

# Concept Map Creator

(Patent Pending)  
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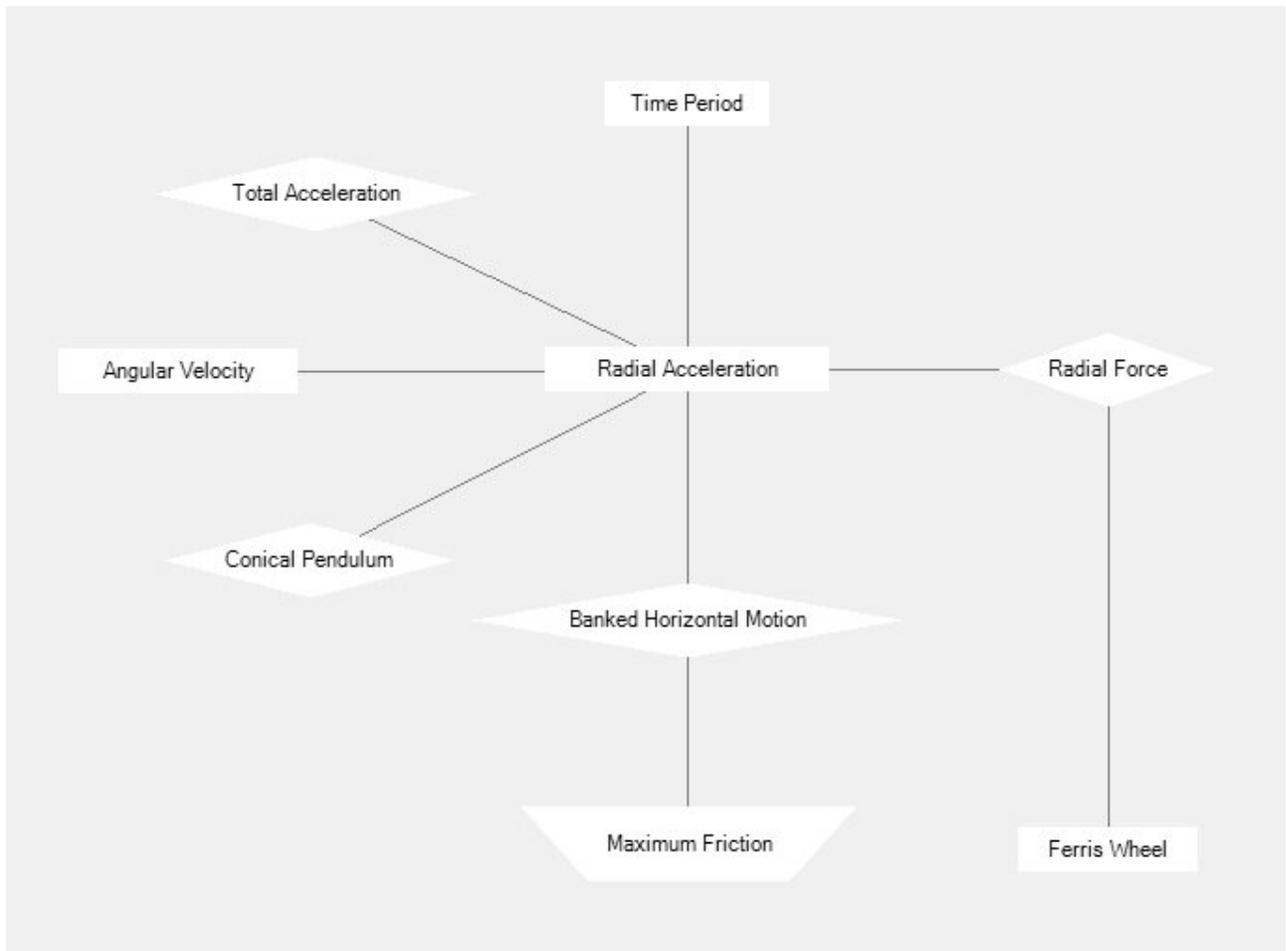
## Why build a Concept Map?

- “To enhance the memory’s storing and recalling capabilities through the use of images for emphasis and association.” (Buzan and Buzan, 1994)
- “Images are...often more evocative than words, more precise..., thereby enhancing creative thinking and memory.” (Buzan and Buzan 1994)
- “Association is...major factor in improving memory and creativity.” (Buzan and Buzan 1994)

Reference: Buzan, T. and Buzan, B., *The Mind Map Book*, Penguin Books USA Inc., 1994.

In the Concept Map for circular motion of a particle, shown in Figure-1, the following ideas associated with the circular motion are assembled.

- Angular velocity, centripetal acceleration, tangential acceleration, total acceleration, and time period.
- Ferris wheel, conical pendulum, banked horizontal motion, and friction.



