A Level AQA Physics

23 Physics of the eye and ear – answers

Question	Answers	Extra information	Mark	AO Spec reference
01.1	Converging As diverging lenses only produce virtual images/would not be able to capture an image for the diverging lens		1 1	AO1 3.10.1.2
01.2	Max 2 marks from: • Metre ruler fixed to the table • Middle of lens combination marked clearly on the ruler • Distance measured to centre of light bulb • Screen clamped in place so that it is touching ruler		max 2	AO1 ATj PS1.1
01.3	Complete line of best fit and use of intercept 15 D		1 1	AO2 MS3.4 3.10.1.1
01.4	15 D = 20 D + power of diverging power of diverging = −5 D The gradient of the graph is 1/both intercepts are the same so confidence in result is high	Must be negative for mark	1 1	AO1 MS3.4 AO3 3.10.1.1
02.1	Eye lens too strong/eyeball too long Cannot be brought to focus on the retina/fovea		1 1	AO1 3.10.1.2
02.2	$u = \infty$ or negative sign for image distance $v = 26 - 2 = 24$ cm $\frac{1}{f} = \frac{1}{\infty} + \left(-\frac{1}{0.24}\right)$ $\frac{1}{f} = -\frac{1}{0.24} = -4.2$ D		1 1 1	AO2 3.10.1.2

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02.3	Image has to form 12 cm from eye/10 cm from lens $-\frac{1}{0.24}=\frac{1}{u}-\frac{1}{0.1}$ $\frac{1}{u}=\frac{1}{0.1}-\frac{1}{0.24}$ $u = 0.17\text{ m} = 17\text{ cm}$	Possible e.c.f. from **02.2** power of lens	1 1	AO2 3.10.1.2
02.4	Non-spherical cornea Image is focused in a given plane and out of focus in perpendicular plane Cylindrical lens		1 1 1	AO1 3.10.1.2
03.1	**X** is blind spot **Y** is fovea		1 1	AO1 3.10.1.1
03.2	None in **X** and **Y** Much higher numbers than cone Decreasing as move towards **A** and **B**		1 1 1	A01 3.10.1.1
03.3	Three curves labelled left to right: blue, green, red Green>red>blue Blue: 375 to 500 Green: 425 to 675 Red: 475 to 725	(All wavelength ranges ±30) All ranges correct for 1 mark	1 1 1	AO1 3.10.1.1
03.4	Bright light –cones used, dim light rods Cones have smaller diameter so resolution greater in bright light/resolution less in dim light Object has colour in bright light/no colour in dim light		1 1 1	AO1 3.10.1.1
04.1	To read the book, the lens must be thicker/more powerful than the board Ciliary muscles contracts This is called accommodation	Allow argument in reverse	1 1 1	AO1 3.10.1.2

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04.2	Rays refracted at cornea Rays refracted (less) at lens Rays meeting beyond the fovea on the optical axis		1 1 1	AO1 3.10.1.2
04.3	Use of negative for image distance $\frac{1}{f} = \frac{1}{0.2} + \left(-\frac{1}{0.78}\right)$ $\frac{1}{f} = P = +3.7\,\text{D}$		1 1	AO2 3.10.1.2
04.4	Lens can be made thinner and achieve same refraction/lenses are lighter		1	AO3 3.10.1.2
05.1	Max 2 marks from: • Human range of hearing is 20 Hz to 20 kHz on average for a young adult • Speaker A does not have sufficient range of frequencies at max and min/losing higher frequencies • Speaker B goes above range of human hearing		max 2	AO2 3.10.2.2
05.2	On average, people above 45 cannot hear above 12 kHz, so range of both speakers is suitable		1	AO2 3.10.2.3
05.3	Use of relative intensity level = $10 \log_{10} \frac{I_1}{I_0}$ Max intensity level – average intensity level = $10 \log_{10} \frac{I_2}{I_0} - 10 \log_{10} \frac{I_1}{I_0}$ $4\,\text{dB} = 10 \log \left(\frac{I_2}{I_0} - \frac{I_1}{I_0}\right)$ $0.4 = \log \frac{I_2}{I_1}$ $\frac{I_2}{I_1} = 2.51$	Need idea of difference in intensity level for 3 marks Simple $4\,\text{dB} = 10 \log \left(\frac{I_2}{I_1}\right)$ with no explanation gains 1 mark	1 1 1	AO2 3.10.2.2

