# OCR B Physics A-Level

## PAG 10.2

### Observing forced and damped oscillations

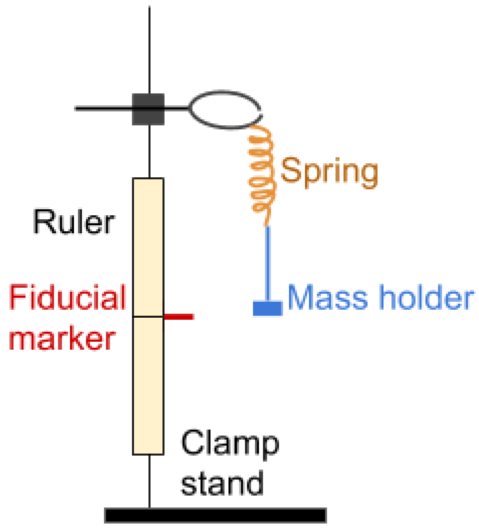
Damped Oscillations

**Equipment**

- Clamp stand
- Two 15 cm rulers
- Spring
- 100 g masses
- 500 g mass holder
- 400 g mass holder
- Stopwatch
- Fiducial marker (e.g pin and blu-tack)
- Damping card (circular cards with a hole in the centre which is smaller than a 100 g mass but larger than the stem of the mass holder so it can be wedged between two masses to hold it in place)
- Rubber bands

**Method**

1. Attach the spring to the clamp stand and attach the 500 g mass holder to the spring as shown in the diagram below.
2. Wait until the spring stops moving completely, then place the fiducial marker at the very bottom of the mass holder. This represents the centre of oscillations and will make it easier to count how many oscillations the mass-spring system has undergone.
3. Attach the 15 cm ruler, either side of the fiducial marker, using rubber bands. These will be used to measure the amplitude of the oscillations.




4. Pull the spring down slightly and let it go so that it is oscillating with a small amplitude and in a **straight line**.
5. As the bottom of the mass holder passes the fiducial marker, start the stopwatch and count the time taken for it to complete 10 full oscillations.
6. Once again, pull down the spring and let it go, allowing it to oscillate with a small amplitude and in a straight line. Remember to record the amplitude that the spring is pulled to, as this will be the maximum amplitude at the start of the first oscillation.

7. Measure the maximum amplitude of the spring at the start of every oscillation for at least 10 oscillations.
8. Repeat the above two steps twice and calculate the mean values of maximum amplitude at each oscillation.
9. Repeat the above procedure but this time using the 400 g mass holder and the damping card wedged between the mass holder and a 100 g mass.

**Calculations**

- Divide the collected values of time period by 10 to get the time period for a single oscillation (T).
- Calculate the frequency of the oscillations by using the equation below, when the damping card is present and when it is not.

$$f = \frac{1}{T}$$

- Plot a graph of the maximum amplitude against the number of oscillations for both systems and draw a line of best fit, which in this instance is an exponential decay curve.

**Safety**

- Be careful when handling the masses. Dropping them may cause injury.
- If the clamp stand is unstable, a counterweight placed on the base of the clamp stand can be used to prevent it from falling over.
- Wear eye protection when using springs.

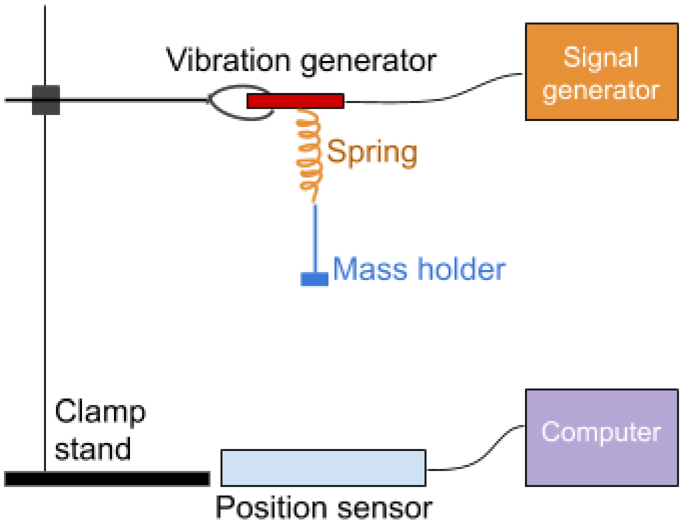
**Notes**

- You will notice that the frequency of the system with the damping card will be less than the system not using the damping card, even though the mass and spring constant is kept constant. This is because the system experiences more damping and so will move slightly slower.
- When comparing your graphs you will see that the maximum amplitude decreases exponentially in both systems, however the amplitude will decay much faster in the damped system as the degree of damping is greater.
- A large mass is attached to the spring so that the time period of oscillations is longer, meaning the maximum amplitude of each oscillation is easier to measure.
- To reduce uncertainty and to more accurately measure the maximum amplitude, you can record the oscillations of both systems using a position sensor connected to a computer.

Forced oscillations

**Equipment**
- Computer
- Position sensor
- Clamp stand
- Spring
- Mass holder
- Signal generator
- Vibration generator
- Metre ruler

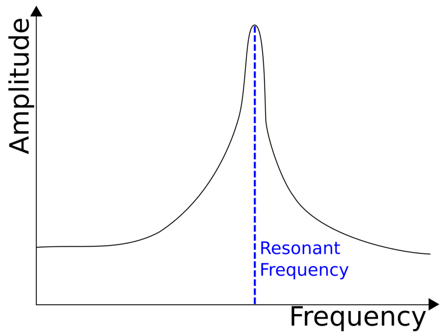
**Method**
1. Set up the equipment as in the diagram.




2. Turn on the signal generator and set it to a frequency much lower than the natural frequency of the spring if it is known - if not set it to 10 Hz. (The natural frequency of the spring can be calculated by letting the spring oscillate freely and calculating the frequency of its oscillations.)
3. Wait until the spring stops moving completely, then measure the distance of the bottom of the mass holder above the sensor using either the position sensor or a metre ruler.
4. Using the position sensor connected to a computer with data-logging software, record the maximum amplitude of the oscillations above its equilibrium position.
5. Increase the frequency of the signal generator by 10 Hz, and repeat the above step.
6. Repeat the last step until the frequency of the signal generator is far above the natural frequency of the spring if known, if not, aim for 10 readings.

**Calculations**

- Plot a graph of maximum amplitude against frequency. You should get a graph similar to the following:




- As the driving frequency is equal to the natural frequency of the spring when it is experiencing resonance, you can calculate the natural frequency of the spring using your graph. You can do this by finding the frequency at which the maximum amplitude of oscillations reaches its peak value.

**Safety**

- Be careful when handling the mass holder. If dropped it may cause injury.
- If the clamp stand is unstable, a counterweight placed on the base of the clamp stand can be used to prevent it from falling over.

**Notes**

- You will be able to see from your graph that the maximum amplitude of oscillations increases greatly as the frequency of the driving force, which in this case is the vibration generator, comes closer to the natural frequency. This is because resonance occurs when the frequency of the driving force is equal to the natural frequency of the spring.