## Figure-1 : Circular Motion

### What to include in a Concept Map?

- A. Identify, with precision, the concepts that are possibly relevant to a problem and make an exhaustive list.
- B. Eliminate overlaps and redundancy of concepts and make the list of concepts, made in Step-1, mutually exclusive.

### Concept Map Creator

Consider the class of problems belonging to one-dimensional motion of a particle. In a typical, physics textbook, the four following equations are used for solving this class of problems. One important observation is that Eqns. 1, 2, and 3 are not independent. Any one of these three equations can be dropped from the set, leaving three independent equations that govern the one-dimensional motion of a particle.

$$x = x_0 + V_0t + \frac{1}{2}at^2 \quad (\text{Eqn.1})$$

$$V = V_0 + at \quad (\text{Eqn.2})$$

$$V^2 - V_0^2 = 2a(x - x_0) \quad (\text{Eqn.3})$$

$$F = ma \quad (\text{Eqn.4})$$

The variables are named as follows:

Variable-1:  $x$  is the coordinate axis aligned with the one-dimensional motion

Variable-2:  $t$  is the elapsed time

Variable-3:  $x_0$  is the location of the particle on the  $x$ -axis at time  $t = 0$

Variable-4:  $V_0$  is the velocity of the particle at time  $t = 0$  along the  $x$ -axis

Variable-5:  $V$  is the velocity of the particle along the  $x$ -axis

Variable-6:  $a$  is the acceleration of the particle along the  $x$ -axis

Variable-7:  $m$  is the mass of the particle

Variable-8:  $F$  is the force applied on the particle along the  $x$ -axis

The equations are also named as follows:

Eqn.1:  $x$ -Kinematics

Eqn.2:  $V$ -Kinematics

Eqn.3:  $a$ -Kinematics

Eqn.4: Newton's 2nd Law

The gateway to Concept Map Creator is shown in Figure-2. The user begins by clicking the “Creator” button and entering the “dependency matrix” to build the data file.

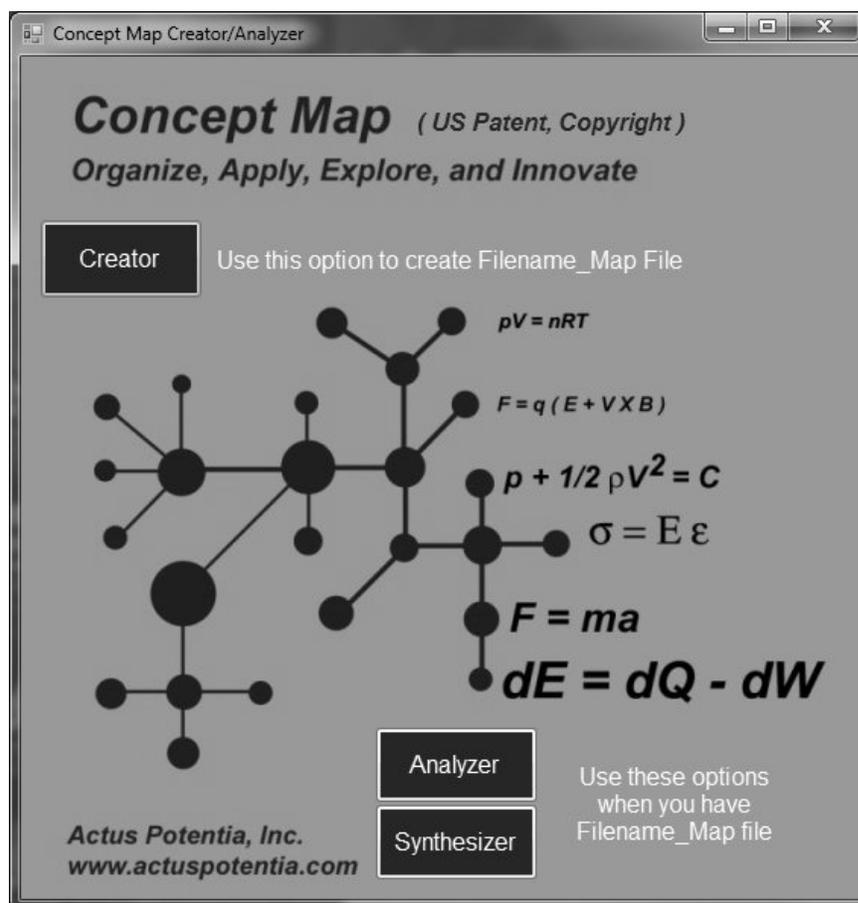


Figure-2: Concept Map Creator gateway.

The user enters Number of Equations = 4 and Number of Variables = 8 (Figure-3).

