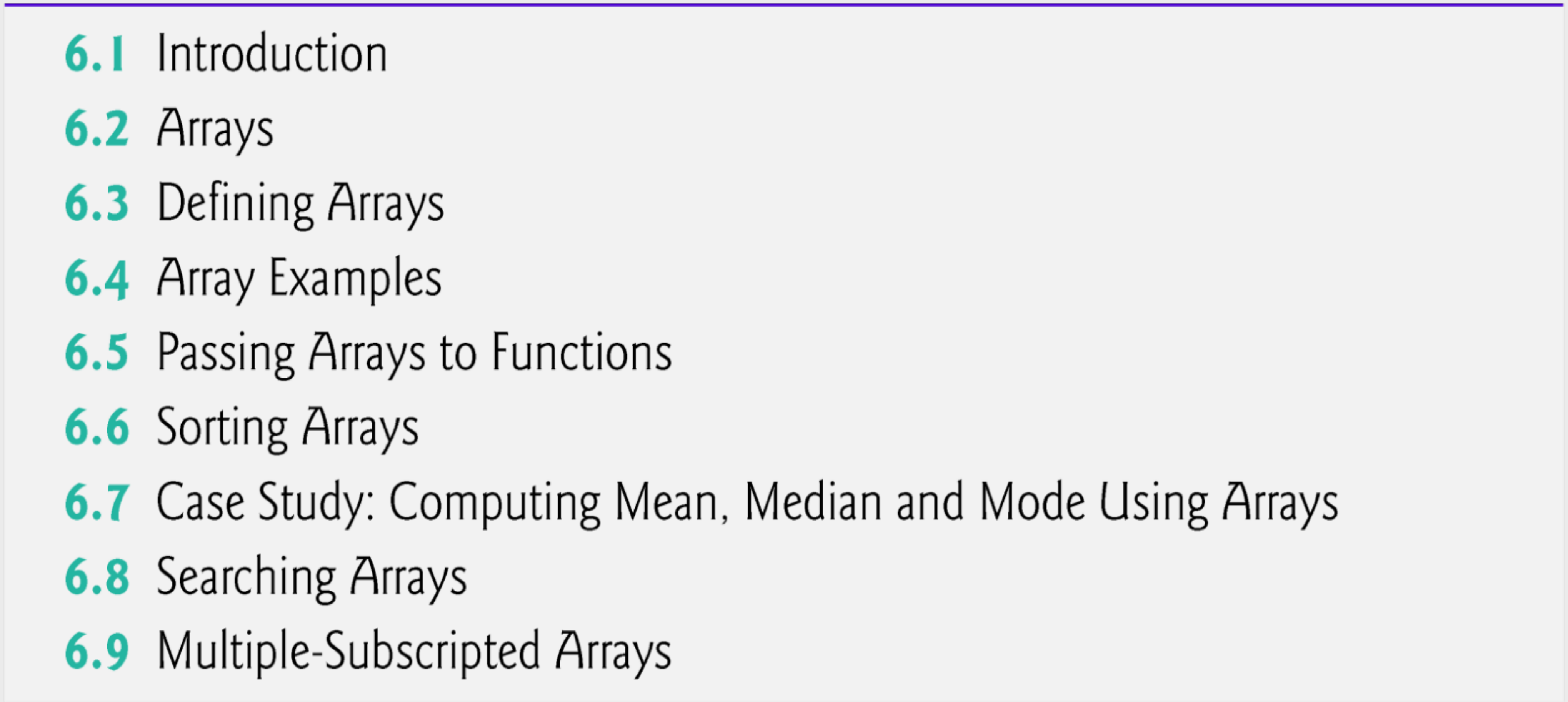


```c
int gcd(int, int);

int main(void) {
    int m = 0;
    int n = 0;

    printf("Please input two numbers (num1 num2): ");
    scanf("%d %d", &m, &n);

    printf("GCD: %d\n", gcd(m, n));

    return 0;
}

int gcd(int m, int n) {
    int r = 0;

    while(n != 0) {
        r = m % n;
        m = n;
        n = r;
    }

    return m;
}
```



```
Please input two numbers (num1 num2): 28 16
GCD: 4
```

C Arrays



6.1 Introduction

6.2 Arrays

6.3 Defining Arrays

6.4 Array Examples

6.5 Passing Arrays to Functions

6.6 Sorting Arrays

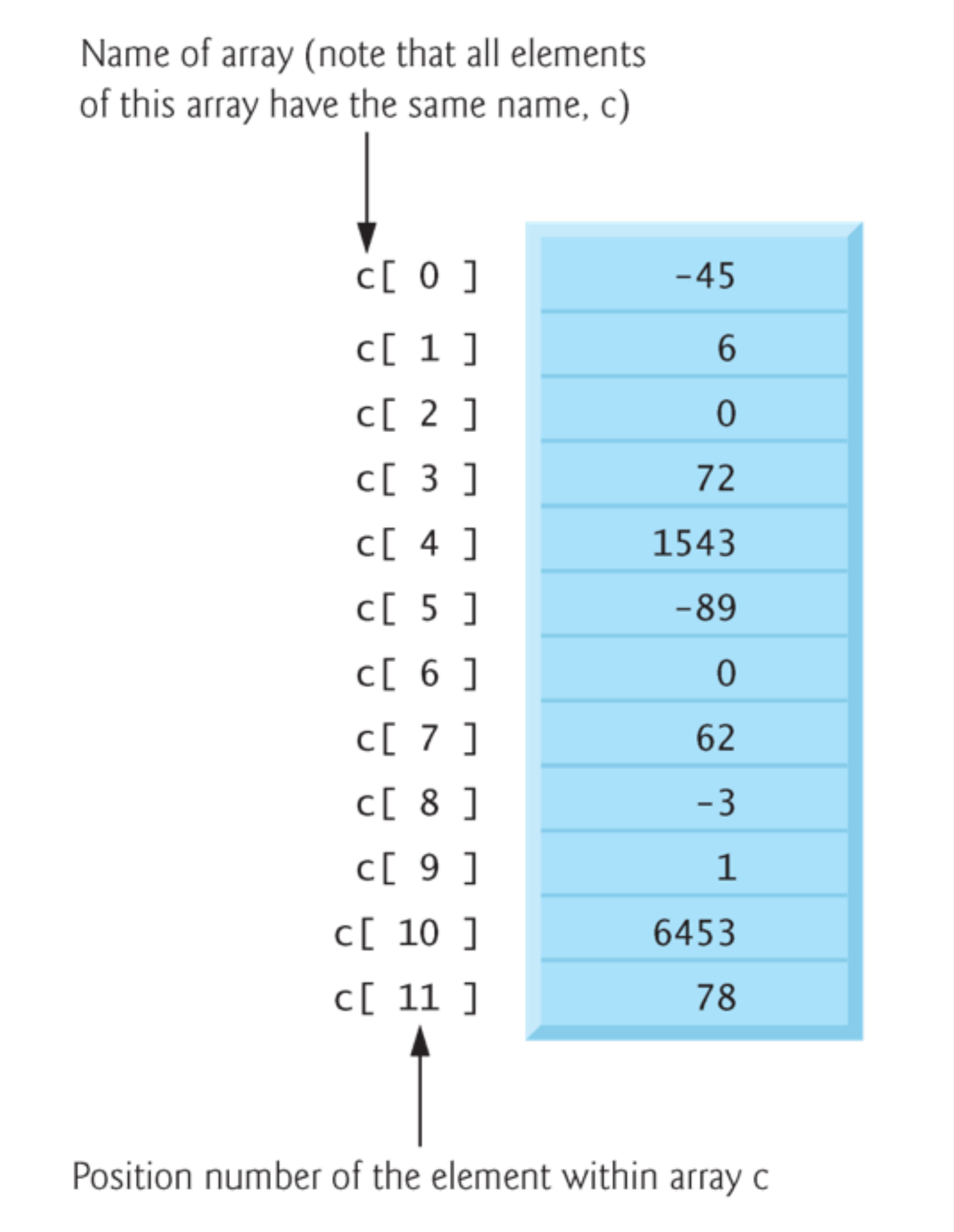
6.7 Case Study: Computing Mean, Median and Mode Using Arrays

6.8 Searching Arrays

6.9 Multiple-Subscripted Arrays

Arrays

- An array is **a group of memory** locations related by the fact that they all have **the same name and the same type**.
- To refer to a particular location or element in the array, we specify **the name of the array** and **the position number** of the particular element in the array.
- The position number contained within square brackets is more formally called a **subscript** (or **index**).



Name of array (note that all elements of this array have the same name, c)

c[0]	-45
c[1]	6
c[2]	0
c[3]	72
c[4]	1543
c[5]	-89
c[6]	0
c[7]	62
c[8]	-3
c[9]	1
c[10]	6453
c[11]	78

Position number of the element within array c

Defining Arrays

- Arrays occupy space in memory.
- To tell the computer to reserve 12 elements for **integer array c**, use the definition

```
int c[12];
```

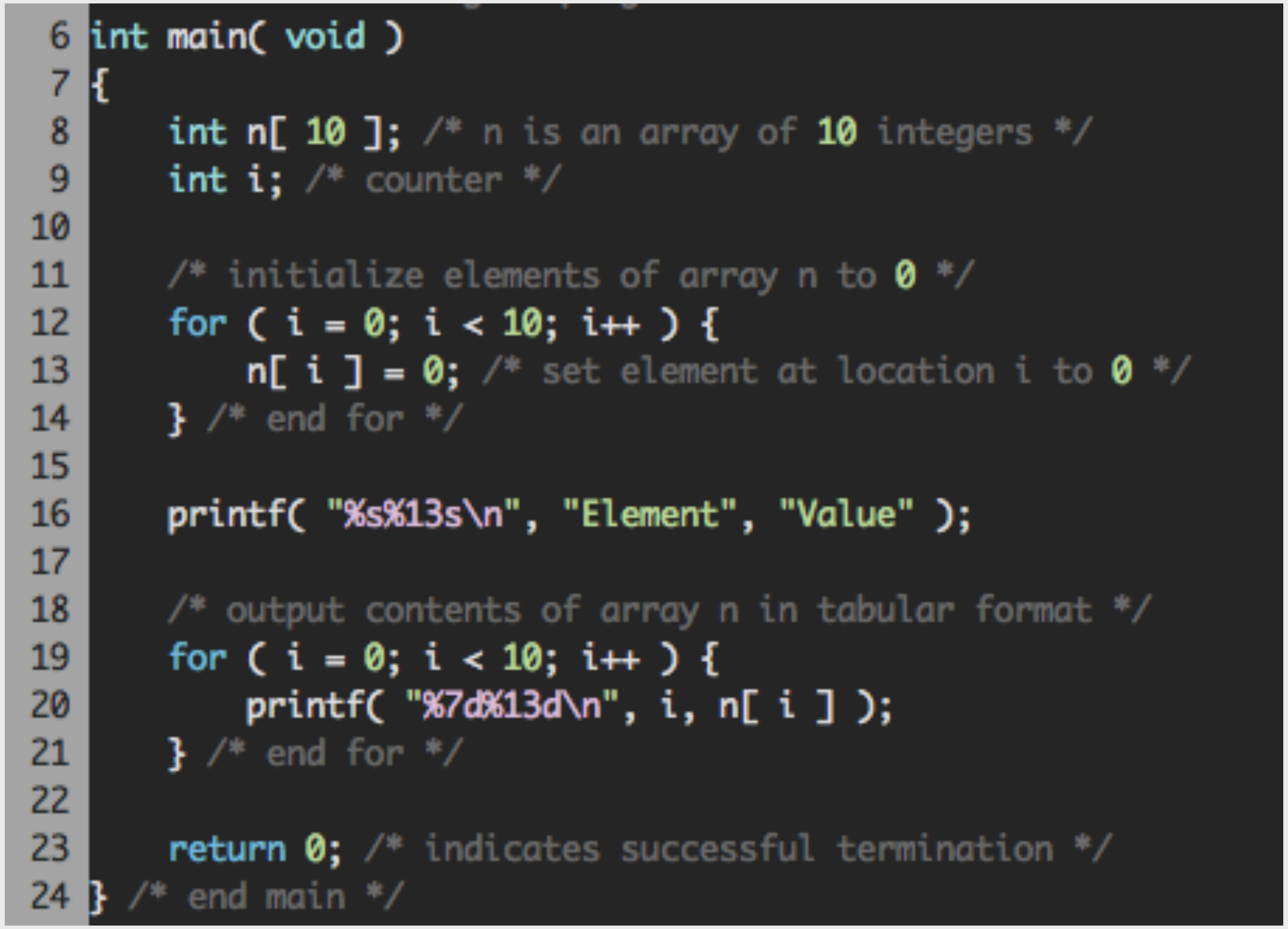
- The following definition

```
int b[ 100 ], x[ 27 ];
```

  - reserves 100 elements for integer array b and 27 elements for integer array x.

Array Examples

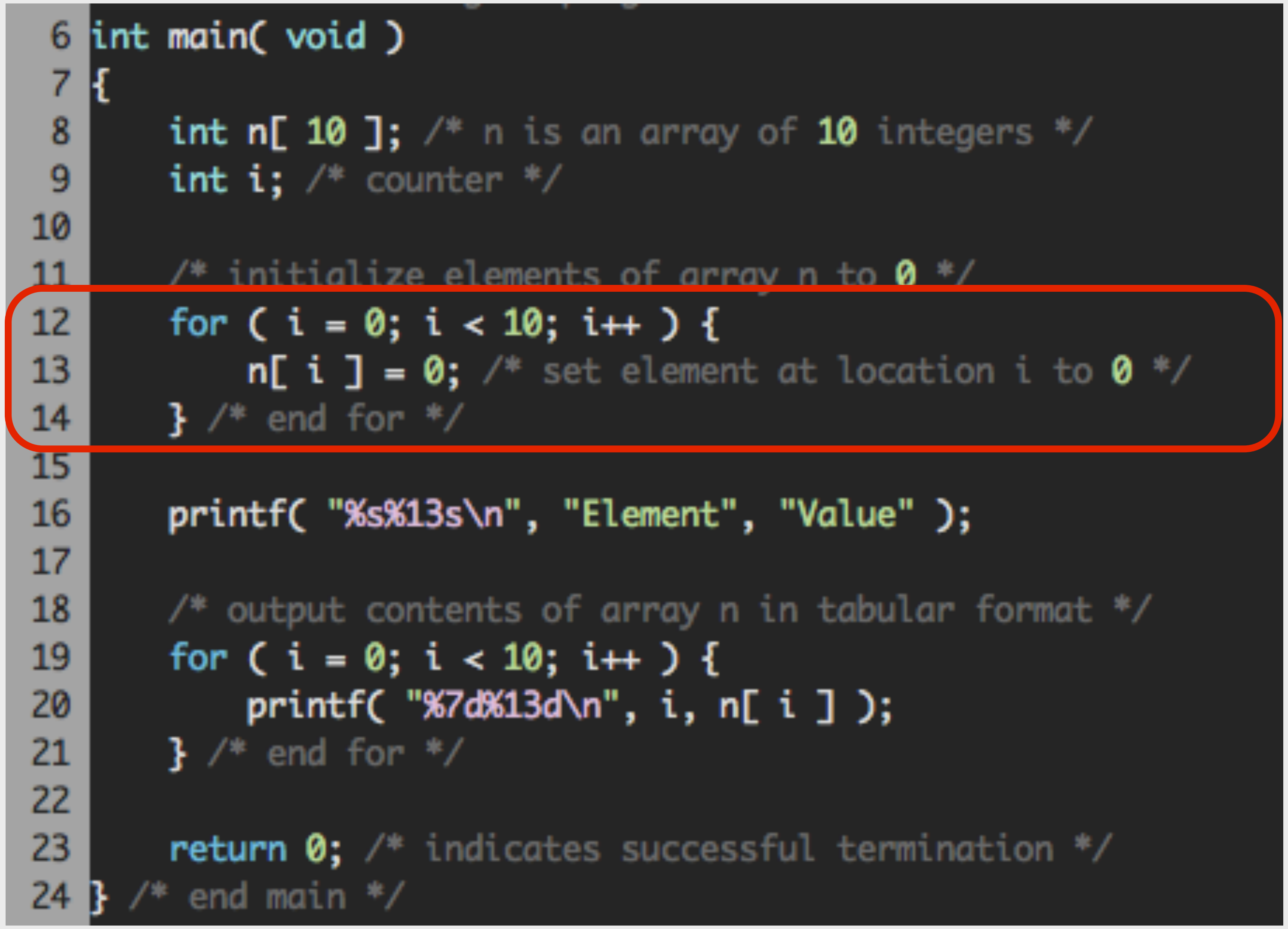
- Example: fig06_03.c



```c
int main( void )
{
    int n[ 10 ]; /* n is an array of 10 integers */
    int i; /* counter */

    /* initialize elements of array n to 0 */
    for ( i = 0; i < 10; i++ ) {
        n[ i ] = 0; /* set element at location i to 0 */
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array n in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

Array Examples

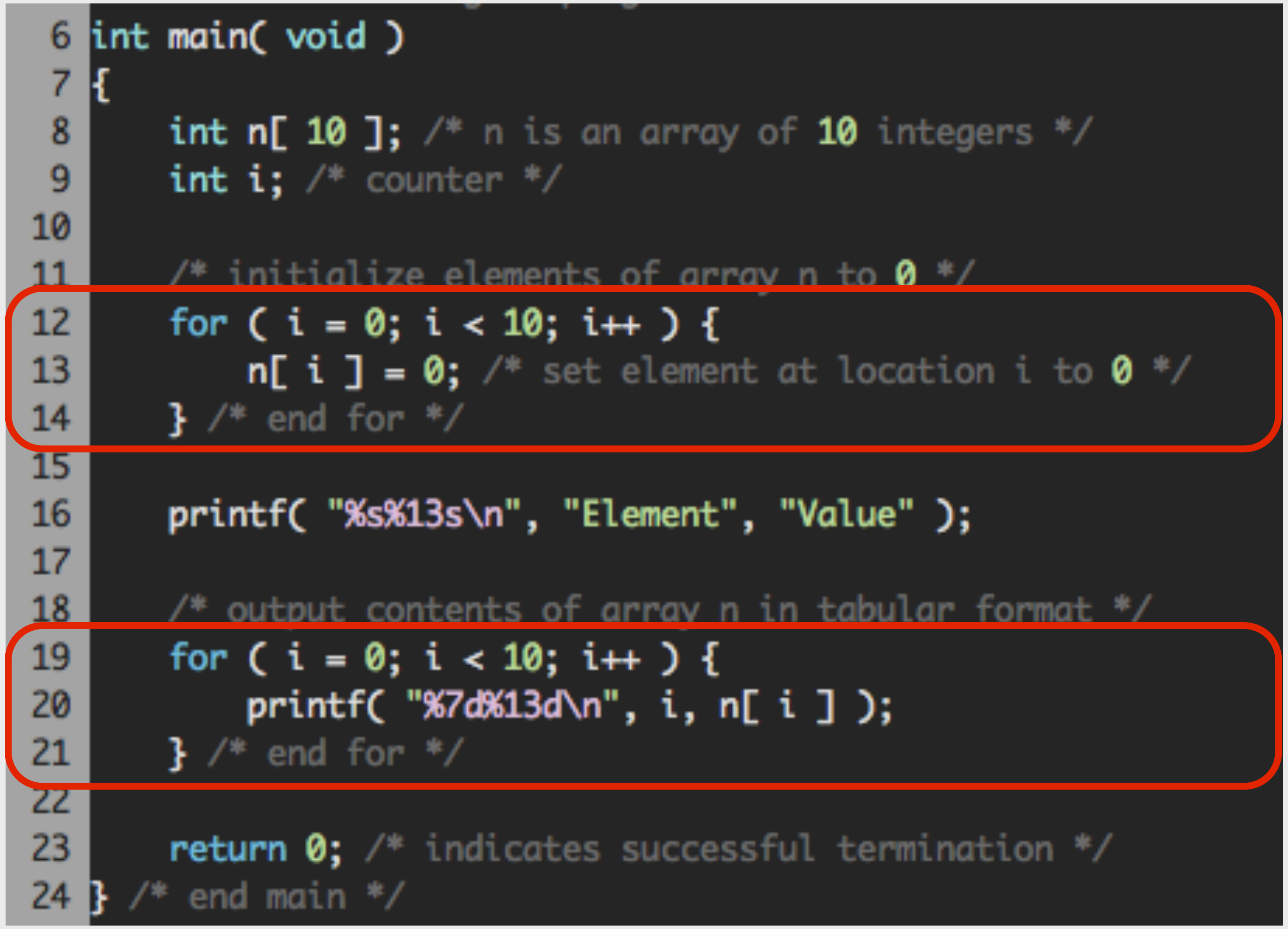
- Example: fig06_03.c



```
int main( void )
{
    int n[ 10 ]; /* n is an array of 10 integers */
    int i; /* counter */

    /* initialize elements of array n to 0 */
    for ( i = 0; i < 10; i++ ) {
        n[ i ] = 0; /* set element at location i to 0 */
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array n in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

