Math to Meaning: Harmony

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System Dynamics Research
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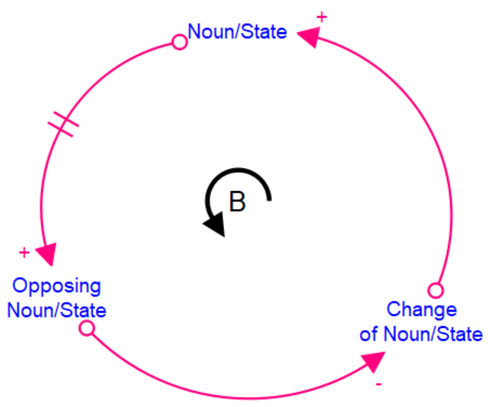
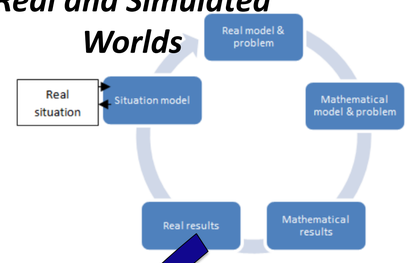


Harmonic Archetype

Real and Simulated Worlds



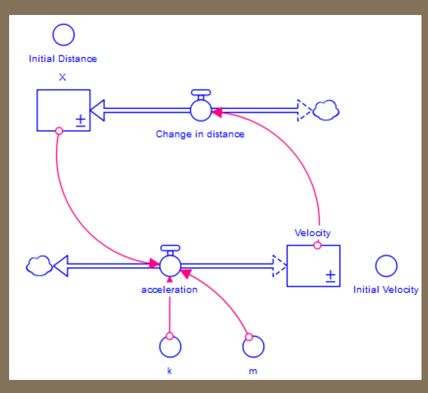
Mathematics

$$m\ddot{x} + kx = 0$$

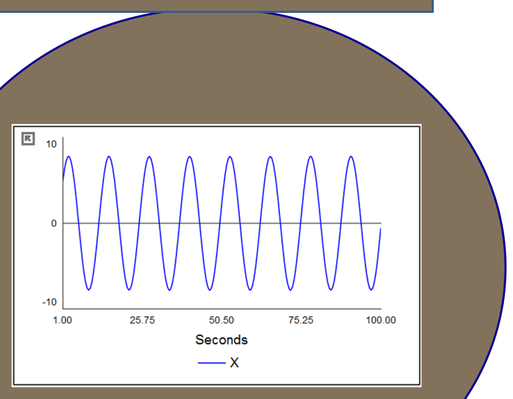
Math to Meaning

Conventional System Dynamics

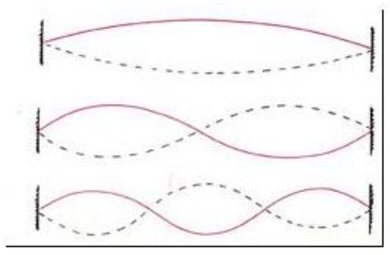
Stock and Flow Diagram



Simulation



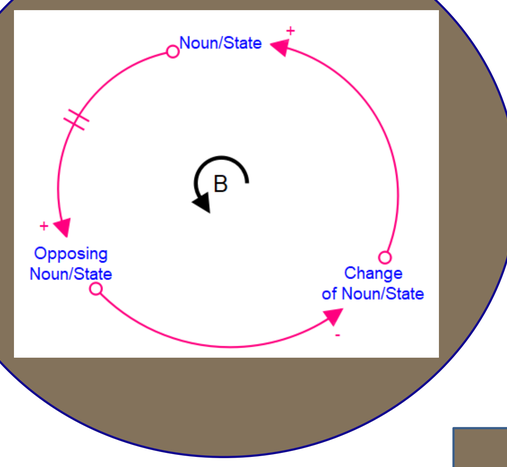
HARMONY



Wave Behavior

Story

Causal Loop Diagram



Problem

Stories are universally interesting to humanity, yet mathematics is only interesting to a fraction of the population. However, if mathematics can be translated into stories, could we discover or rediscover valuable stories? Can generic mathematics represent generic, useful stories like new system archetypes?

Hypothesis

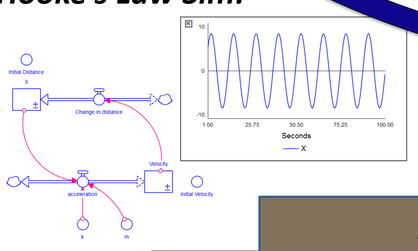
Using the system dynamics methodology in reverse, from mathematics to meaningful stories, we can uncover valuable stories consumable by the general population.

