

**Concept 0 - Basic Resonant Systems**

- Part 1
1. Run the *ResonanceVPeriod.IP* simulation in Interactive Physics and set the driving amplitude to 2.00, and the damping to 0.20
  2. Try different driving periods (1.60, 1.80, 2.00, 2.20, 2.40) and see what happens to the ultimate amplitude of the system. You will have to let it run for some time. Notice that it eventually settles on an equilibrium where the oscillator is receiving and dissipating energy at the same rate, so the energy (amplitude) levels off.
  3. The system has a resonant period of 2.00 s. **What is the relationship between the driving period and the ultimate amplitude of the system?? Which driving period achieves the highest amplitude?**
  4. The damping is a frictional force that is proportional to the velocity. For a driving period of 2.00 seconds, change the damping. **What is the relationship between the damping and the ultimate amplitude of the system?**

## Part 2

1. Run the *ResonanceVPeriod.IP* simulation in Interactive Physics and set the driving amplitude to 2.00, and the damping to 0.20
2. Set the period to the resonant period (2.00 s) and let it run for 100 seconds, then hit Stop.
3. Notice that at around 40 seconds on the graph the system goes into equilibrium.
4. The damping force is proportional to the velocity of the mass:
  - a. **What is happening to the velocity of the oscillator as the amplitude increases? (Why?)**
  - b. **What is happening to the damping force as the amplitude increases? (Why?)**
  - c. **What is happening to the rate at which the system dissipates energy as the amplitude increases?**
  - d. **Compare the rate that the system receives energy to the rate at which it dissipates energy:**
    - i. **from 0 - 40 seconds?**
    - ii. **from 40-100 seconds?**

**Concept 1 - Q factor is related the degree of damping.**

Systems with a high Q factor are lightly damped, and those with a low Q factor are heavily damped.

## Part 1

1. Run the *QFactor.IP* simulation in Interactive Physics and set the Period to 2.00 seconds, and the Q factor to 10
2. About how many cycles does it go through before it stops?
3. Try some different values of Q factor (1-15?), and notice what happens.
4. **What is the relationship between the Q factor and the number of cycles it goes through before it stops?**

## Part 2

1. Run the *QFactor.IP* simulation in Interactive Physics and set the Period to 2.00 seconds.
2. A system is critically damped when it returns to equilibrium with a velocity of zero in the fastest time possible. Try several Q factors that are less than 1.00 (0.90, 0.80, 0.70...)
3. **What is the Q factor that corresponds to critical damping? Does this make sense in terms of what you determined in part 1?**

## Concept 2 - The relationship between oscillator phase and Driving Phase in resonant systems

### Part 1

1. Run the *BartonsPendulums-fewer.IP* simulation in Interactive Physics and set the Driving Amplitude to 2.00, and the Damping to 0.10
2. Set the Driving Period to 1.20, 1.40, 1.60, 1.80, 2.00, 2.20s and watch the different oscillators that are tuned to these periods go nuts. (You don't have to try all those periods, just get the general idea)

### Part 2

1. Run the *BartonsPendulums-fewer.IP* simulation in Interactive Physics and set the Driving Amplitude to 2.00, and the Damping to 0.10, **and the Driving Period to 1.60** (This is the middle oscillator)
2. Let it go until the 1.60 oscillator reaches equilibrium, and then hit stop. (at around counter 2500 in the lower right corner)
3. Notice that there is a bar that moves around that is labeled driving phase. When this bar is above zero, there is an upward force, and below, a downward force. When the bar and the oscillator are at the top and bottom together, they are in phase.
  - a. **What is the relationship between the Driving Phase and the Phase of the faster oscillators? (1.0, 1.2, 1.4)**
  
  
  
  
  
  
  
  
  
  
  - b. **What is the relationship between the Driving Phase and the Phase of the slower oscillators? (1.8, 2.0, 2.2)**
  
  
  
  
  
  
  
  
  
  
  - c. **What is the relationship between the Driving Phase and the Phase of the resonant oscillator? (1.60)**

It is hard to see this with the simulation running, so with it stopped, use the frame by frame buttons at the bottom right to freeze the phase bar at 0, 90, 180, 270, 360 degrees (like a trig circle)