9.4 Resolution

Question Paper

Course	DP IB Physics
Section	9. Wave Phenomena (HL only)
Topic	9.4 Resolution
Difficulty	Easy

Time allowed: 70

Score: /51

Percentage: /100

Question 1a

A famous painting has just been displayed in a gallery and is being viewed by hundreds of people every hour from different angles and distances away.

(a)
State the Rayleigh Criterion for resolution.

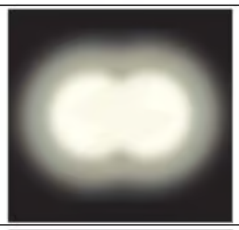
[1]

[1 mark]

Question 1b

Viewers at the very back of the room are struggling to make out two white dots on the black background at the top right of the oil painting.

The table shows three different images from three different viewers.

Image	Two dots that are only just resolved	Two dots that show the limiting case of the Rayleigh criterion	Two dots that could not be resolved
			
			
			

(b)
Identify the best description of each image by placing a tick (✔) in the correct box .

[3]

[3 marks]

Question 1c

The two dots are 0.004 m apart when viewed by an observer 20 m away.

(c)
Calculate the angular separation of the two dots.

[3]

[3 marks]

Question 1d

To enhance the viewing experience of the painting it is possible to observe the red dots on the image through a diffraction grating. The wavelength of red light is 700 nm. One viewer has an angle of diffraction through their diffraction grating of 1.4×10^{-5} rad.

(d)
Calculate the slit width of the diffraction grating used.

[5]

[5 marks]

Question 2a

A woman is observing two ships on the horizon using different apertures.

(a)
Identify by placing a tick (✔) in the correct boxes the apertures Rayleigh's criterion applies to.

Aperture	Rayleigh's Criterion Applies
The pupil of her eye	
The lens of her camera	
The lens of her telescope	
The screen of her phone	

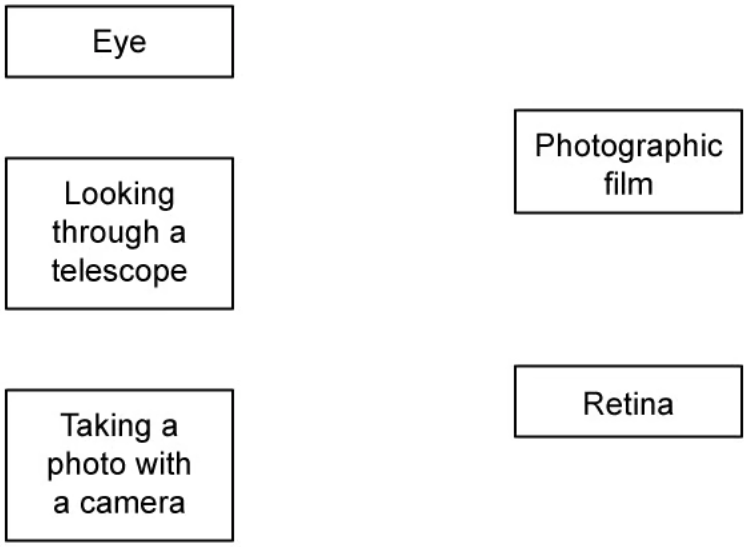
[3]

[3 marks]

Question 2b

(b)

Link the following apertures and their detectors by drawing a line between them. The same answer may be used more than once.



[3]

[3 marks]

Question 2c

(c)
Identify the situations, by underlining the correct word, when the two ships will become resolved by the woman's eyes:

(i)
The two ships move **closer to / further away from** the woman.

[1]

(ii)
The two ships move **closer to / further apart from** each other.

[1]

(iii)
Increasing / decreasing the diameter of the aperture used by the woman to observe the two ships.

[1]

(iv)
Increasing / decreasing the angle of diffraction between the aperture used by the woman and the two ships.

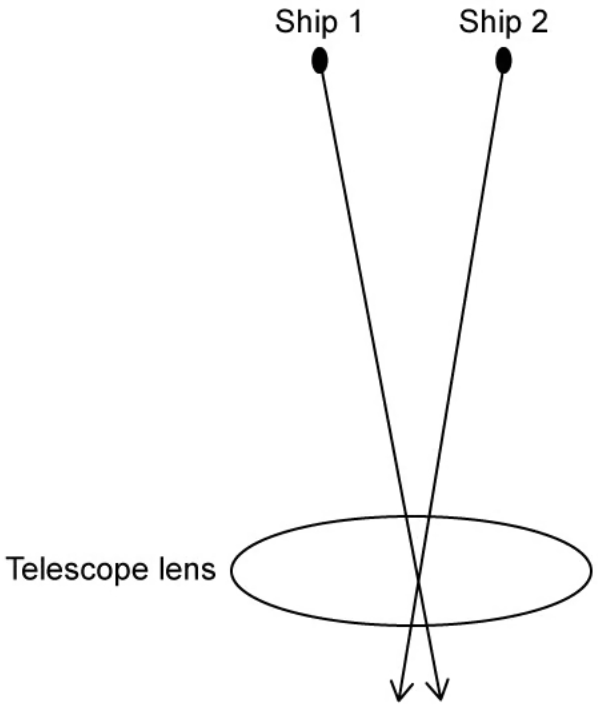
[1]