Array Examples

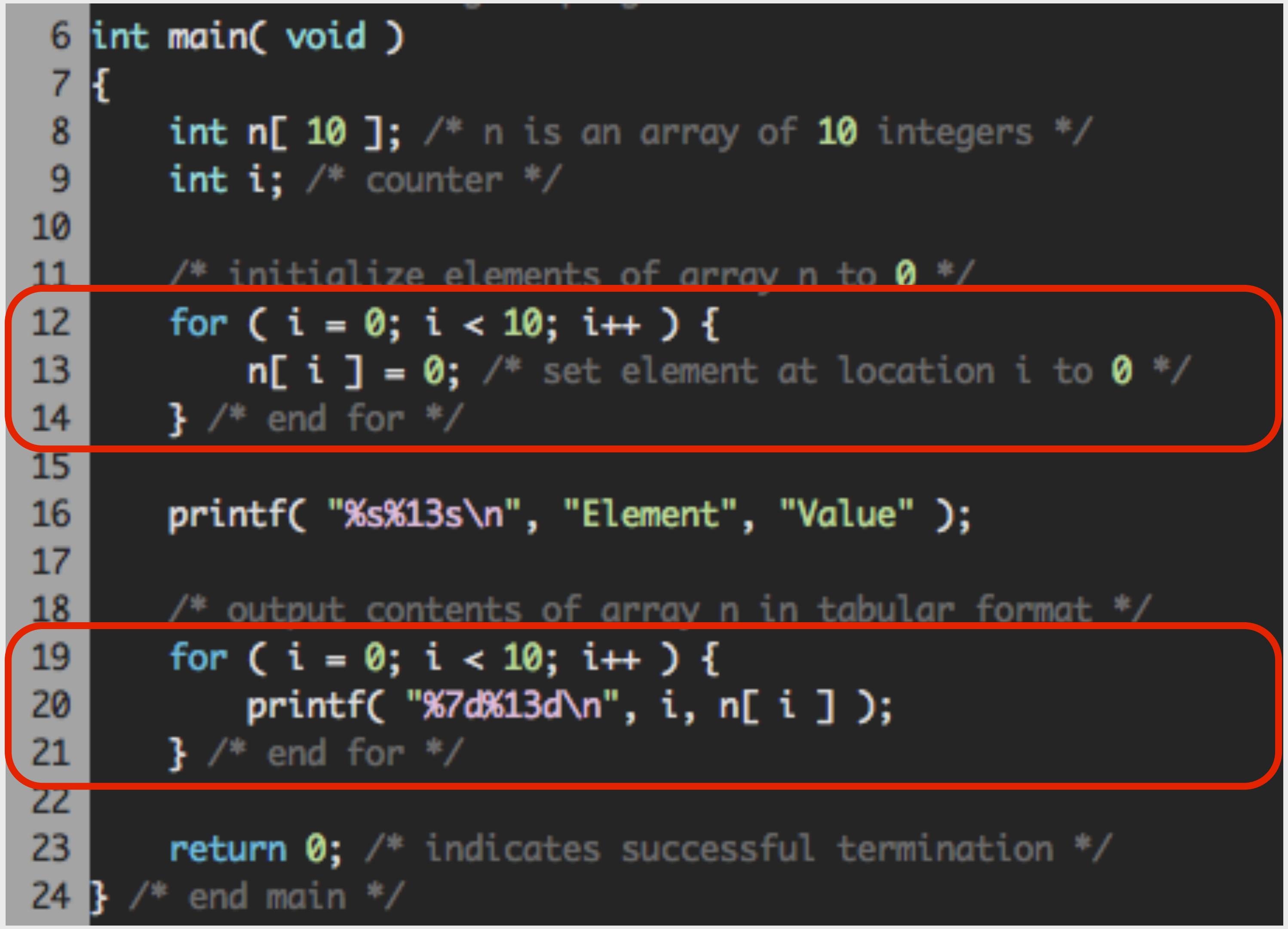
- Example: fig06_03.c



```c
int main( void )
{
    int n[ 10 ]; /* n is an array of 10 integers */
    int i; /* counter */

    /* initialize elements of array n to 0 */
    for ( i = 0; i < 10; i++ ) {
        n[ i ] = 0; /* set element at location i to 0 */
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array n in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

Array Examples

- Example: fig06_03.c

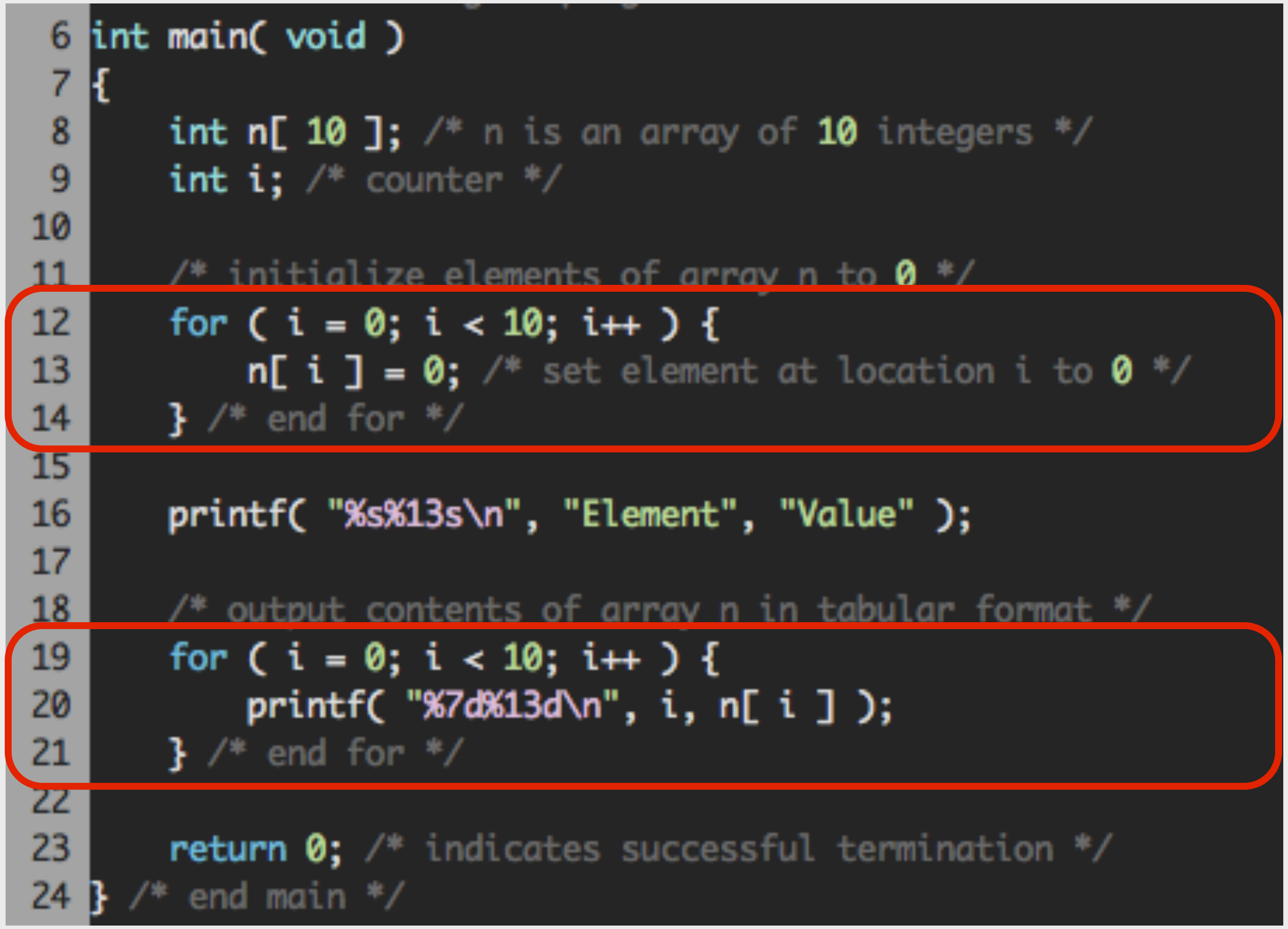


```
int main( void )
{
    int n[ 10 ]; /* n is an array of 10 integers */
    int i; /* counter */

    /* initialize elements of array n to 0 */
    for ( i = 0; i < 10; i++ ) {
        n[ i ] = 0; /* set element at location i to 0 */
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array n in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

use for loop to initialize the array

Array Examples

- Example: fig06_03.c



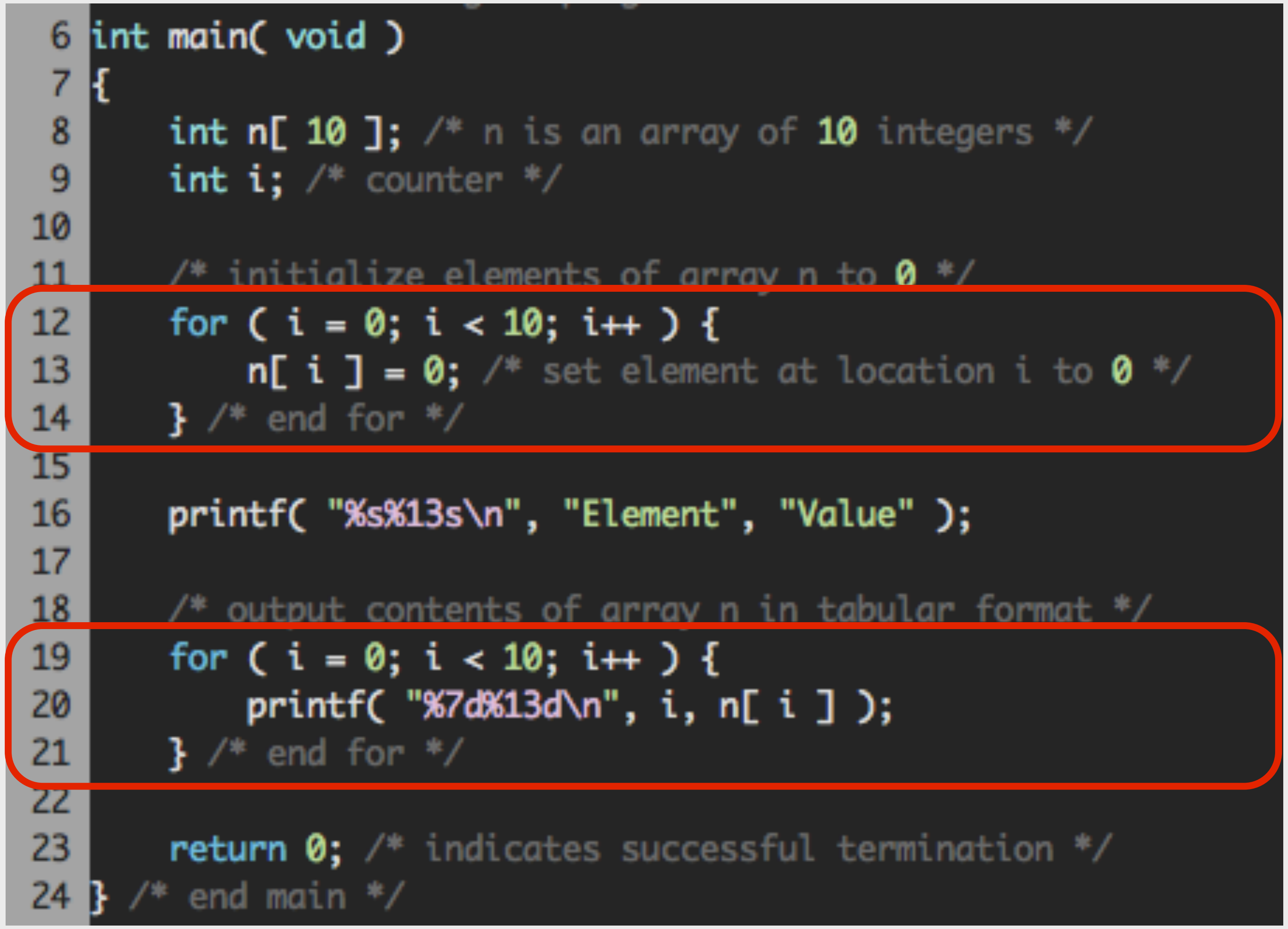
```
int main( void )
{
    int n[ 10 ]; /* n is an array of 10 integers */
    int i; /* counter */

    /* initialize elements of array n to 0 */
    for ( i = 0; i < 10; i++ ) {
        n[ i ] = 0; /* set element at location i to 0 */
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array n in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

use for loop to initialize the array

use for loop to access the array

Array Examples

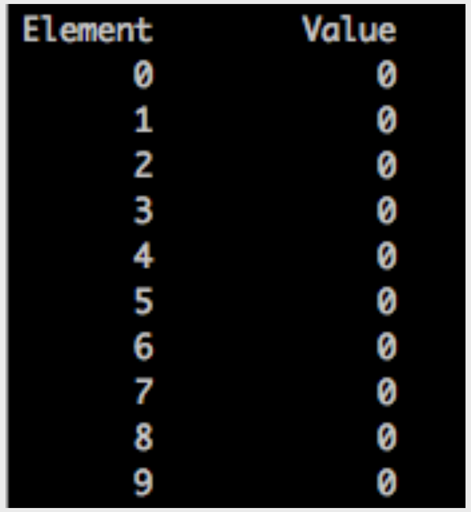
- Example: fig06_03.c



```c
int main( void )
{
    int n[ 10 ]; /* n is an array of 10 integers */
    int i; /* counter */

    /* initialize elements of array n to 0 */
    for ( i = 0; i < 10; i++ ) {
        n[ i ] = 0; /* set element at location i to 0 */
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array n in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

use for loop to initialize the array

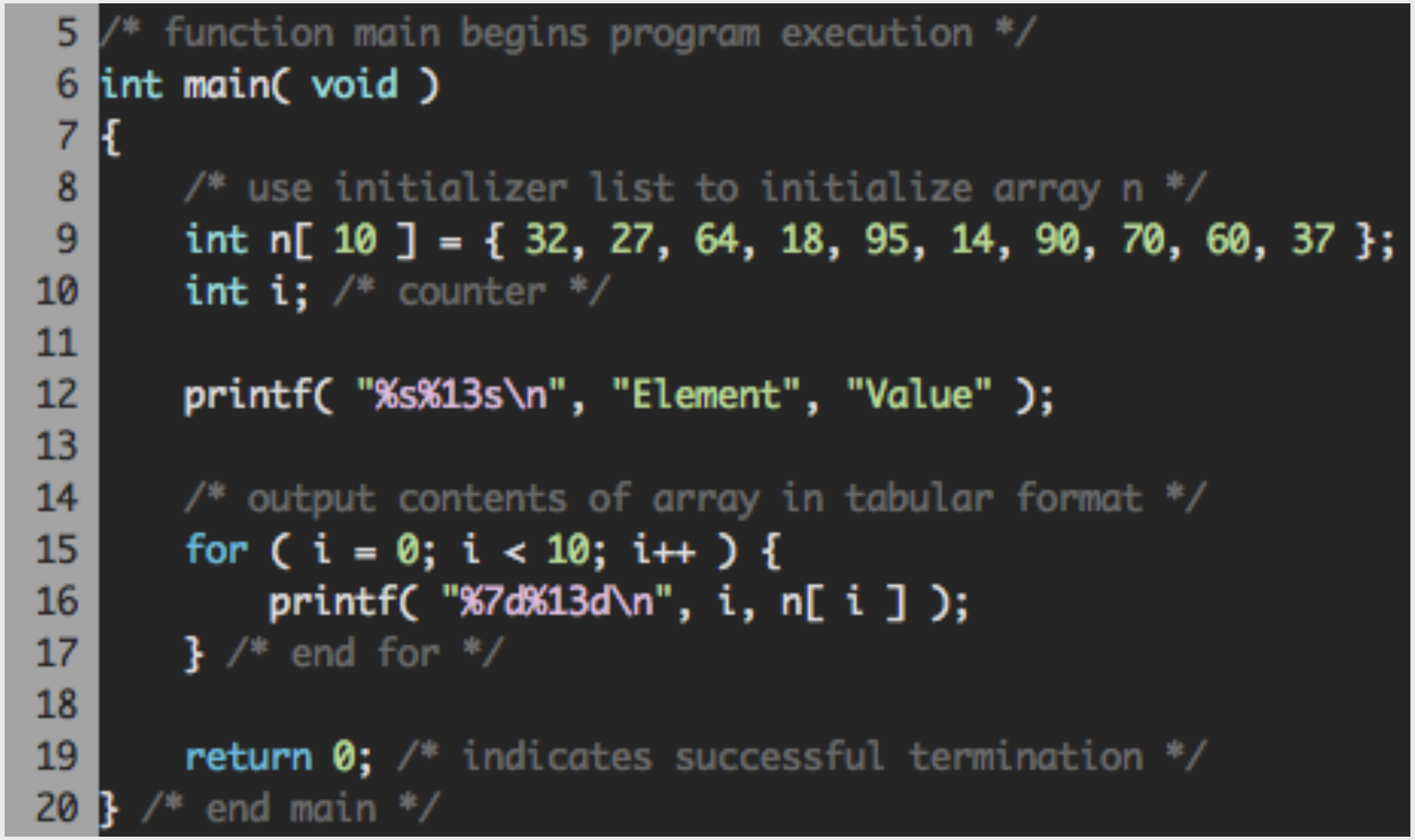
use for loop to access the array



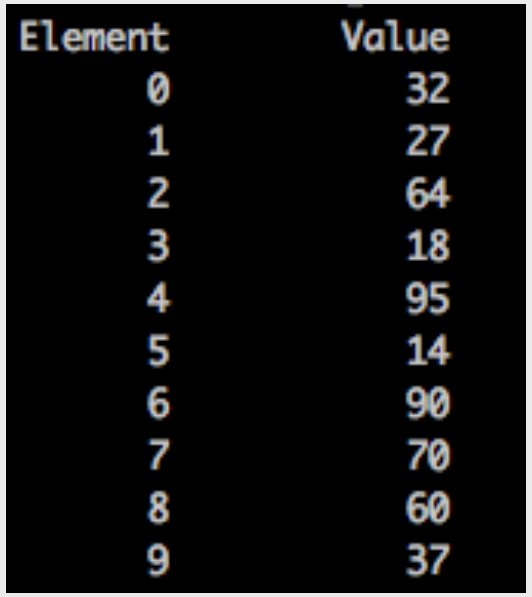
```
Element        Value
      0            0
      1            0
      2            0
      3            0
      4            0
      5            0
      6            0
      7            0
      8            0
      9            0
```

Array Examples (Cont.)

