Exploring Mathematical and Computational Concepts for the STEM Education in Colleges

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Some General Principles:

- Embrace a “Holy Curiosity” of students;
- Motivate, but not drill students;
- Analyze from complexity to simplicity;
- Search for practical applications.

Part 1: Motivational Case Studies in Introductory Math Classes and Clubs

- Restore Digits in Calculations:	- Factor Analysis of Large Numbers:
$$\begin{array}{r} *1** \\ \times\quad 1** \\ \hline *1** \\ ***1* \\ +\quad ***1 \\ \hline 8***4** \end{array}$$	Prove that any six-digit number, which has the same three first and last digits (written in the same order), has factors (divisors) of 7, 11, and 13.

- Find the number of 0’s in the expression:

  $1^x\ 2^x\ 3^x \ldots {}^x\ 98^x\ 99^x\ 100$.

- What is the last digit of the number 2597^{5927} [mod(10)]? (Try to calculate 7^N at N > 18 with MS Excel™. Why “0”?).

- Explore primes and Modular Arithmetic! Learn more about Galois fields, Euler’s totient function, Fermat's Little Theorem...

- Study the RSA Public-Key encryption algorithm and message digital signatures.

- Link to other disciplines: Explore linguistic text properties in deciphering ciphertexts. ■

Part 2: Math and Computer Graphics

Based on the human perception of light (3 eye cone sells sensitive to red, green, and blue), the RGB color model [1] allocates 24 bits for each pixel to represent 2^{24} = 16,777,216 different colors. *Jython* programs [1] can be used for manipulating with image colors, creating a negative (Fig.1), reducing red-eye, etc.

a) Original image (© V. Riabov’s photograph) **b)** Negative image

Fig. 1: Creating the negative image.

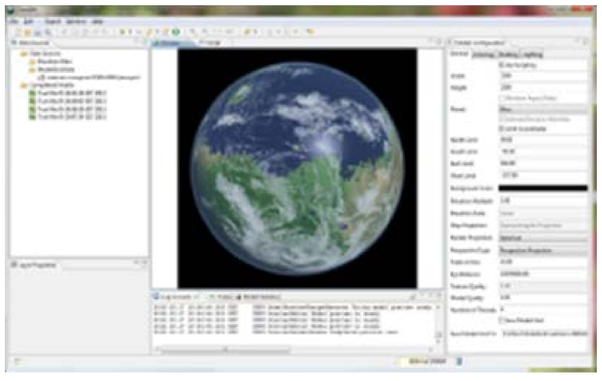


Fig. 2: jDem846 with the Living Mars project.

Kevin Gill developed the Living Mars project [2] that included methods of computer graphics and planetary science. With the jDem846 tool, he created a visualization of the Mars (see Fig. 2) as could look with a living biosphere. ■

Part 3: Strange Attractors: an evolution of dynamic systems

Case studies examine numerical modeling of chaotic dynamic systems (e.g., turbulence, weather forecast, and economic system development).

Lorenz’s system bifurcations model convection in the Earth’s atmosphere:

$$dx / dt = a\,(y - x) \quad (1)$$

$$dy / dt = x\,(b - z) - y \quad (2)$$

$$dz / dt = xy - c\,z \quad (3)$$

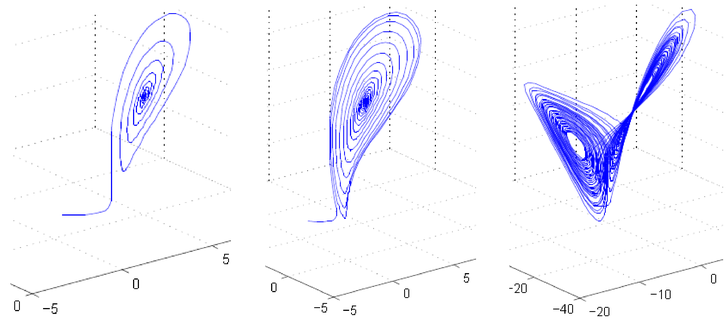
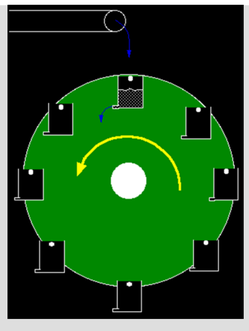


Fig. 3: *L*-*R*: Solutions of the Lorenz system (Eqs. 1-3) for different values of the Rayleigh number b = 12, 16, and 28; a = 10, c = 8/3.



The waterwheel (a physical model of the Lorenz’s system) was built by P. Paultje for the Dutch Annual Physics Teacher Conference in 2005. ■

REFERENCES:

[1] Guzdial, M. *Introduction to Computing and Programming in Python: A Multimedia Approach*. Upper Saddle River, NJ: Pearson, Prentice Hall, 2005.

[2] Gill, K. M. Putting Life on Mars, Rivier Academic Journal, Vol. 9, No. 1, 2017, pp. 1-27.

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