

MAE 8 – Final Project

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Winter 2013 – Due on 03/14/2013 @ 9:00 PM

Universal Product Code (UPC) barcodes are used in products to identify the manufacturer and type of a product. In this final project you will learn how UPC barcodes work and write matlab code to process and generate your own barcodes. UPC is a 12-digit code organized as follows:

Field:	Product Prefix	Manufacturer Code	Product Code	Check Digit
# of digits:	1	5	5	1

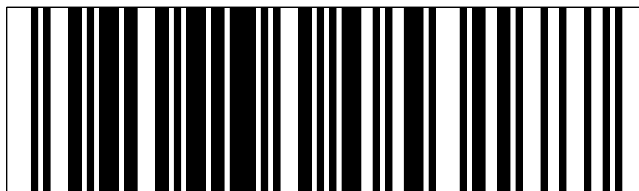
For example, 341226906227 is the code for *Perfect Choice 70% Isopropyl Rubbing Alcohol, 16 fl oz*, where

$\underbrace{3}_{\text{prefix}} \underbrace{41226}_{\text{manufacturer}} \underbrace{90622}_{\text{product}} \underbrace{7}_{\text{check}}$

Another example is 070734053177, the code for *Celestial Seasonings Herb Tea Natural Lemon Zinger Caffeine Free, 20 bags, 1.6 oz*, where

$\underbrace{0}_{\text{prefix}} \underbrace{70734}_{\text{manufacturer}} \underbrace{05317}_{\text{product}} \underbrace{7}_{\text{check}}$

Barcodes are designed so that they can be printed and recognized by electronic scanners. At the end of this project you shall be able to use matlab to process and print the barcode

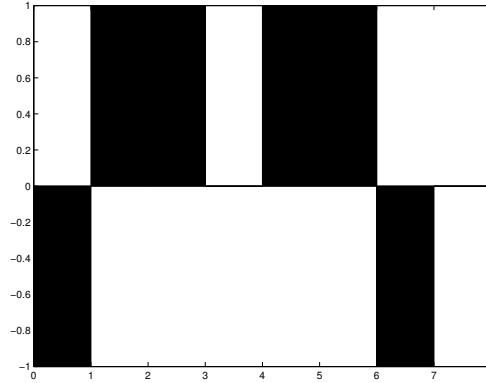


which is associated with the UPC 070734053177 and much more.

The answer to the following tasks should be provided as a single matlab script, except functions, which should be provided on their own files.

Part I

1. (5 marks) Write the function `plotupc` that takes as input a single vector and uses the function `bar` to produce a plot as the one shown on the top of the next page.



This graphic was produced with the command

```
plotupc([-1 1 1 0 1 1 -1 0])
```

Make sure the axes fit your plot tightly preserving any spaces induced by possible 0's at both ends of the vector and that no space is left between adjacent bars. Also make sure that the plot is colored black.

- (10 marks) Write a function `encodedgt` that takes as input a column or row vector with integer entries and produces as output a row vector where each integer is encoded according to the following table

Integer	Encoding
0	0 0 0 1 1 0 1
1	0 0 1 1 0 0 1
2	0 0 1 0 0 1 1
3	0 1 1 1 1 0 1
4	0 1 0 0 0 1 1
5	0 1 1 0 0 0 1
6	0 1 0 1 1 1 1
7	0 1 1 1 0 1 1
8	0 1 1 0 1 1 1
9	0 0 0 1 0 1 1
10	0 0 0 0 1 0 1
11	1 0 1 0 0 0 0
12	0 1 0 1 0

and the rule $\text{encodedgt}(x) = 1 - \text{encodedgt}(-(x+1))$ when $x < 0$.

For example

```
encodedgt([1 12 -3])
```

produces the vector

```
[0 0 1 1 0 0 1 0 1 0 1 0 1 1 0 1 1 0 0]
```

Your function should produce an error if the input is not a column or row vector.

- (2 bonus marks) If your function `encodedgt` does not use `for` or `while` loops.

4. (5 marks) Write a function `encodeupc` that takes as input an 1 x 12 vector with a valid UPC code, splits it in two 6-digit half vectors, `left` and `right`, and produces an encoded UPC vector by calling `encodedgt` with

$$[10 \text{ left } 12 \text{ } -(right+1) \text{ } 11]$$

as input. Your function should produce an error if the input is not a 1 x 12 vector.

5. (5 marks) Produce the UPC barcode printed in the first page of this document by calling the function `plotupc` using as input the encoded UPC vector produced by `encodeupc` for the UPC 070734053177. You may need to scale your axes or your data appropriately!

Hint: Use `set(gca,'xtick',[],'ytick',[])` to clean up ticks for better results.

Optional: Pick up your favorite product, type in the UPC code and use matlab to produce a barcode. Scan the barcode with a smartphone barcode scanner to validate your answer.

6. (2 bonus marks) Using your code, produce barcodes for the UPC 000000111111 and also for the UPC 111111000000. Compare the answers and explain how a scanner can tell whether a UPC code is being read upside down or not.

Part II

6. (10 marks) Let x_i represent the i th digit in a UPC code read from left to right. For example, in the UPC 341226906227 the digit $x_1 = 3$ and $x_5 = 2$. If a digit is missing or not known than its value is -1 . Using this notation, we can check if a UPC code is valid by computing:

$$y = \left(\sum_{j=1}^6 x_{2j} + 3 \sum_{k=0}^5 x_{2k+1} \right) \mod 10.$$

If $y = 0$ the UPC is a valid code. For the UPC 341226906227

$$\begin{aligned} y &= (4 + 2 + 6 + 0 + 2 + 7) + 3 \times (3 + 1 + 2 + 9 + 6 + 2) \mod 10 \\ &= (21 + 3 \times 23) \mod 10 \\ &= 90 \mod 10 \\ &= 0 \end{aligned}$$

and therefore the UPC is valid. Write a matlab function called `checkupc` that returns $-n$ if a UPC, represented as a 1 x 12 array of integers, has n missing entries (that is -1 's), 1 if the UPC is valid and 0 otherwise. Your function should also return y as a second output argument. Your function should not use `for` or `while` loops to compute the sums. Instead, use `sum` or another vectorized style instruction. Your function should issue an error if the array does not have exactly 1 row and 12 columns.

Optional: Your function should not issue an error and compute one check per row if an m x 12 array with $m > 1$ is provided.

Hint: The matlab function `mod` computes the remainder of an integer division. For example, `mod(14,10)` calculates $14 \mod 10$.

7. (10 marks) The file `upcs.txt` contains a list of UPC codes that were scanned in a grocery store. Each line should, ideally, contain 12 digits corresponding to a single product. Read the contents of the file and store the entries into an $m \times 12$ sized numeric array named `codes`, where m is the number of *valid* lines in the file. Lines that have less or more than 12 digits should be discarded. Some lines with 12 digits may have digits that were not correctly scanned, which were replaced by the letter 'X'. These missing digits should be represented in the array `codes` by the integer '-1'. After processing the file, print the total number of lines read, the number of lines discarded, and the number of lines correctly processed and stored in `codes`.
8. (5 marks) Use the function `checkupc` to classify and print the total number of UPC entries stored in the array `codes` that are valid, invalid or missing digits. Delete all rows from the array `codes` that have an invalid UPC or missed digits.
9. (5 bonus marks) Use `subplot` and the functions developed so far to plot the first valid 4 barcodes in file `upcs.txt` in a single graphic figure. Add a label below each barcode that shows the numeric value of the UPC. The layout of your answer should be similar to the following plot. The actual UPCs might be different than what you will obtain!

