EDEXCEL A LEVEL PHYSICS · TOPIC 5 · 6-MARK PROSE · PRACTICE QUESTIONS

Waves and the particle nature of light: the 6-mark questions

Use the standing wave chain for questions about strings, pipes and instruments, and the interference chain for waves from two or more sources. Answers at the back.

6-MARK PROSE

Standing waves

THE STANDING WAVE CHAIN reflect → superpose

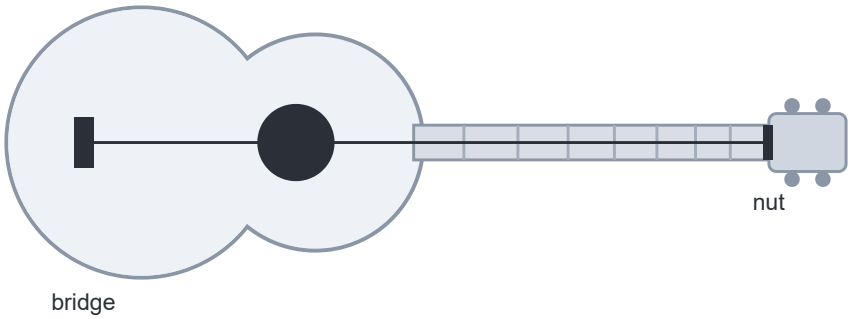
Two waves first, then where the nodes and antinodes form

1. **Two waves, opposite directions**
   The wave reflects at the end, so two coherent waves travel in opposite directions.
2. **Superpose**
   Where they meet, the two waves superpose (interfere).
3. **In phase → constructive**
   Where the waves are in phase (path difference nλ), they interfere constructively.
4. **Antiphase → destructive**
   Where the waves are in antiphase (path difference (n + ½)λ), they interfere destructively.
5. **Nodes and antinodes form**
   Nodes form at the points of destructive interference; antinodes at the points of constructive interference.
6. **Min and max**
   Nodes are points of minimum (zero) amplitude; antinodes are points of maximum amplitude.

Question 1 · A standing wave on a guitar string

Edexcel A Level Physics past paper · 6 marks

The photograph shows a guitar. The strings of the guitar are at the same tension.



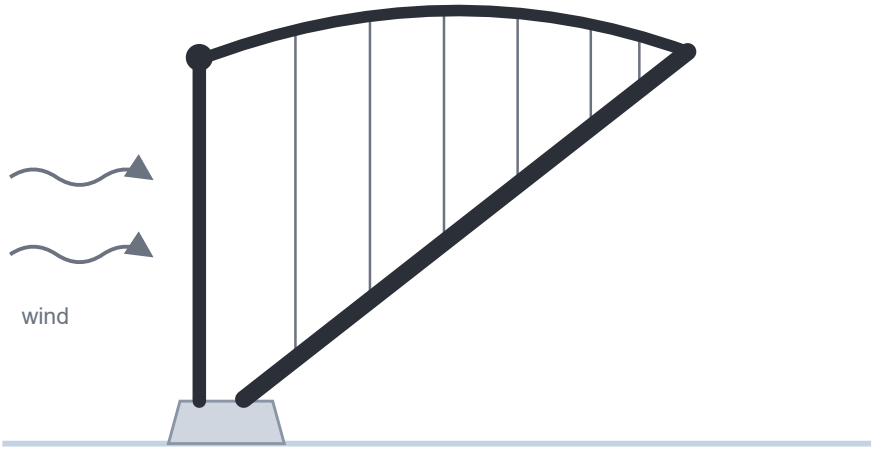
When a string is plucked, a standing wave is set up on the string.

(a) * Explain how a standing wave is set up on a string. **(6)**

Question 2 · The Aeolian harp

Edexcel A Level Physics past paper · 2 marks

An Aeolian harp is a stringed musical instrument that is ‘played’ by the wind.



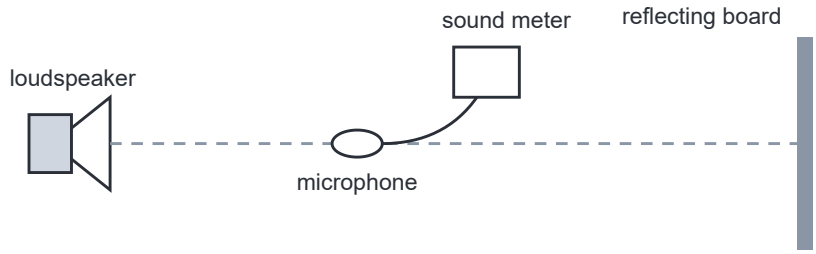
As air passes the strings, it forces them to vibrate, creating stationary waves on the strings.