Objectives

Use the Loop Stock Transform (specific system dynamics methodology) to transition the harmonic oscillator equation into a story:

1) Define the Harmonic Oscillator in raw mathematics
2) Re-organize the equation into differential equations
3) Reconstruct the differential equations into stocks and flows
4) Abstract the stocks and flows into a Causal Loop Diagram (CLD)
5) Replace specific concepts with generic concepts
6) Re-apply generic CLD to a different application (Predators/Prey) and test of simulation produces meaningful results

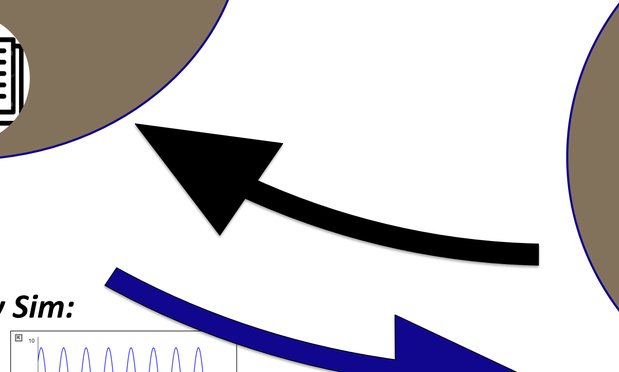
Hooke's Law Sim:

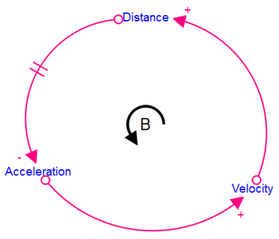


Method

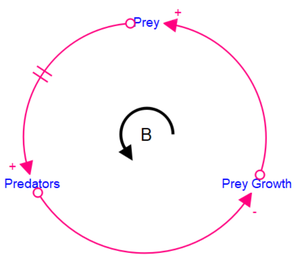
The Loop Stock Transform is a step-wise approach to constructing a system dynamics simulation, starting with a problem/story statement. Next the story is expanded into a causal loop diagram and further into a stock and flow diagram. The stocks and flows are then transformed into mathematical equations and the simulation constructed. Throughout the process, verification and validation takes place between the steps. In this specific application, the process is first done in reverse (mathematics to story) and then applied to predator prey dynamics.

Loop Stock Transform

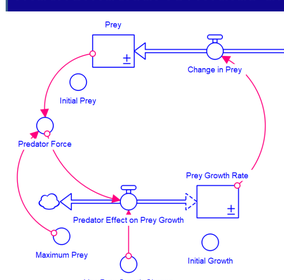




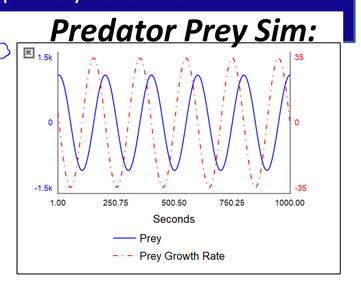
Hooke's Law CLD

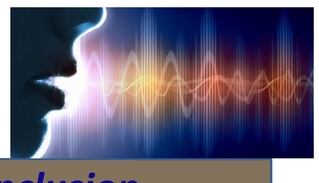


Applied Prey CLD



Predator Prey Sim:





Conclusion

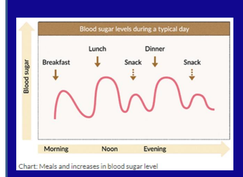
1) The paradigm (mental model) of Yin and Yang emerged out of the math to meaning application of Hooke's law. Both theories speak about balance, harmony and that opposing forces create stability.
2) The generic CLD (harmonic archetype) can be re-applied to predator and prey which recreates the predator prey dynamics from the Lotka Volterra mathematical equations.
2) A valuable connection exists between stories and mathematics
3) System Dynamics can act as a mediator between niche mathematical formulas and publicly consumable stories.

Background

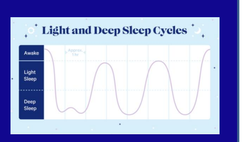
The Harmonic Equation comes from Hooke's Law, in 1660, to describe elastic oscillations:

$$m\ddot{x} + kx = 0$$

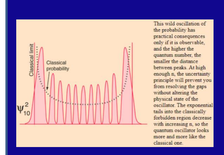
Furthermore, similar Oscillatory behavior has been seen in multiple divergent fields:



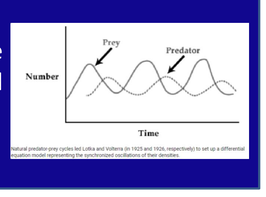
Blood sugar dynamics show how the glucose in the bloodstream oscillates throughout the day



The light and deep sleep cycles during resting also shows wave-like cycles.



Oscillations and waves also exist in the quantum physics energy probability. Vibrations are fast oscillations/waves between two states.



Oscillatory behavior between the populations dynamics of predator and prey over seasons

Results

1) Reverse Loop Stock Transform (SD), identified a generic single Causal Loop Diagram: Noun/State, change of noun/state and opposing noun/state.
2) Generic CLD applied to Predator-Prey Harmony
3) Causal Relationship identified in ecological sciences (Serenghetti Rules – Feedback Regulation, 2018)
4) Yin and Yang relationship where the union of opposites produce harmony (3rd Century BCE - estimate)
5) Heraclitus defined harmony in 500 BC similarly
6) Hooke's law was defined in 1660 (2000 years later) into mathematics

'There is a harmony in the tension of opposites, as in the case of the bow and lyre' Heraclitus, 500 BC

GENERAL RULES OF REGULATION AND THE LOGIC OF LIFE

Positive regulation
A → B — A positively regulates the abundance or activity of B

Negative regulation
A ⊣ B — A negatively regulates the abundance or activity of B

Double-negative logic
A ⊣ B ⊣ C — A negatively regulates B, which negatively regulates C; A increases the abundance of C through double-negative logic

Feedback regulation
A → B → C — The accumulation of C feeds back to negatively regulate A and the production of B and C

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