Practice on complex systems

Exercise 1

Look through the table in [Lipsitz and Goldberger, 1992]; link. Choose one "loss of complexity" fact and corresponding measure from the table. Check out the original study where the loss of complexity was shown. Do you trust the approach suggested in this article? Explain your answer. Try to find more recent research on this topic. If you succeed, add a reference to the report.

Examples of Decreased Structural (Anatomic) and Functional (Physiologic) 'Complexity' in Advanced Age

	Measure of Complexity	Age Effect
Anatomic structures Neuronal dendrites[28]	Branching arbor	Dendrite loss and reduced branching
Bone trabeculae[42]	Meshwork	Trabecular loss, disconnection
Physiologic systems Heart rate variability[18,20]	Dimension, entropy	Decrease
Blood pressure variability[20]	Dimension, entropy	Decrease
Pulsatile thyrotropin release[33]	SD of interpulse interval	Decrease
Electroencephalographic evoked potentials[27]	Range of frequencies evoked	Decrease
Auditory[17]	Range of audible frequencies	High-frequency loss

I chose Heart arte variability. To the naked eye, there is clearly a nonlinear change between the components, which is one of the signs of Complexity Loss. In the article such methods as ratio of expiratory to inspiratory R-R intelvals, as well as as spectral analysis, consistently demonstrate a decrease in heart rate variability with aging were used. I think these methods are classic and old, they can be trusted, because they are time-tested. But new studies should use more modern methods . Approaches in this article (for other Complexity Loss) cannot be completely trusted, because in the lecture it was said that Entropy index does not always work.

Exercise 2

Consider the model $\dot{x} = ax^2$:

- Find an analytical solution for the model, assuming that $x(0) = x_0 > 0$;
- Compute a potential function for it;
- Compute its fixed points;
- Make a conclusion about the stability of fixed points;
- Look up this paper. Explain how the author uses the model you just learned. And it was supposed to happen in 2025? What do you think of the author's reasoning?

$$\begin{cases} \dot{x} = a x^2 \\ x(0) = x_0 > 0 \end{cases}$$

$$\frac{dx}{x^2} = a\,dt$$

$$-\frac{1}{x} = at + c$$

$$x = -\frac{1}{at + c}$$

$$x_0 = x(0) = -\frac{1}{c} \Rightarrow c = -\frac{1}{x_0}$$

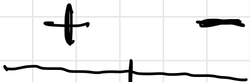
$$x(t) = -\frac{1}{at - \frac{1}{x_0}}$$

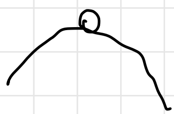
$$U(x) = \int -a x^2 \, dx = -\frac{a x^3}{3} + U_0$$

$$U'(x) = 0 \Rightarrow -ax^2 = 0 \Rightarrow x = 0$$

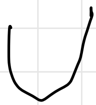
fixed point

$$U''(x) = -2a x$$

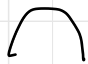




stable



unstable



meta

$x_1 = 0$ - unstable fixed point.

Kapitza uses the phenomenological model to describe the empirical regularities of world population growth over the past century, without necessarily identifying the underlying mechanisms that drive population growth. He identifies a number of factors that he believes contribute to population growth, such as economic development, urbanization, and cultural attitudes towards family size. By analyzing the patterns and trends in population growth data, Kapitza aims to develop a broad understanding of how population growth rates have changed over time and across different regions of the world.

Regarding the year 2025, Kapitza does not make any specific predictions or projections about population growth rates in that year. But the author consumes that he approach year 2025 the population of the world will go off to infinity. However, he does note that population growth rates have been declining since the mid-20th century and that this trend is likely to continue in the future.