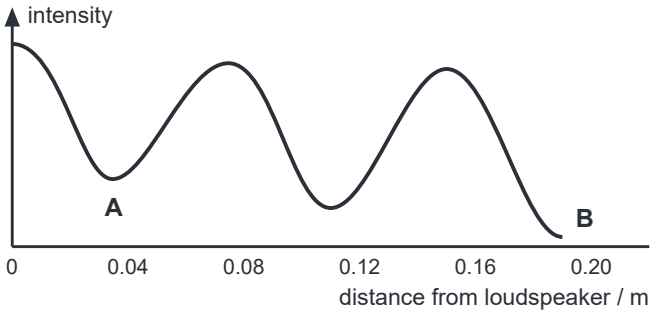
(a) Explain how stationary waves are formed on the strings. **(2)**

Question 3 · Loudspeaker and reflecting board

Edexcel A Level Physics past paper · 3 marks

(c) An alternative method to determine a value for the speed of sound is shown in the diagram.





A loudspeaker is placed at a distance from a vertical reflecting board. Sound waves reflect off the board and set up a standing wave between the loudspeaker and the board. A microphone connected to a sound meter is moved in a straight line from the loudspeaker to the board.

As the microphone is moved, the sound meter records the varying intensity of the standing wave. The sketch graph shows how the intensity varies with distance from the loudspeaker.

(i) Explain why the intensity at point B is less than the intensity at point A. **(3)**

6-MARK PROSE

Interference

THE INTERFERENCE CHAIN sources → path difference

Where the waves come from, then how far each one travels

1 Two sources

Waves reach the point from two (or more) coherent sources (same frequency, constant phase difference), or by different paths. Name them from the question.

2 Superpose

At the point, the waves superpose (interfere).

3 Path difference

The waves travel different distances, so there is a path difference, and so a phase difference.

4 nλ → constructive BRIGHT / LOUD

Path difference a whole number of wavelengths (phase difference 0, 2π…): in phase, constructive interference, maximum.

5 (n + ½)λ → destructive DARK / QUIET

Path difference an odd number of half wavelengths (phase difference π, 3π…): antiphase, destructive interference, minimum.

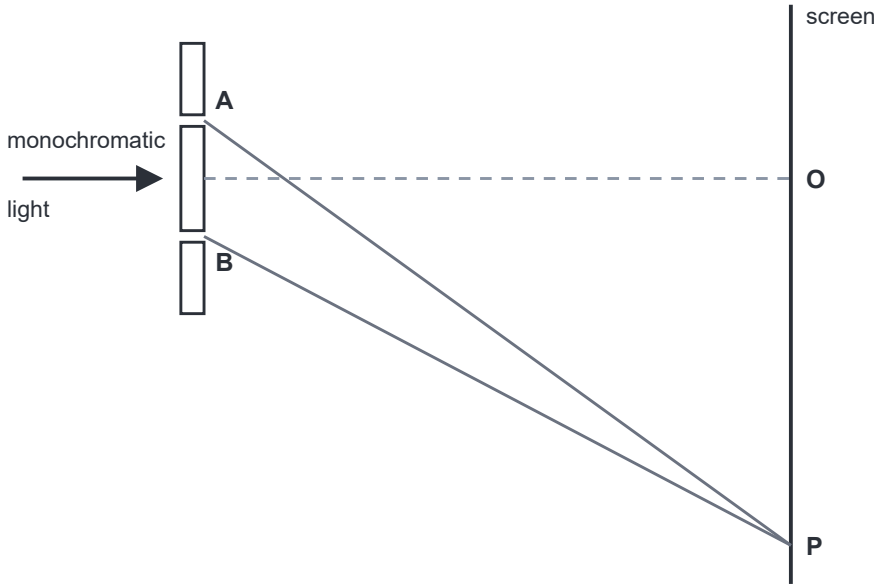
6 So…

Link it back to the question: the bright line, the quiet seat, the colours.

Question 4 · The bright lines from two slits

Edexcel A Level Physics past paper · 4 marks

The experiment was carried out with laser light of wavelength 600 nm. The diagram below shows two paths taken by the light after it has passed through the two slits A and B. The diagram is not to scale.