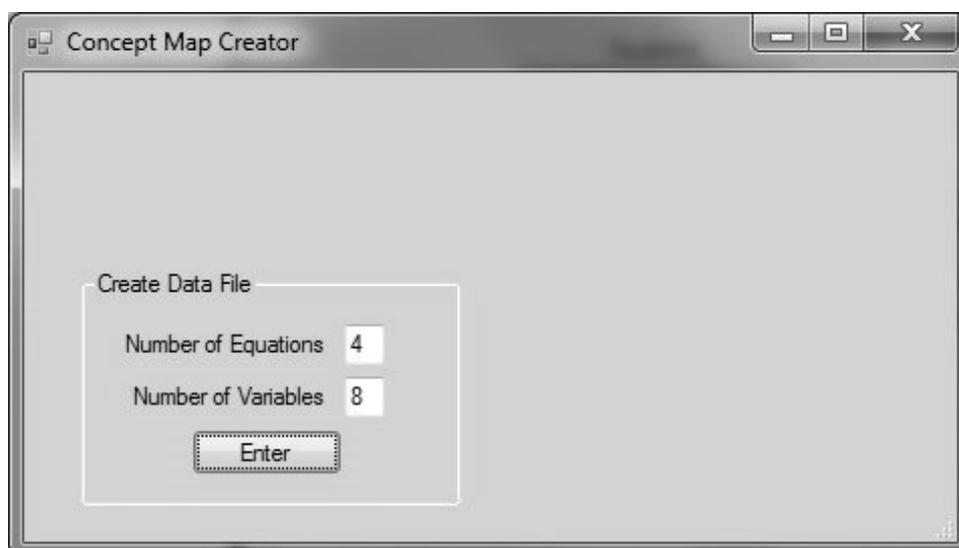


Figure-3: Entering number of equations and variables.

The user renames the variables by clicking on a variable, entering the new name, and clicking the “Rename Variable” button (Figure-4).

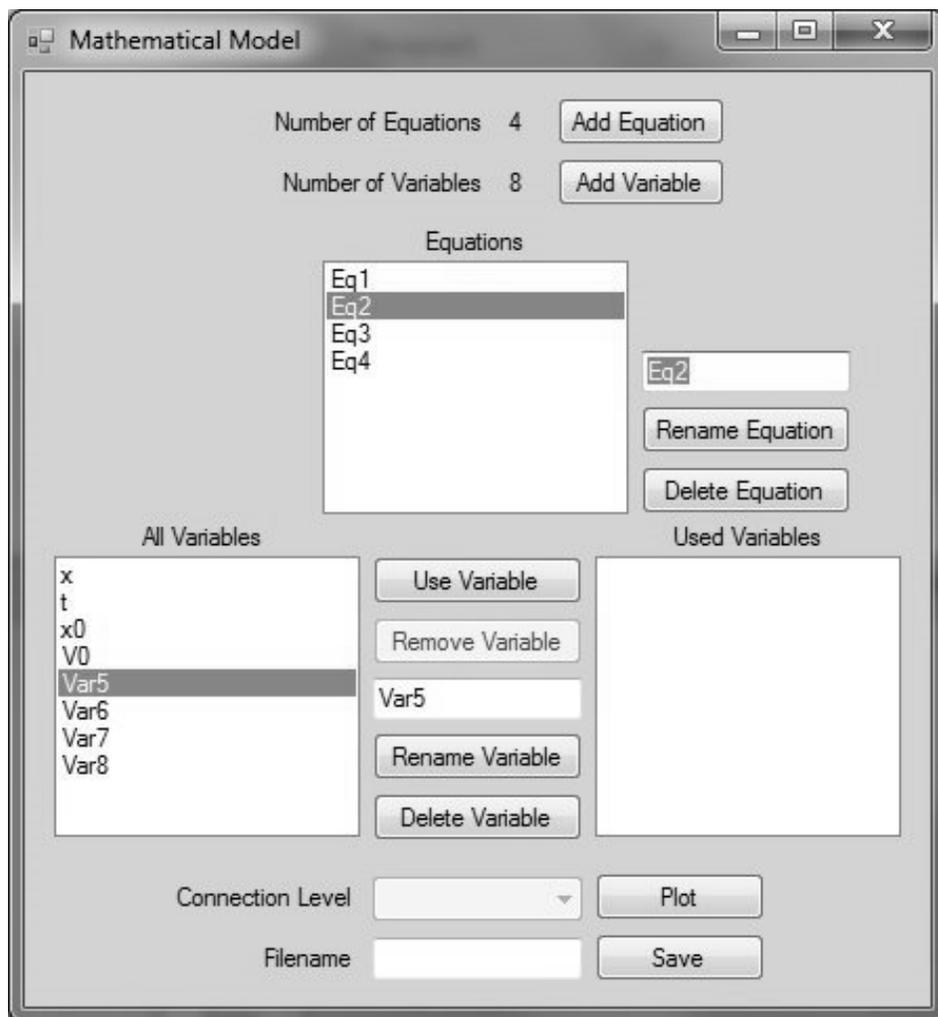


Figure-4: Renaming variables.

