Background Information on Simulation Created for
Lesson 2: Romeo and Juliet: In Rapturous Oscillation?

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in collaboration with the Creative Learning Exchange

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Note: The model used in this lesson is structurally similar to the spring-mass simulation (Lesson 1) and is intended to follow it. It challenges students to apply what they have learned about springs to intangible subject matter. For example, "resistance" from the spring simulation gets recast as "fatigue" to show what happens when one party in a relationship gets tired of the up-and-down dynamic. Students should recognize that their own personal relationships include themselves as part of the system; therefore, they do have the opportunity to influence an unwanted dynamic.

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Introduction

This lesson features Shakespeare's characters Romeo and Juliet as a pair of oscillating dyads. A dyad is a group of two people. They may be linked romantically or as friends; it could also refer to a parent-child relationship or a boss-employee relationship. The simulation features a romantic love-hate relationship, but also shows how the same basic dynamic can be applied to any such up-and-down relationship, even that of two countries. It is not a commentary on the play *Romeo and Juliet*, nor does it reflect the actual relationship dynamics described in the play (there is a handout included in the simulation lesson plan to support a contrasting analysis, however). To run a simulation that will allow the exploration of the play's ever-increasing love between Romeo and Juliet, please see the simulation titled "Romeo and Juliet: Parallel Universe," available for download from the Creative Learning Exchange website.

Overview of Model Behavior

Run the Model with the Default Settings

Romeo and Juliet start the simulation with positive values in their stocks of love. Romeo is said to be fickle; his feelings for Juliet move in the opposite direction of her feelings for him. Of course, it takes time for feelings to change, so he doesn't instantly turn from love to hate. Rather, her love for him saps his love for her. Juliet is the follower in the relationship. She matches her feelings to Romeo's feelings. With fatigue factors set to zero, the default behavior of the simulation is simple harmonic motion. To create the run shown in Figure 1, click the "Run" button.

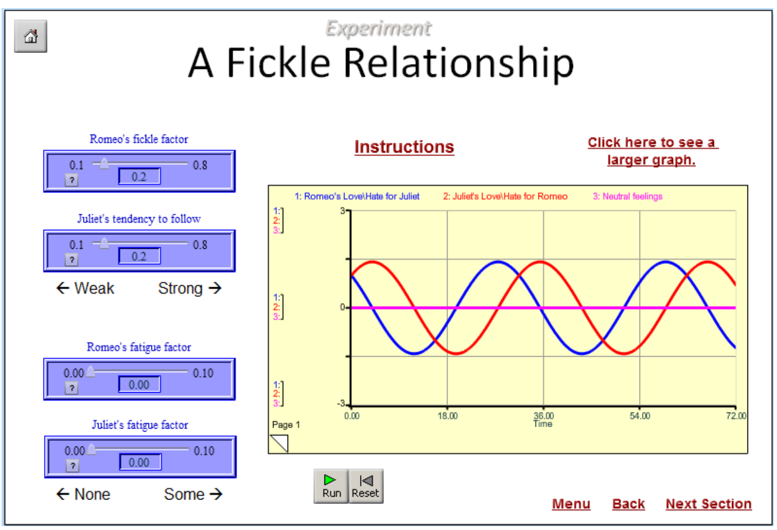

Figure 1: The Control Panel of the simulation showing the default behavior pattern of the simulation.

On your screen, click the white triangle in the lower left of the graph to page through graphs showing each stock individually.

Notice that the simulation runs from 0 to 72, but the unit of time is not specified. The time unit would depend on the situation being examined. As suggested by the debrief screens, two people in a relationship could be replaced by two countries in a political situation of cycling tension. Whereas teenage romance could be measured in days, up-and-down political tensions more realistically play out over decades.

What Changes the Speed of the Cycles?

"Romeo's fickle factor" and "Juliet's tendency to follow" are actually factors that determine how strongly they each react to the feelings of the other. Setting either or both these factors higher will speed up the cycles. In the graph in Figure 2, both factors have been changed from the default values of 0.2 to 0.7. Because his reaction to her is stronger, i.e., set to a higher value, Romeo reacts more quickly to her feelings for him. His love takes a nosedive and turns to hate almost right away. Juliet, because she's following him more strongly, then turns from increasing love to decreasing love in a very short amount of time. She can be said to be pushing him away (or drawing his attention when she doesn't love him anymore) more quickly. The overall result is that the cycles come much faster as the two lovers bounce back and forth between love and hate.