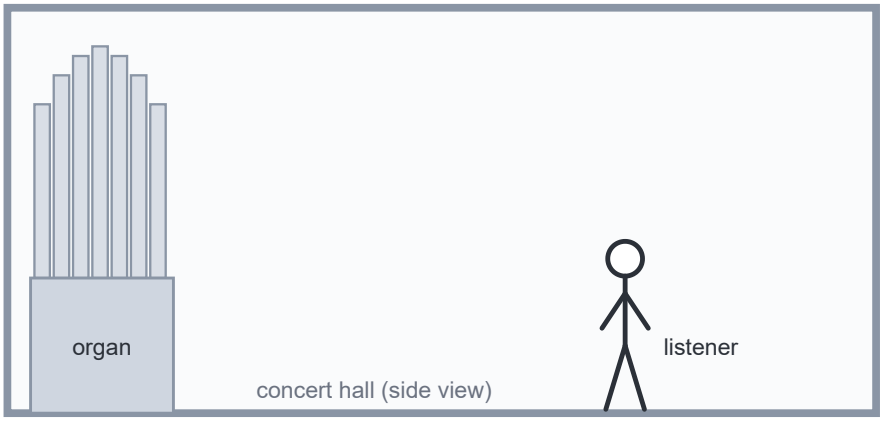
(i) Point O is a point equidistant from the two slits. Explain why there is a bright line at this point. **(3)**

(ii) The next bright line is observed on the screen at point P. Lines AP and BP show the path of the light from each slit to the screen at P. State the difference in the lengths of the paths AP and BP. **(1)**

Question 5 · The pipe organ in a concert hall

Edexcel A Level Physics past paper · 6 marks

* The photograph shows a pipe organ in a concert hall.



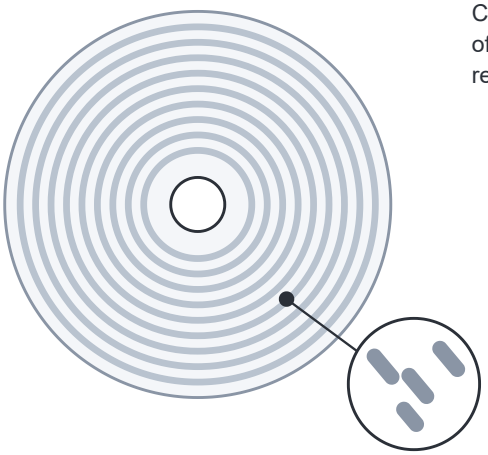
When the organ is played, sound travels through the air to a person in the audience as a wave. It is found that there are some positions in the concert hall where particular frequencies are quieter than others.

Explain why this might be the case and give an action that could be taken to eliminate this problem. **(6)**

Question 6 · Colours from a CD

Edexcel A Level Physics past paper · 6 marks

* The light from a lamp is reflected from the surface of a CD, which consists of a spiral track of elongated bumps.



CD surface showing spiral track of bumps with a smooth reflective surface in between.

A physics student notices that although the light from the lamp is white, different colours are seen in the reflected light. He suggests that the colours are produced when diffraction occurs at the surface of the CD.

Discuss the extent to which the student's suggestion explains the presence of colours in the light reflected from the surface of the CD. **(6)**

Answers

Question 1 · A standing wave on a guitar string

STEP 1 Run the chain in note form

1. reflects at fixed ends: 2 coherent waves, opposite directions
2. superpose
3. in phase → constructive
4. antiphase → destructive
5. nodes at destructive, antinodes at constructive
6. node = min amplitude, antinode = max

STEP 2 Write it in full sentences

1. When the string is plucked, a wave travels along the string and **reflects at the fixed ends**, so there are **two coherent waves travelling in opposite directions** along the string. ✓ 1 mark
2. Where the two coherent waves meet, they **superpose (interfere)**. ✓ 1 mark
3. At points where the two waves are **in phase** (path difference nλ), there is **constructive interference**. ✓ 1 mark
4. At points where the two waves are **in antiphase** (path difference (n + ½)λ), there is **destructive interference**. ✓ 1 mark
5. **Nodes** form at the points of **destructive** interference, and **antinodes** form at the points of **constructive** interference. ✓ 1 mark
6. Nodes are points of **minimum (zero) amplitude**, and antinodes are points of **maximum amplitude**. The fixed ends are always nodes. ✓ 1 mark

Six marking points, six marks available: every link earns its mark.