The user renames the equations by clicking on an equation, entering the new name, and clicking the “Rename Equation” button (Figure-5).

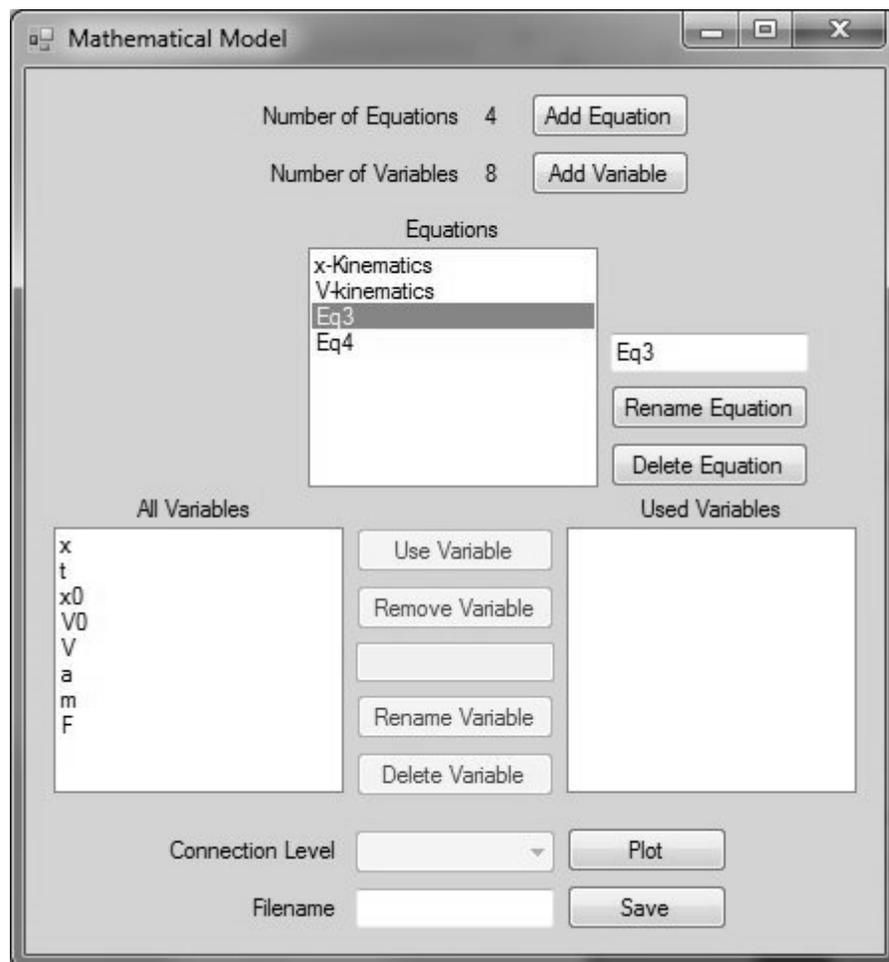


Figure-5: Renaming equations.

The user enters variables in the “x-Kinematics” equation by clicking on the equation, selecting the variables that appear in that equation, and clicking the “Use Variables” button. The variable names appear in the “Used Variables” list (Figure-6).

