7.3 Doppler effect for sound waves

Name: ______________ Class: __________ Date: ____________ **Total: 12 marks**

Objective

Build the skills to answer exam questions on the **Doppler effect** 多普勒效应 for sound (moving source, stationary observer).

You must be able to:

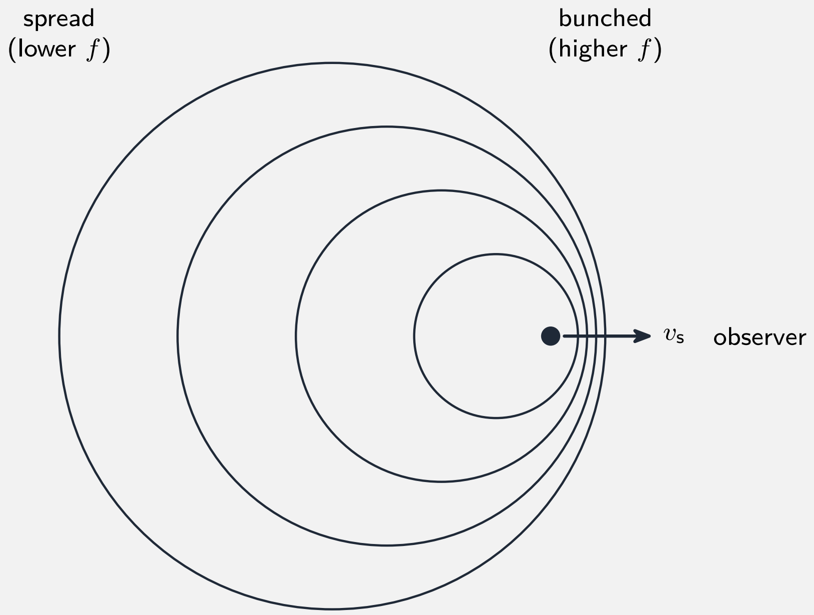
- explain why a moving source changes the observed frequency
- use $f_o = \dfrac{v f_s}{v \pm v_s}$ with the correct sign

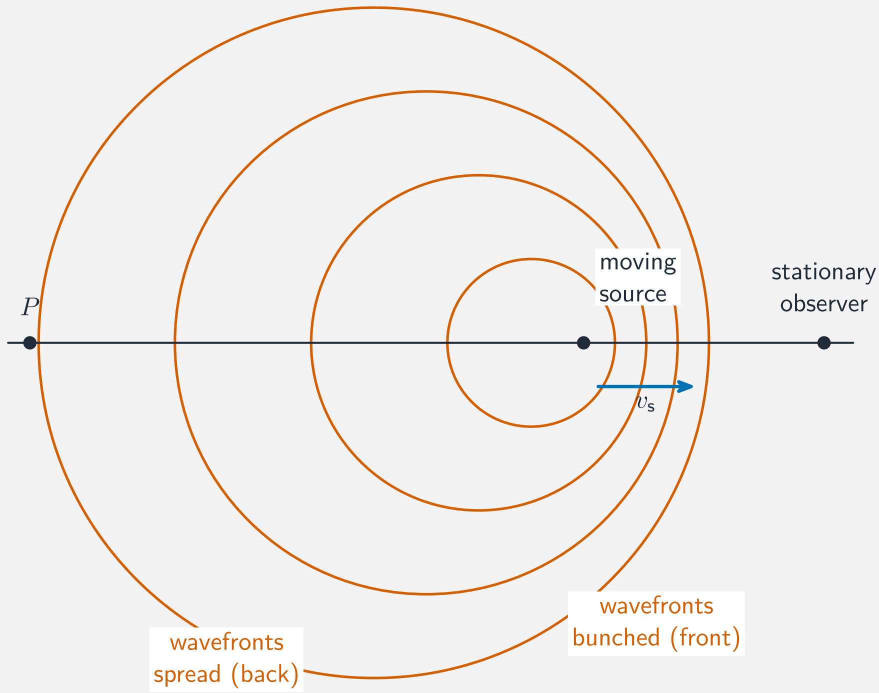
1 Worked examples

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.

■ The Doppler effect

When the source moves, the wavefronts **bunch up ahead** (shorter λ, **higher** f) and **spread behind** (longer λ, **lower** f):





The Doppler effect shifts observed frequency

■ The formula

$$f_o = \frac{v f_s}{v \pm v_s}$$

- **minus** sign → source moving **towards** observer ($f_o > f_s$);
- **plus** sign → source moving **away** ($f_o < f_s$).

Worked example. Horn $f_s = 800$ Hz at 30 m s^{-1} **towards** a listener, $v = 340$ m s^{-1}:

$$f_o = \frac{340 \times 800}{340 - 30} = \frac{272\,000}{310} \approx 877 \text{ Hz}.$$

2 Practice

Now apply the methods above.

2.1 State what the **Doppler effect** is. [1]

2.2 State whether the observed frequency **increases** or **decreases** as a source moves **towards** the observer. [1]

2.3 State which **sign** (+ or −) is used in the denominator when the source moves **towards** the observer. [1]

2.4 Explain why the wavelength is **shorter** ahead of an approaching source. [1]

3 Exam-style questions

For these, take the speed of sound as $v = 340\ \text{m s}^{-1}$.

3.1 A horn of frequency 800 Hz moves at 30 m s^{-1} **towards** a stationary listener. Calculate the observed frequency. [3]

3.2 The same horn now moves **away** at 30 m s^{-1}. Calculate the observed frequency. [2]

3.3 A source moving **away** from an observer gives an observed frequency that is: [1]

- **A** higher than the source frequency
- **B** lower than the source frequency
- **C** the same as the source frequency
- **D** zero

3.4 Explain, in terms of **wavefronts**, why an approaching ambulance siren sounds **higher-pitched**. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **7.3 Doppler effect** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/11 N25 —Q27 (Doppler effect)
- 9702/21 J25 —Q5 (Doppler calculation)
- 9702/22 M25 —Q5 (observed frequency)
- 9702/12 J25 —Q26 (Doppler effect)

Solutions

2.1 The change in the **observed frequency** when the source of a wave **moves relative to** the observer.

2.2 It **increases**.

2.3 **Minus** ($-$).

2.4 As the source moves forward, each new wavefront is emitted from slightly **closer** to the observer, so the wavefronts ahead are **closer together** (shorter λ).

3.1 Source moving towards $\rightarrow$ minus sign; $f_o = \dfrac{340 \times 800}{340 - 30} = \dfrac{272\,000}{310} \approx 877$ Hz.

3.2 Source moving away $\rightarrow$ plus sign; $f_o = \dfrac{340 \times 800}{340 + 30} = \dfrac{272\,000}{370} \approx 735$ Hz.

3.3 **B** —lower than the source frequency.

3.4 As the ambulance approaches, the wavefronts ahead are **bunched closer together**, giving a shorter wavelength and a **higher frequency** (higher pitch).