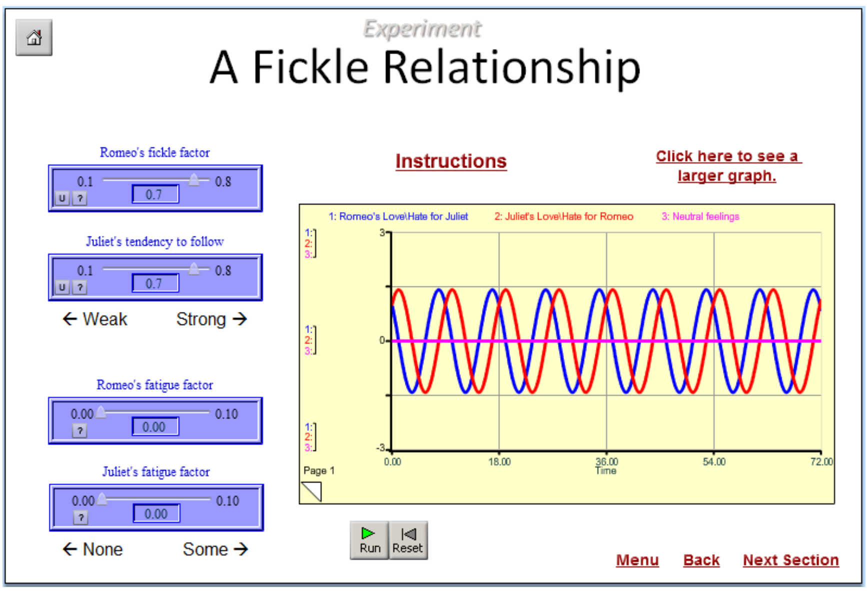

Figure 2: The Control Panel with the new settings for the reaction factors.

Conversely, cycles are slowed by setting the reaction factors to low values. As long as the factors are set approximately equally between the two lovers, they will experience similar levels of love and hate, but operating at faster or slower cycles.

What Changes the Amplitude of the Cycles?

The amplitude of the cycles is most affected by the difference between the reactions of Romeo and Juliet to each other. In other words, when one has a strong reaction but the other has a weak reaction, it tends to exaggerate the drama. In the Control Panel in Figure 3, "Romeo's fickle factor" is set to 0.8 and "Juliet's tendency to follow" is set to 0.1. The graphs of Figure 4 and Figure 5 show Romeo's feelings and Juliet's feelings as individual graphs. Run 1 in those graphs is the default simulation run and the second run shows the behavior generated by the new settings.

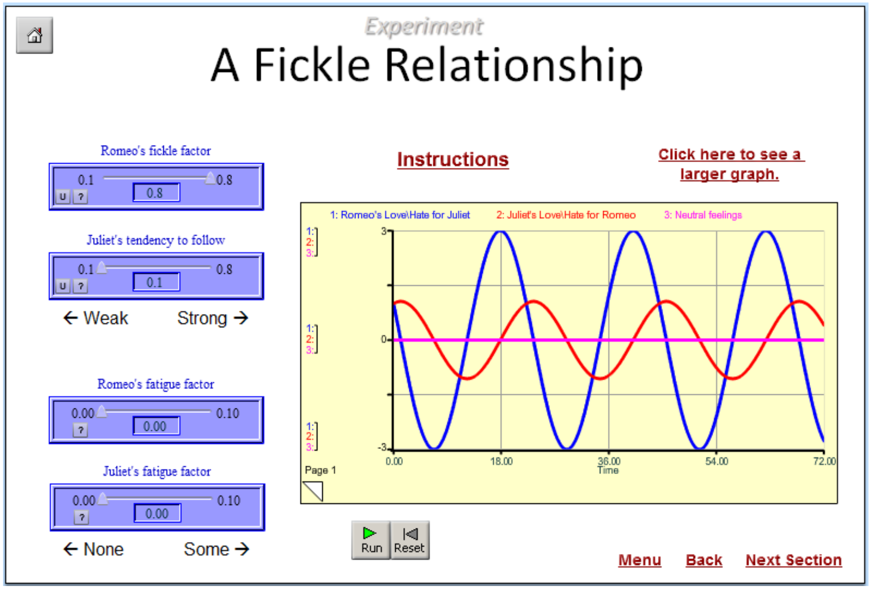

Figure 3: The Control Panel showing one strong reaction and one weak reaction.