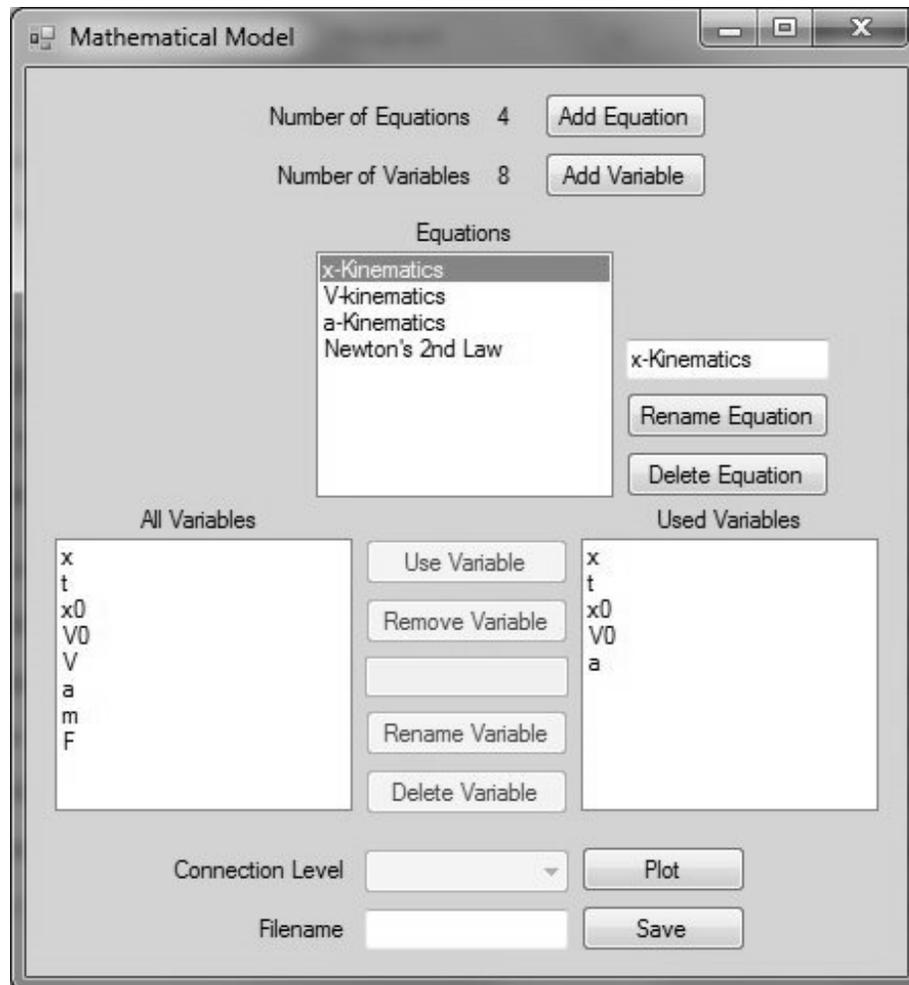


Figure-6: Adding variables to equations.

The user continues to add “Used Variables” in “V-kinematics”, “a-Kinematics”, and “Newton’s 2<sup>nd</sup> Law” equations.

The user saves the mathematical model as Newton.txt file (Figure-7).

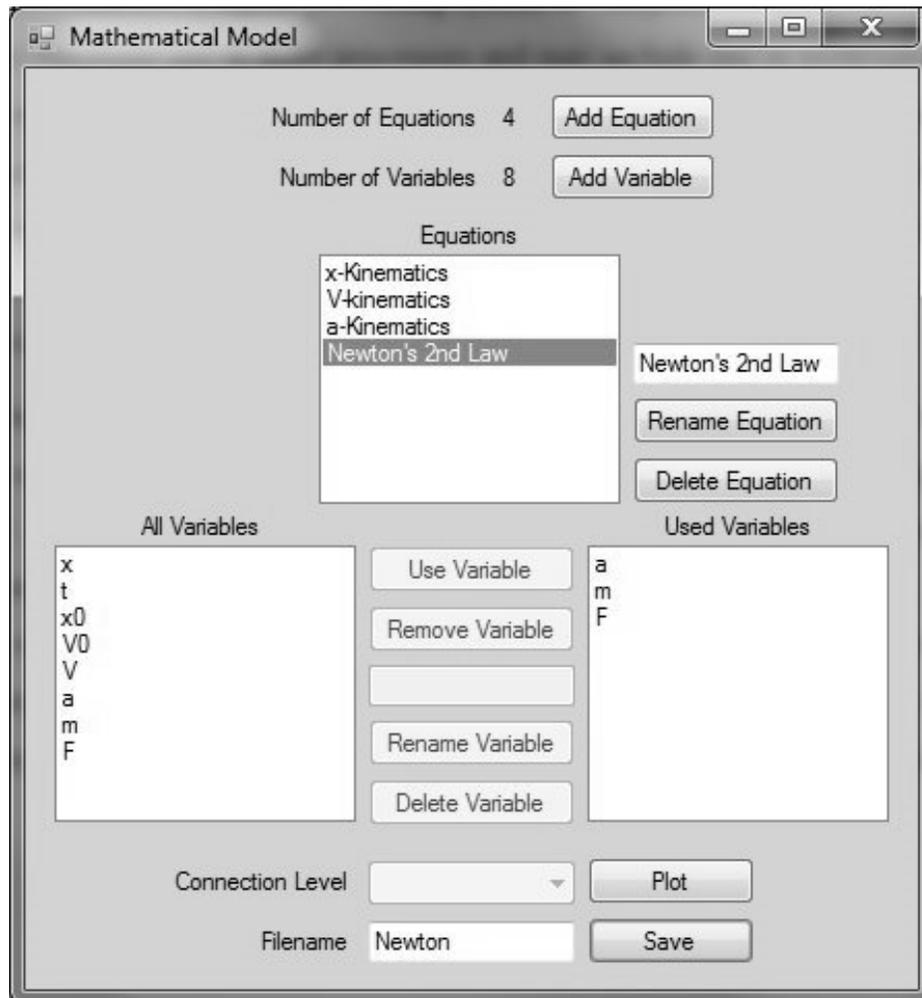


Figure-7: Saving the mathematical model.

