A-LEVEL PHYSICS • EXERCISE SHEET

17.3 Damped and forced oscillations, resonance

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

Objective

Build the skills to answer exam questions on **damping** and **resonance**.

You must be able to:

- describe **light**, **critical** and **heavy** damping and sketch their graphs
- explain **resonance** and the condition for it

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

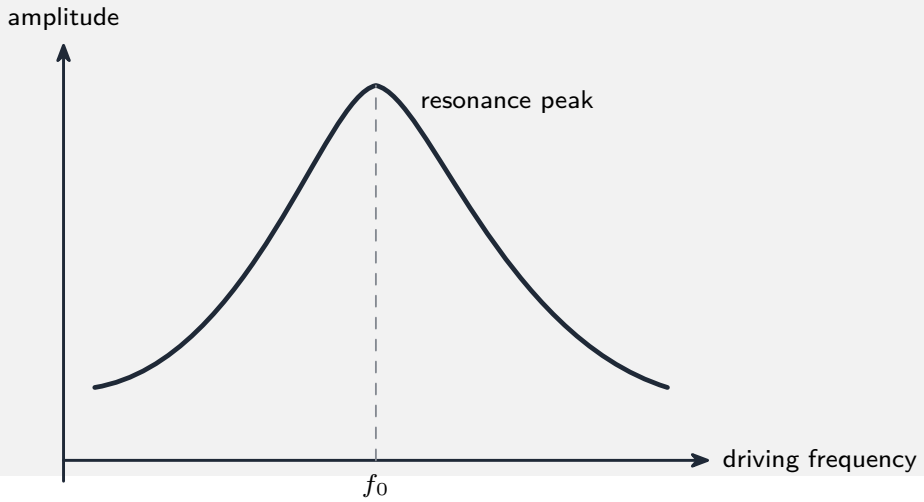
Damping

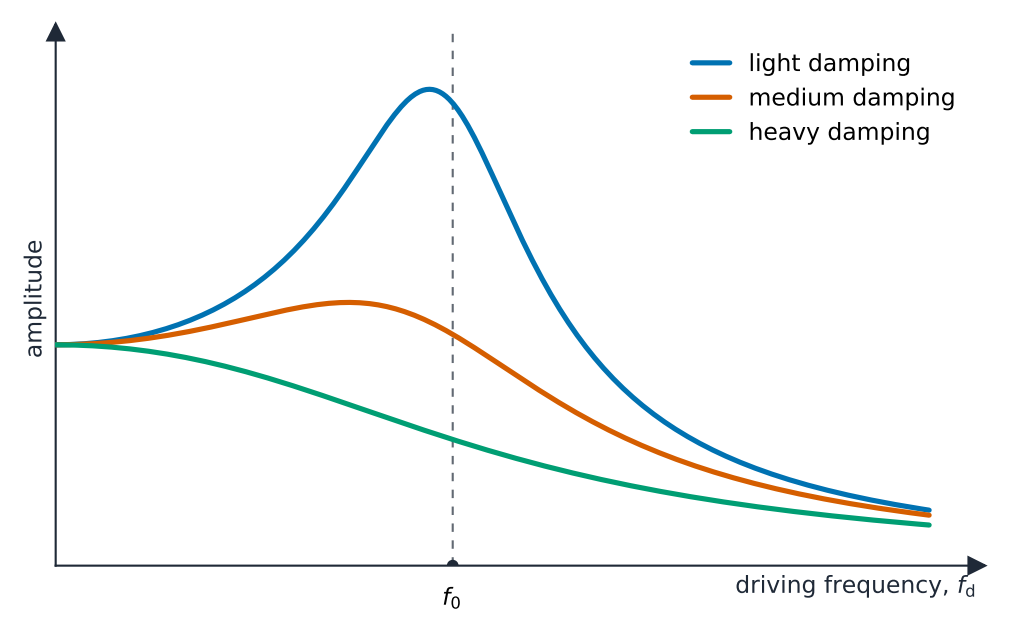
A **resistive force** removes energy, so the amplitude **shrinks** —this is **damping**:

- **light:** amplitude dies away slowly over many cycles;
- **critical:** returns to equilibrium **fastest** with **no overshoot**;
- **heavy:** returns slowly, no oscillation.

Resonance

A system **forced** to oscillate has the largest amplitude when the **driving frequency equals its natural frequency** f_0 —this is **resonance**:





The resonance curve and damping

More damping makes the resonance peak **lower and broader**.

2 Practice

Now apply the methods above.

2.1 State what causes **damping**. [1]

2.2 Name the **three** types of damping. [2]

2.3 State what is meant by **resonance**. [1]

2.4 State the condition for resonance to occur. [1]

3 Exam-style questions

3.1 Critical damping is the damping that: [1]

- **A** lets the system oscillate forever
- **B** returns the system to equilibrium fastest, without overshooting

- **C** returns the system to equilibrium most slowly
- **D** increases the amplitude

3.2 Describe how the **amplitude** of a forced oscillation changes as the driving frequency is increased through the natural frequency. [3]

3.3 Give **one** example each of where **light** damping and **critical** damping are useful. [2]

3.4 Explain what happens to the **resonance peak** when more damping is added. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **17.3 Damped and forced oscillations, resonance** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/42 N25 —Q5 (damping and resonance)
- 9702/44 J25 —Q7 (forced oscillations, structured)

Solutions

2.1 A **resistive force** (friction / drag / air resistance) removing energy from the oscillator.

2.2 **Light**, **critical** and **heavy** damping.

2.3 The condition where a forced oscillation reaches its **maximum amplitude**.

2.4 The **driving frequency equals the natural frequency** of the system.

3.1 **B** —returns to equilibrium fastest without overshooting.

3.2 The amplitude **rises** as the driving frequency approaches the natural frequency, reaching a **maximum at** f_0 (resonance), then **falls** again as the frequency increases past f_0.

3.3 Light damping —e.g. a pendulum/clock or musical instrument (sustained oscillation); critical damping —e.g. a galvanometer/voltmeter needle or car suspension/door closer (quick settle).

3.4 The peak becomes **lower** (smaller maximum amplitude) and **broader** (occurs over a wider range of frequencies).