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What is a Constant?

**In mathematics,** a *constant* is a value that cannot change.

**In programming,** a *constant* is like a variable, except that its value cannot change.
The Difference Between a Variable and a Constant

The **difference** between a variable and a constant is:

- a **variable**’s value can **vary**, but
- a **constant**’s value is **constant**.

Note that the variable varies, and the constant’s value is constant, at **runtime**.
Categories of Constants: Literal & Named

There are two categories of constants:

- **literal constants**, whose values are expressed **literally**;
- **named constants**, which have **names**.
Literal Constants

A *literal constant* is a constant whose value is expressed *literally*:

- **int** literal constants
  **EXAMPLES:** 5, 0, −127, +403298, −385092809

- **float** literal constants
  **EXAMPLES:** 5.2, 0.0, −127.5, +403298.2348, −3.85092809e+08

- **char** literal constants
  **EXAMPLES:** 'A', '7', '?'

- character string literal constants
  **EXAMPLES:** "A", "Henry", "What’s it to ya?"
Literal Constant Example Program #1

% cat tax1997_literal.c
#include <stdio.h>
int main ()
{ /* main */
  float income, tax;
  printf("I'm going to calculate the federal income\n");
  printf("  tax on your 1997 income.\n");
  printf("What was your 1997 income in dollars?\n");
  scanf("%f", &income);
  tax = (income - (4150.0 + 2650.0)) * 0.15;
  printf("The 1997 federal income tax on $%2.2f\n", income);
  printf("  was $%2.2f.\n", tax);
} /* main */
% gcc -o tax1997_literal tax1997_literal.c
% tax1997_literal
I'm going to calculate the federal income
tax on your 1997 income.
What was your 1997 income in dollars?
20000
The 1997 federal income tax on $20000.00
  was $1980.00.
Literal Constant Example Program #2

% cat tax1997_literal.c
#include <stdio.h>
int main ()
{
    float income, tax;
    printf("I'm going to calculate the federal income\n");
    printf(" tax on your 1997 income.\n");
    printf("What was your 1997 income in dollars?\n");
    scanf("%f", &income);
    tax = (income - (4150.0 + 2650.0)) * 0.15;
    printf("The 1997 federal income tax on $%2.2f\n", income);
    printf(" was $%2.2f.\n", tax);
} /* main */

% gcc -o tax1997_literal tax1997_literal.c
% tax1997_literal
I'm going to calculate the federal income
tax on your 1997 income.
What was your 1997 income in dollars?
20000
The 1997 federal income tax on $20000.00
was $1980.00.
Literal Constant Example Program #3

% cat tax1997_literal.c
#include <stdio.h>
int main ()
{ /* main */
    float income, tax;
    printf("I'm going to calculate the federal income\n");
    printf(" tax on your 1997 income.\n");
    printf("What was your 1997 income in dollars?\n");
    scanf("%f" &income);
    tax = (income - (4150.0 + 2650.0)) * 0.15;
    printf("The 1997 federal income tax on $%2.2f\n", income);
    printf(" was $%2.2f.\n", tax);
} /* main */
% gcc -o tax1997_literal tax1997_literal.c
% tax1997_literal
I'm going to calculate the federal income
tax on your 1997 income.
What was your 1997 income in dollars?
20000
The 1997 federal income tax on $20000.00
was $1980.00.
Literal Constant Example Program #4

% cat tax1997_literal.c
#include <stdio.h>
int main ()
{ /* main */
  float income, tax;
  printf("I'm going to calculate the federal income
"); 
  printf("  tax on your 1997 income.\n") ;
  printf("What was your 1997 income in dollars?\n") ;
  scanf("%f", &income);
  tax = (income - (4150.0 + 2650.0)) * 0.15;
  printf("The 1997 federal income tax on $%2.2f\n", income);
  printf("  was $%2.2f.\n", tax);
} /* main */

% gcc -o tax1997_literal tax1997_literal.c
% tax1997_literal
I'm going to calculate the federal income
  tax on your 1997 income.
What was your 1997 income in dollars?
20000
The 1997 federal income tax on $20000.00
  was $1980.00.
Named Constants

A **named constant** is a constant that has a name:

```c
const float pi = 3.1415926;
```

- A named constant is **exactly like a variable, except** its value is set at compile time (by initializing it) and **CANNOT** change at runtime.
- A named constant is **exactly like a literal constant, except** it **HAS A NAME**.

In a named constant declaration,
- we indicate that it’s a constant via the `const attribute`, and
- we **MUST** initialize the named constant.
Name Constant Example Program

```c
#include <stdio.h>

int main ()
{
    const float pi = 3.1415926;
    const float diameter_factor = 2.0;
    float radius, circumference, area;

    printf("I'm going to calculate a circle's\n");
    printf(" circumference and area.\n");
    printf("What's the radius of the circle?\n");
    scanf("%f", &radius);
    circumference = pi * radius * diameter_factor;
    area = pi * radius * radius;
    printf("The circumference is %f\n", circumference);
    printf(" and the area is %f.\n", area);
}
```

```bash
% gcc -o circlecalc circlecalc.c

% circlecalc
I'm going to calculate a circle's circumference and area.
What's the radius of the circle?
5
The circumference is 31.415924
and the area is 78.539810.
```
The Value of a Named Constant Can’t Be Changed

% cat constassign.c
#include <stdio.h>

int main ()
{ /* main */
    const float pi = 3.1415926;

    pi = 3.0;
} /* main */
%
% gcc -o constassign constassign.c
constassign.c: In function ‘main’:
constassign.c:7: error: assignment of read-only variable ‘pi’

You can’t change the value of a named constant at runtime!
This shows why you have to initialize every named constant: if you didn’t initialize it, then its value would be garbage, forever.

