STEM SMART Phase One, 2022

Physics Week 11 – Interference & Diffraction

https://isaacphysics.org/gameboards#smart_p_1_11

Essential GCSE Physics 44.2

Year 9 - Challenge (C2)
GCSE - Challenge (C1)

In the following table, label whether there is an obvious shadow behind the obstacle (Y) or not (N).

		Obstacle size		
		$50.0\,\mathrm{cm}$	$25.0\,\mathrm{cm}$	$10.0\,\mathrm{cm}$
Wavelength	$50.0\,\mathrm{cm}$	-	(a)	(b)
	$25.0\,\mathrm{cm}$	(c)	-	(d)
	$10.0\,\mathrm{cm}$	(e)	(f)	-

Part A A wave of wavelength $50.0\,\mathrm{cm}$ passing a $25.0\,\mathrm{cm}$ wide object

Can a shadow be seen if a wave with a wavelength $50.0\,\mathrm{cm}$ passes by an object $25.0\,\mathrm{cm}$ wide?

- No
- Yes

Part B A wave of wavelength $50.0\,\mathrm{cm}$ passing a $10.0\,\mathrm{cm}$ wide object

Can a shadow be seen if a wave with a wavelength $50.0\,\mathrm{cm}$ passes by an object $10.0\,\mathrm{cm}$ wide?

- Yes
- No

Part C **A wave of wavelength $25.0\ \mathrm{cm}$ passing a $50.0\ \mathrm{cm}$ wide object**

Can a shadow be seen if a wave with a wavelength $25.0\ \mathrm{cm}$ passes by an object $50.0\ \mathrm{cm}$ wide?

- Yes
- No

Part D **A wave of wavelength $25.0\ \mathrm{cm}$ passing a $10.0\ \mathrm{cm}$ wide object**

Can a shadow be seen if a wave with a wavelength $25.0\ \mathrm{cm}$ passes by an object $10.0\ \mathrm{cm}$ wide?

- Yes
- No

Part E **A wave of wavelength $10.0\ \mathrm{cm}$ passing a $50.0\ \mathrm{cm}$ wide object**

Can a shadow be seen if a wave with a wavelength $10.0\ \mathrm{cm}$ passes by an object $50.0\ \mathrm{cm}$ wide?

- Yes
- No

Part F **A wave of wavelength $10.0\ \mathrm{cm}$ passing a $25.0\ \mathrm{cm}$ wide object**

Can a shadow be seen if a wave with a wavelength $10.0\ \mathrm{cm}$ passes by an object $25.0\ \mathrm{cm}$ wide?

- No
- Yes

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Essential GCSE Physics 44.3

Year 9 - Challenge (C2)
GCSE - Challenge (C1)

This question has been reworded to make it clearer. It may look different to the question in your book, but it contains the same data and has the same correct answer.

Rank the waves below from the one which will spread out the most after passing a gap to the one which will spread out the least.

[Hint: the smaller the wavelength in comparison to the gap, the less the wave will spread out.]

Case	Wavelength	Gap Width
1	$550\,\mathrm{nm}$	$0.010\,0\,\mathrm{mm}$
2	$700\,\mathrm{nm}$	$0.100\,\mathrm{mm}$
3	$1\,400\,\mathrm{nm}$	$100\,\mu\mathrm{m}$
4	$5.00\,\mathrm{cm}$	$10.0\,\mathrm{cm}$
5	$15.0\,\mathrm{cm}$	$1\,000\,\mu\mathrm{m}$

Rank the waves below from the one which will spread out the most after passing a gap to the one which will spread out the least. Give your answer as a 5 digit number e.g. if you think that case 3 spreads out the most, then 2, then 1, then 4 and 5 spreads out the least you would type 32145.

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Essential GCSE Physics 44.4

Year 9 - Challenge (C2)
GCSE - Challenge (C1)

A young astronomer has a telescope with a $6.0\,\mathrm{cm}$ diameter lens, and uses it to take pictures using visible light (wavelength $= 500\,\mathrm{nm}$). The main factor causing blurring in a good telescope is diffraction.

If a professional astronomer wanted images just as precise using $30\,\mathrm{cm}$ radio waves, what diameter of dish would be needed?

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Modified Double Slit

A Level - Challenge (C2)

The diagram below illustrates an experimental arrangement that produces interference fringes with a double slit.