- Example: fig06_04.c



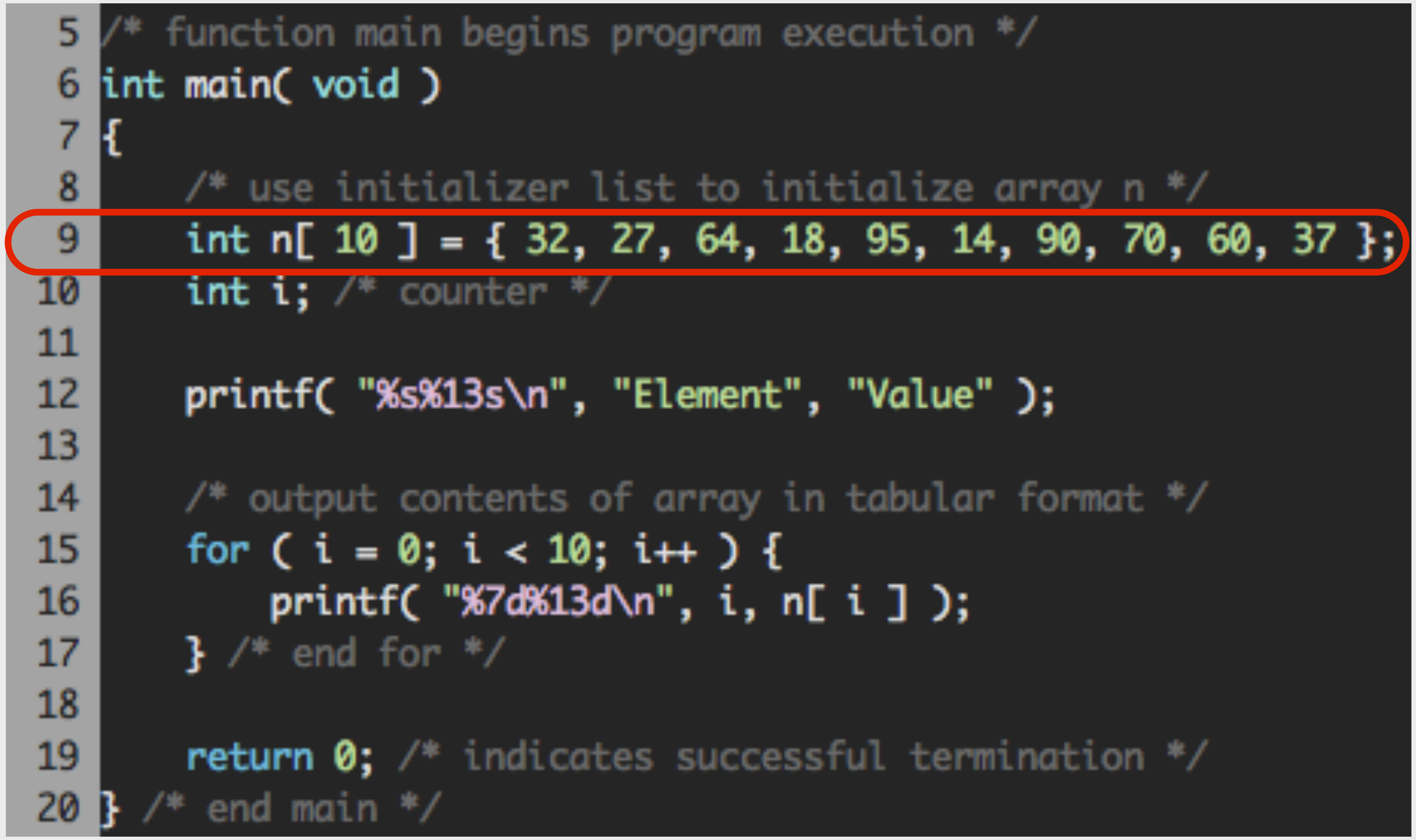
```c
/* function main begins program execution */
int main( void )
{
    /* use initializer list to initialize array n */
    int n[ 10 ] = { 32, 27, 64, 18, 95, 14, 90, 70, 60, 37 };
    int i; /* counter */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```



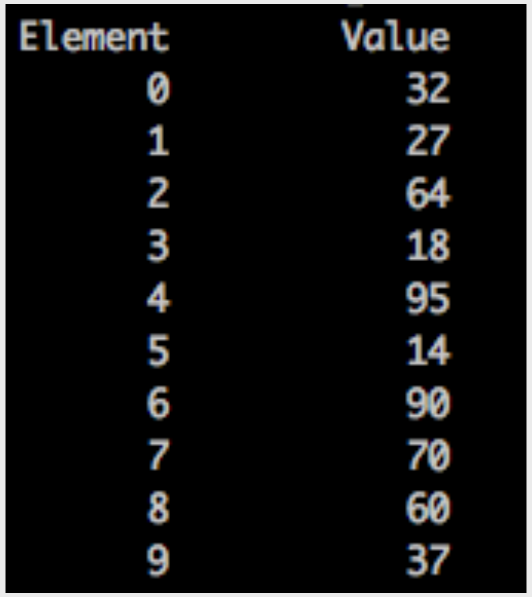
```
Element        Value
      0           32
      1           27
      2           64
      3           18
      4           95
      5           14
      6           90
      7           70
      8           60
      9           37
```

Array Examples (Cont.)

- Example: fig06_04.c



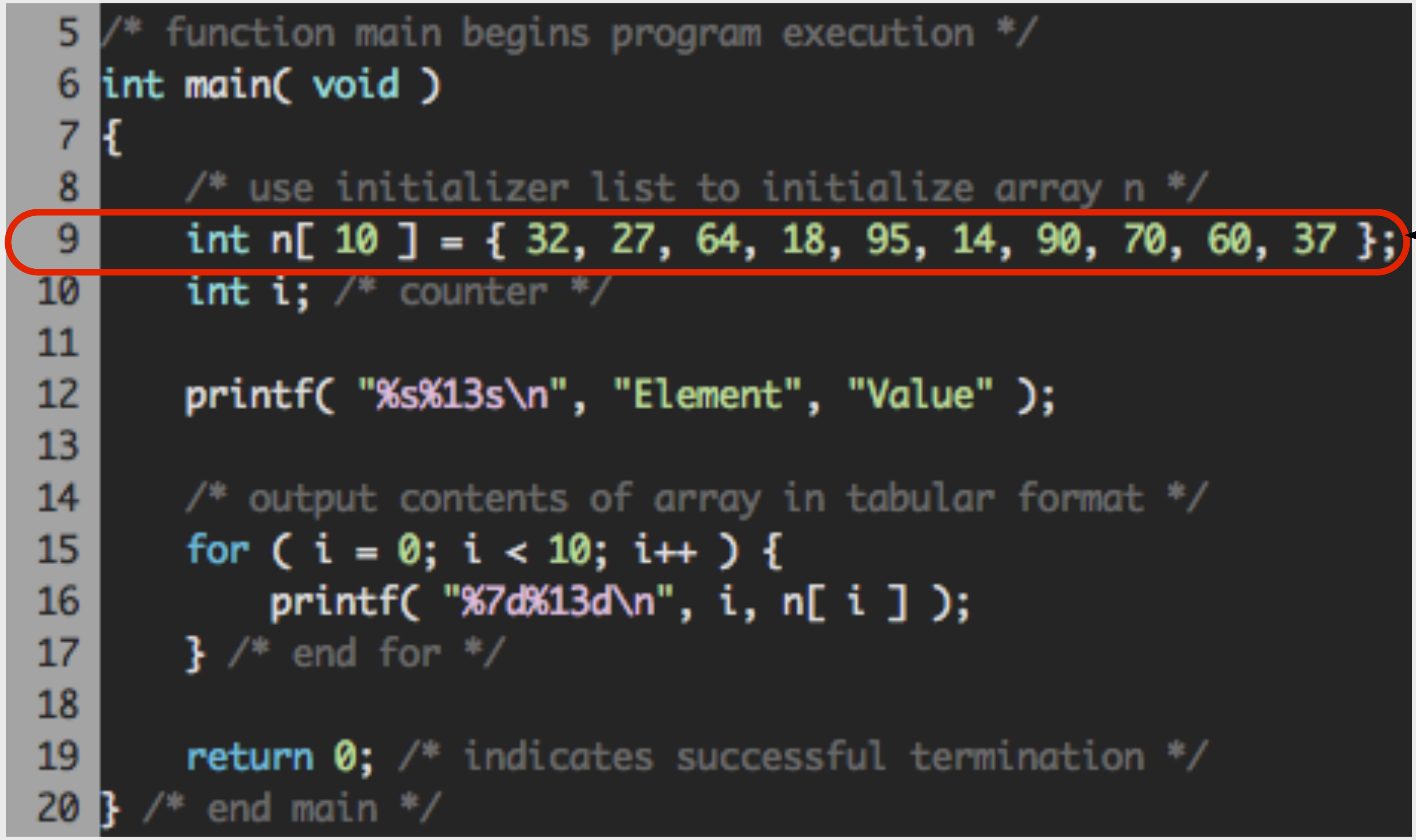
```c
/* function main begins program execution */
int main( void )
{
    /* use initializer list to initialize array n */
    int n[ 10 ] = { 32, 27, 64, 18, 95, 14, 90, 70, 60, 37 };
    int i; /* counter */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```



```
Element        Value
      0           32
      1           27
      2           64
      3           18
      4           95
      5           14
      6           90
      7           70
      8           60
      9           37
```

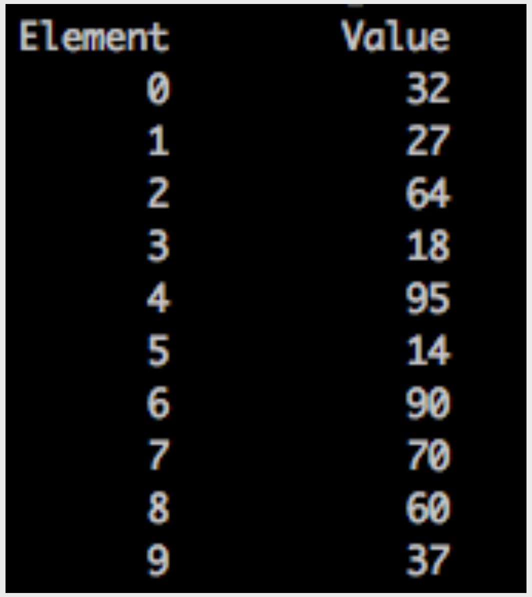
Array Examples (Cont.)

- Example: fig06_04.c



```c
/* function main begins program execution */
int main( void )
{
    /* use initializer list to initialize array n */
    int n[ 10 ] = { 32, 27, 64, 18, 95, 14, 90, 70, 60, 37 };
    int i; /* counter */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array in tabular format */
    for ( i = 0; i < 10; i++ ) {
        printf( "%7d%13d\n", i, n[ i ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

use { } to initialize values



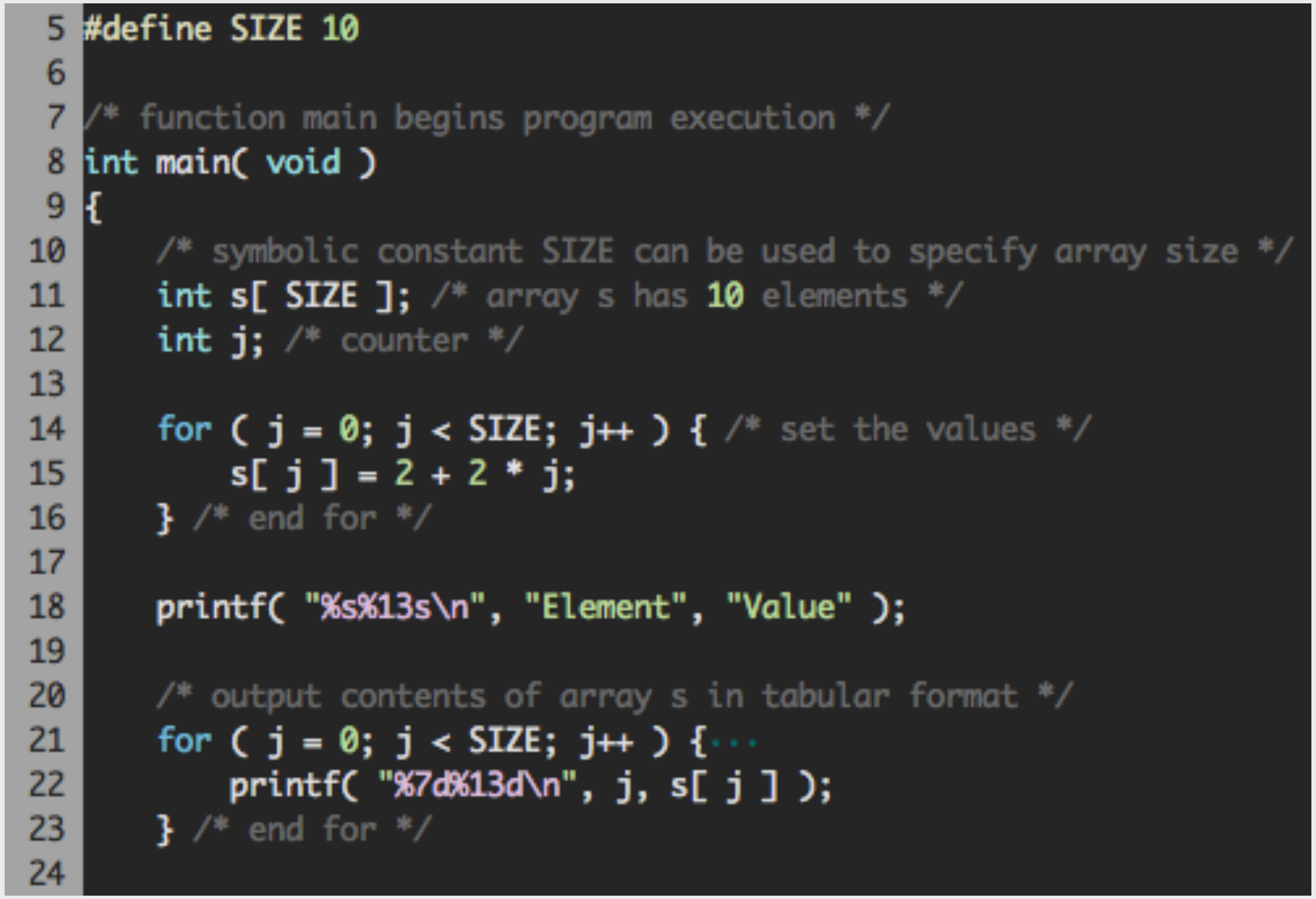
```
Element        Value
      0           32
      1           27
      2           64
      3           18
      4           95
      5           14
      6           90
      7           70
      8           60
      9           37
```

Array Examples (Cont.)

- **`int n[ 10 ] = { 0 };`**
  - initialize to all zeros
- **`int n[5] = {32,27,64,18,95,14};`**
  - syntax error
- **`int n[] = { 1, 2, 3, 4, 5 };`**
  - array size can be omitted if using {} to initialize

Array Examples (Cont.)

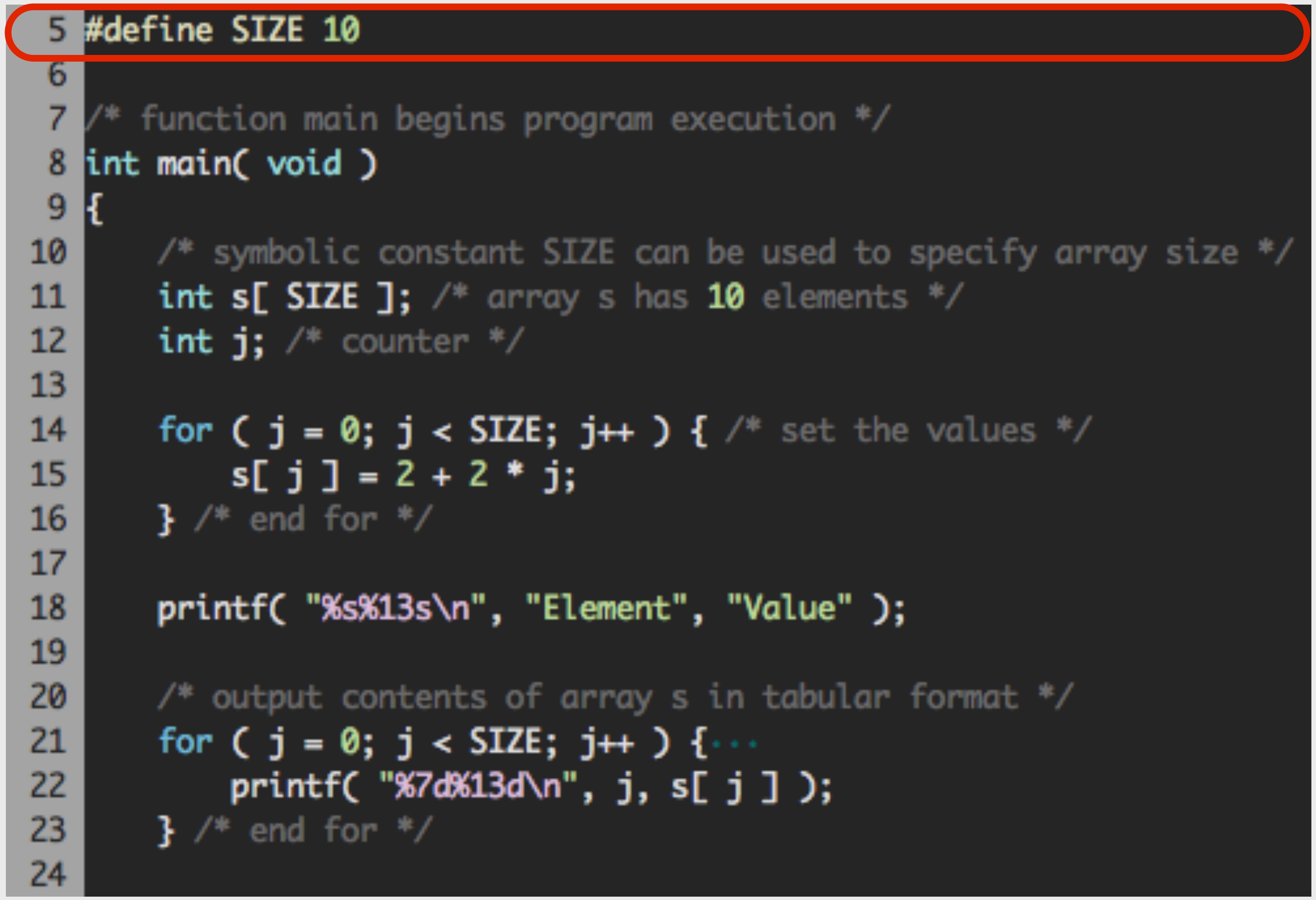
- Example: fig06_05.c



```c
#define SIZE 10

/* function main begins program execution */
int main( void )
{
    /* symbolic constant SIZE can be used to specify array size */
    int s[ SIZE ]; /* array s has 10 elements */
    int j; /* counter */

    for ( j = 0; j < SIZE; j++ ) { /* set the values */
        s[ j ] = 2 + 2 * j;
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array s in tabular format */
    for ( j = 0; j < SIZE; j++ ) {···
        printf( "%7d%13d\n", j, s[ j ] );
    } /* end for */

```

Array Examples (Cont.)

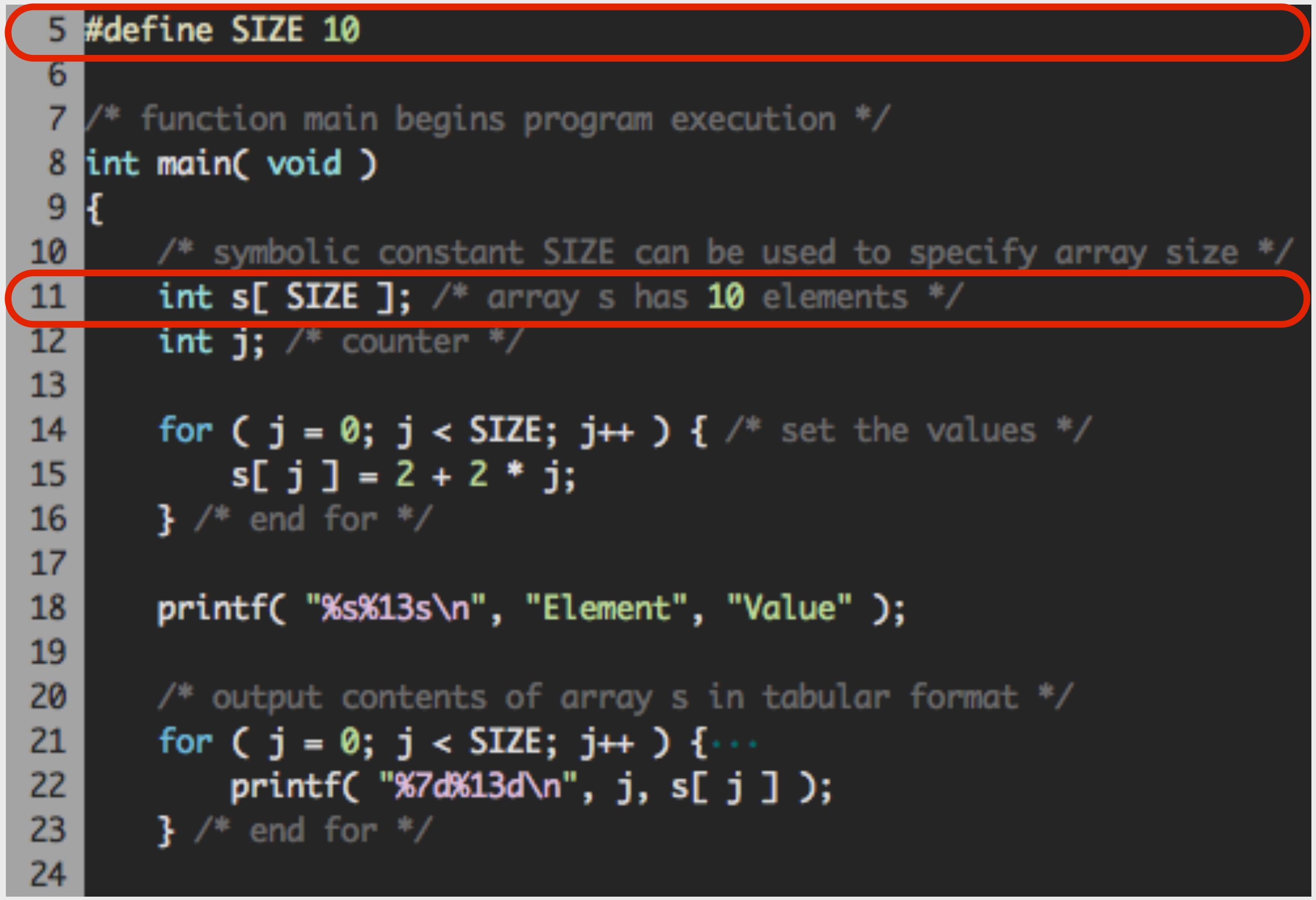
- Example: fig06_05.c



```
#define SIZE 10

/* function main begins program execution */
int main( void )
{
    /* symbolic constant SIZE can be used to specify array size */
    int s[ SIZE ]; /* array s has 10 elements */
    int j; /* counter */

    for ( j = 0; j < SIZE; j++ ) { /* set the values */
        s[ j ] = 2 + 2 * j;
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array s in tabular format */
    for ( j = 0; j < SIZE; j++ ) {
        printf( "%7d%13d\n", j, s[ j ] );
    } /* end for */

```

Array Examples (Cont.)

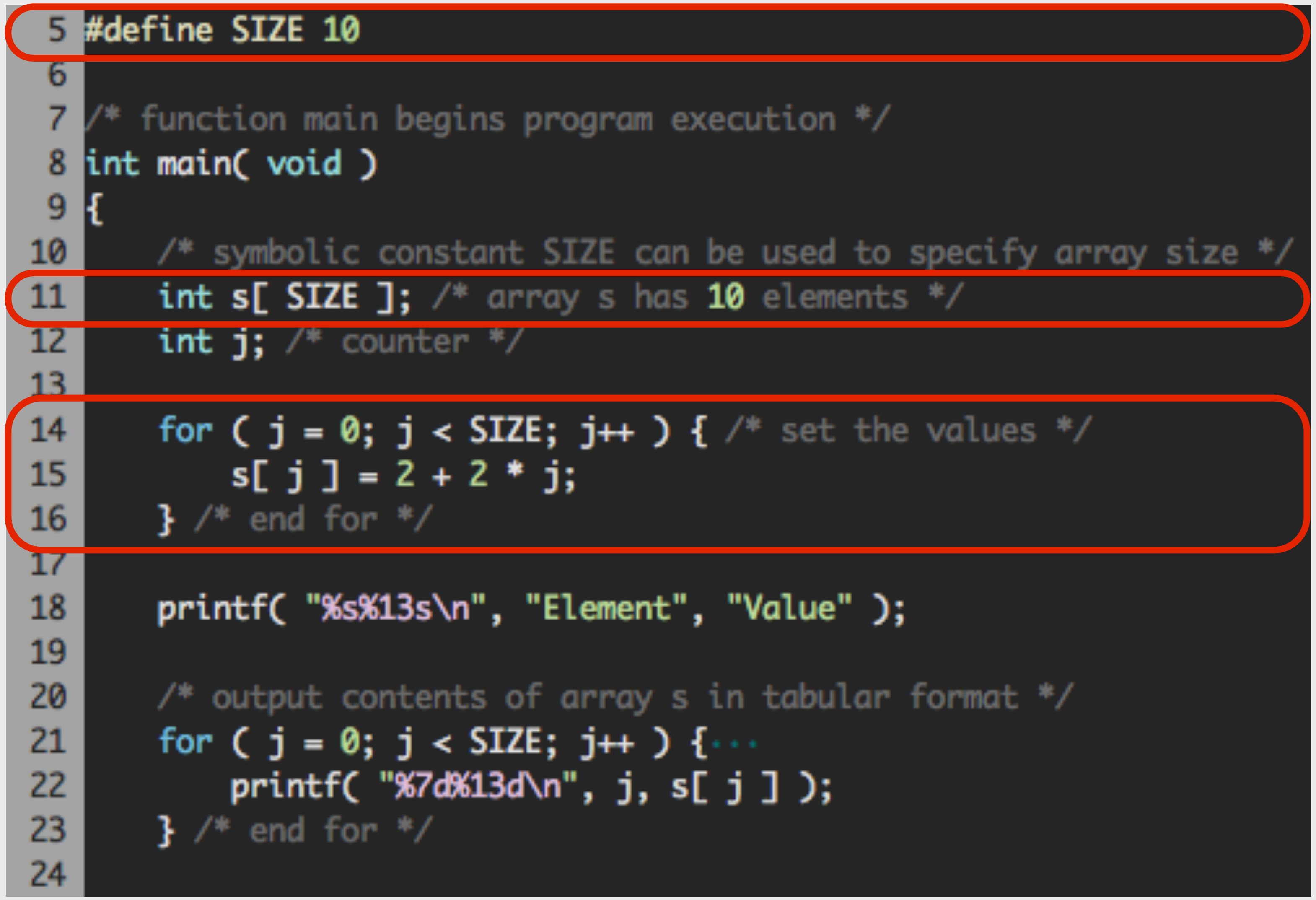
- Example: fig06_05.c