For any future editing and analysis, the user can open the saved file (Figure-8).

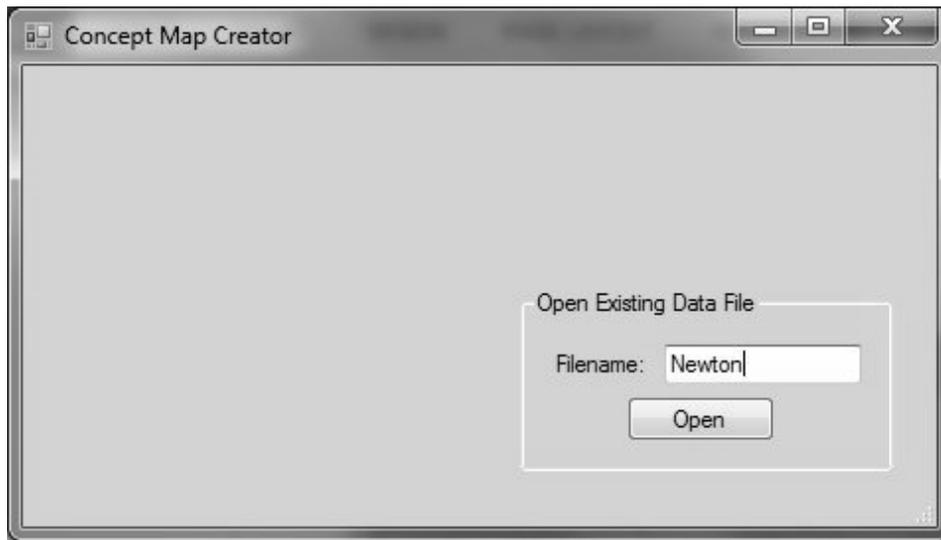


Figure-8: Opening saved mathematical model.

The user draws the Concept Map for motion of a particle in one dimension by clicking the “Plot” button of Figure-7 (Figure-9). The software automatically saves the Map-data in the file Newton\_Map.txt.