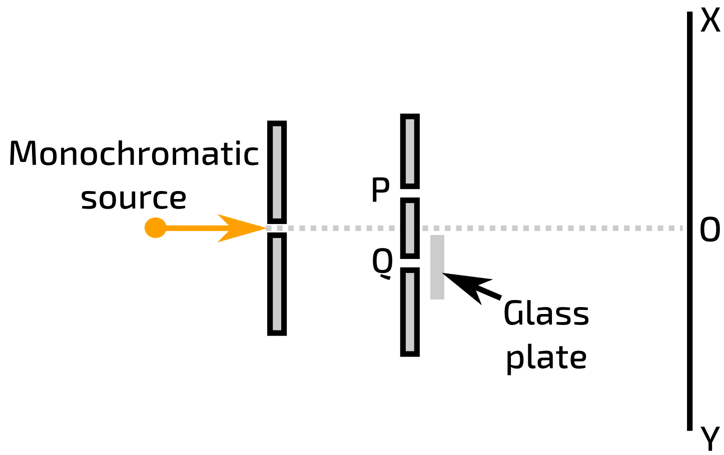

Figure 1: Double slit arrangement.

Part A Description of change

What change occurred when slit Q was covered with a very thin plate of glass as shown, compared to the situation before with no glass?

- The fringe pattern moved towards Y.
- The fringe pattern moved towards X.
- The separation of the fringes decreased.
- The separation of the fringes decreased in the region OY but was unchanged in the region OX
- The separation of the fringes increased.

Part B Distance of change

The distance between the double slits and the screen is $L = 50.0\,\mathrm{cm}$, and the slit spacing is $d = 2.00\,\mathrm{mm}$. The glass plate has a refractive index of $n = 1.25$.

If the glass can be considered to be thin enough that any deflection in the trajectory of rays due to refraction can be ignored, how thick must the plate be in order that the distance between O and the central maximum is $5.00\,\mathrm{mm}$

Adapted with permission from UCLES, A Level Physics, June 1984, Paper 2, Question 13

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Essential Pre-Uni Physics D4.1

A Level - Practice (P2)

Complete the questions in the table:

Wavelength	Slit separation	Distance to screen / m	Fringe spacing / mm
633nm	0.10mm	4.00	(a)
530nm	(b)	6.00	4.0
(c)	1.0mm	1.50	0.20
0.30cm	0.10m	2.50	(d)

Part A Fringe spacing

Wavelength	Slit separation	Distance to screen / m	Fringe spacing / mm
633nm	0.10mm	4.00	(a)

a) Fringe spacing in mm?

Part B Slit separation

Wavelength	Slit separation	Distance to screen / m	Fringe spacing / mm
530nm	(b)	6.00	4.0

b) Slit separation?

Part C Wavelength

Wavelength	Slit separation	Distance to screen / m	Fringe spacing / mm
(c)	$1.0\mathrm{mm}$	1.50	0.20

c) Wavelength?

Part D Fringe spacing

Wavelength	Slit separation	Distance to screen / m	Fringe spacing / mm
$0.30\mathrm{cm}$	$0.10\mathrm{m}$	2.50	(d)

d) Fringe spacing in mm?

(Note that the values given in the book were incorrect for some printings, so make sure that you are using the values given above.)

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Essential Pre-Uni Physics D4.2

A Level - Practice (P2)

Complete the questions in the table:

Wavelength	Slit separation	Order of interference n	Angle to 'straight through direction'
$633\,\mathrm{nm}$	$0.10\,\mathrm{mm}$	2	(a)
$530\,\mathrm{nm}$	$600\,\mathrm{lines/mm}$	1	(b)
(c)	$1000\,\mathrm{lines/mm}$	1	10°
$1.0\times10^{-11}\mathrm{m}$	(d)	3	20°

Part A Angle

Wavelength	Slit separation	Order of interference n	Angle to 'straight through direction'
$633\,\mathrm{nm}$	$0.10\,\mathrm{mm}$	2	(a)

a) Angle to 'straight through' direction to 2 significant figures?

Part B Angle

Wavelength	Slit separation	Order of interference n	Angle to 'straight through direction'
$530\,\mathrm{nm}$	$600\,\mathrm{lines/mm}$	1	(b)

b) Angle to 'straight through' direction to 3 significant figures?