```c
#define SIZE 10

/* function main begins program execution */
int main( void )
{
    /* symbolic constant SIZE can be used to specify array size */
    int s[ SIZE ]; /* array s has 10 elements */
    int j; /* counter */

    for ( j = 0; j < SIZE; j++ ) { /* set the values */
        s[ j ] = 2 + 2 * j;
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array s in tabular format */
    for ( j = 0; j < SIZE; j++ ) {
        printf( "%7d%13d\n", j, s[ j ] );
    } /* end for */

```

Array Examples (Cont.)

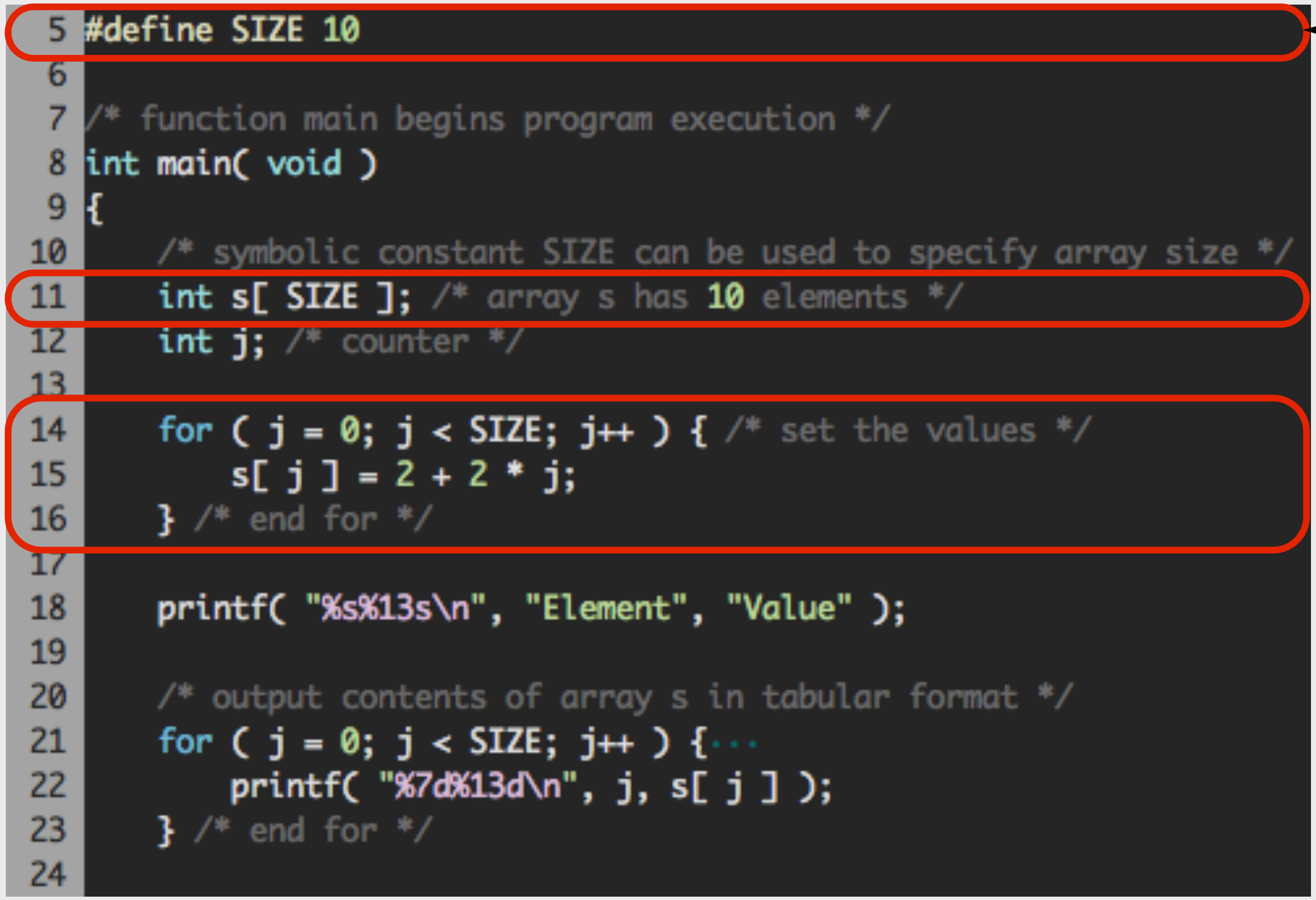
- Example: fig06_05.c



```c
#define SIZE 10

/* function main begins program execution */
int main( void )
{
    /* symbolic constant SIZE can be used to specify array size */
    int s[ SIZE ]; /* array s has 10 elements */
    int j; /* counter */

    for ( j = 0; j < SIZE; j++ ) { /* set the values */
        s[ j ] = 2 + 2 * j;
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array s in tabular format */
    for ( j = 0; j < SIZE; j++ ) {
        printf( "%7d%13d\n", j, s[ j ] );
    } /* end for */

```

Array Examples (Cont.)

- Example: fig06_05.c

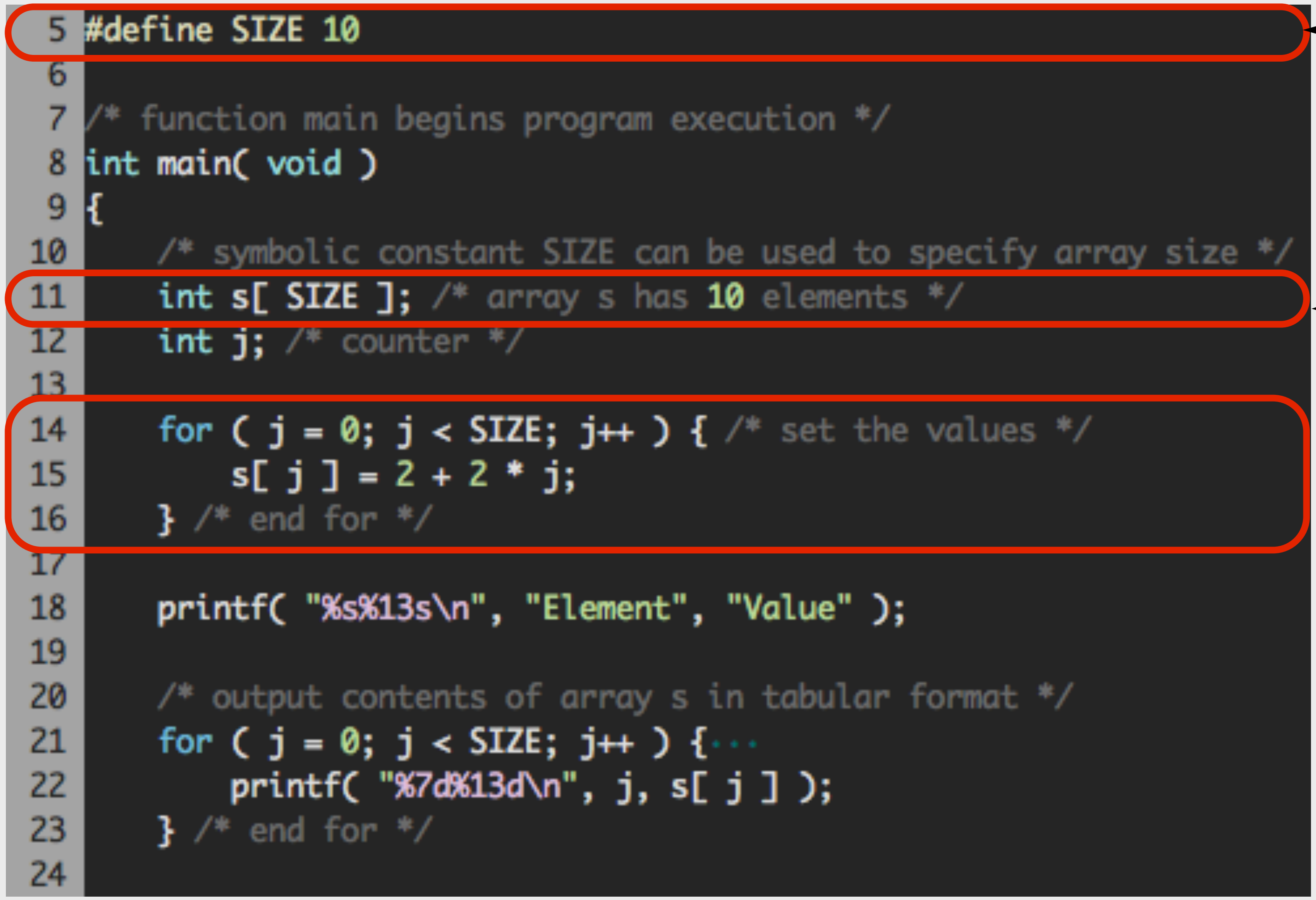


```
#define SIZE 10

/* function main begins program execution */
int main( void )
{
    /* symbolic constant SIZE can be used to specify array size */
    int s[ SIZE ]; /* array s has 10 elements */
    int j; /* counter */

    for ( j = 0; j < SIZE; j++ ) { /* set the values */
        s[ j ] = 2 + 2 * j;
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array s in tabular format */
    for ( j = 0; j < SIZE; j++ ) {
        printf( "%7d%13d\n", j, s[ j ] );
    } /* end for */

```

use **#define** preprocessor to define a symbolic constant SIZE

Array Examples (Cont.)

- Example: fig06_05.c



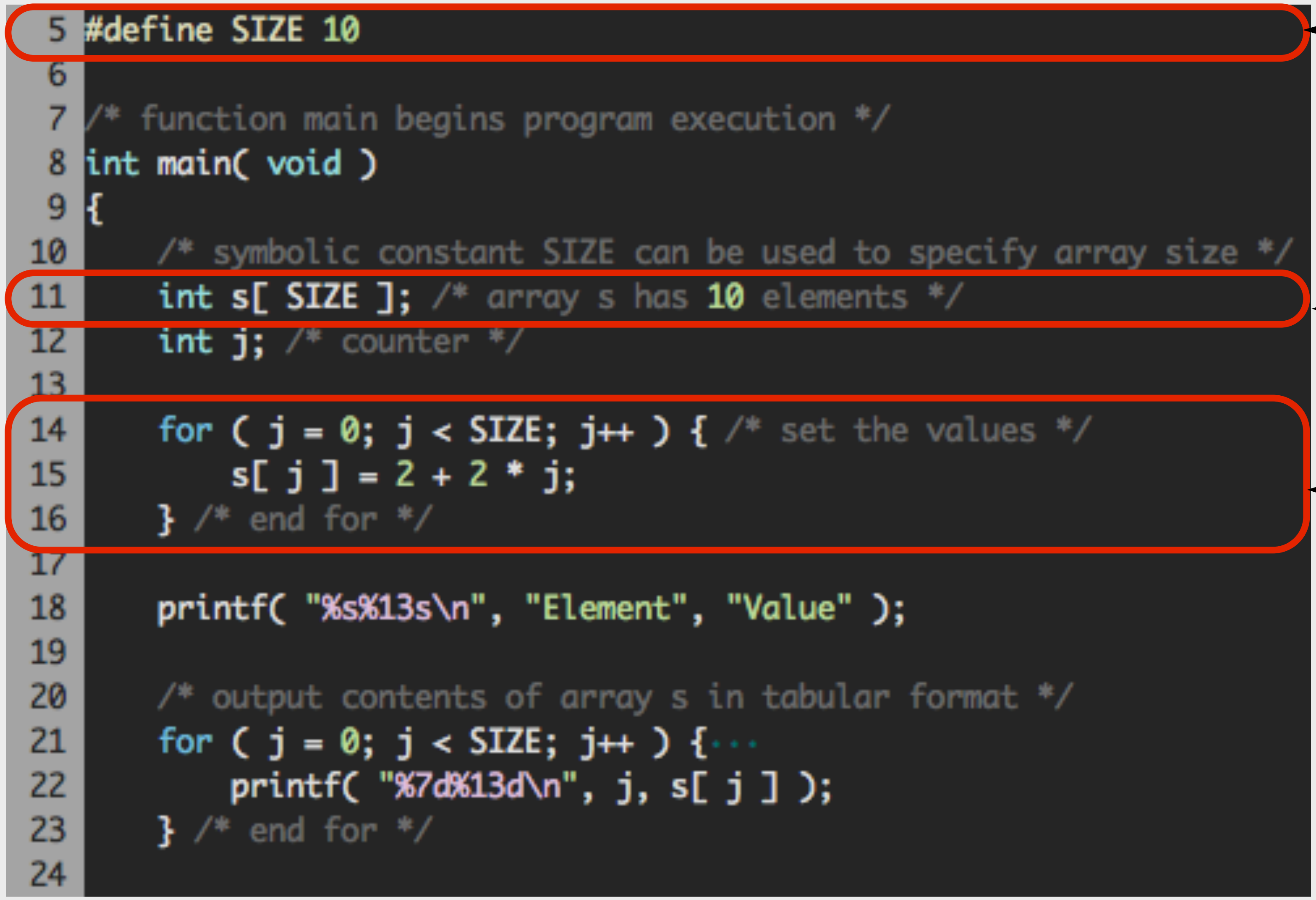
```c
#define SIZE 10

/* function main begins program execution */
int main( void )
{
    /* symbolic constant SIZE can be used to specify array size */
    int s[ SIZE ]; /* array s has 10 elements */
    int j; /* counter */

    for ( j = 0; j < SIZE; j++ ) { /* set the values */
        s[ j ] = 2 + 2 * j;
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array s in tabular format */
    for ( j = 0; j < SIZE; j++ ) {
        printf( "%7d%13d\n", j, s[ j ] );
    } /* end for */

```

use **#define** preprocessor to define a symbolic constant SIZE

equal to
int s[10];

Array Examples (Cont.)

- Example: fig06_05.c



```
#define SIZE 10

/* function main begins program execution */
int main( void )
{
    /* symbolic constant SIZE can be used to specify array size */
    int s[ SIZE ]; /* array s has 10 elements */
    int j; /* counter */

    for ( j = 0; j < SIZE; j++ ) { /* set the values */
        s[ j ] = 2 + 2 * j;
    } /* end for */

    printf( "%s%13s\n", "Element", "Value" );