Notice in Figure 4 that because Romeo's reaction to Juliet is stronger, his love grows to greater heights (and his hate to greater depths) as compared to the default run. We can say that the drama is mostly experienced by Romeo; Juliet, because she's following, doesn't get time to reach the same extremes. Her cycles have lower amplitude in the second run. Overall, the relationship experiences more peaks and valleys in the same amount of time, compared to the default run.

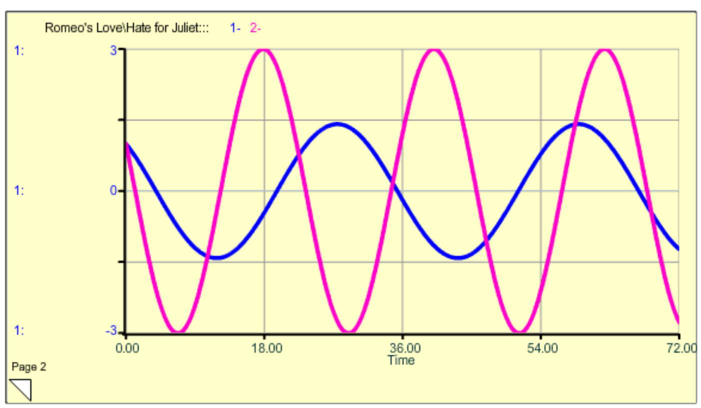

Figure 4: Romeo's oscillations are now more pronounced when he has a high "fickle factor" and Juliet's reaction to him is weak.

Juliet is still mimicking Romeo's feelings for her, meaning she follows his cycles, but with a delay. These cycles are now coming faster due to the increase in "Romeo's fickle factor." Our "real life" explanation would be that Romeo, being the more enthusiastic of the two, experiences more love in the time it takes for Juliet to follow along. By the time she does return his feelings, however, he's plunging into the depths of hate. Her reaction is again more tempered, so she never reaches the heights and depths that he does.

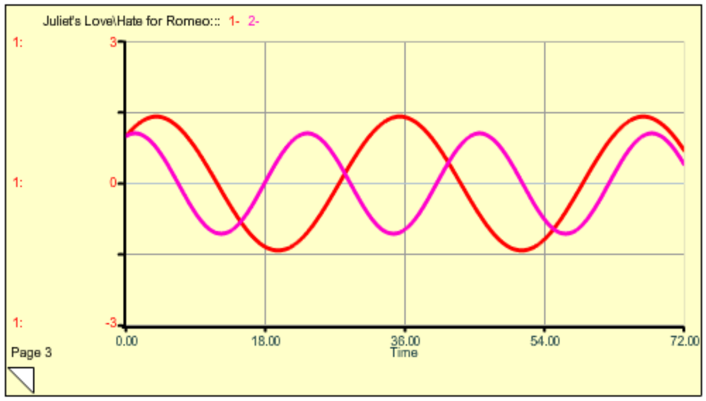

Figure 5: Juliet experiences less drama (in terms of amplitude) when she reacts less strongly to Romeo's feelings for her.

This situation can be reversed by setting "Romeo's fickle factor" to a low value and "Juliet's tendency to follow" to a high value. The drama is then experienced most by Juliet.

What Kills the Cycles?

Are the two lovers destined to keep cycling through this love-hate relationship? Students may recognize that this is unrealistic. The fatigue factors act as damping forces, returning both people to neutral feelings. For instance, if Romeo is very fickle, but also tires of the relationship quickly, the behavior may look as shown in Figure 6. Compare this graph to the default behavior shown in Figure 1. In the run in Figure 6, Romeo's fickle factor is set to 0.8 and his fatigue factor to 0.1. Juliet's settings are unchanged from the default run. Because she is the follower, she takes her cues from Romeo. The relationship, while stronger at first from Romeo's side, eventually dies.

