# ESSAY
# APPLIED CALCULUS FOR IT - 501031

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## 1 Introduction

Think of a sequence of numbers like Fibonacci numbers - these sequences are patterns. Patterns can be seen everywhere: in animals, plants and minerals. Have you ever observed the similarity between the shape of your lungs and the structure of a tree? Or maybe the pathways of lightning and the way a river breaks through the earth? These patterns are called fractals. *"whenever you observe a series of patterns repeating over and over again, at many different scales, and where any small part resembles the whole, that's a fractal."* - Ben Weiss.
In the case of sequences, a fractal sequence contains an infinitie number of copies itself, embedded within itself. For example, The Koch snowflake can be simply encoded as a Lindenmayer system (L-System) with initial string F–F–F, string rewriting rule F = F+F–F+F, and angle $\alpha = 60$ degrees.

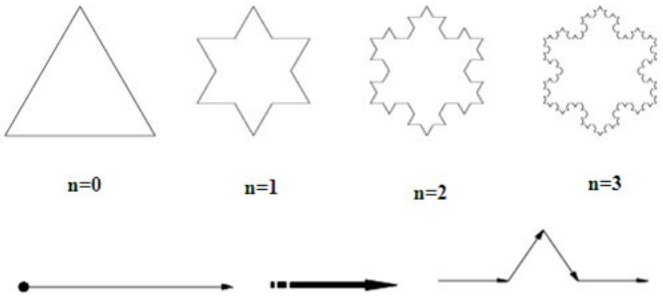


Figure 1: The Koch snowflake presents in many different levels

At each symbol 'F', it presents for moving forward by line length $d$ drawing a line, therefore we must compute the new point as follows

$$x_{new} = x_{old} - d.cos(\alpha\frac{\pi}{180})$$
$$y_{new} = y_{old} + d.sin(\alpha\frac{\pi}{180})$$

## 2 Requirements

In this assignment, every student is required to implement some of the L-System in *StudentID.txt* and the corresponding parameters to create greeting cards for new year 2022.

| Symbols | Descriptions |
|---|---|
| 'F' | Move forward by line length drawing a line |
| '+' | Turn left by turning angle |
| '-' | Turn right by turning angle |
| '\|' | Reverse direction (ie: turn by 180 degrees) |
| '[' | Push current drawing state onto stack (could be replaced by vector/list/array) |
| ']' | Pop current drawing state from the stack (could be replaced by vector/list/array) |
| 'o' | Draw flower |

Table 1: Description of symbols in L-System

Student could refer to *StudentID.jpg* to check your greeting card. Howerver, it is only used as the reference picture.

**Requirement 1:** ***(1 score)*** Compute the coordinate $x$ and $y$ of every point the heart shape.

(a) $x_h = 4sin(t)^5 + 5$ (b) $y_h = 3 * cos(t) - 1.7cos(2t) - cos(3t) + 1$

where, the $t \in [-\pi, \pi]$ and $t_{i+1} = t_i + 0.1$. Then, assign your results into **xh** and **yh** variables.

**Requirement 2:** ***(2 score)*** Compute the coordinate $x$ and $y$ of every point in the snowflake shape. Then, assign your results into **Pxn** and **Pyn** variables. The parameters are described in *StudentID.txt*

- $ID - snowflake$: the id of snowflake.
- $n$: the level of snowflake.
- $d$: the line length.
- $I$: axiom (these symbols the initial string)
- $F =$ or $X =$: the replacement rule.
- $alpha0$: the initial angle.
- $alpha$: the predefined angle.
- $x_0, y_0$: the initial coordinates of $x$ and $y$.

**Requirement 3:** ***(1 score)*** Compute the coordinate $x$ and $y$ of every point in the tree shape. Then, assign your results into **Px** and **Py** variables. The parameters are described in *StudentID.txt*

- $ID - Tree$: the id of the tree fractal.
- $n$: the level of the tree fractal.
- $d$: the line length.
- $I$: axiom (these symbols the initial string)
- $F =$ or $X =$ or $Z =$: the replacement rule.
- $alpha0$: the initial angle.
- $alpha$: the predefined angle.
- $x_0, y_0$: the initial coordinates of $x$ and $y$.

**Requirement 4:** ***(1 score)*** Compute the coordinate $x$ and $y$ of every flower. Then, assign your results into **Pfx** and **Pfy** variables.

**Requirement 5:** ***(1 score)*** Compute the number of the firework. The equation is defined as

$$n_{fw} = (\lceil \int_{x_{min}}^{x_{max}} \frac{1}{2}x \rceil + 1) \bmod 3 + 1 \quad (1)$$

where $x_{min} = min(d_1, d_2)$, $x_{max} = max(d_1, d_2)$, $d_1$ and $d_2$ are the last two digits of your student id. Then, assign your result into **nfw** variable.