    /* output contents of array s in tabular format */
    for ( j = 0; j < SIZE; j++ ) {
        printf( "%7d%13d\n", j, s[ j ] );
    } /* end for */

```

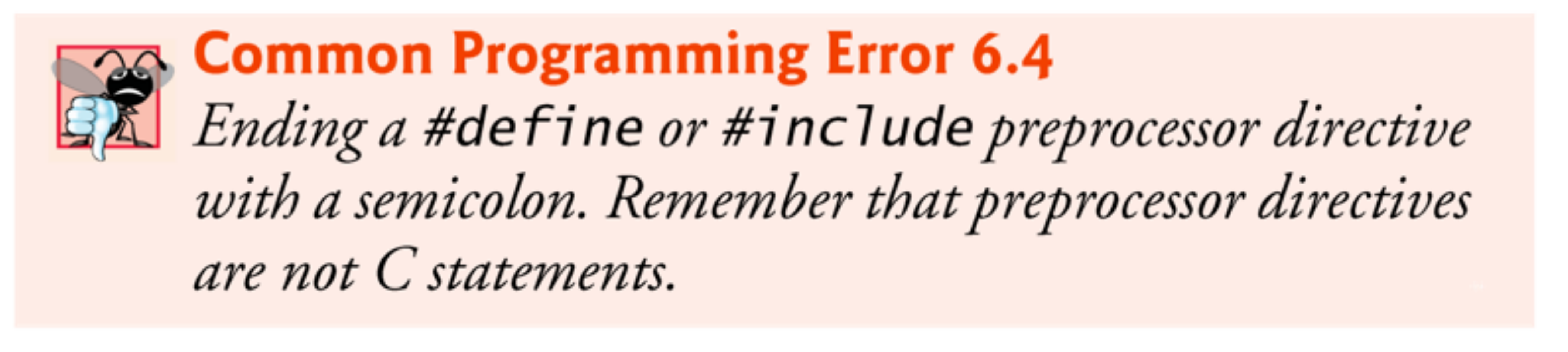
use **#define** preprocessor to define a symbolic constant SIZE

equal to
int s[10];

The values are generated by multiplying the loop counter by 2 and adding 2

Array Examples (Cont.)

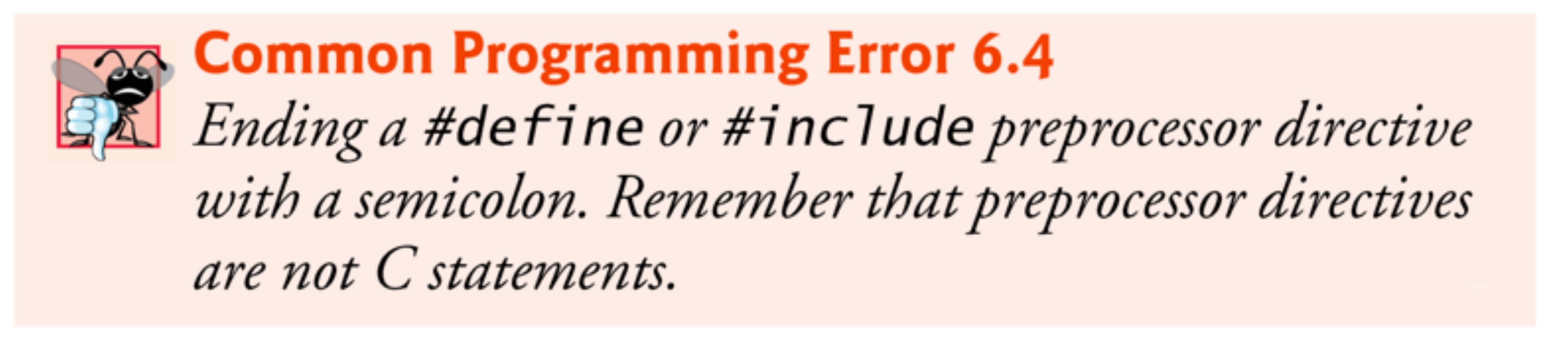
Array Examples (Cont.)



Common Programming Error 6.4

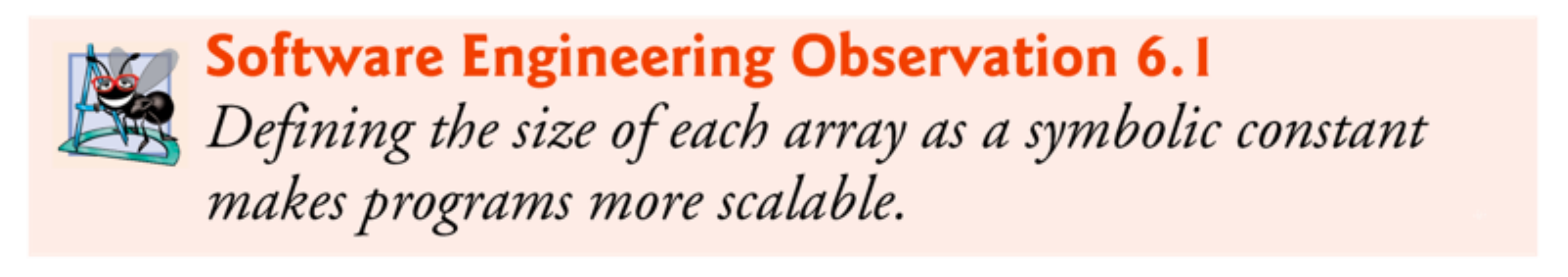
Ending a `#define` *or* `#include` *preprocessor directive with a semicolon. Remember that preprocessor directives are not C statements.*

Array Examples (Cont.)



Common Programming Error 6.4

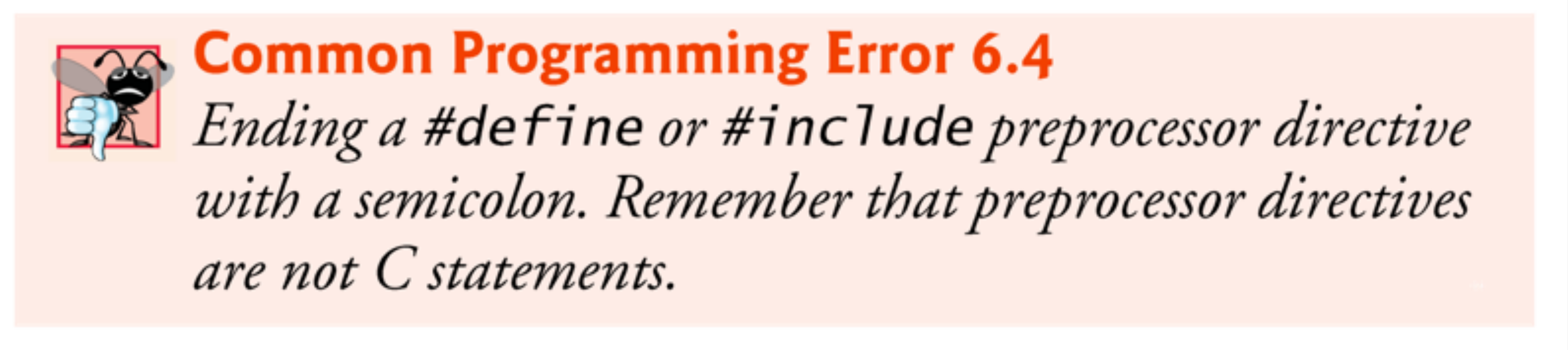
Ending a `#define` or `#include` preprocessor directive with a semicolon. Remember that preprocessor directives are not C statements.



Software Engineering Observation 6.1

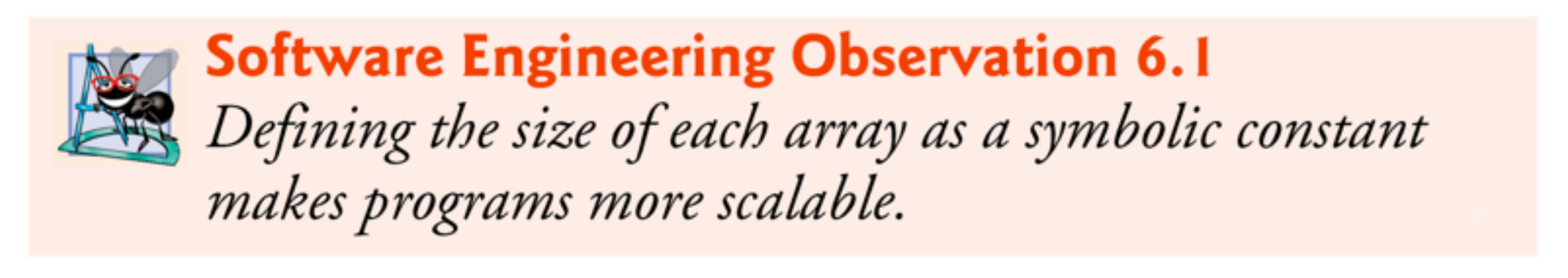
Defining the size of each array as a symbolic constant makes programs more scalable.

Array Examples (Cont.)



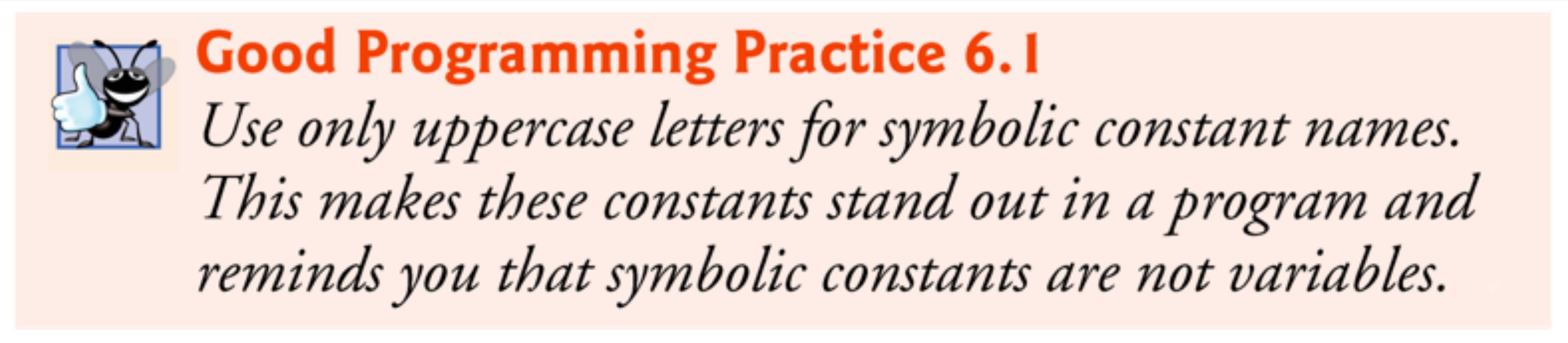
Common Programming Error 6.4

Ending a `#define` or `#include` preprocessor directive with a semicolon. Remember that preprocessor directives are not C statements.



Software Engineering Observation 6.1

Defining the size of each array as a symbolic constant makes programs more scalable.

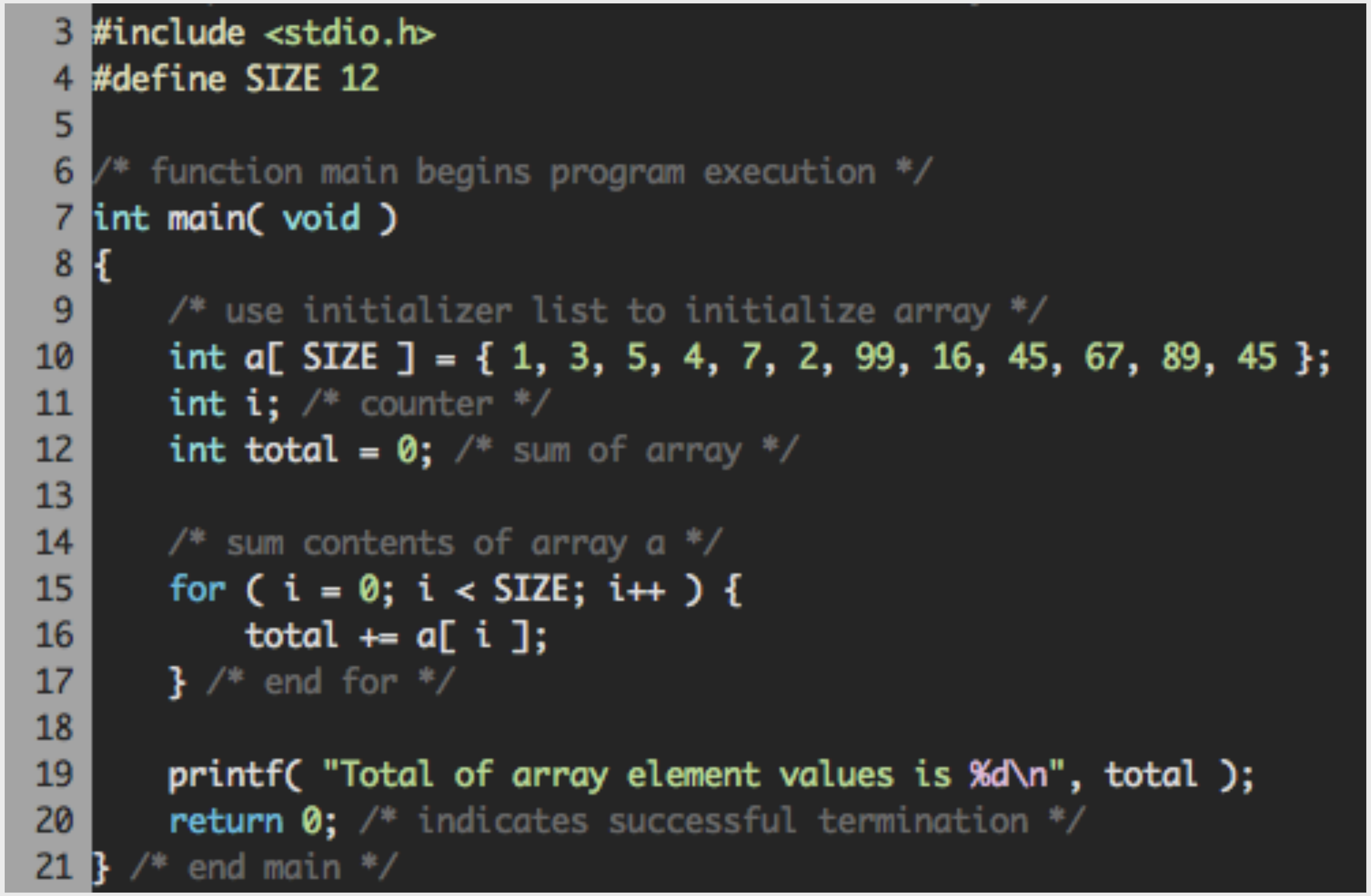


Good Programming Practice 6.1

Use only uppercase letters for symbolic constant names. This makes these constants stand out in a program and reminds you that symbolic constants are not variables.

Array Examples (Cont.)

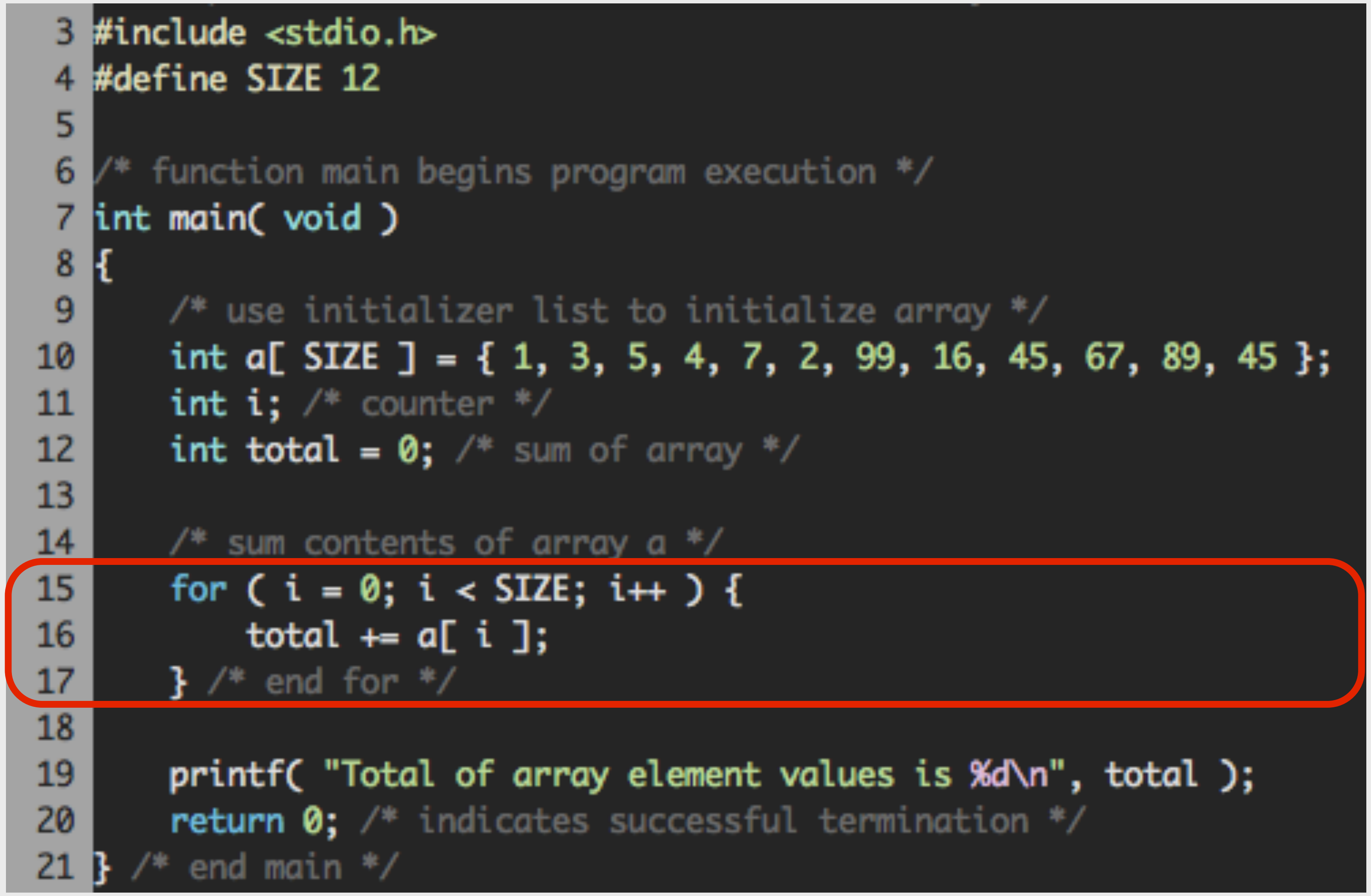
- Ex: fig06_06.c



```c
#include <stdio.h>
#define SIZE 12

/* function main begins program execution */
int main( void )
{
    /* use initializer list to initialize array */
    int a[ SIZE ] = { 1, 3, 5, 4, 7, 2, 99, 16, 45, 67, 89, 45 };
    int i; /* counter */
    int total = 0; /* sum of array */

    /* sum contents of array a */
    for ( i = 0; i < SIZE; i++ ) {
        total += a[ i ];
    } /* end for */

    printf( "Total of array element values is %d\n", total );
    return 0; /* indicates successful termination */
} /* end main */
```

Array Examples (Cont.)

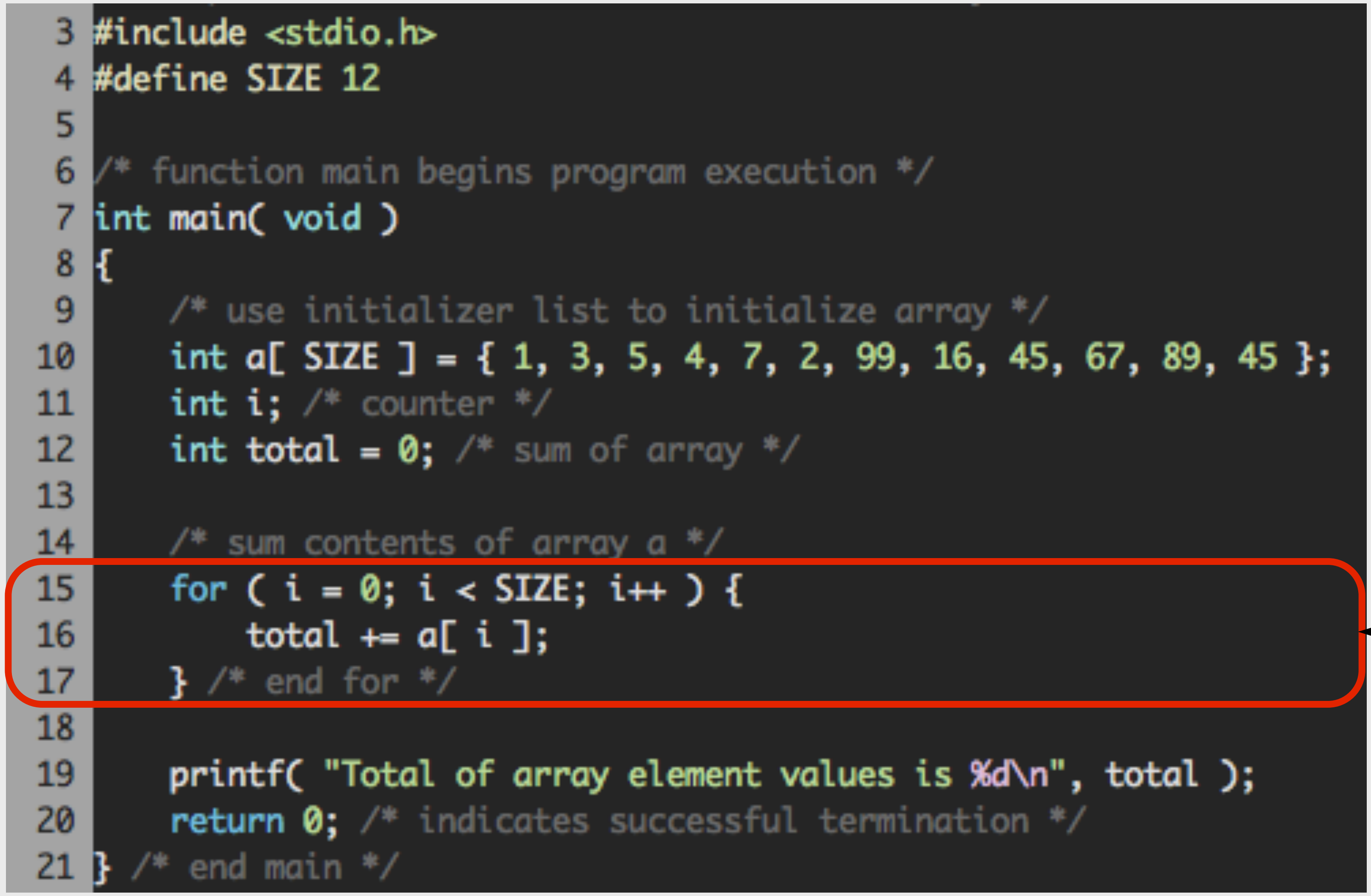
- Ex: fig06_06.c



```c
#include <stdio.h>
#define SIZE 12

/* function main begins program execution */
int main( void )
{
    /* use initializer list to initialize array */
    int a[ SIZE ] = { 1, 3, 5, 4, 7, 2, 99, 16, 45, 67, 89, 45 };
    int i; /* counter */
    int total = 0; /* sum of array */

    /* sum contents of array a */
    for ( i = 0; i < SIZE; i++ ) {
        total += a[ i ];
    } /* end for */

    printf( "Total of array element values is %d\n", total );
    return 0; /* indicates successful termination */
} /* end main */
```

Array Examples (Cont.)

- Ex: fig06_06.c

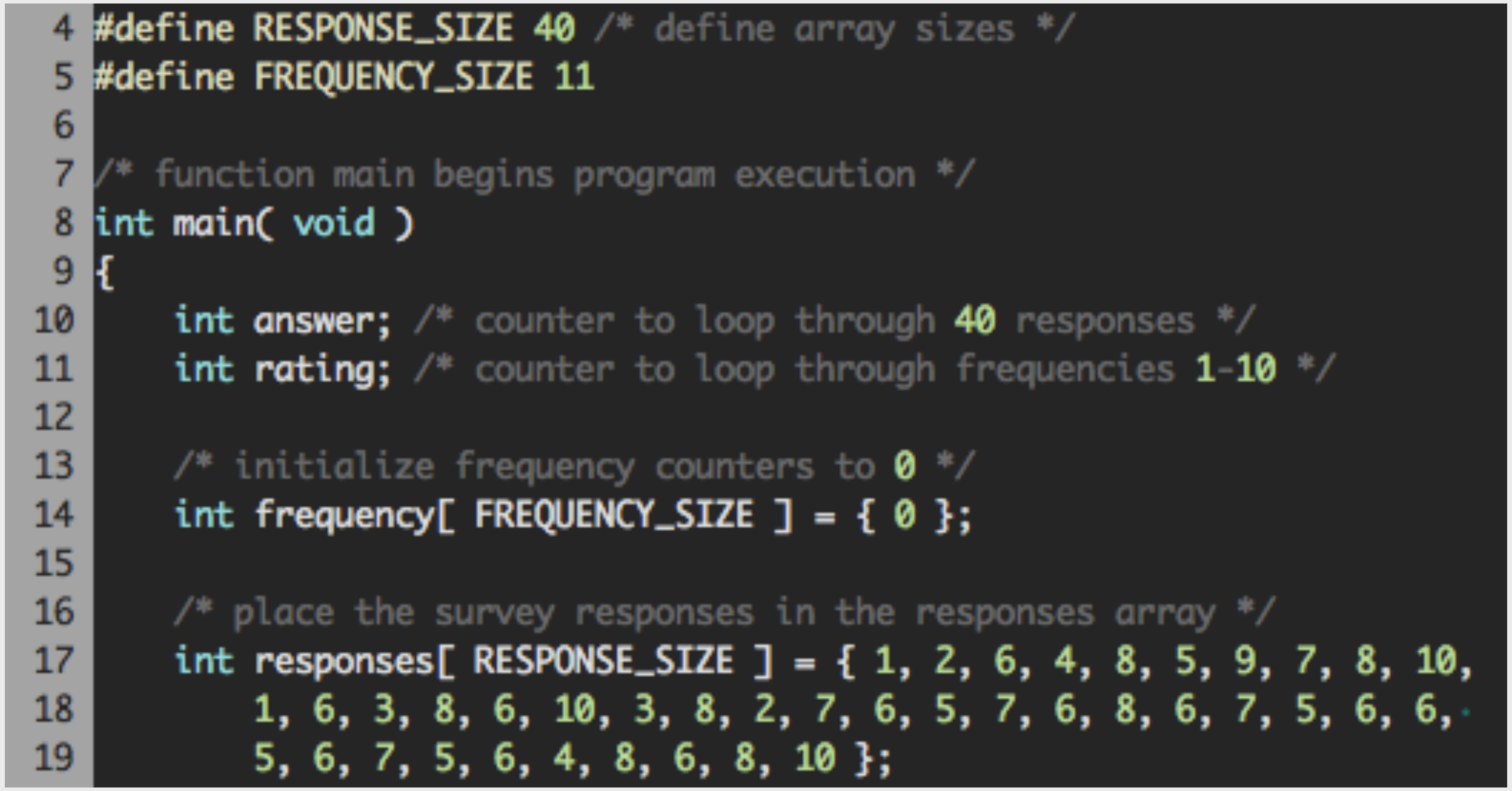


```
#include <stdio.h>
#define SIZE 12

/* function main begins program execution */
int main( void )
{
    /* use initializer list to initialize array */
    int a[ SIZE ] = { 1, 3, 5, 4, 7, 2, 99, 16, 45, 67, 89, 45 };
    int i; /* counter */
    int total = 0; /* sum of array */