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05.4	dB is a logarithmic scale and so increases in powers of 10 Factor: $10 = 10 \log \frac{I_2}{I_1}$ $\frac{I_2}{I_1} = 10$ This is 4 times greater		1 1	AO3 3.10.2.2
06.1	**A**: malleus/hammer **B**: incus/anvil **C**: stapes/stirrup	All 3 correct 2 marks 1 error 1 mark	1 1	AO1 3.10.2.1
06.2	The small bones in the ear act as levers/increase by factor of 1.5 The area of the oval window is much smaller than the area of membrane; therefore, pressure increased/15 × smaller since $P = \frac{F}{A}$	Allow force magnifiers	1 1 1	AO1 3.10.2.1
06.3	Max 3 marks from: • Helical spiral-shaped cavity filled with fluid • Contains three membranes • Covered in rows of hairs • Different frequencies detected at different parts of cochlea/high frequencies base/low frequencies apex		max 3	AO1 3.10.2.1
06.4	$60 \text{ dB} = 10 \log_{10} \frac{I_1}{I_0}$ $0.6 = \log_{10} \frac{I_1}{1 \times 10^{-12}}$ $I_1 = 4.0\ (3.98) \times 10^{-12}$ W m^{-2}		1 1 1	AO2 3.10.2.2

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Question	Answers	Extra information	Mark	AO Spec reference
07.1	The threshold of (normal) human hearing		1	3.10.2.2 A02
07.2	Halfway between 30 and 30 phon curve 25 phon ±2		1	3.10.2.2 A03
07.3	Max 4 marks from: 40 phon loss: • Recognition that conversation above 40 phon so can hear • Conversation will be quiet but should be able to follow • They may need to speak up 60 phon loss: • Normal conversation falls below 60 phon curve for all but the lowest frequencies would struggle to hear unless much louder • Would struggle to hear women's voices	Answer should reference not just loss but difficulty with conversations for both hearing losses	max 4	3.10.2.2 A03
07.4	A peak rise in intensity levels for 4000 Hz		1	3.10.2.2 AO1
08.1	Noise damage can have a cumulative effect/exposure every day can cause damage A single loud noise can instantly cause damage (owtte)		1 1	3.10.2.3 AO3
08.2	Difference in intensity levels = $10 \log_{10} \frac{I_2}{I_0} - 10 \log_{10} \frac{I_1}{I_0}$ $140 - 135 = 10 \log_{10} \left(\frac{I_2}{I_0} - \frac{I_1}{I_0} \right)$ $0.5 = \log_{10} \frac{I_2}{I_1}$ $\frac{I_2}{I_1} = 3.2$ 3.2 × greater		1 1	3.10.2.2 AO2

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08.3	Intensity level = $10 \log_{10} \frac{I_1}{I_0}$ $= 10 \log_{10} \frac{I_1}{1 \times 10^{-12}}$ $= 110$ dB		1 1	3.10.2.2 AO2
08.4	Use of $P \propto \frac{1}{r^2}$ Pr^2 = constant $0.1 \times 1^2 = P \times 5^2$ $P = \frac{0.1}{25} = 4 \times 10^{-3}$ W Intensity level = $10 \log_{10} \frac{4 \times 10^{-3}}{1 \times 10^{-12}}$ $= 96$ dB Yes, they should wear ear defenders		1 1 1 1	3.10.2.2 AO2

Skills box answers

Question	Answer
1	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{0.26} - \frac{1}{0.25}$. $\frac{1}{f} = -0.15$ D
2	$\frac{1}{f} = 2.3$ D; $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = 2.3 - \frac{1}{0.25}$; $\frac{1}{v} = -1.7$, so $v = \frac{1}{-1.7} = -0.59$ m. This is a virtual image (v is negative).
3	In order for the image to be seen, it must be formed at the unaided near point and be virtual. $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{0.25} - \frac{1}{0.65} = 2.5$ D