**Requirement 6:** ***(1 score)*** Compute the coordinate $x$ and $y$ of the firework. The equation is defined as

$$x_{fw} = cos(k\theta)cos(\theta) * 15 \quad (1)$$
$$y_{fw} = cos(k\theta)sin(\theta) * 15 \quad (2)$$

where $\theta \in [0, 4\pi]$ and $\theta_{i+1} = \theta_i + \frac{1}{2\pi}$, $k = \frac{d_2 + 1}{d_1 + 1}$, $d_1$ is the last digit in your student id, and $d_2$ is the previous digit of $d_1$. If $(d_2 + 1) \bmod d_1 + 1$ is zero then you recompute $k = \frac{d_2 + 1}{d_1 + 2}$. Then, assign your result into **x_fw** and **y_fw** variables.

**Requirement 7:** ***(1 score)*** Find the local minimum $x^*$ value of the function $f(x) = x^2 - \beta x + 1$ in the interval between $x_{min}$ and $x_{max}$, where $\beta = d_1$. The finding value $\lceil x^* \rceil$ presents the number of the snownflake. Assign it into **nsnowflake** variable.

**Requirement 8:** ***(2 score)*** Create a greeting card with black background:

(a) Draw text description *Happy New Year 2022* into picture. This text is drawn at $x_t = 50$, $y_t = 0$

(b) Draw all snowflakes into picture. It notes that every snowsflake is reduced to the corresponding *scale* value (this value is found in *StudentID.txt*).The new coordinates of every snowsflake are computed as

$$x^{(i)}_{n_{new}} = \frac{Pxn}{scale} + \Delta x \quad (1)$$
$$y^{(i)}_{n_{new}} = \frac{Pyn}{scale} + \Delta y \quad (2)$$

where $\Delta x$ and $\Delta y$ are the random values in $[-10, 100]$ and $[50, 100]$ respectively. $i$ denotes the $i^{th}$ snowflake.

(c) Draw a tree shape into picture.

(d) Draw all fireworks into picture. The new coordinates of every firework are computed as

$$x^{(i)}_{fw_{new}} = 5(Pxn) + \Delta x \quad (1)$$
$$y^{(i)}_{fw_{new}} = 5(Pyn) + \Delta y \quad (2)$$

where $\Delta x$ and $\Delta y$ are the random values in $[100, 250]$ and $[100, 300]$ respectively. $i$ denotes the $i^{th}$ snowflake.

(e) Draw the heart shape into picture. It note that the position $x_h$ and $y_h$ of the heart shape are re-computed as $x_{h_{new}} = 2x_h + x_t - 20$ and $y_{h_{new}} = 2y_h$, then fill color in the heart shape. Colors are used to draw each shape, described as

- The heart shape is drawn and filled by **'red'** color and *line-width = 1.*
- The snowflake is drawn by **'white'** color and *line-width = 1.*
- The tree shape is drawn by **'green'** color and *line-width = 2.*

- The flower is drawn by $z$ color which based on your student ID. The last digit $d_1$ in your student id is satisfied by:
  - $d_1$ mod 3 = 0 then $z$ color is **'r'**
  - $d_1$ mod 3 = 1 then $z$ color is **'y'**
  - otherwise, $z$ color is **'m'**

  Assign $z$ color into **xcolor** ***(0.25 score)***
- The flower symbol is selected by the digit of $d_2$.
  - $d_2$ is '0' then symbol is **'p'**
  - $d_2$ is '1' then symbol is **'h'**
  - $d_2$ is '2' then symbol is **'*'**
  - $d_2$ is '3' then symbol is **'o'**
  - $d_2$ is '4' then symbol is **'+'**
  - $d_2$ is '5' then symbol is **'v'**
  - $d_2$ is '6' then symbol is **'x'**
  - $d_2$ is '7' then symbol is **'d'**
  - $d_2$ is '8' then symbol is **'s'**
  - $d_2$ is '9' then symbol is **'>'**

  and *line-width = 3*. Assign the symbol value into **flower** ***(0.25 score)***
- The firework is drawn by $c$ color and $s$ symbol as follows
  - $j$ mod 4 = 0 then $s$ is '*' and $c$ is **'r'**
  - $j$ mod 4 = 2 then $s$ is '+' and $c$ is **'m'**
  - otherwise, $s$ is '*' and $c$ is **'c'**
    where $j$ denotes the $j^{th}$ element in the current firework shape.

Then, your picture will be saved with file name *picStudentID.jpg*.

**Note:**

- Every floating value is computed and rounded with 1 digit.
- Every shape presents in the viewpoint.
- At each symbol ']', put *NaN* before adding new point into the set point.

# 3 Submissions

The student must perform the following requirements before submitting your assignment.

- Create a StudentID file with name *StudentID.py*.
  For example, if your StudentID is 5210676 then your assignment file will be **5210676.py**
- **DO NOT IMPORT** the different libraries in your code.
- **DO NOT COPY** resource code from the different students.
- Make sure you upload your work to the correct link.
- Student will receive **ZERO** point if you do not comply the requirements or your code doesn't run.