

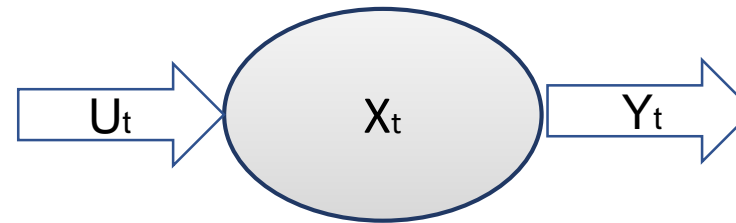


**RZESZOW UNIVERSITY
OF TECHNOLOGY**



Erasmus+

System Dynamics modeling



Input variables $U(t)$

Output variables $Y(t)$

State variables $X(t)$

("Memory" variables)

State variables are a record of the history of the system.

$$\mathbf{x}_t = \int (\mathbf{u}_t - \mathbf{y}_t) \cdot dt + \mathbf{C}$$

Causal Loops

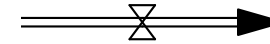
- Provide insight into a system's structure
- It's difficult to deduce the behavior of the system from its casual loops representation
- Need to use computer simulations
- Simulation model:
 - flow diagrams
 - equations
 - simulation environment

Flow Diagram Symbols

Level



Rate



Source/Sink



Cause-and-effect arrow



Flow diagram building blocks

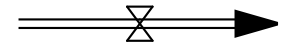
LEVEL:

- AKA stock, accumulation, or state variable
- A quantity that accumulates over time
- Change its value by accumulating or integrating rates
- Change continuously over time



RATE:

- AKA flow, activity, movement
- Change the values of levels



SOURCE/SINK:

- Source represents environment outside of the model
- Sink is where flows terminate outside the system



CAUSE-AND-EFFECT ARROW



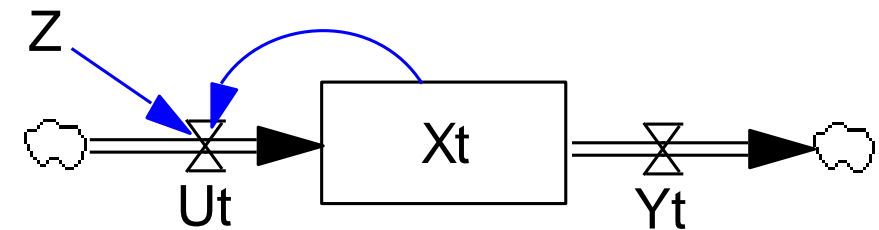
Equations in System Dynamics

- Levels are described with integral equations
- Rates are given with algebraic equations