▼ **Check it against the mark scheme**

Mark scheme says	Link	
Two waves travelling in opposite directions	1	(1)
Superpose / interfere	2	(1)
Constructive (interference) if waves in phase, or if path difference = nλ	3	(1)

Destructive (interference) if waves in antiphase, or if path difference = (n + ½)λ	4	(1)
Nodes are formed from points of destructive (interference) or antinodes are formed from points of constructive (interference)	5	(1)
Nodes are points with min amplitude and antinodes are points with max amplitude	6	(1)

6 marks. Indicative content, so quality of written communication counts: write it in order, and the chain does that for you. Always say the waves are **coherent** (same frequency, constant phase difference): that word earns credit, “the same frequency” on its own doesn’t.

Question 2 · The Aeolian harp

STEP 1 Run the chain in note form

1 reflects at fixed ends: 2 coherent waves, opposite directions

2 superpose

2 marks: stop here

STEP 2 Write it in full sentences

1 Waves travel along each string and **reflect at the fixed ends**, so there are **two coherent waves travelling in opposite directions** along the string. ✓ 1 mark

2 The two waves **superpose (interfere)**, producing nodes and antinodes: a stationary wave. ✓ 1 mark

Two marks, two links. Writing links 3–6 won’t lose marks, but it costs time you need for the rest of the paper.

▼ **Check it against the mark scheme**

Mark scheme says	Link	
(Two) waves travelling in opposite directions, or wave reflected back on itself	1	(1)
Superposition / interference occurs	2	(1)

2 marks. Always say the waves are **coherent** (same frequency, constant phase difference): that word earns credit, “the same frequency” on its own doesn’t.

Question 3 · Loudspeaker and reflecting board

STEP 1 Run the chain in note form

1. A and B are nodes: antiphase, destructive
2. amplitude falls with distance travelled
3. at A: very different amplitudes
4. at B: similar distances, similar amplitudes
5. B cancels more: lower intensity

STEP 2 Write it in full sentences

1. A and B are both **nodes**, where the wave from the loudspeaker and its reflection (two coherent waves) are in antiphase and **interfere destructively**. ✓ 1 mark
2. The **amplitude (and intensity) of the sound decreases with the distance travelled**. ✓ 1 mark
3. At A, the wave from the loudspeaker has travelled only a short distance but the reflected wave has travelled much further, so their amplitudes are very different and they **only partly cancel**. goes with 4
4. At B, near the board, the two waves have **travelled similar distances**, so they have **similar amplitudes**. ✓ 1 mark
5. So at B the waves **cancel almost completely**, and the intensity is lower than at A. answers the question

The answer isn't "B is further away so it's quieter". It's about how well the two waves cancel.

Check it against the mark scheme

Mark scheme says	Link	
Amplitude/energy/intensity of the sound wave reduces with distance travelled	2	(1)
Appreciate that at A or B two waves are interfering destructively, or at A and B there are nodes	1	(1)
At B the waves have travelled similar distances so have similar amplitudes	4	(1)

Question 4 · The bright lines from two slits

STEP 1 Run the chain in note form

1 2 coherent sources: slits A and B
2 superpose at O
3 equidistant: path difference 0
4 in phase → constructive
6 maximum intensity: bright line
(ii) next bright line: n = 1, so λ

STEP 2 Write it in full sentences

(I)

1 Light from the two slits is **coherent**, and the waves **superpose** at O. — sets it up

2 O is equidistant from the slits, so the **path lengths AO and BO are equal**: the **path difference is zero**. — ✓ 1 mark

3 So the waves **arrive in phase** (phase difference zero). — ✓ 1 mark

4 They undergo **constructive interference**, giving maximum intensity: a **bright line**. — ✓ 1 mark

(II)

5 P is the next bright line, so the path difference is **one wavelength**: AP − BP = **600 nm** (6.0×10^{-7} m). — ✓ 1 mark

For (ii) give the number. "nλ" on its own scores nothing: the mark scheme says so.

▼ Check it against the mark scheme

Mark scheme says	Link	
(i) Path lengths (A–O and B–O) are equal, or path difference is zero	2	(1)
(i) Will arrive in phase, or phase difference is zero	3	(1)
(i) (Bright line is position of) constructive interference/superposition	4	(1)
(ii) 600 nm, or 600×10^{-9} m, or 6.0×10^{-7} m, or one wavelength, or λ. Do not accept nλ	5	(1)

4 marks. "Constructive" needs underlining in your head: it's the word the mark is for. Always say the waves are **coherent** (same frequency, constant phase difference): that word earns credit, "the same frequency" on its own doesn't.