    /* sum contents of array a */
    for ( i = 0; i < SIZE; i++ ) {
        total += a[ i ];
    } /* end for */

    printf( "Total of array element values is %d\n", total );
    return 0; /* indicates successful termination */
} /* end main */
```

Sum the values contained in the array **a**

Array Examples (Cont.)

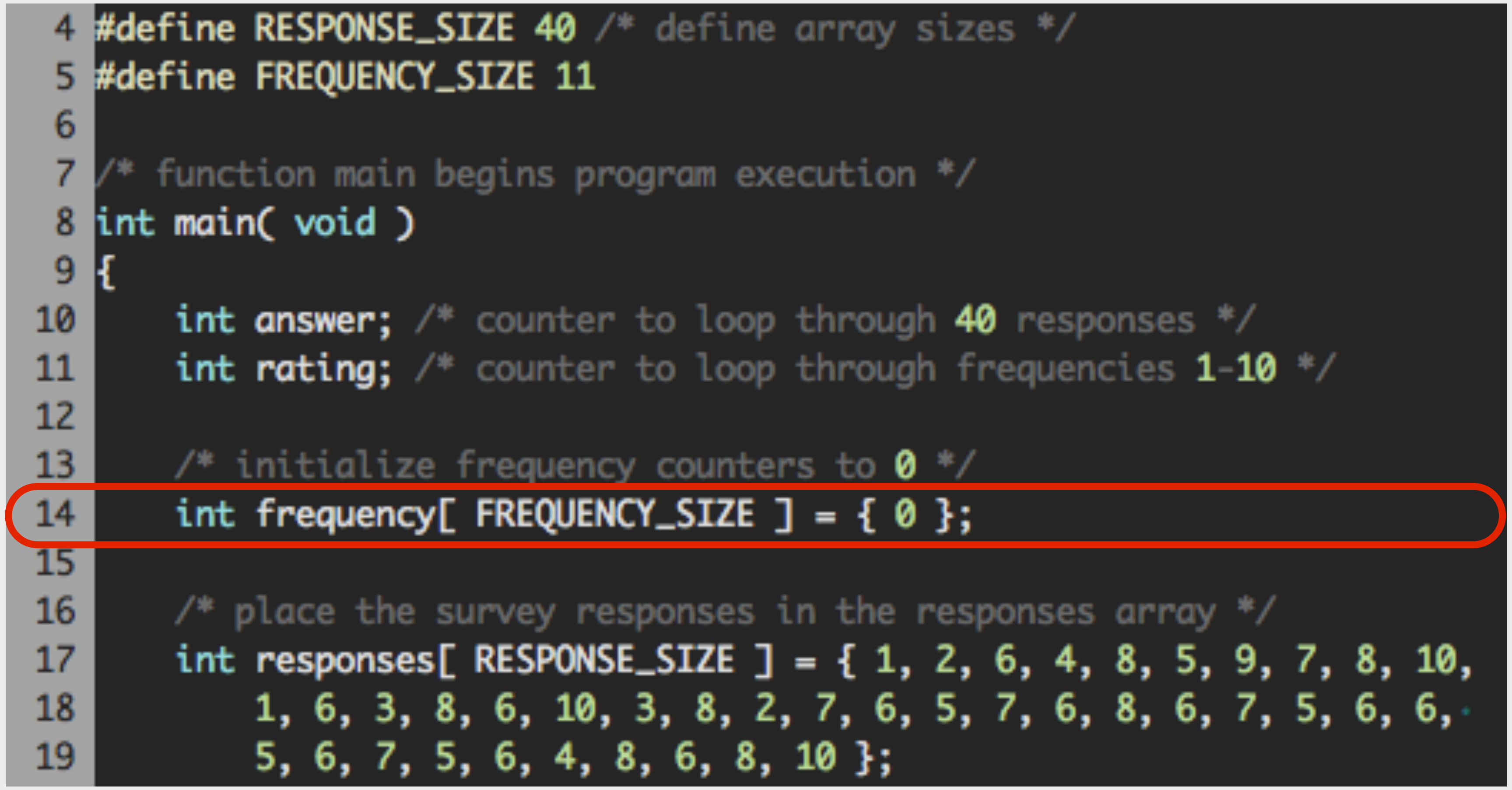
- Ex: fig06_07.c



```c
#define RESPONSE_SIZE 40 /* define array sizes */
#define FREQUENCY_SIZE 11

/* function main begins program execution */
int main( void )
{
    int answer; /* counter to loop through 40 responses */
    int rating; /* counter to loop through frequencies 1-10 */

    /* initialize frequency counters to 0 */
    int frequency[ FREQUENCY_SIZE ] = { 0 };

    /* place the survey responses in the responses array */
    int responses[ RESPONSE_SIZE ] = { 1, 2, 6, 4, 8, 5, 9, 7, 8, 10,
        1, 6, 3, 8, 6, 10, 3, 8, 2, 7, 6, 5, 7, 6, 8, 6, 7, 5, 6, 6,
        5, 6, 7, 5, 6, 4, 8, 6, 8, 10 };
```

Array Examples (Cont.)

- Ex: fig06_07.c



```c
#define RESPONSE_SIZE 40 /* define array sizes */
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/* function main begins program execution */
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{
    int answer; /* counter to loop through 40 responses */
    int rating; /* counter to loop through frequencies 1-10 */

    /* initialize frequency counters to 0 */
    int frequency[ FREQUENCY_SIZE ] = { 0 };

    /* place the survey responses in the responses array */
    int responses[ RESPONSE_SIZE ] = { 1, 2, 6, 4, 8, 5, 9, 7, 8, 10,
        1, 6, 3, 8, 6, 10, 3, 8, 2, 7, 6, 5, 7, 6, 8, 6, 7, 5, 6, 6,
        5, 6, 7, 5, 6, 4, 8, 6, 8, 10 };
```
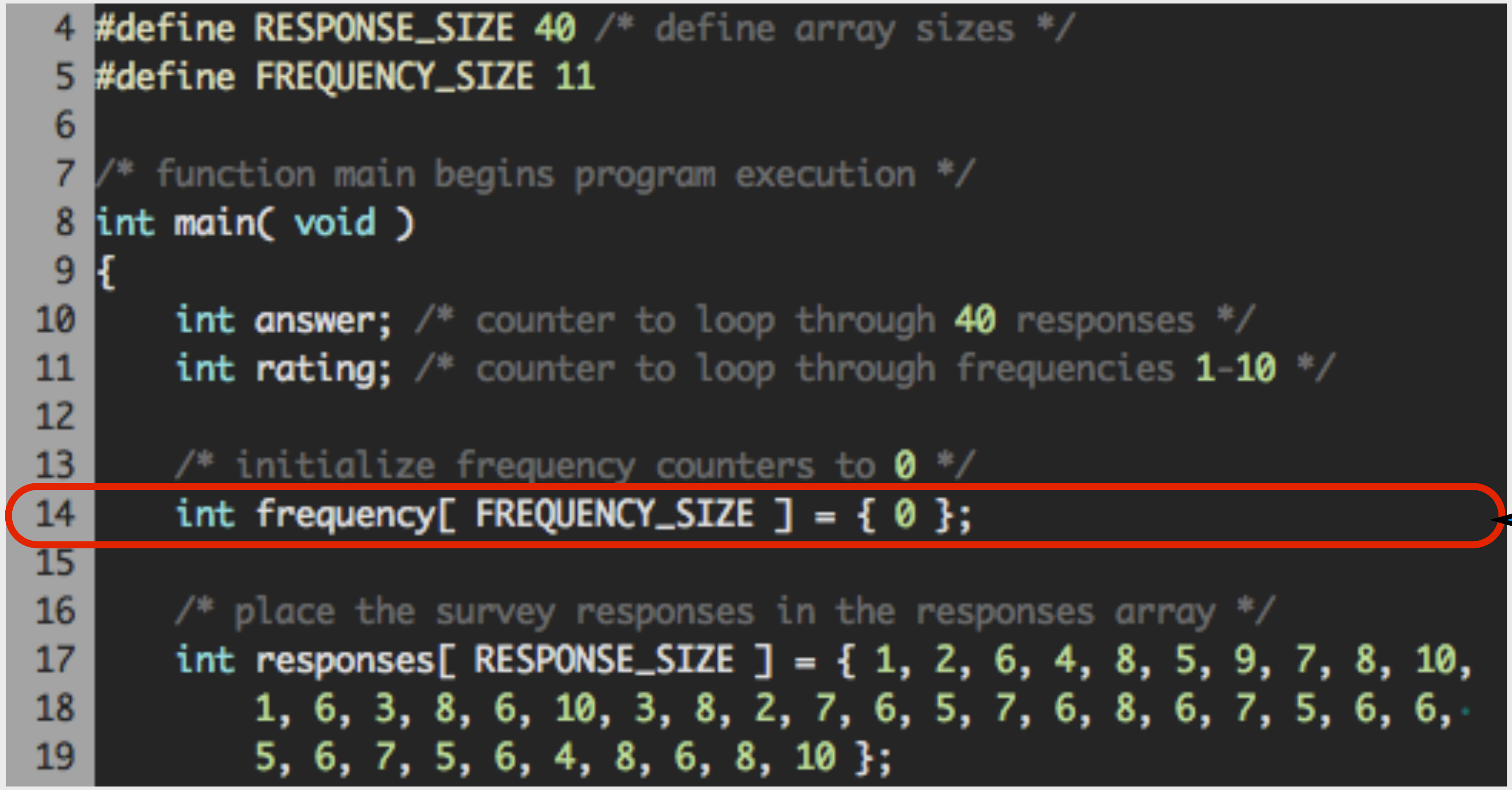

Array Examples (Cont.)

- Ex: fig06_07.c



```
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#define FREQUENCY_SIZE 11

/* function main begins program execution */
int main( void )
{
    int answer; /* counter to loop through 40 responses */
    int rating; /* counter to loop through frequencies 1-10 */

    /* initialize frequency counters to 0 */
    int frequency[ FREQUENCY_SIZE ] = { 0 };

    /* place the survey responses in the responses array */
    int responses[ RESPONSE_SIZE ] = { 1, 2, 6, 4, 8, 5, 9, 7, 8, 10,
        1, 6, 3, 8, 6, 10, 3, 8, 2, 7, 6, 5, 7, 6, 8, 6, 7, 5, 6, 6,
        5, 6, 7, 5, 6, 4, 8, 6, 8, 10 };
```
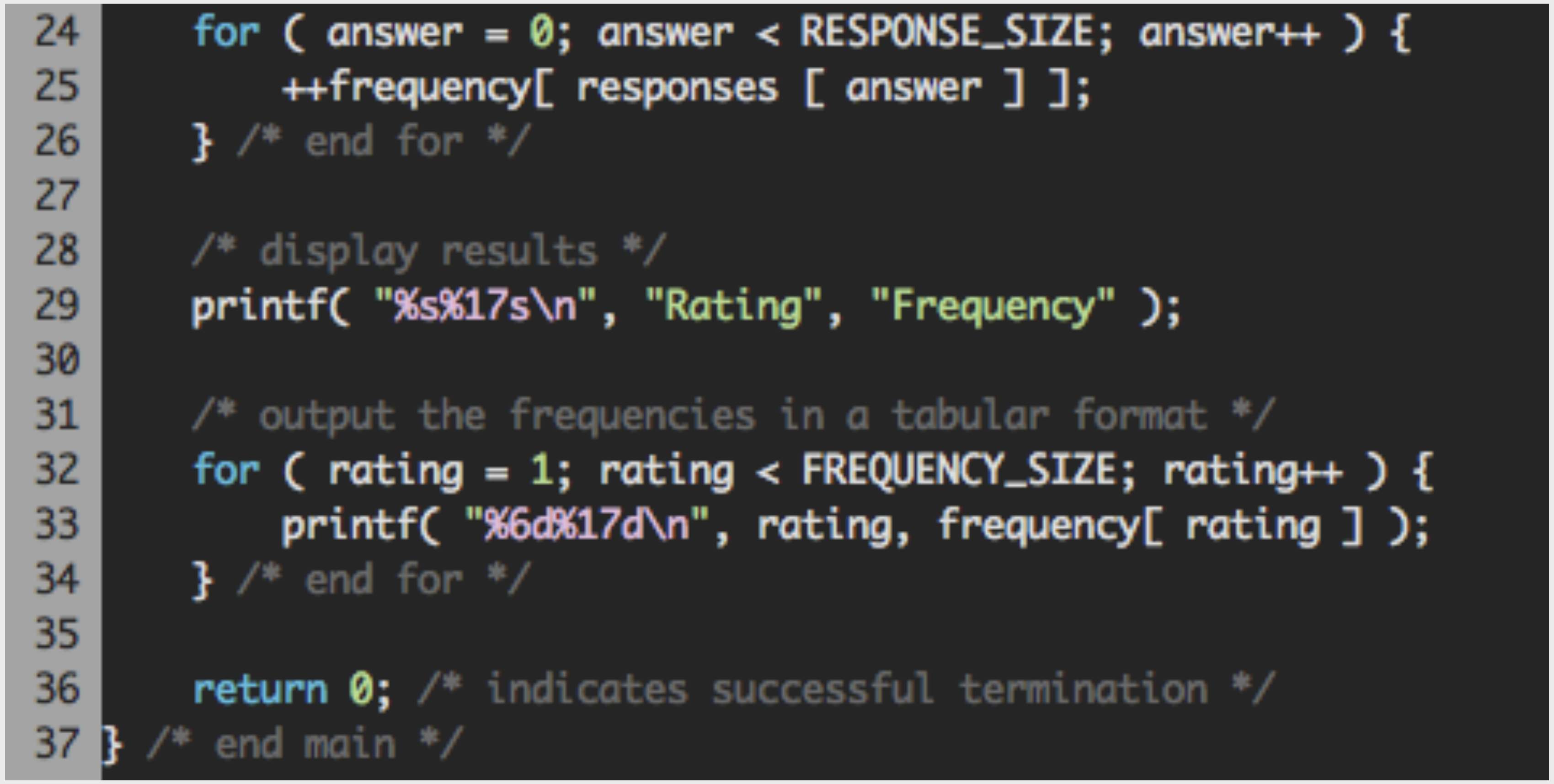

Use **frequency** to count the number of occurrences of each response

Array Examples (Cont.)

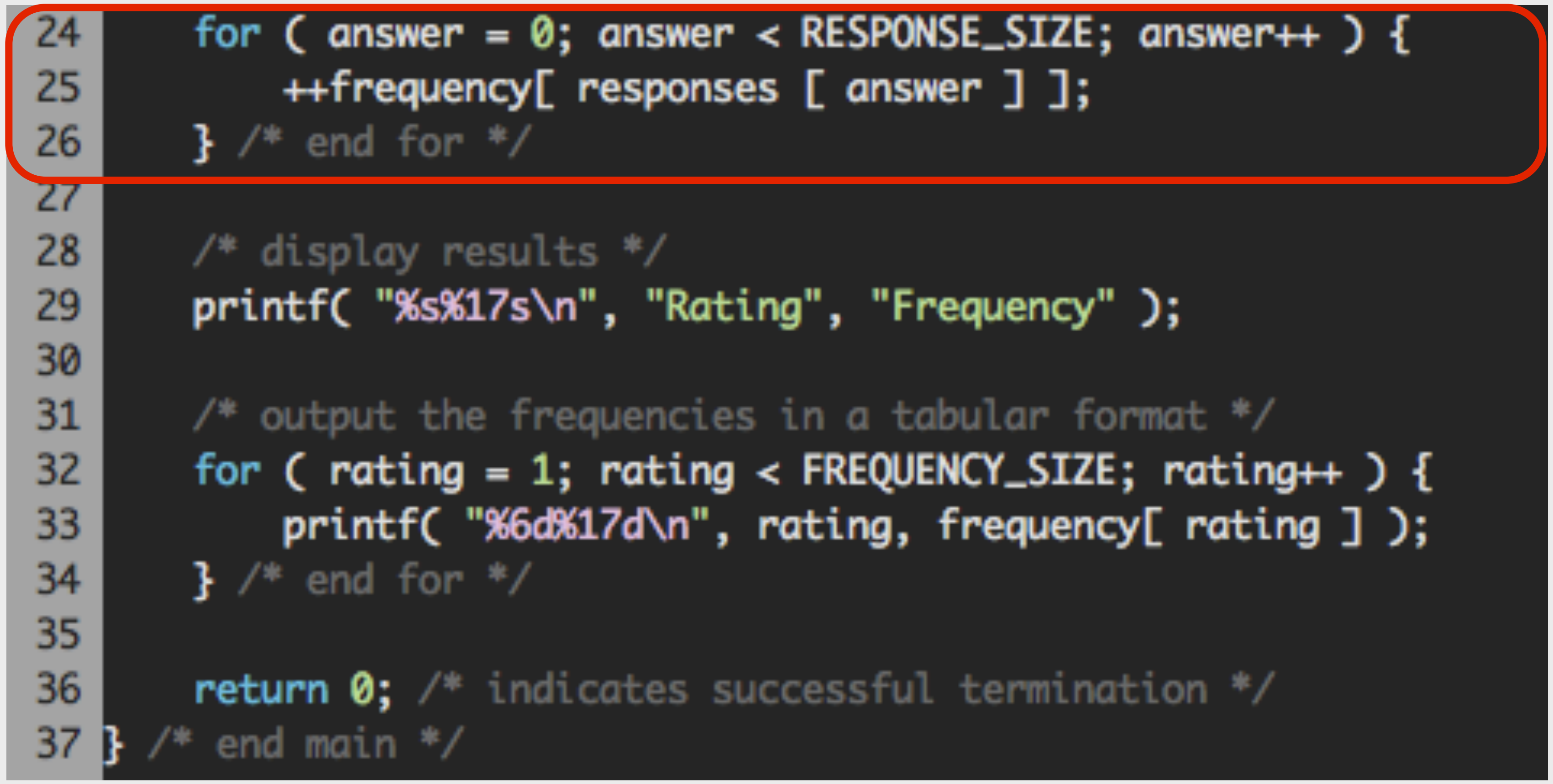
- Example: fig06_07.c



```c
    for ( answer = 0; answer < RESPONSE_SIZE; answer++ ) {
        ++frequency[ responses [ answer ] ];
    } /* end for */

    /* display results */
    printf( "%s%17s\n", "Rating", "Frequency" );

    /* output the frequencies in a tabular format */
    for ( rating = 1; rating < FREQUENCY_SIZE; rating++ ) {
        printf( "%6d%17d\n", rating, frequency[ rating ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

Array Examples (Cont.)

- Example: fig06_07.c



```
    for ( answer = 0; answer < RESPONSE_SIZE; answer++ ) {
        ++frequency[ responses [ answer ] ];
    } /* end for */

    /* display results */
    printf( "%s%17s\n", "Rating", "Frequency" );

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    for ( rating = 1; rating < FREQUENCY_SIZE; rating++ ) {
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    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```
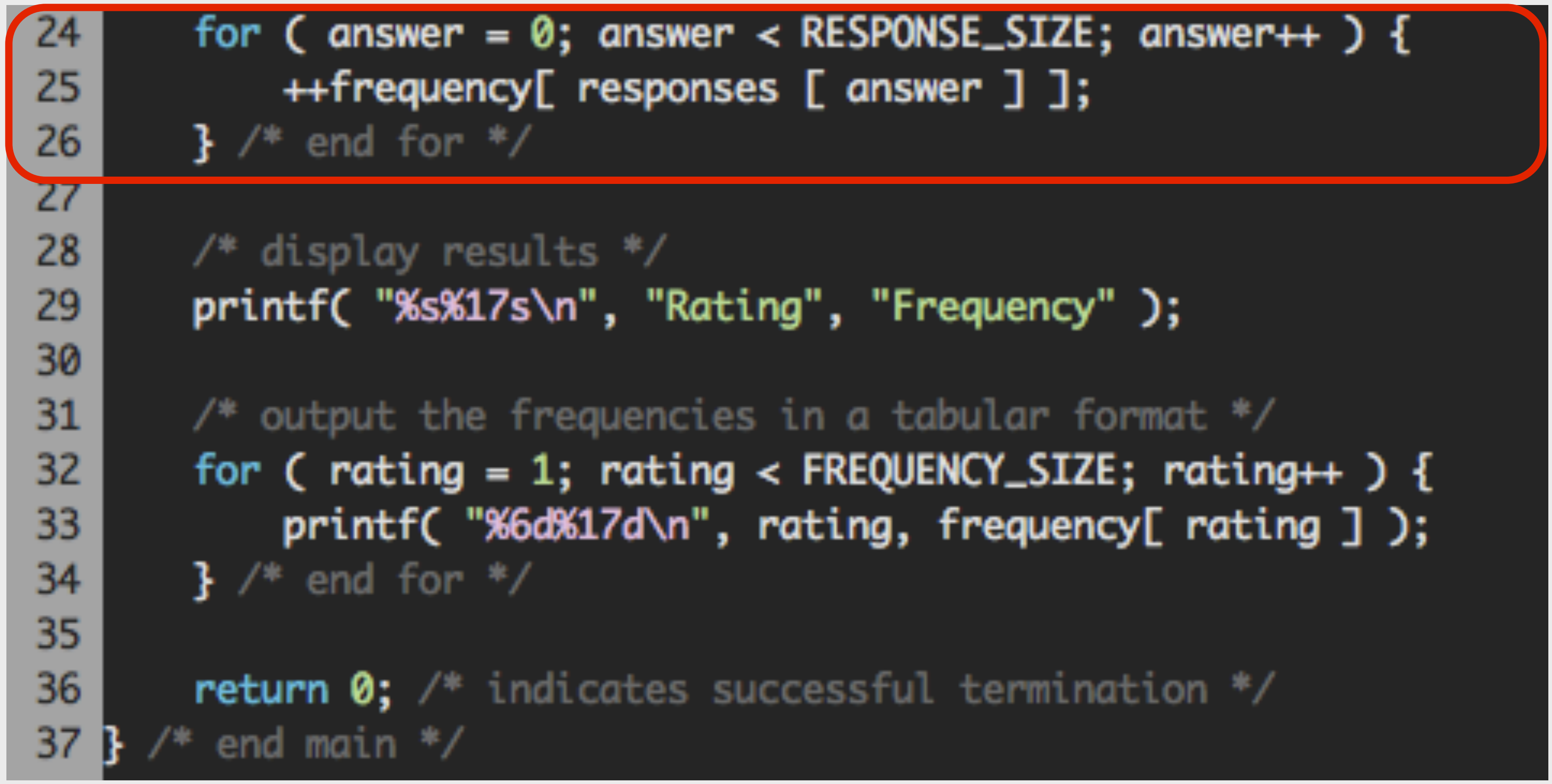

Array Examples (Cont.)

- Example: fig06_07.c

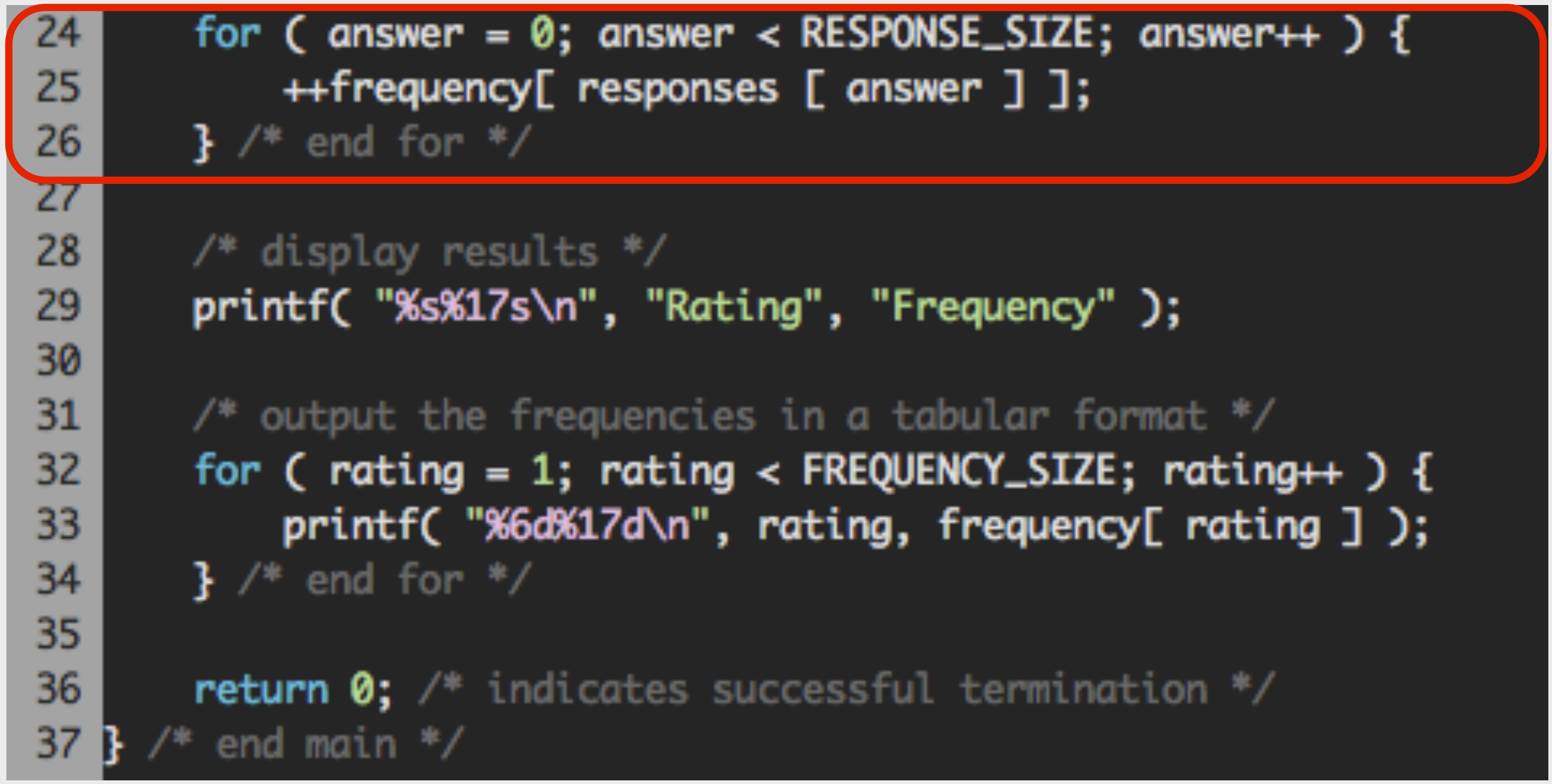