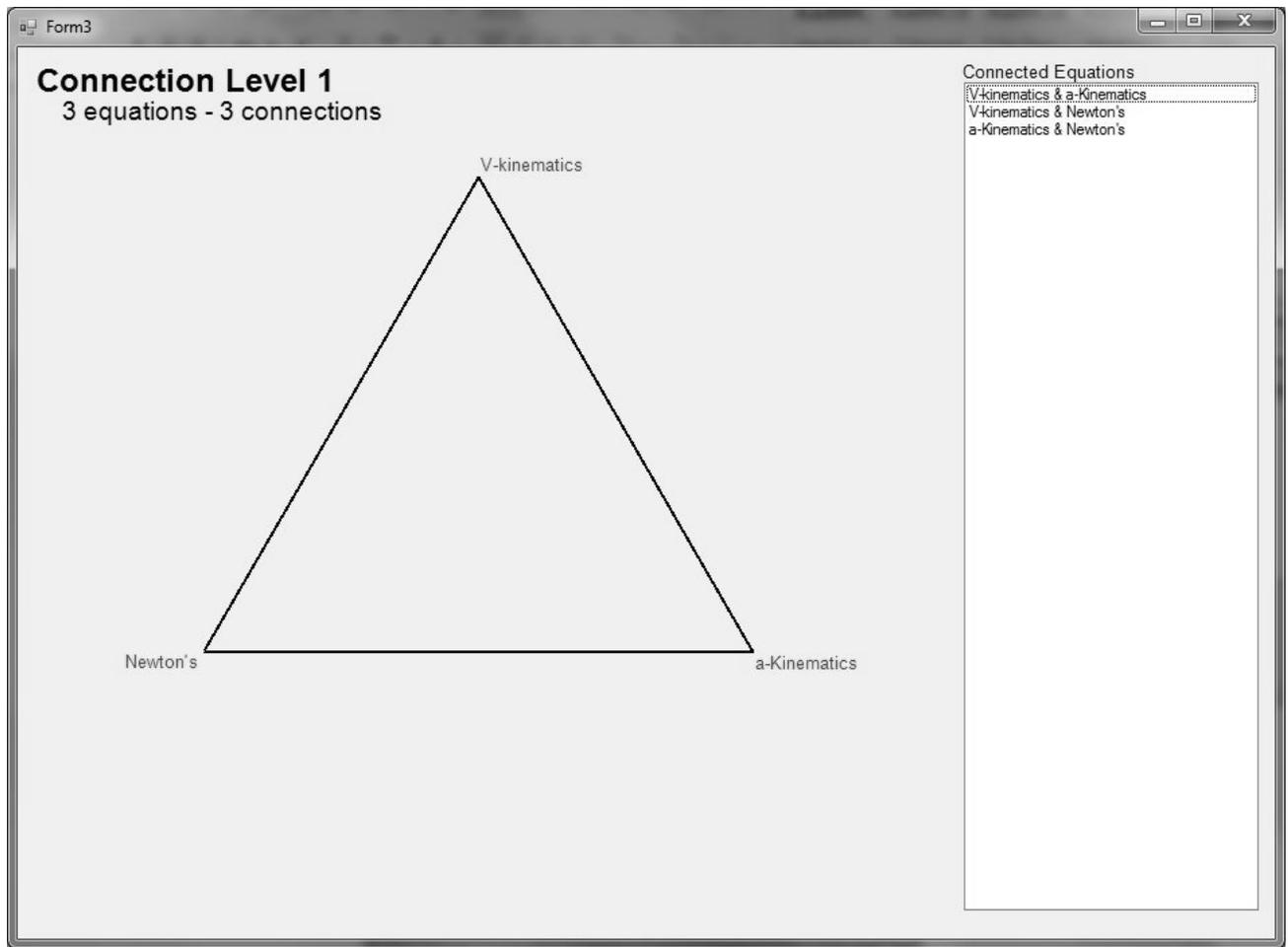


Figure-9: Concept Map for one-dimensional motion of a particle.

The Concept Map of Figure-9 includes equations for V-Kinematics, a-Kinematics, and Newton's 2nd Law. However, the x-kinematics equation is excluded.

1. Concept Map Creator determines that four equations are unnecessary for the analysis of one-dimensional motion of a particle. Only three equations are sufficient to completely and uniquely determine the unknowns in a well-posed problem.
2. Concept Map Creator determines that five variables (out of eight) must be provided to determine the remaining three variables from the three equations. In other words, the Concept Map Creator correctly determines that

$$\text{Degrees of Freedom} = \text{Number of Variables (8)} - \text{Number of Equations (3)} = 5$$

The five degrees of freedom typically are: mass, force, initial position, initial velocity, and time. Other combinations of five input variables are possible, but some of those combinations lead to contradiction. Concept Map Analyzer identifies the situations with contradiction. The functionality of the Analyzer is discussed elsewhere.

3. Concept Map Creator classifies the eight variables into two groups: (a) five degrees of freedom, and (b) three state variables. This classification is important in engineering design problems. This functionality of the Concept Map Creator introduces basic design concepts in the context of any mathematical modeling of phenomena.
4. Concept Map Creator also provides the connectivity among the nodes. The use of this Concept Map for solving specific problems with numerical values is shown in another part of this description, where the functionality of the Concept Map Solver is described.
5. The Concept Map Creator partitions the four equations into two groups: (a) three essential equations, and (b) one additional equation. Learning only the essential equations and excluding the additional equations reduces the cognitive load in the learning process. In more complex situations, the cognitive load in learning can be significantly reduced when students learn smaller amount of essential information.
6. The Concept Map Creator makes a mutually exclusive list of concepts.

### Example

The schematic and the mathematical model for the horizontal circular motion of a particle in contact with a banked surface are shown in Figure-10.

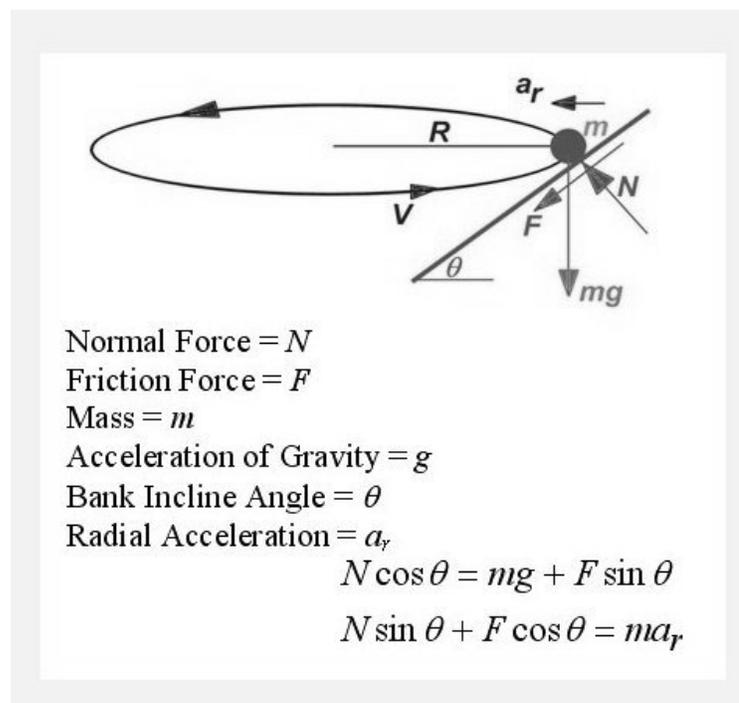


Figure-10: Banked motion of a particle on a circular path.