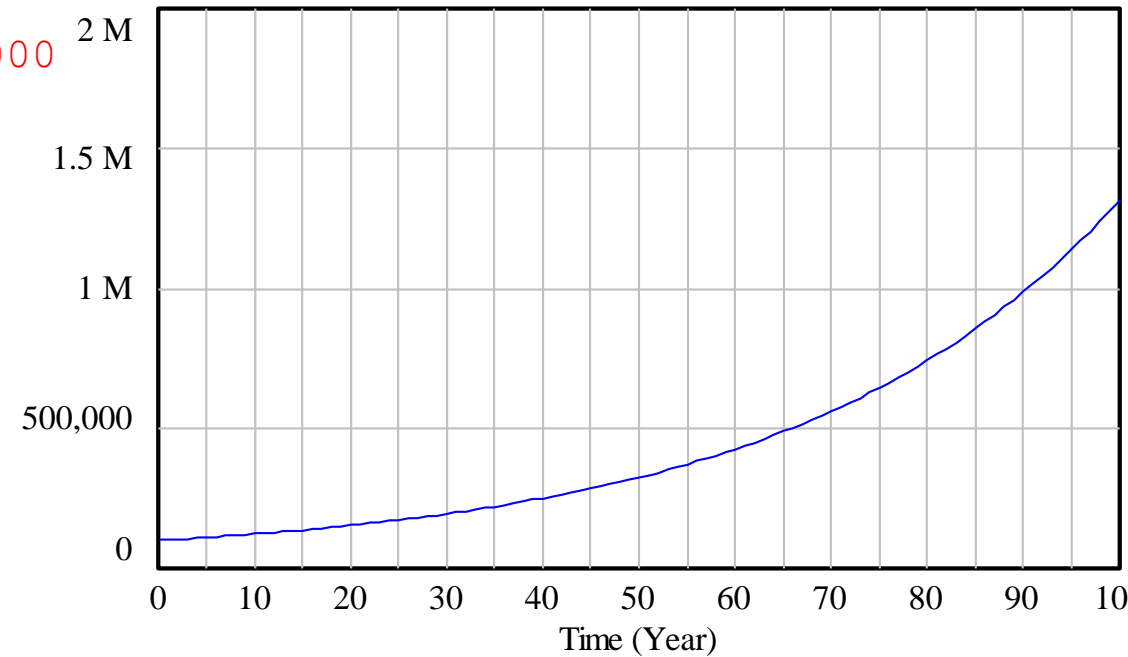
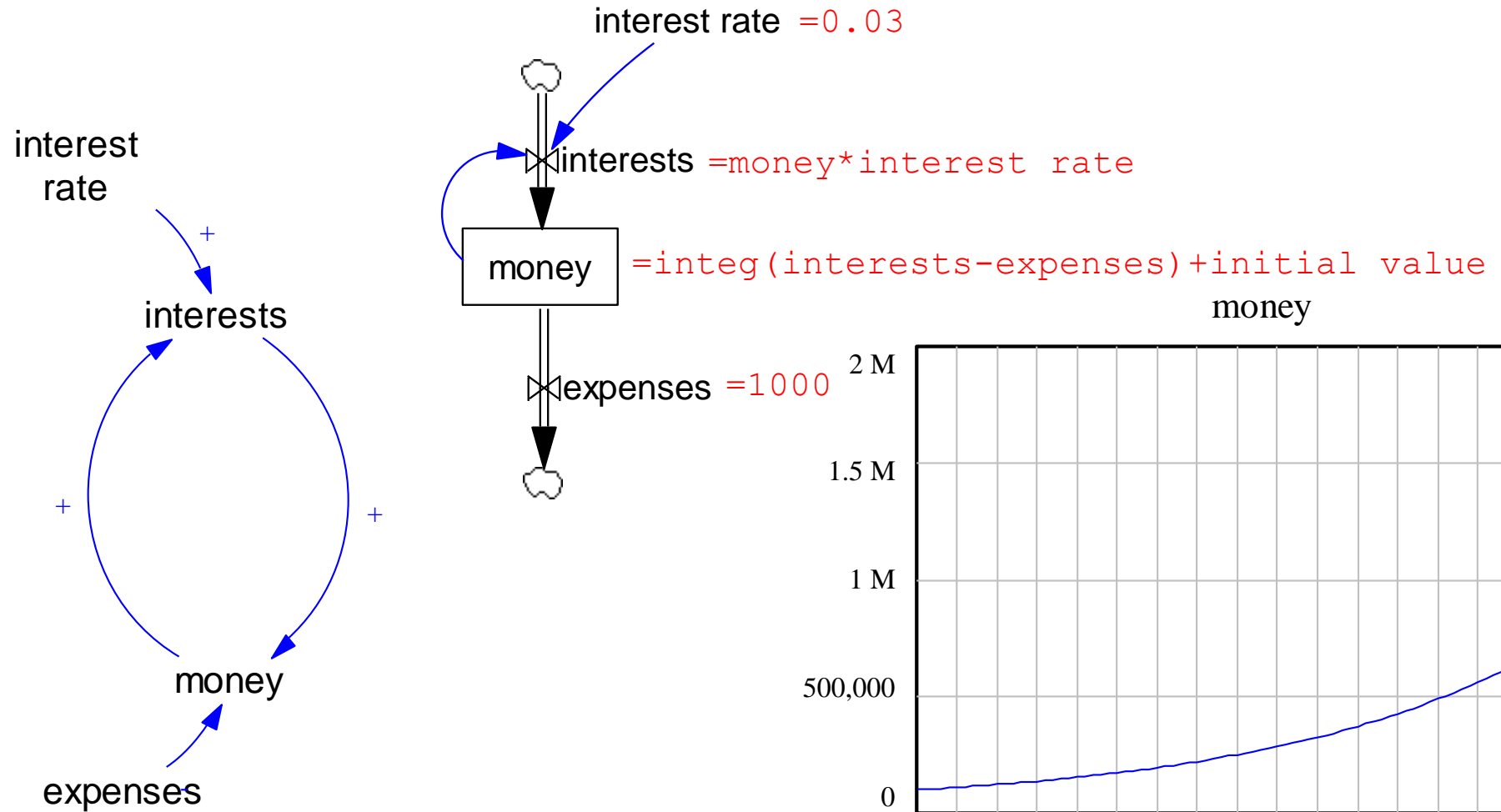
For example:

