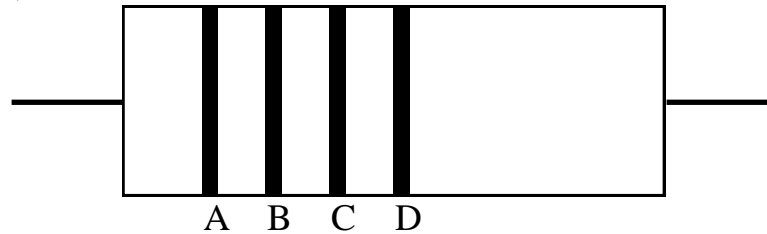# Programming Assignment #4:   Resistor Color Code Class

Background:

Resistance is a measure of the opposition of the flow of charge through a material (measured in Ohms, Ω). A resistor is an electrical circuit element that has been manufactured to have a particular value of resistance. Carbon resistors are often color coded using 12 different colors which appear in 4 bands on a resistor, as shown below.

The numerical value of the resistance, R, is determined using the four bands as follows:

$$R = AB \times 10^C, \text{ with a tolerance (accuracy) of } D,$$

where the values of A, B, C, and D are derived from the tables below.

Bands A, B, and C

Color	Numeric Value
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9
Silver	-1
Gold	-2

Band D

Color	Tolerance
Gold	5 %
Silver	10 %
None	20 %

Notes:

1. Band A may not be black, gold, or silver.
2. Band B may not be gold or silver.

Examples:

1. Yellow, violet, blue, none $R = 47 \times 10^6 = 47000000 \ \Omega$ (or 47 MΩ), 20%
2. Green, brown, red, gold $R = 51 \times 10^2 = 5100 \ \Omega$ (or 5.1 kΩ), 5%
3. Blue, green, gold, silver $R = 56 \times 10^{-1} = 5.6 \ \Omega$, 10%

The tolerance gives the maximum deviation from the nominal value for a good component. If the tolerance is 5%, the maximum possible value is 5% above the nominal value and the minimum possible value is 5% below the nominal value.

Example: If R = 1500 Ω, 5% tolerance, then R_{min} = 0.95R = 1425 Ω and R_{max} = 1.05R = 1575 Ω

Program Description:

Write a C++ program that begins by giving the user two options:

1) The user can enter the 4 resistor color codes and the program will display the values of resistance, tolerance, max resistance, and min resistance.
2) The user can enter a desired resistor value and tolerance and the program will determine the closest standard resistance value and the corresponding 4 color codes.

The program must also satisfy a number of specific requirements as listed below.

Program Requirements:

1) Write and use **class Resistance** as described below:
   - Data members: Include data members for
     - o Resistance
     - o Tolerance
     - o 4 color bands (strings)
   - Member functions: Include member functions for
     - o Converting color bands (strings) to resistance and tolerance
     - o Converting resistance and tolerance to color bands (strings)
     - o Determining Rmax and Rmin given resistance and tolerance
     - o Determining the nearest standard resistance value given the desired resistance and tolerance (see the background information provided below). This should be done efficiently. Round UP if the desired resistance value is exactly halfway between two standard values.
   - Additional member function requirements:
     - o Each member function should perform error checking to make sure that the inputs are valid. The function should have a return type of int and return 1 if no error occurred and 0 otherwise. It is not required, but you could also use return 2, return 3, etc., to indicate specific errors (such as which color band was incorrect, etc).
     - o Do not use global variables. All function inputs should be passed as arguments and all function outputs should be passed through reference parameters (other than the return type used as described above).
     - o Do not print/display results inside the functions. All input prompts and all results should be printed from the main function.
   - File structure: Use separate header and implementation files for class Resistance.
2) The program should also include a non-member function that will take a string variable containing only letters in any case and convert all of the letters to lower case (already done in the class notes!. Use this function to convert input colors to lowercase.
   Input to the function: 1 string variable consisting of letters in any case
   Output from the function: 1 string variable consisting of all lower case letters
3) Other non-member functions can be used, but are not required.

4) Give the user options to re-run the program and to re-enter values if any invalid inputs are used. Valid/invalid inputs are described below:
   Option 1:
   - Input colors should be accepted using any combination of upper and lower case letters.
   - Allow input color bands corresponding to resistance values from 0.1 ohms to 100,000,000 ohms (100 MΩ).