[4 marks]

Question 2d

The angle of diffraction between the woman's telescope aperture can be denoted with the letter θ and the diameter of the telescope aperture with the letter b.

(d)
Identify, by correctly labelling the diagram with θ and b, the angle of diffraction and the diameter of the aperture.



[2]

[2 marks]

Question 3a

An astronomer is observing the light from two distant stars using his telescope.

(a)
Identify, by placing a tick (✔) next to, the correct equation for the Rayleigh criterion for a circular aperture.

Equation	
$\theta = \frac{s}{d}$	
$R = \frac{\lambda}{\Delta\lambda}$	
$n\lambda = d\sin\theta$	
$\theta = 1.22\frac{\lambda}{b}$	

[1]

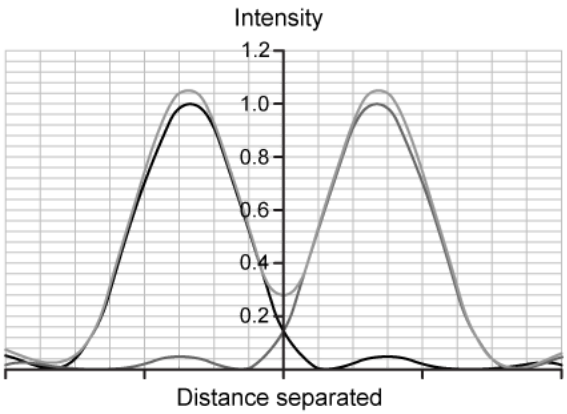
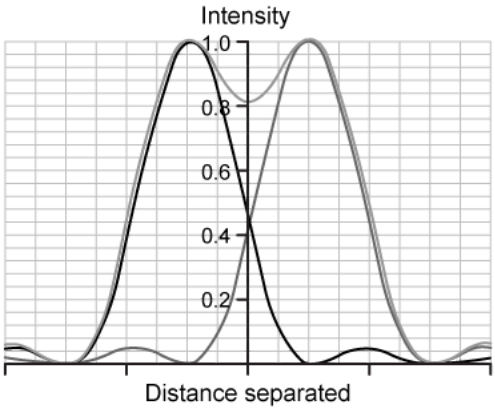
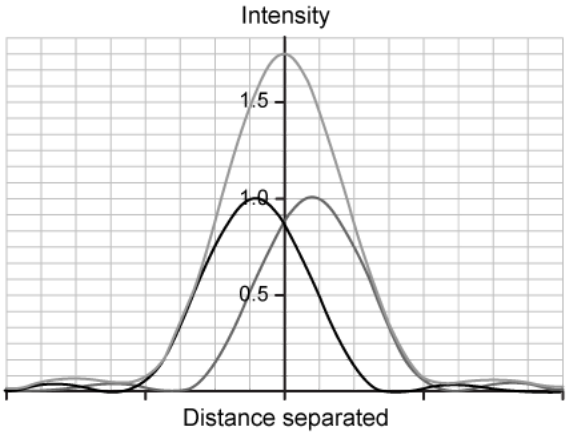
[1 mark]

Question 3b

Three different intensity-distance graphs of the two stars are obtained by the astronomer.

(b)
Label each graph, using the phrases below:

Two sources that can be fully resolved.
Two sources that cannot be resolved.
Two sources that are only just resolved.

Graph	Label
	
	
	

3]

[3 marks]

Question 3c

The following statements describing light from the two different stars entering the telescope aperture are false.

(c)
Rewrite each statement below so it is correct.

(i)
The two stars are situated far apart from each other, so they are viewed through the telescope by the astronomer as a single unresolved source of light.

[1]

(ii)
The two stars are close to the Earth, so they are viewed through the telescope by the astronomer as a single unresolved source of light.

[1]

[2 marks]

Question 3d

The sentences below describe how light from the distant stars will pass through the aperture of the telescope.

(d)
Complete the sentences using the correct words from the textbox.

circular	**diffract**	**detector**
rectangular	**refract**	**receptor**

Light from the distant stars passes through the _____ aperture of the telescope. The light will then _____ before creating a diffraction pattern upon the _____ inside.