Part C Wavelength

Wavelength	Slit separation	Order of interference n	Angle to 'straight through direction'
(c)	$1000\,\text{lines/mm}$	1	10°

c) Wavelength?

Part D Slit separation

Wavelength	Slit separation	Order of interference n	Angle to 'straight through direction'
$1.0 \times 10^{-11}\text{m}$	(d)	3	20°

d) Slit separation in m?

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Physics. You work it out.

Essential Pre-Uni Physics D4.4

A Level - Practice (P2)

A slide looks like it has one fine transparent line ruled on a black background. In fact there are two lines very close together. When red light ($633\,\mathrm{nm}$) is shone through it, and a screen is placed $5.0\,\mathrm{m}$ away from the slits, ten fringe-spacings measure $5.3\,\mathrm{cm}$. Calculate the separation of the slits on the slide.

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Essential Pre-Uni Physics D4.5

A Level - Challenge (C2)

The light from a `special LED' consists of two colours of light with wavelengths of $530\,\mathrm{nm}$ and $630\,\mathrm{nm}$ respectively. The light is shone through a diffraction grating with $500\,\mathrm{lines/mm}$, and the two colours need to be separated by at least 5.0° . What is the minimum order of interference needed in order to do this?

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Essential Pre-Uni Physics D4.6

A Level - Practice (P2)

A teacher is trying to demonstrate `Young's fringes' using green $(530\,\mathrm{nm})$ light. Assuming that the slit separation is $0.050\,\mathrm{mm}$, how far away from the slits will she need to put the screen to ensure that the fringe spacing is at least $1.0\,\mathrm{mm}$?

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Thin Film Colour

A Level - Challenge (C2)

A thin film of soap is held vertically by an upright square frame. The film is allowed to drain under gravity so that the film is very thin at the top and gets thicker further down. A horizontal light beam is shone onto the film, and the reflected light observed. The thickness of the film changes slowly enough that the sides of the film can be considered to be effectively vertical at all thicknesses.

Light is shone into the film horizontally, so that it is incident normally to the film.

The light will undergo a phase change of $\pi\,\mathrm{rad} = 180^\circ$ when it reflects off the film, when incident from the air, but there is no phase change when it is inside the film and reflects off the boundary with air. This swaps the usual conditions for fully constructive and destructive interference.

Part A Reason for iridescence

Why, when white light is shone upon the film, does the film not appear to reflect white light, and what does it reflect instead?

- Some light is reflected from the front surface while some is transmitted into the film. Some of this transmitted light then reflects from the back surface, and when some of it emerges from the front surface this interferes with the originally reflected beam. This produces bright fringes of different colours as the thickness of the film must be different for constructive interference to occur for light of different wavelengths.
- Some light is transmitted into the soap film, but refracts, travels along its length and is reflected from the ends. This can reappear at any point and will interfere with light when it does.
- The soap film is completely transparent thus transmits all light. So no light is seen to return from the soap film.
- Some of the light is absorbed by the soap film, the amount absorbed depends upon the incident angle and the wavelength, thus rainbows are seen.

Part B First colour to appear

Given that the thickness of the film can be less than $100\,\mathrm{nm}$, which is the first colour to appear as the thickness of the film increases from the top?

- Blue
- Green
- Yellow
- Red
- Violet
- Orange
- Indigo

Part C Red appears

What is the minimum thickness that the film must be for normally incident red light of wavelength $670\,\mathrm{nm}$ (in air) to be at its brightest, if the refractive index of the film is $n = 1.4$?

Part D Twice dark

The light that is observed from the film will have one or more wavelengths lost as it is undergoes destructive interference, this leaves the complementary colour of the lost light.

Recall that the light will undergo a phase change of $\pi\,\mathrm{rad} = 180°$ when it reflects off the film, having been incident from the air, but not when it is inside the film and reflects off the boundary with air. This swaps the usual conditions for fully constructive and destructive interference.

Given that the refractive index of the film is 1.4 and the wavelength of visible light (in air) ranges from $400\,\mathrm{nm}$ to $700\,\mathrm{nm}$, what is the minimum non-zero thickness at which two different wavelengths of reflected visible light will both undergo completely destructive interference? [Take the incident light to be normal to the film.]

Part E Transmission

How would this change if the light is incident from the opposite side, so that the interfering light has either passed straight through the film or reflected twice?

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