   Option 2:
   - Allow input resistance values from 0.1 ohms to 100,000,000 ohms (100 MΩ).
   - Only allow tolerances of 5%, 10%, or 20%

Sample Program Outputs
Example 1 (assuming that the user already selected Option 1):
Please enter a color for band A: Orange
Please enter a color for band B: ORANGE
Please enter a color for band C: red
Please enter a color for band D: silver
Results:
R = 3300 ohms
Tolerance = 10%
Rmax = 3630 ohms
Rmin = 2970 ohms

Example 2 (assuming that the user already selected Option 1):
Please enter a color for band A: black
Please enter a color for band B: brown
Please enter a color for band C: yellow
Please enter a color for band D: none
Results:
Invalid color band entered

Example 3 (assuming that the user already selected Option 2):
Please enter the desired resistance value in ohms: 280000
Please enter the desired tolerance as a percentage (5, 10, or 20): 5
Results:
Closest standard value = 270000 ohms
Color band A: red
Color band B: violet
Color band C: yellow
Color band C: gold

Example 4 (assuming that the user already selected Option 2):
Please enter the desired resistance value in ohms: 200000000
Please enter the desired tolerance as a percentage (5, 10, or 20): 5
Results:
Invalid input

Background – Standard Resistor Values

Resistors are not commonly available in all values, but are typically available only in *standard values*. For example, supposed you need a 1.25 kΩ resistor with a 10% tolerance. If you check with electronic parts suppliers, such as Jameco Electronics or DigiKey, you will find that 10% tolerance resistors are available only in 1.0 kΩ, 1.2 kΩ, 1.5 kΩ, 1.8 kΩ, 2.2 kΩ, …., so you would probably pick the closest value: 1.2 kΩ.

Standard values are set by the Electronics Industry Association (EIA) and are designed to represent overlapping ranges. For example, note how the ranges overlap for standard 10% resistor values:

> 1.0 kΩ: represents the range 0.9 - 1.1 kΩ (10% low to 10% high)
> 1.2 kΩ: represents the range 1.08 - 132 kΩ
> 1.5 kΩ: represents the range 1.35 – 1.65 kΩ
> 1.8 kΩ: represents the range 1.62 - 1.98 kΩ
> 2.2 kΩ: represents the range 1.98 – 2.42 kΩ

Standard resistors are generally available with the following values (multiplied by 10^N) from 0.1 Ω to 100 MΩ:

5% tolerance standard resistor values:

10	11	12	13	15	16	18	20	22	24	27	30
33	36	39	43	47	51	56	62	68	75	82	91

10% tolerance standard resistor values:

10	12	15	18	22	27	33	39	47	56	68	82

20% tolerance standard resistor values:

10	15	22	33	47	68

Extra Credit Suggestions: (for a maximum of 10 additional points)

1. Return different error codes from member functions to indicate the type of error and then display an accurate error message. For example, in the member function to convert color bands (strings) to resistance and tolerance, you could use the following:
   return 0 – no errors
   return 1 – error in color band A
   return 2 – error in color band B
   etc.
   Use a similar approach with other member functions.
2. Use prefixes for any input or output value of resistance (for R, R_{min}, and R_{max}) as follows:
   a) < 999 Ω   print values in ohms
   b) 1000 - 999000 Ω   print values in kohms (1 kΩ - 999 kΩ)
   c) ≥ 1000000 Ω   print values in megaohms
3. Similar to 2 above, except make the prefix a data member of class Resistance.
4. Use a string array to hold the four colors rather than using 4 separate strings.
5. Use input and output data files with the required valid test cases shown on the next page.
6. Use your imagination!

Report:

Follow the guidelines listed in <u>Format for Programming Projects</u> (available on the instructor's web page).   Include all required test cases described below.

Testing your program:

Test your program for the following cases and copy the results into a simple text file. Print the text file and turn it in with your report.

<u>Tests for Option 1</u>:

1) Each of the following color codes:
    - RED   red   yellow none
    - green blue   black silver
    - brown black red   silver
    - orange orange orange silver
    - white brown green gold
    - gray red   red   NONE
    - brown green BLUE   none
2) A misspelled color in each band (4 cases)
3) An invalid color in each band (4 cases)

<u>Tests for Option 2</u>:

1)   A negative resistance
2)   A resistance value > 100,000,000 ohms
3)   A resistance value < 0.1 ohms
4)   An invalid tolerance
5)   Each of the following resistance values and tolerances

0.105 ohms, 5%	50 ohms, 10%
1.65 ohms, 5%	3000 ohms, 10%
270 ohms, 5%	20000 ohms, 10%
3399.9 ohms, 5%	1400000 ohms, 10%
44444 ohms, 5%	270 ohms, 20%
6300000 ohms, 5%	3900 ohms, 20%
90000000 ohms, 5%	56000 ohms, 20%
0.7 ohms, 10%	820000 ohms, 20%

Want to check your results?

There are several online resistor color code calculators, such as:

http://www.dannyg.com/examples/res2/resistor.htm