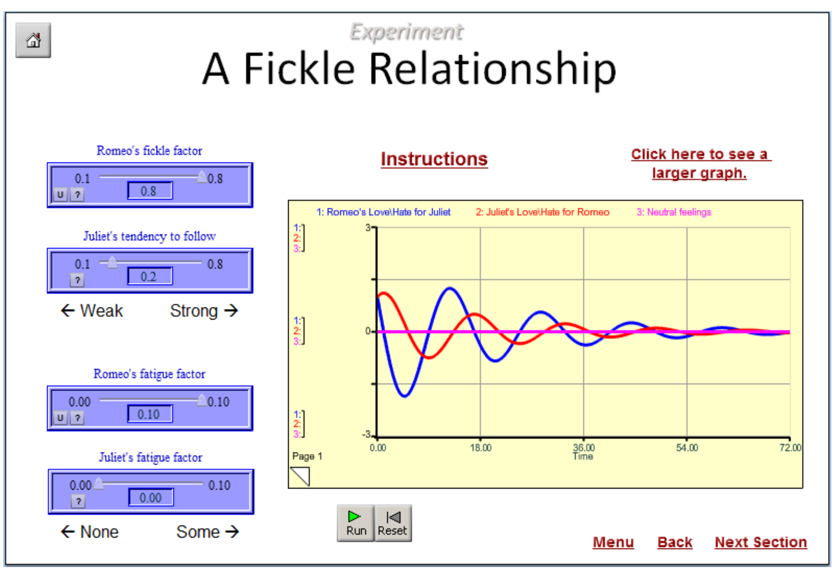

Figure 6: Fatigue from either person will dampen the oscillations and eventually lead to neutral feelings, despite the strength of their reactions to each other.

There are numerous combinations that students can explore. Students should understand and be able to articulate what situations create fast cycles, slow cycles, more dramatic cycles and less dramatic cycles.

Model Structure and Assumptions

The model structure is presented on the screen shown in Figure 7. This screen is accessed via the menu by clicking the link "Explore the Model."

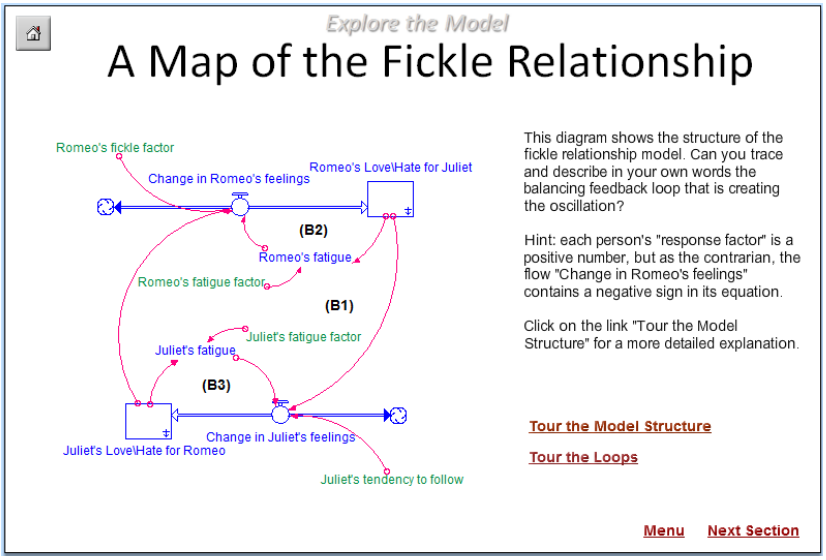

Figure 7: The structure of the model; green variables are changed in the Control Panel.

The links "Tour the Model Structure" and "Tour the Loops" give an overview of the model structure and the feedback loops governing its behavior. These loops are labeled "B1", "B2" and "B3" in the picture. Loop "B1" is the main balancing loop of the model. Without the actions of the other loops acting through fatigue, loop "B1" is responsible for the harmonic oscillation behavior pattern.