$$U_t = Z - X_t$$

$$x_t = \int (u_t - y_t) \cdot dt + C$$



Model of a bank account

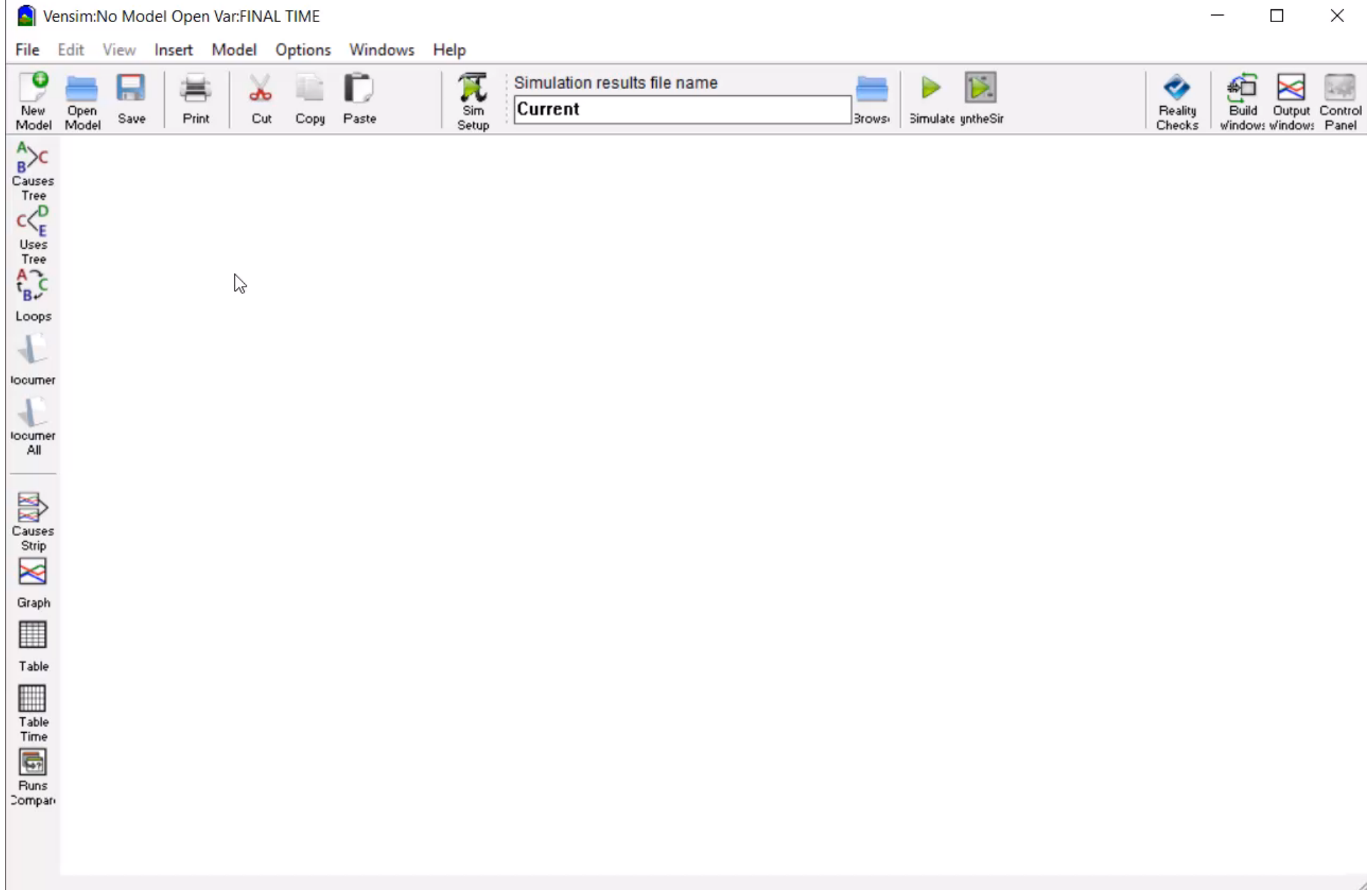




Simulation environment Vensim PLE Software

Vensim is a product of Ventana Systems inc. It's industrial strength simulation software for improving the performance of real systems. Vensim PLE (Personal Learning Edition) is fully functional system dynamics software that is **free for personal and educational use**, and comes complete with sample models, help engine, and Adobe Acrobat format User's Guide. You can download Vensim PLE from vensim.com.

How to build a Vensim model?





Thank You!