Question 5 · The pipe organ in a concert hall

STEP 1 Run the chain in note form

1 reflect off walls: waves arrive by different paths
2 superpose
3 some frequencies: (n + ½)λ, odd multiple of π
4 destructive → quieter
5 others: nλ, 0 or 2π
6 constructive → louder
7 absorbing material on walls

STEP 2 Write it in full sentences

1. Sound waves from the organ **reflect off the walls, ceiling and other surfaces**, so coherent waves reach a listener by different paths. ✓ 1 mark
2. The waves arriving from different directions **superpose** at the listener. goes with 3
3. For some frequencies the **path difference is an odd number of half wavelengths**, so the waves arrive with a **phase difference of an odd multiple of π** (antiphase). ✓ 1 mark
4. They interfere **destructively**, so those frequencies are **quieter**. ✓ 1 mark
5. For other frequencies the **path difference is a whole number of wavelengths** (phase difference zero or a multiple of 2π), so the waves arrive in phase. ✓ 1 mark
6. They interfere **constructively**, so those frequencies are **louder**. ✓ 1 mark
7. The problem comes from reflections, so cover the walls and ceiling with **sound-absorbing material** (soft panels, curtains) to **reduce the reflections**. ✓ 1 mark

Why only *some* frequencies? At one seat the path difference is fixed, but the wavelength depends on the frequency. So whether the path difference comes out as nλ or (n + ½)λ depends on the frequency.

▼ Check it against the mark scheme

Mark scheme says	Link	
Sound waves incident upon surfaces within the concert hall will be reflected	1	(1)

Some frequencies arrive from different directions with a phase difference of (any odd multiple of) π radians, or path difference is an odd number of half wavelengths	**2–3**	**(1)**
Destructive superposition/interference will occur, causing the waves with those frequencies to be quieter than others	**4**	**(1)**
Other frequencies arrive with a phase difference of zero or (any multiple of) 2π radians, or a whole number of wavelengths	**5**	**(1)**
Constructive superposition/interference will occur, causing waves with those frequencies to be louder than others	**6**	**(1)**
Problem arises due to reflections from walls, so use absorbing material on surfaces to reduce reflections	**7**	**(1)**

Indicative content, so your writing is marked too. The organ *pipes* make their notes with standing waves, but this question is about the hall: that's interference. Always say the waves are **coherent** (same frequency, constant phase difference): that word earns credit, "the same frequency" on its own doesn't.

Question 6 · Colours from a CD

STEP 1 Run the chain in note form

1. yes, diffraction at the CD surface
2. each ring = a source, scatters in all directions
3. superpose: interference
4. nλ (even multiple of π) → constructive
5. white light = range of λ
6. each λ constructive at a different angle: spectrum

STEP 2 Write it in full sentences

1. The student is partly right: **diffraction does occur** when light is reflected from the CD surface. ✓ 1 mark
2. **Each ring of the track acts as a source**, diffracting (scattering) the light **in all directions**. ✓ 1 mark
3. The coherent light from the many rings **superposes**, so **interference** occurs. ✓ 1 mark
4. In directions where the **path difference is a whole number of wavelengths** (phase difference an even multiple of π), the waves are in phase and interfere **constructively** (reinforce). ✓ 1 mark

5 **White light is a mixture of wavelengths.** ✓ 1 mark

6 So **each wavelength has constructive interference at a different angle**, separating the colours into a **spectrum**. ✓ 1 mark

7 So diffraction on its own doesn't explain the colours: it's **diffraction followed by interference**, just as in a diffraction grating. answers "discuss"

"Discuss the extent" wants a verdict. Start by saying how far the student is right, and finish by saying what's missing.

▼ Check it against the mark scheme

Mark scheme says	Link	
Analyses and interprets the text to conclude that diffraction occurs when light is reflected from the CD surface	1	(1)
Each ring on the CD acts as a diffraction centre scattering light in all directions	2	(1)
Interference occurs (superposition of light from the multiple light sources)	3	(1)
In directions with a phase difference equal to an even multiple of π rad, or a path difference equal to a whole number of wavelengths, constructive interference (reinforcement) occurs	4	(1)
White light is a range (mixture) of wavelengths	5	(1)
Hence each wavelength of light reinforces in a different direction, which explains why a spectrum is seen	6	(1)

6 marks, indicative content. Same chain as the organ, plus links 5 and 6 for the colours. Always say the waves are **coherent** (same frequency, constant phase difference): that word earns credit, "the same frequency" on its own doesn't.