[3]

[3 marks]

Question 4a

Diffraction gratings have a wide range of different uses.

(a)
Identify some of these uses by placing a tick (✔) next to those that use a diffraction grating.

	Place a tick (✔) next to the uses of a diffraction grating
Spectroscopy	
Loudspeakers	
Lasers	
Mirror coatings	

[2]

[2 marks]

Question 4b

A student is using a diffraction grating to resolve emission spectra from different elements.

He observes the emission spectra of two wavelengths of sodium:

$$\lambda_1 = 588.99\,\text{nm}$$

$$\lambda_2 = 589.59\,\text{nm}$$

(b)
Calculate the difference in meters between the two wavelengths of sodium.

[3]

[3 marks]

Question 4c

(c)
Calculate the average wavelength, λ in meters of the sodium light.

[3]

[3 marks]

Question 4d

(d)
Calculate the resolvance of the diffraction grating used in this experiment.

[2]

[2 marks]

Question 5a

A helicopter engineer is improving the design of helicopter headlights. He is first investigating the angular separation of the lights.

(a)
Identify, by placing a tick (✔) in the box, the correct information about the angular separation and Rayleigh criterion.

Information	Place a tick (✔) in this box if the information is correct
The angular separation is measured in degrees	
The angular separation is the angle between the diffraction aperture and the light rays coming from the two sources	
The angular separation, $\theta \geq 1.22\frac{\lambda}{b}$ when the two sources can be fully resolved	
Decreasing the angular separation between two objects means they can be resolved	

[2]

[2 marks]

Question 5b

The engineer is using a diffraction grating to observe the headlights at different distances away. A second-order spectrum is created by a diffraction grating with 9000 lines.

(b)
Calculate the resolving power of the diffraction grating.

[2]

[2 marks]

Question 5c

The engineer collects the following data on the separation of and the light intensity from the two helicopter headlights.

For headlight 1:

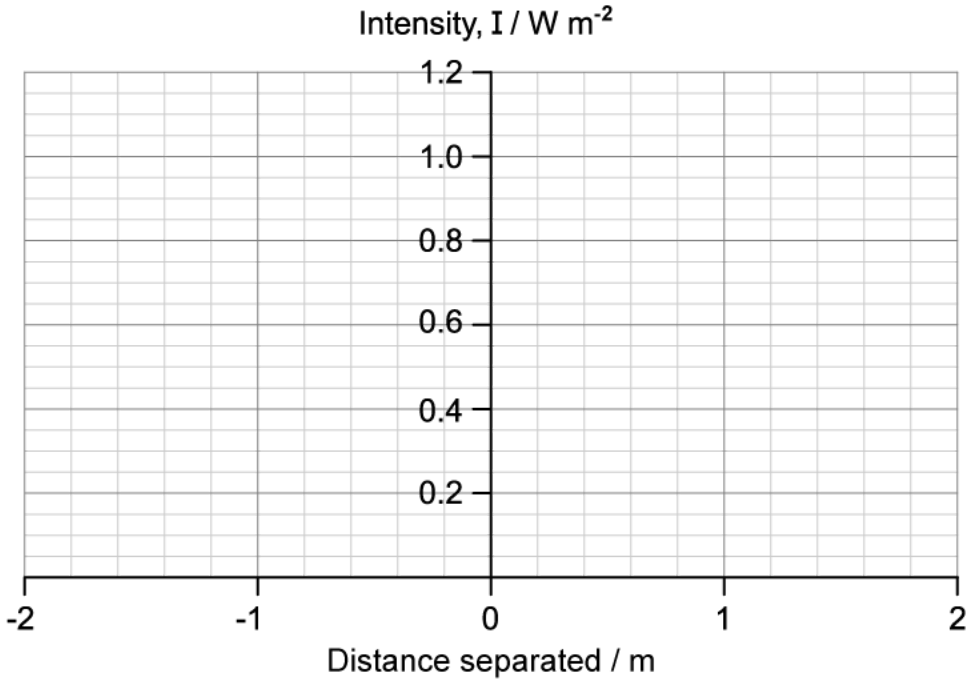
Distance separated, /m	Intensity, I / W m^{-2}
–1.80	0
–0.80	1
0.20	0

For headlight 2:

Distance separated / m	Intensity, I / W m^{-2}
–0.20	0
0.80	1
1.80	0

(c)

Plot a graph of the results on the axes below to show the combined intensity of the light from the two headlights.



[3]

[3 marks]

Question 5d

(d)
Identify the type of resolution shown by the two headlamps in the graph in part c.

[1]

[1 mark]