The concept map for this model is shown in Figure-11.

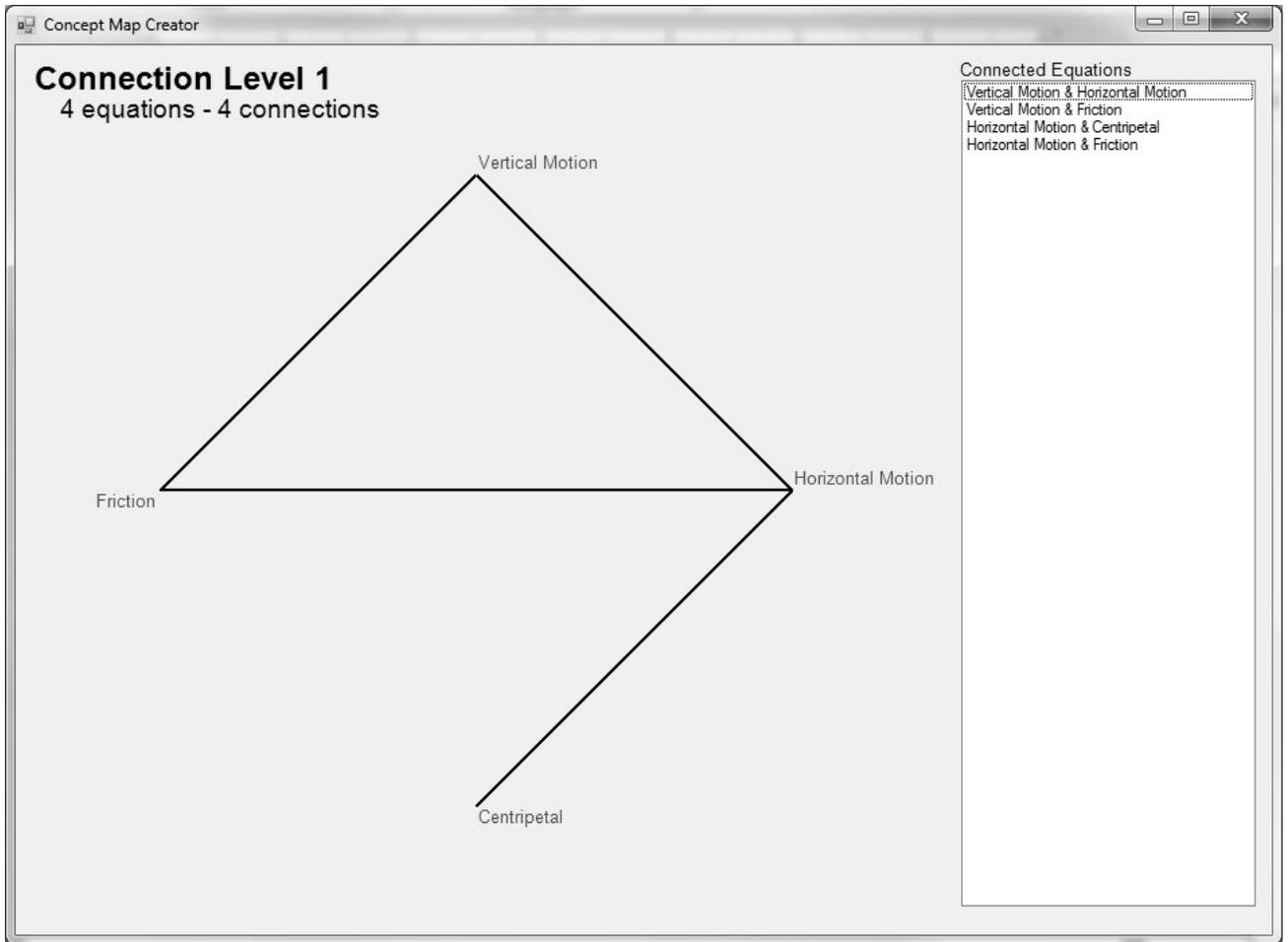


Figure-11: Concept Map for banked circular motion of a particle.