(By contrast, you DON’T have to initialize every variable.)
Why Literal Constants Are BAD BAD BAD

When you embed numeric literal constants in the body of your program, you make it much harder to maintain and upgrade your program.
1997 Tax Program with Numeric Literal Constants

% cat tax1997_literal.c
#include <stdio.h>

int main ()
{ /* main */
    float income, tax;

    printf("I'm going to calculate the federal income\n");
    printf(" tax on your 1997 income.\n");
    printf("What was your 1997 income in dollars?\n");
    scanf("%f", &income);
    tax = (income - (4150.0 + 2650.0)) * 0.15;
    printf("The 1997 federal income tax on $%2.2f\n", income);
    printf(" was $%2.2f.\n", tax);
} /* main */

% gcc -o tax1997_literal tax1997_literal.c
% tax1997_literal
I'm going to calculate the federal income
tax on your 1997 income.
What was your 1997 income in dollars?
20000
The 1997 federal income tax on $20000.00
    was $1980.00.
1999 Tax Program with Numeric Literal Constants

```c
#include <stdio.h>

int main ()
{
    float income, tax;

    printf("I'm going to calculate the federal income\n");
    printf(" tax on your 1999 income.\n");
    printf("What was your 1999 income in dollars?\n");
    scanf("%f", &income);
    tax = (income - (4300.0 + 2750.0)) * 0.15;
    printf("The 1999 federal income tax on $%2.2f\n", income);
    printf(" was $%2.2f.\n", tax);
}
```

```
% gcc -o tax1999_literal tax1999_literal.c
% tax1999_literal
I'm going to calculate the federal income
tax on your 1999 income.
What was your 1999 income in dollars?
20000
The 1999 federal income tax on $20000.00
was $1942.50.
```
Why Named Constants Are Good

When you use named constants in the body of your program instead of literal constants, you isolate the constant values in the declaration section, making them trivial to find and to change.
1997 Tax Program with Named Constants

```c
#include <stdio.h>

int main ()
{
    const float standard_deduction = 4150.0;
    const float single_exemption = 2650.0;
    const float tax_rate = 0.15;
    const int tax_year = 1997;
    float income, tax;

    printf("I'm going to calculate the federal income tax\n");
    printf(" on your \%d income.\n", tax_year);
    printf("What was your \%d income in dollars?\n", tax_year);
    scanf("\%f", &income);
    tax = (income - (standard_deduction + single_exemption)) * tax_rate;
    printf("The \%d federal income tax on $\%2.2f\n", tax_year, income);
    printf(" was $\%2.2f.\n", tax);
}
```

```
cat tax1997_named.c
#include <stdio.h>

int main ()
{
    const float standard_deduction = 4150.0;
    const float single_exemption = 2650.0;
    const float tax_rate = 0.15;
    const int tax_year = 1997;
    float income, tax;

    printf("I'm going to calculate the federal income tax\n");
    printf(" on your \%d income.\n", tax_year);
    printf("What was your \%d income in dollars?\n", tax_year);
    scanf("\%f", &income);
    tax = (income - (standard_deduction + single_exemption)) * tax_rate;
    printf("The \%d federal income tax on $\%2.2f\n", tax_year, income);
    printf(" was $\%2.2f.\n", tax);
}
```

```
gcc -o tax1997_named tax1997_named.c

I'm going to calculate the federal income tax on your 1997 income.
What was your 1997 income in dollars?
20000
The 1997 federal income tax on $20000.00 was $1980.00.
```
1999 Tax Program with Named Constants

```c
#include <stdio.h>

int main ()
{ /* main */
    const float standard_deduction = 4300.0;
    const float single_exemption = 2750.0;
    const float tax_rate = 0.15;
    const int tax_year = 1999;
    float income, tax;

    printf("I'm going to calculate the federal income tax\n");
    printf(" on your %d income.\n", tax_year);
    printf("What was your %d income in dollars?\n", tax_year);
    scanf("%f", &income);
    tax = (income - (standard_deduction + single_exemption)) * tax_rate;
    printf("The %d federal income tax on $%2.2f\n", tax_year, income);
    printf(" was $%2.2f.\n", tax);
} /* main */
```

```
% cat tax1999_named.c
#include <stdio.h>

int main ()
{ /* main */
    const float standard_deduction = 4300.0;
    const float single_exemption = 2750.0;
    const float tax_rate = 0.15;
    const int tax_year = 1999;
    float income, tax;

    printf("I'm going to calculate the federal income tax\n");
    printf(" on your %d income.\n", tax_year);
    printf("What was your %d income in dollars?\n", tax_year);
    scanf("%f", &income);
    tax = (income - (standard_deduction + single_exemption)) * tax_rate;
    printf("The %d federal income tax on $%2.2f\n", tax_year, income);
    printf(" was $%2.2f.\n", tax);
} /* main */
```

```bash
% gcc -o tax1999_named tax1999_named.c
% tax1999_named
I'm going to calculate the federal income tax
 on your 1999 income.
What was your 1999 income in dollars?
20000
The 1999 federal income tax on $20000.00
 was $1942.50.
```