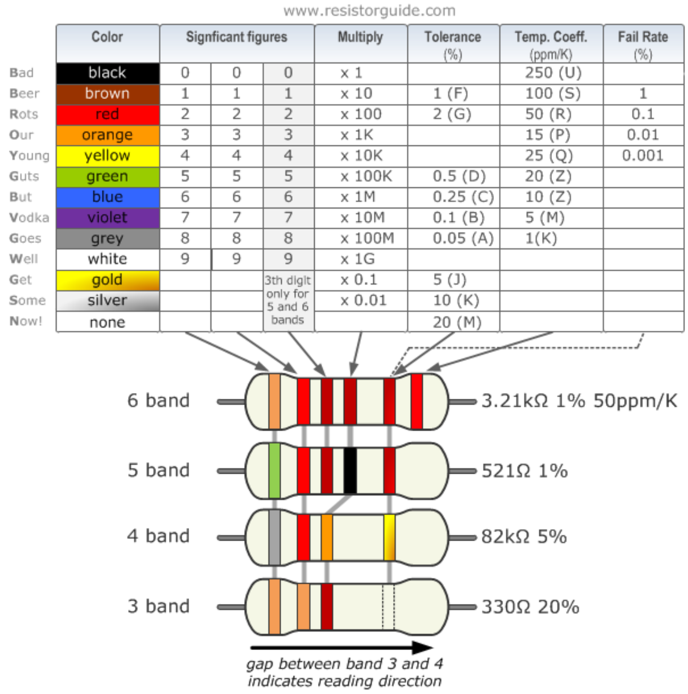
## Part 1: Resistance is Futile

Electronic resistors often use colour codes to indicate their value. Such resistors are roughly cylindrical in shape and the code is arranged in several "bands" which can be decoded to determine the value.  The figure below shows how to read the values:



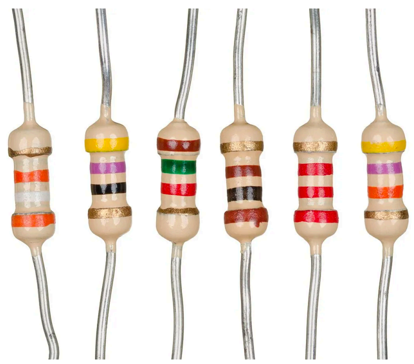
www.resistorguide.com

| | Color | Signficant figures | | | Multiply | Tolerance (%) | Temp. Coeff. (ppm/K) | Fail Rate (%) |
|---|---|---|---|---|---|---|---|---|
| Bad | black | 0 | 0 | 0 | x 1 | | 250 (U) | |
| Beer | brown | 1 | 1 | 1 | x 10 | 1 (F) | 100 (S) | 1 |
| Rots | red | 2 | 2 | 2 | x 100 | 2 (G) | 50 (R) | 0.1 |
| Our | orange | 3 | 3 | 3 | x 1K | | 15 (P) | 0.01 |
| Young | yellow | 4 | 4 | 4 | x 10K | | 25 (Q) | 0.001 |
| Guts | green | 5 | 5 | 5 | x 100K | 0.5 (D) | 20 (Z) | |
| But | blue | 6 | 6 | 6 | x 1M | 0.25 (C) | 10 (Z) | |
| Vodka | violet | 7 | 7 | 7 | x 10M | 0.1 (B) | 5 (M) | |
| Goes | grey | 8 | 8 | 8 | x 100M | 0.05 (A) | 1(K) | |
| Well | white | 9 | 9 | 9 | x 1G | | | |
| Get | gold | | | 3th digit only for 5 and 6 bands | x 0.1 | 5 (J) | | |
| Some | silver | | | | x 0.01 | 10 (K) | | |
| Now! | none | | | | | 20 (M) | | |



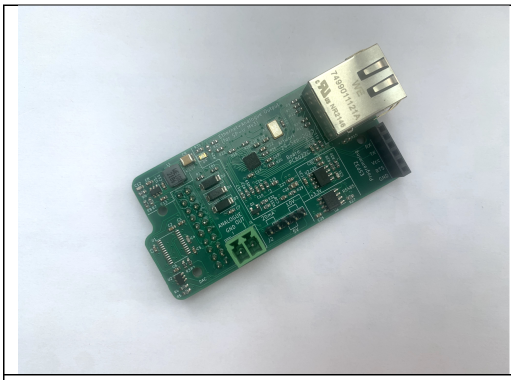
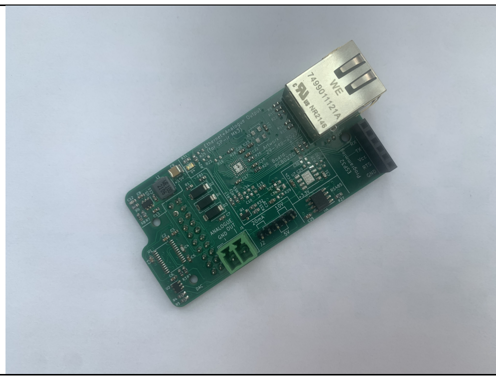
There is a handy calculator here [https://www.calculator.net/resistor-calculator.html](https://www.calculator.net/resistor-calculator.html)

