Intro to "tens complement encoding"

- **Encoding**: a mapping of one system into another system

  Comment: encoding is like a kind of "secret word" game that kids like to play where they replace one letter by another. For example, one common code used by kids is "+1 psoition", so that B means A, C means B, and so on (A means Z). So a secret massage "Ifmmp" means "Hello".

- Example encoding: Morse code

  encode letters in English alphabet using short and long pulses

  ```
  Example:

     . . .      is S
     - - -      is O
  ```

  Try this Morse code applet: click here

- Remember that numeric value is something ***intrinsic*** and does not depends on the system of representation: click here.

We now introduce the 10's complement encoding to represent **signed** values

---

- We define the following "Odometer code":
  - 3 digits odometer
  - The odometer encoding:

    ```
    Odometer reading:   500  ... 996 997 998 999 000 001 002 003 ...   499
    -----------------    +--------+---+---+---+---+---+---+---+---------+
    Value represented: -500  ... -4  -3  -2  -1   0   1   2   3  ...   499
    ```

- Various notes & comments:
  - **Negative** values are represented
  - Values greater than 499 and less -500 cannot be represented ("out of range")
  - Operations can produce values that are **out of range**. This condition is called **overflow**.

    When overflow occurs, **erroneous** results will be produced

    Demo program for OVERFLOW: click here

To effectively use a code, you need to be able to: (1) encode and (2) decode

So: to use 10s complement code, we need to know how to convert a value to 10s complement and vice versa

---

- Convert a value **v** to its 3 digit 10's complement encoding:
  - If value **v** is positive, just write the number out in 3 digits

- If value **v** is negative, compute 1000 + **v** and write the result out in 3 digits

  Example:

```
v = 3     3 digit 10's complement representation: 003
v = 103   3 digit 10's complement representation: 103

v = -3    3 digit 10's complement representation: 1000 - 3 = 997
v = -103  3 digit 10's complement representation: 1000 - 103 = 897
```

- Convert a 3 digit 10's complement encoding **c** to a signed value

  - If the encoding **c** begins with 0, 1, 2, 3 or 4, it is a positive value and the value is "face value" (without the leading 0's)
  - If the encoding **c** begins with 5, 6, 7, 8 or 9, it is a negative value and the value is equal to 1000 - **c**

  Example:

```
code c = 413  -> it is a positive number
                 the value = 413

code c = 613  -> it is a negative number...
                 Compute: 1000 - 613 = 387
                 the value = -387
```

- Properties of 10's complement encoding:

  - Only one representation for ZERO (check for yourself)
  - Operations are "natural" - see examples below

- **Adding** 10's complement numbers:

```
               Values        3 digit 10's compl repr
Adding 2
positive          5               005
values        +   9             + 009
               -----            ------
                 14               014  -> represents 14

Adding
positive +        5               005
negative      + -9              + 991
               -----            ------
                 -4               996  -> represents -4


Adding
negative +       -5               995
positive      +   9             + 009
```

```
                -----           ------
                  4               004  -> represents 4

Adding 2
negative         -5               995
values         + -9             + 991
                -----           ------
                -14               986  -> represents -14
```

- **Subtracting** 10's complement numbers:

```
               Values        3 digit 10's compl repr
Subtract 2
positive          5               005
values         -  9             - 009
                -----           ------
                 -4               996  -> represents -4

Subtract
positive -        5               005
negative       - -9             - 991
                -----           ------
                 14               014  -> represents 14


Subtract
negative -       -5               995
positive       -  9             - 009
                -----           ------
                -14               986  -> represents -14

Subtract 2
negative         -5               995
values         - -9             - 991
                -----           ------
                  4               004  -> represents 4
```