```c
    for ( answer = 0; answer < RESPONSE_SIZE; answer++ ) {
        ++frequency[ responses [ answer ] ];
    } /* end for */

    /* display results */
    printf( "%s%17s\n", "Rating", "Frequency" );

    /* output the frequencies in a tabular format */
    for ( rating = 1; rating < FREQUENCY_SIZE; rating++ ) {
        printf( "%6d%17d\n", rating, frequency[ rating ] );
    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
```

Allows us to use each response directly as the subscript in the **frequency** array.

Array Examples (Cont.)

- Example: fig06_07.c



```c
    for ( answer = 0; answer < RESPONSE_SIZE; answer++ ) {
        ++frequency[ responses [ answer ] ];
    } /* end for */

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    /* output the frequencies in a tabular format */
    for ( rating = 1; rating < FREQUENCY_SIZE; rating++ ) {
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    } /* end for */

    return 0; /* indicates successful termination */
} /* end main */
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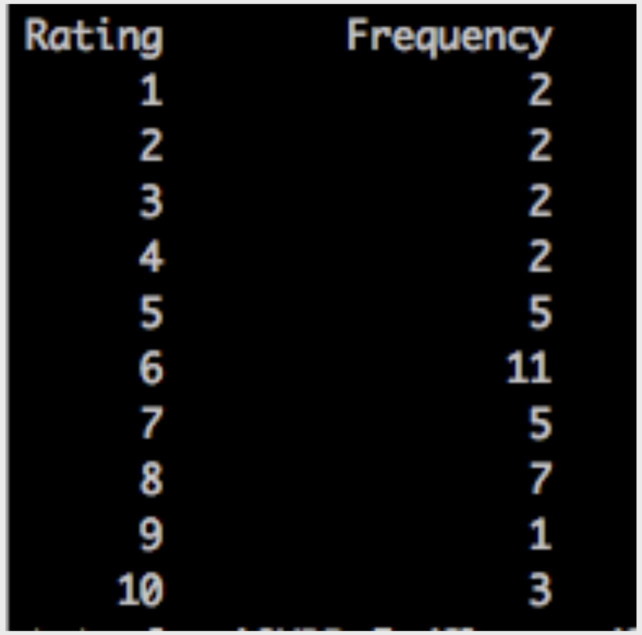
Allows us to use each response directly as the subscript in the **frequency** array.



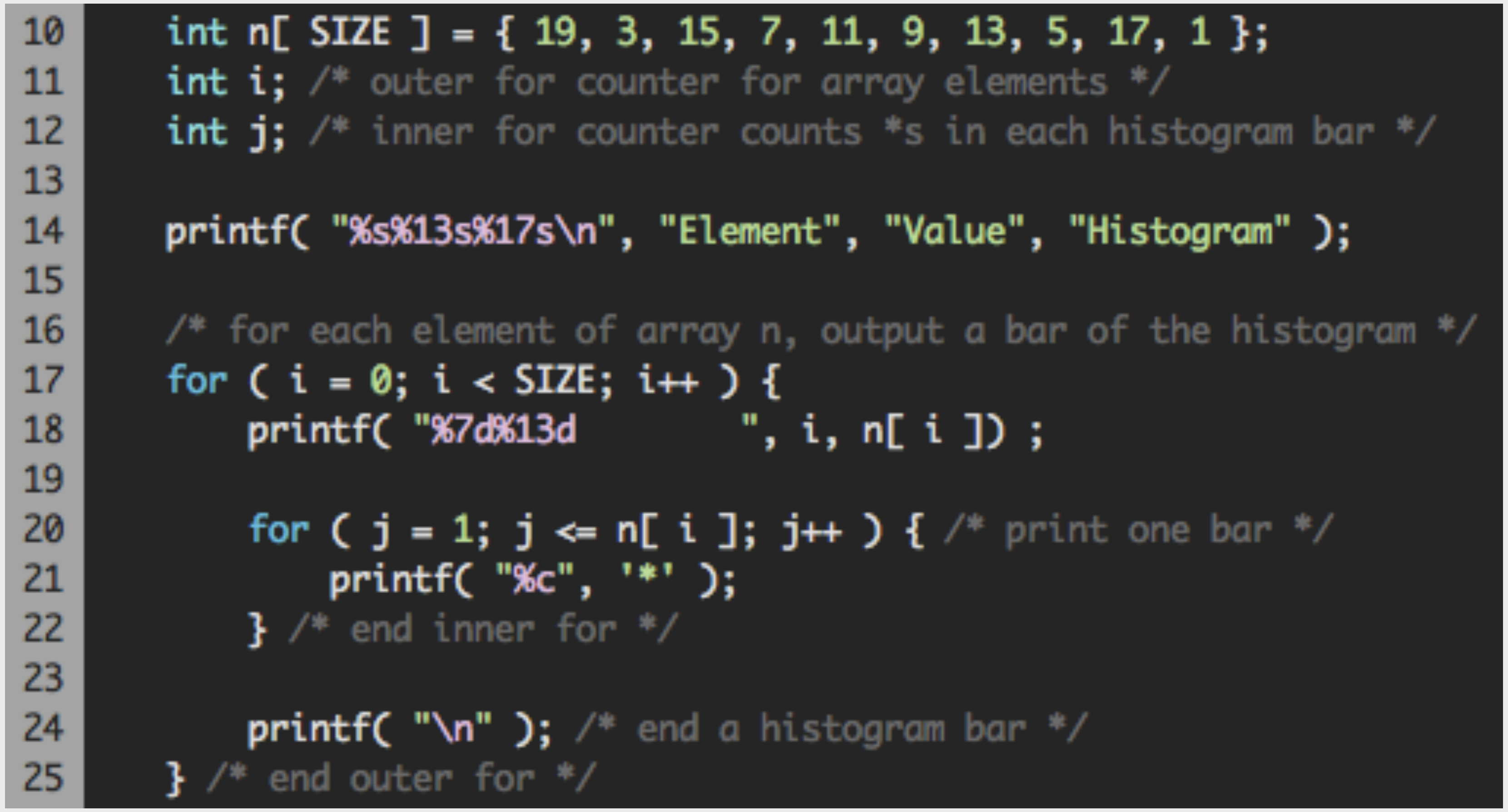
```
Rating        Frequency
     1                2
     2                2
     3                2
     4                2
     5                5
     6               11
     7                5
     8                7
     9                1
    10                3
```

Array Examples (Cont.)

- *C has no array bounds checking to prevent the program from referring to an element that does not exist.*
- Thus, an executing program can “walk off” the end of an array without warning.
- You should **ensure that all array references remain within the bounds of the array.**

Array Examples (Cont.)

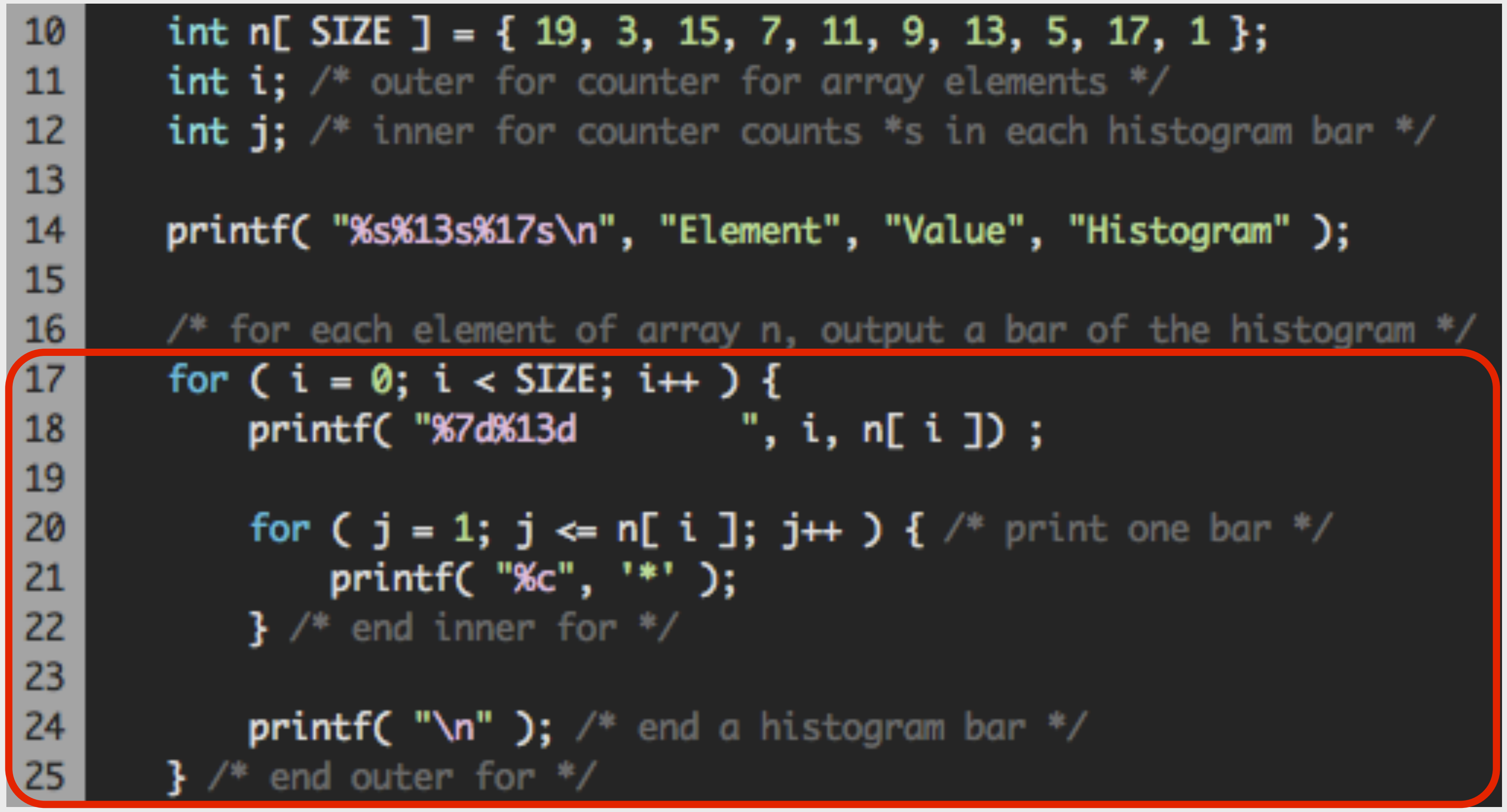
- Example: fig06_08.c



```c
int n[ SIZE ] = { 19, 3, 15, 7, 11, 9, 13, 5, 17, 1 };
int i; /* outer for counter for array elements */
int j; /* inner for counter counts *s in each histogram bar */

printf( "%s%13s%17s\n", "Element", "Value", "Histogram" );

/* for each element of array n, output a bar of the histogram */
for ( i = 0; i < SIZE; i++ ) {
    printf( "%7d%13d        ", i, n[ i ]) ;

    for ( j = 1; j <= n[ i ]; j++ ) { /* print one bar */
        printf( "%c", '*' );
    } /* end inner for */

    printf( "\n" ); /* end a histogram bar */
} /* end outer for */
```

Array Examples (Cont.)

- Example: fig06_08.c



```c
    int n[ SIZE ] = { 19, 3, 15, 7, 11, 9, 13, 5, 17, 1 };
    int i; /* outer for counter for array elements */
    int j; /* inner for counter counts *s in each histogram bar */

    printf( "%s%13s%17s\n", "Element", "Value", "Histogram" );

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    for ( i = 0; i < SIZE; i++ ) {
        printf( "%7d%13d        ", i, n[ i ]) ;

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            printf( "%c", '*' );
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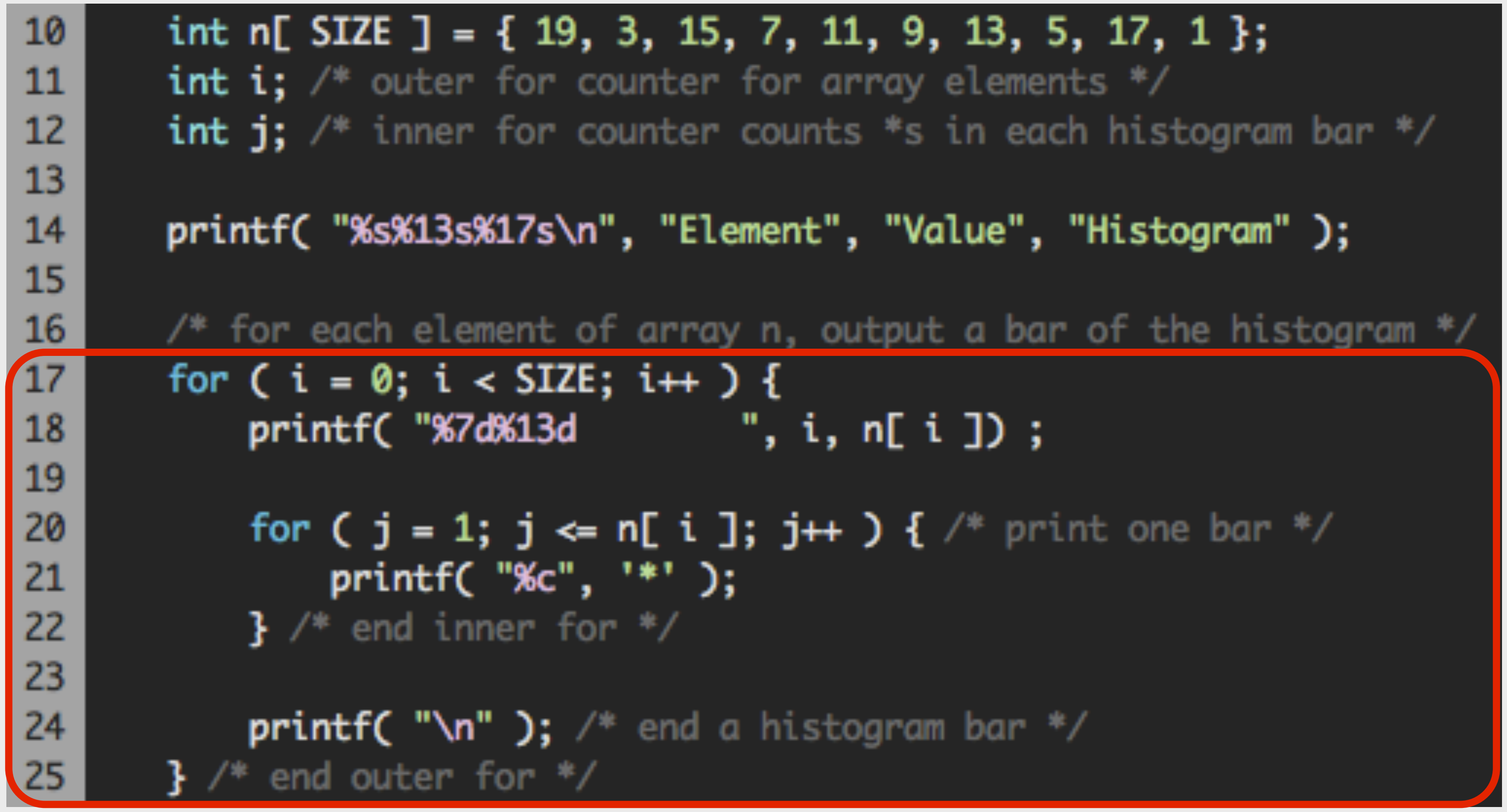
    } /* end outer for */
```

Array Examples (Cont.)

- Example: fig06_08.c



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    printf( "%7d%13d        ", i, n[ i ]) ;

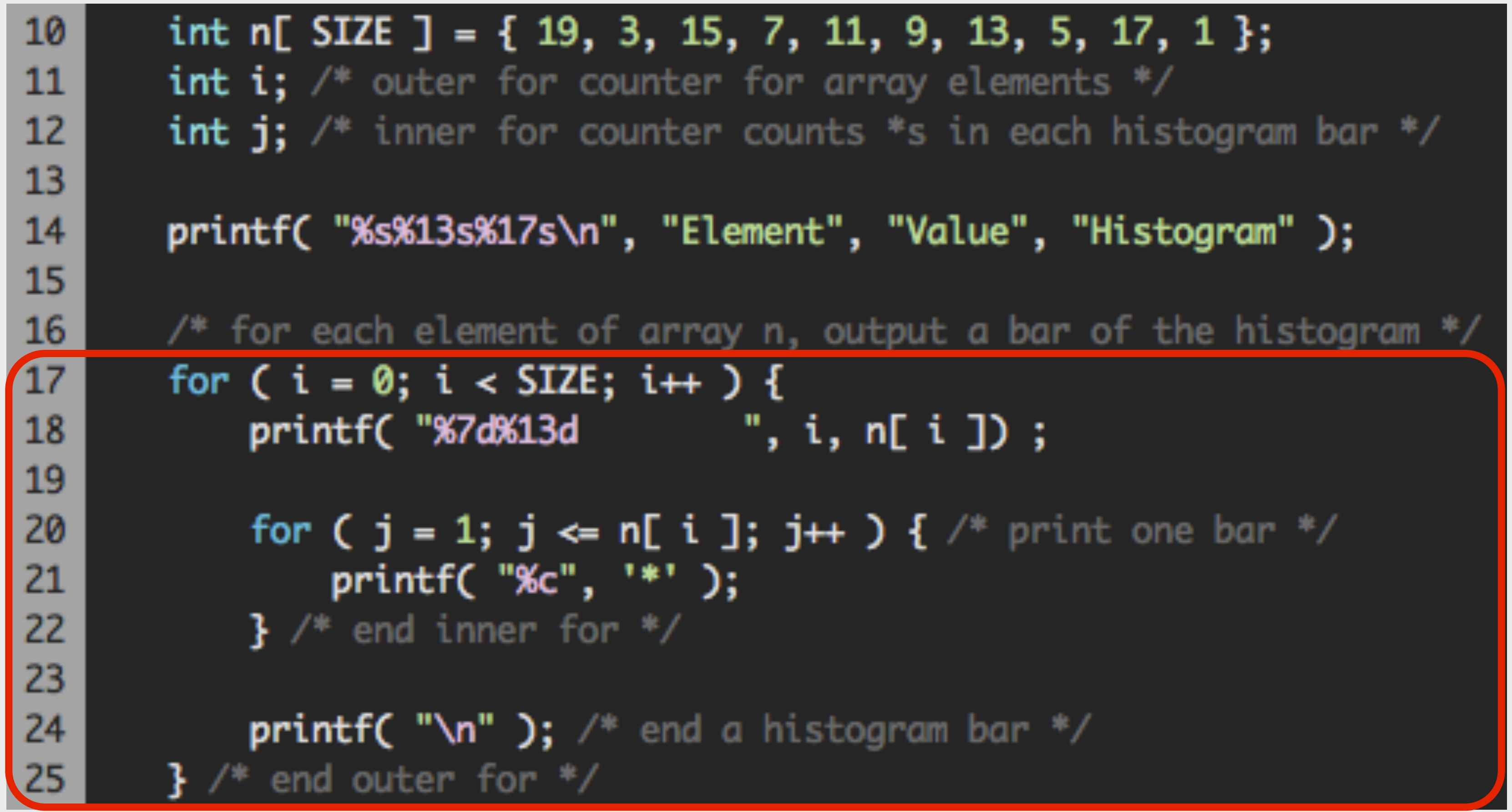
    for ( j = 1; j <= n[ i ]; j++ ) { /* print one bar */
        printf( "%c", '*' );
    } /* end inner for */

    printf( "\n" ); /* end a histogram bar */
} /* end outer for */
```

Reads numbers from an array and graphs the information in the form of a bar chart or histogram; the **for** statement draws the bars

Array Examples (Cont.)

- Example: fig06_08.c



