Solutions

Each answer shows the steps, then the **result**.

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

- critical damping **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)

3.5

(a) the system is driven by a **periodic force** whose frequency equals the **natural frequency** of the system

- there is a **maximum transfer of energy** to it, so its amplitude becomes maximum

(b) the natural frequency of the part is 24 Hz

$$T = \frac{1}{f} = \frac{1}{24\ \text{Hz}} = \mathbf{0.042}\ \text{s}$$

(c) curve A: a sharp peak at 24 Hz

- curve B: its peak is at a **higher** frequency, is **lower** in amplitude, and is **broader** — heavier damping flattens and widens the resonance curve; both curves start at a non-zero amplitude at zero frequency and fall away at high frequency

(d) the machine's running frequency is now **further from** the part's natural frequency, so the part is driven well away from resonance

- the extra damping lowers the amplitude at every frequency, so even at resonance the oscillation would be smaller and less likely to cause damage