For example the RESISTORS-1 image has a set of 4-band resistors with values: 39KΩ, 47Ω, 1500Ω, 100Ω, 2200Ω, 4700Ω (Ω = Ohms) (note the 4th-band is the tolerance and not of interest in this task):



The task is to **automatically identify the resistance value** of each resistor in the RESISTORS images.

## Part 2: Spot-the-difference

| | |
|---|---|
|  |  |
| Board 3 | Board 2 |

In this part, given images of a three PCBs at various stages of manufacture, the task is to accurately identify places where the PCBs are different, i.e. have missing or misplaced components.

BOARD1 does not have any components on it (unpopulated) and you might wish to use this a reference.

BOARD3 is (almost) fully populated (it is missing one chip), but BOARD2 was defective and some of the components were removed.

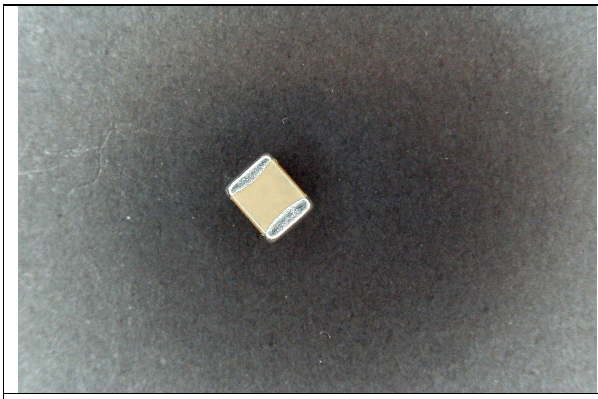
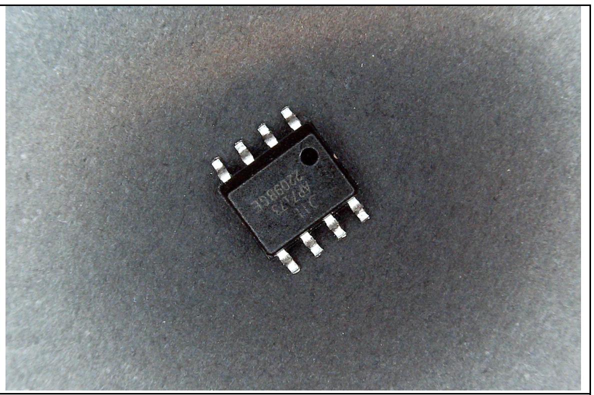
For this part, (1) align BOARD3 and BOARD2, so you can accurately **blend** between the two images of the respective boards; (2) **Highlight** the places where BOARD3 is significantly different from BOARD2.

Note for this task, there are 3 images of each board, which may help you with the solution.

## Part 3: Pick-and-Place

The final task is to locate the positions of several components given an image of BOARD3. In the COMPONENTS folder, there are separate images of certain electronic components (chips, resistors, diodes etc) from the board design

Here are two examples:

| | |
|---|---|
|  |  |
| Capacitor | Regulator Chip |

There are 3 images of each component. All the component images were taken at the same scale with a high-resolution device, but the resolution is different from BOARD images.

Note also that the DAC is not actually on the board, but you may be able to discover where it might go. Also, there is no place for the DSP on the visible side of the PCB!

**Annotations** I have provided bounding box annotations for image BOARD3-1 which has all the component sites labelled, plus some other areas. There are also annotations for the individual component images that give the bounding box of the object.

The annotations are stored in XML format and an example notebook called `load-and-display-annotations` shows how to interpret them (note this notebook uses the python package xmltodict.)

**Identify the exact position or** positions where particular components have been soldered on the board. You might show this as a bounding-box and/or a text label or a colour overlay.

Note that you should **only** use the annotations to support the solving of this task, for example using it as a ground-truth, or to perhaps extract useful regions form BOARD3-1. If you choose to use the annotation data, you **must** show your method works on different BOARD images!