```c
int n[ SIZE ] = { 19, 3, 15, 7, 11, 9, 13, 5, 17, 1 };
int i; /* outer for counter for array elements */
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    printf( "%7d%13d        ", i, n[ i ]) ;

    for ( j = 1; j <= n[ i ]; j++ ) { /* print one bar */
        printf( "%c", '*' );
    } /* end inner for */

    printf( "\n" ); /* end a histogram bar */
} /* end outer for */
```
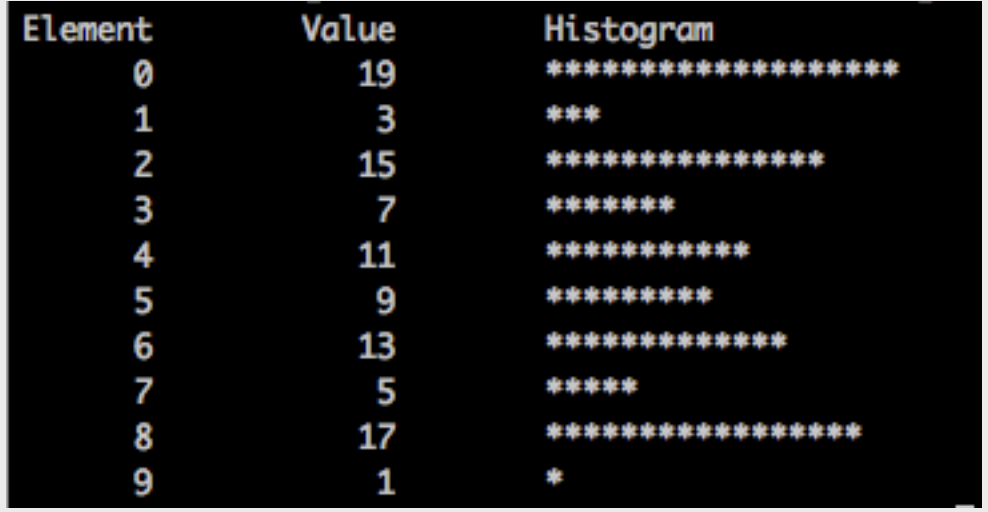
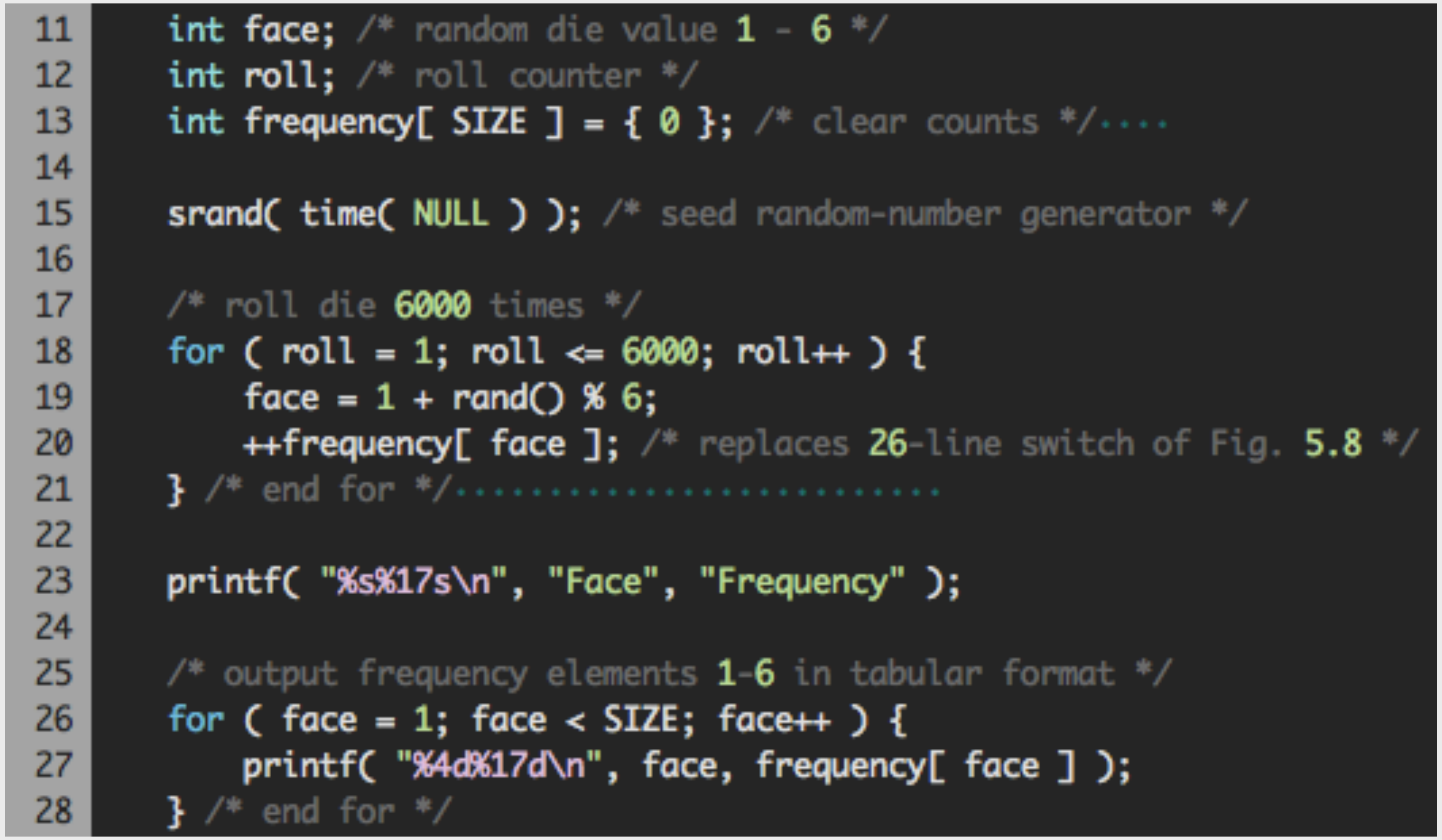

Reads numbers from an array and graphs the information in the form of a bar chart or histogram; the **for** statement draws the bars



```
Element        Value        Histogram
      0           19        *******************
      1            3        ***
      2           15        ***************
      3            7        *******
      4           11        ***********
      5            9        *********
      6           13        *************
      7            5        *****
      8           17        *****************
      9            1        *
```

Array Examples (Cont.)

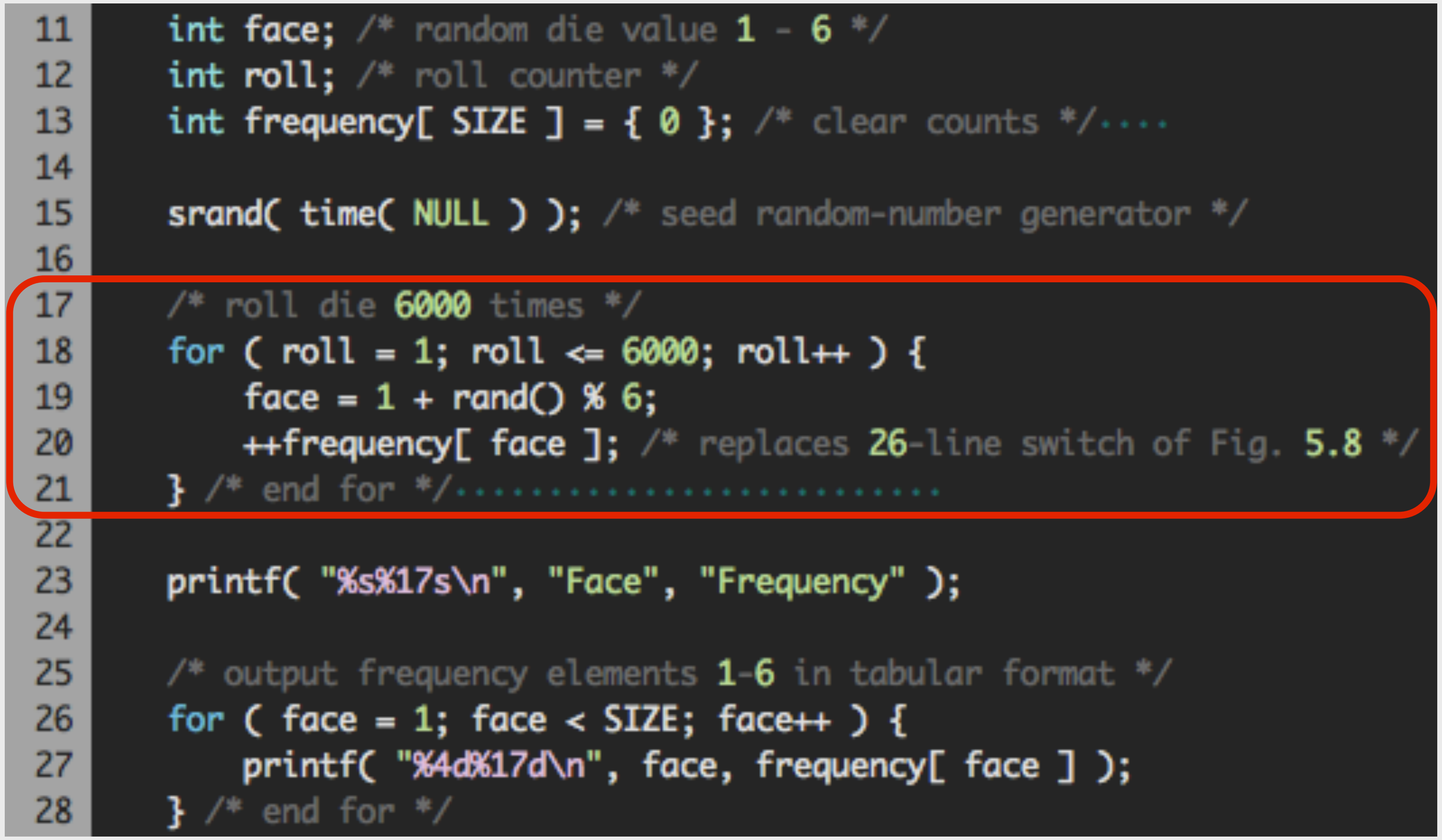
- Ex: fig06_09.c



```
    int face; /* random die value 1 - 6 */
    int roll; /* roll counter */
    int frequency[ SIZE ] = { 0 }; /* clear counts */

    srand( time( NULL ) ); /* seed random-number generator */

    /* roll die 6000 times */
    for ( roll = 1; roll <= 6000; roll++ ) {
        face = 1 + rand() % 6;
        ++frequency[ face ]; /* replaces 26-line switch of Fig. 5.8 */
    } /* end for */

    printf( "%s%17s\n", "Face", "Frequency" );

    /* output frequency elements 1-6 in tabular format */
    for ( face = 1; face < SIZE; face++ ) {
        printf( "%4d%17d\n", face, frequency[ face ] );
    } /* end for */
```

Array Examples (Cont.)

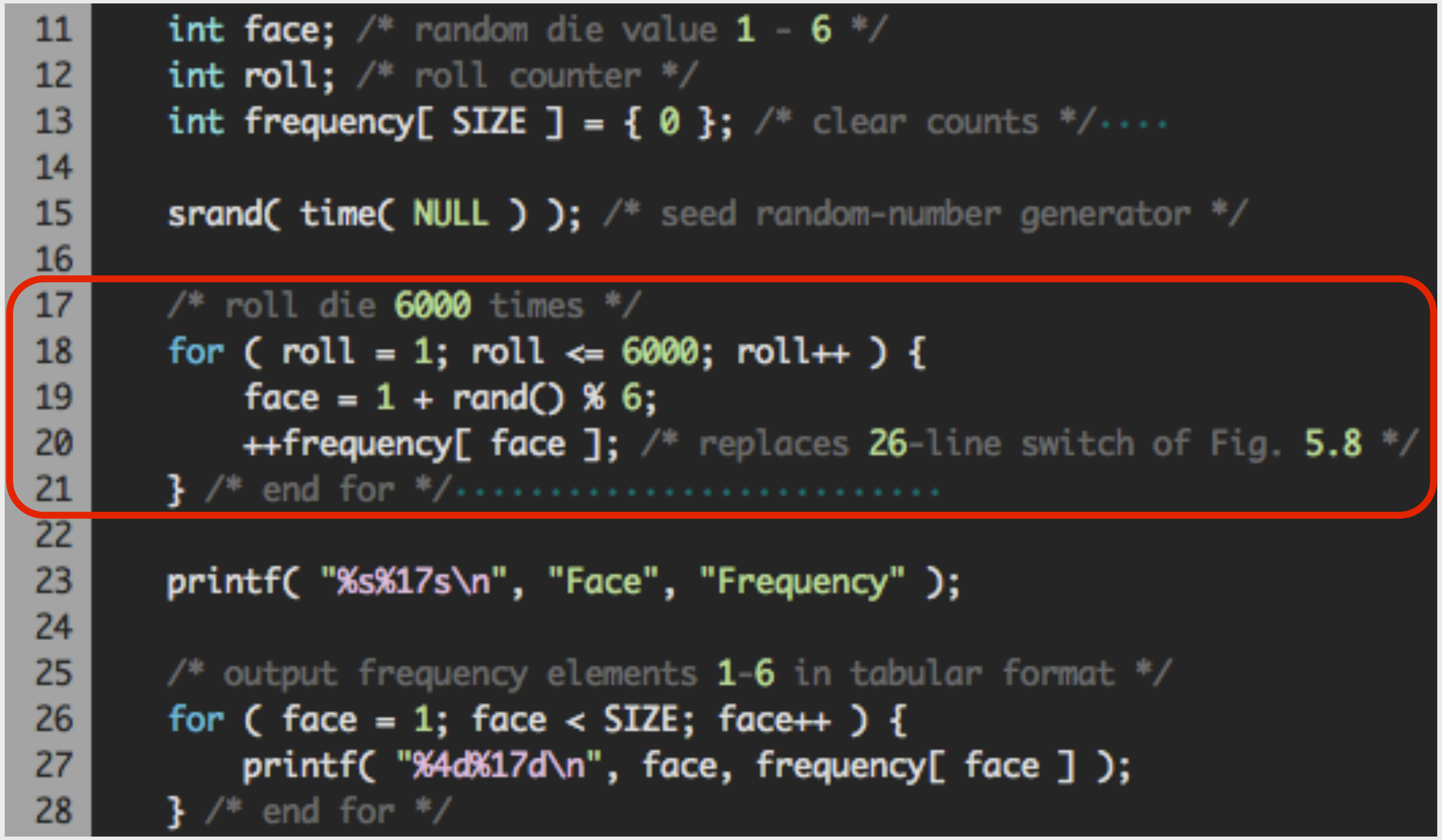
- Ex: fig06_09.c



```c
    int face; /* random die value 1 - 6 */
    int roll; /* roll counter */
    int frequency[ SIZE ] = { 0 }; /* clear counts */

    srand( time( NULL ) ); /* seed random-number generator */

    /* roll die 6000 times */
    for ( roll = 1; roll <= 6000; roll++ ) {
        face = 1 + rand() % 6;
        ++frequency[ face ]; /* replaces 26-line switch of Fig. 5.8 */
    } /* end for */

    printf( "%s%17s\n", "Face", "Frequency" );

    /* output frequency elements 1-6 in tabular format */
    for ( face = 1; face < SIZE; face++ ) {
        printf( "%4d%17d\n", face, frequency[ face ] );
    } /* end for */
```

Array Examples (Cont.)

- Ex: fig06_09.c

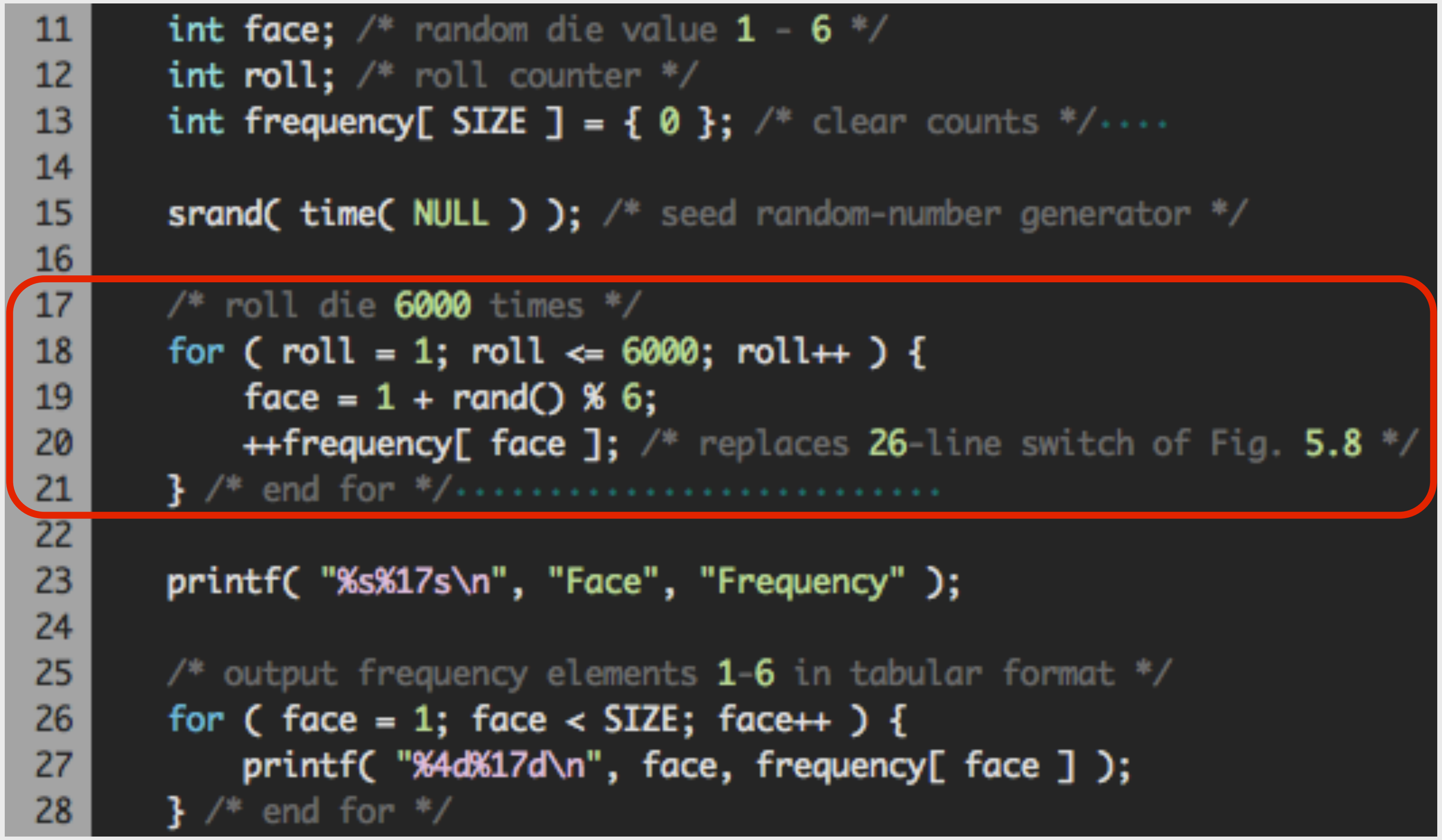


```
   int face; /* random die value 1 - 6 */
   int roll; /* roll counter */
   int frequency[ SIZE ] = { 0 }; /* clear counts */

   srand( time( NULL ) ); /* seed random-number generator */

   /* roll die 6000 times */
   for ( roll = 1; roll <= 6000; roll++ ) {
      face = 1 + rand() % 6;
      ++frequency[ face ]; /* replaces 26-line switch of Fig. 5.8 */
   } /* end for */

   printf( "%s%17s\n", "Face", "Frequency" );

   /* output frequency elements 1-6 in tabular format */
   for ( face = 1; face < SIZE; face++ ) {
      printf( "%4d%17d\n", face, frequency[ face ] );
   } /* end for */
```

Roll a single six-sided die 6000 times to test whether the random number generator actually produces random numbers.

Array Examples (Cont.)

- Ex: fig06_09.c



```c
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   int roll; /* roll counter */
   int frequency[ SIZE ] = { 0 }; /* clear counts */

   srand( time( NULL ) ); /* seed random-number generator */

   /* roll die 6000 times */
   for ( roll = 1; roll <= 6000; roll++ ) {
      face = 1 + rand() % 6;
      ++frequency[ face ]; /* replaces 26-line switch of Fig. 5.8 */
   } /* end for */

   printf( "%s%17s\n", "Face", "Frequency" );

   /* output frequency elements 1-6 in tabular format */
   for ( face = 1; face < SIZE; face++ ) {
      printf( "%4d%17d\n", face, frequency[ face ] );
   } /* end for */
```

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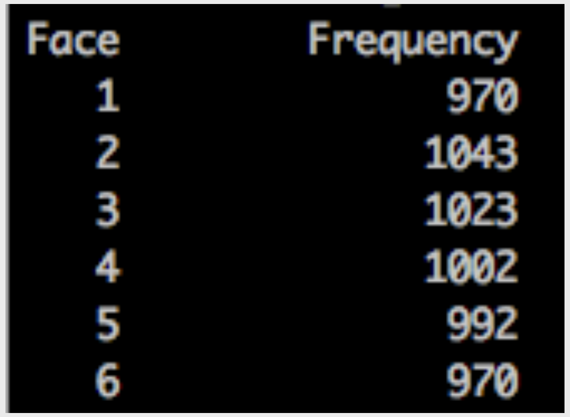

```
Face        Frequency
   1              970
   2             1043
   3             1023
   4             1002
   5              992
   6              970
```