Limitations of the Model

The model is generic; it is not intended to represent a real relationship, romantic or otherwise. Like the model of the spring-mass system (Lesson 1 of the Oscillation curriculum), it will not generate behavior patterns other than oscillation. This is because the flow "Change in Romeo's feelings" contains a negative sign, which forces his feelings to move in the opposite direction as Juliet's feelings. As such, he's called the "contrarian" of the relationship. Many people will be able to relate to such a person – when everyone else is moving to the left, the contrarian moves to the right. This is because he or she is a leader, always looking ahead to something new and exciting. Such people are often called trendsetters; they look for ways to show their uniqueness and then when everyone else copies them, they are ready to move on to something else.

Talking Points – Linking the Simulation to Real Life

There are a number of ways in which this simulation can be used in the classroom[1]. The simulation can support discussion of teen romance. There is the angle of "immaturity" exhibited by Romeo's desire for what he can't have. The other side of this is doubt. Teenagers can experience intense feelings of love, but also face many choices about the future. They may ask themselves, where is this relationship going? When doubt sets in, it's natural to "put the brakes on" (act as a contrarian) even when things are going well.

Beyond teen romance, students may link the simulation to the ups and downs experienced by people who have been married a long time. While our society certainly values the institution of marriage, popular culture features the ideal of "happily ever after." Realistically, what would that look like in terms of behavior over time? Is exponentially increasing love a likely scenario? How would various personality types (leader + leader, follower + follower, etc.) fare in romantic relationships? How about as business partners or friends?

Marriage can look very different in other countries because culture and religion influence relationship dynamics. The simulation features an oscillating dyad that does not disengage, but can reach neutral feelings through the action of fatigue. In western society, how likely is divorce in such a situation? What about in countries where divorce is difficult? In extreme cases, love-hate relationships can be violent. This simulation can be used to focus discussion about when, how and if such relationships are likely to be perpetuated or ended, depending on one's culture or nationality.

This simulation can also support discussion about political tensions between two countries. On this level, what are possible implications of "disengagement," rather than continuing the cycles of high and low tension? Is the "contrarian-follower" description of oscillation still relevant in the realm of political tensions, or would such a behavior pattern be rooted in a different structure?

Finally, students may enjoy discussing the leader-follower dynamic in terms of trendsetters and their emulators. Just as Romeo starts to lose interest in Juliet when she loves him, so goes the interest held by a trendsetter in a particular fashion or behavior when "the crowd" is on board with it, too. Social media, driven by technological advances, speeds the trend cycle and expands the influence any one person or group can have over others almost regardless of physical location in the world.

The Cause of the Problem is Within the System

The overall goal of the Oscillation curriculum is to teach a principle of complex systems: The cause of the problem is within the system. Socioeconomic systems that oscillate are often not recognized as oscillating due to their intrinsic structure. Explanations often point to outside influences that either are themselves oscillating, or that a particular combination of outside factors must serve to "drive" an oscillation. This

[1] Besides supporting a character analysis of the relationship dynamics in *Romeo and Juliet*, this simulation connects to standards in several other areas, including *Individual Development and Identity*; *Individuals, Groups and Institutions;* and *Global Connections*. Please see the website http://www.socialstudies.org/standards.

model shows that two people can exhibit love-hate dynamics simply by reacting to each other in a particular fashion. If Romeo did not react to Juliet's love in a negative (opposite) manner, the oscillation would not occur. In fact, the same model structure, absent the negative sign in Romeo's flow "Change in Romeo's feelings" and with different parameter values, will produce other behavior patterns, such as exponential growth and decline. The balancing loop connecting the two stocks would then be a reinforcing loop. Changing the structure changes the behavior of the system.

Similarly, other familiar systems can oscillate due to their intrinsic structure. Predator-prey systems are well-known real-life examples and are included in this curriculum as a mini-series of lessons (Lessons 3, 4 and 5, showing logistic growth in a single population, cyclic interactions between predators and prey, and trophic interactions between predators, prey and biomass, respectively). Other lessons are also included to show that the dynamics that create oscillation arise due to system structure. Because the cause of a system's behavior is due to its structure, the solution to changing the behavior also lies with the system's structure (rather than eliminating an outside influence). For example, Lesson 1 shows that a spring stops oscillating due to damping forces such as surface friction and gravity; this lesson shows that love-hate dynamics die out if one or both parties in the relationship tire of the drama and thus temper their reactions to each other. These lessons show that inherent oscillation can be tamed through the proper leverage. The cause of the problem, and the solution to the problem, is indeed within the system.