The Sun's rays heat up the surface of the road. The heated road then heats the surrounding air so that the layer of air just above the road is at a higher temperature than the air above it. Warm air has a lower refractive index than cool air.

State what is meant by a virtual image.

(1)

.....

.....

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Acceptable Answers	Additional guidance	Mark
	• Light rays pass through the image **Or** Light rays converge to a point where the image is formed (1)		1

Q2.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	• measure angle of incidence at edge (53°) **(1)** • use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ **(1)** • value of angle in glass = 32° **(1)**	±1° tolerance Allow ecf for candidate's value Example of calculation: $1 \times \sin 53° = 1.5 \times \sin\theta_2$ $\theta_2 = 32°$	**3**
(ii)	• show refraction towards normal entering glass and how refraction away from normal exiting glass **(1)**		**1**

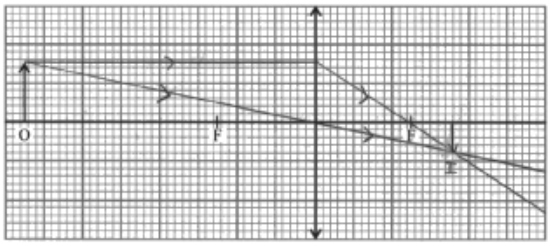
Q3.

Question Number	Acceptable Answers	Additional guidance	Mark
	• Use of $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ **(1)** • Use of $P = \frac{1}{f}$ **(1)** • P = 46 D / Dioptre / dioptre **(1)**	Accept MP2 if you see $\frac{1}{25}$ or $\frac{1}{2.4}$ for $\frac{1}{f}$ Example of Calculation $\frac{1}{0.25}+\frac{1}{0.024} = 46$ D	**3**

Q4.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• use of $1/v + 1/u = 1/f$ **(1)** • use of magnification = v/u **(1)** • magnification = 3.5 **(1)**	Example of calculation $1/v = 1/7.0 – 1/5.0$ v = 17.5 cm $M = 17.5 / 5.0 = 3.5$	**3**

Q5.

Question Number	Acceptable Answers		Additional guidance	
(i)	• One ray correctly drawn • Second ray correctly drawn • Completes diagram with image at position 3.6 to 3.8 cm and height of 0.7 to 0.8 cm	(1) (1) (1)		3
(ii)	• Use of $m = \frac{v}{u}$ **or** $m = \frac{image\ height}{object\ height}$ using values from (a)(i) • Magnification of 0.47 to 0.53	(1) (1)	Example of Calculation $m = \frac{v}{u} = \frac{3.7}{7.5} = 0.5$	2
(iii)	• Real **and** image on different side of converging lens to object **Or** rays pass through the image	(1)		1

Q6.

Question Number	Answer	Additional Guidance	Mark
	• Use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ **and** $P = \frac{1}{f}$ • Use of $P = P_1 + P_2$ • (−) 0.6 D • Diverging	MP4 dependent on MP3 Example of calculation Power of eye $P = \frac{1}{1.5\ (m)} + \frac{1}{0.024(m)} = 42.3$ D P of spectacles = 41.7 (D) – 42.3 (D) = -0.6 D diverging	4

Q7.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • Only a real image will be produced on a screen **(1)** • The object cannot be closer than *f* for a real image **(1)** • Because light diverges after passing through the lens **(1)** **OR** • If object closer than *f* rays still diverge after passing though lens **(1)** • So a virtual image is formed **(1)** • which cannot be seen on a screen. **(1)**		**3**

Q8.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$ with $u = 100$ and $v = (-)300$ **(1)** • $f = 150$ (mm) **(1)** • converging lens with focal length 150 mm **(1)**	**(MP3 dependent on MP2)** Example of calculation $\frac{1}{f}=\frac{1}{100\text{ mm}}-\frac{1}{300\text{ mm}}$ $\frac{1}{f}=\frac{3-1}{300\text{ mm}}$ $f = 150$ mm MP3 accept if annotated in question Accept convex for converging	**3**

Q9.

Question Number	Acceptable Answer		Additional Guidance	Mark
	• use of $1/v + 1/u = 1/f$ **and** $P = 1/f$ to determine power required	(1)	Example of calculation $1/f = 1/0.02$ cm + $1/0.275$ cm $f = 0.0186$ cm $P = 1/f = 53.6$ D For person, $P = 1/0.0193$ $= 51.81$	
	• use of $P = 1/f$ to determine power of person's lens	(1)	Spectacle power = 53.63 – 51.81 = 1.82 D Choose +2.0 D	
	• use of $P = P_1 + P_2$ to determine additional power required	(1)		
	• $P = 1.82$ (D)	(1)		**(4)**

Q10.

Question Number	Acceptable Answers		Additional guidance	Mark
	• Use of $m = \frac{v}{u}$ (to calculate m)	(1)	Example of calculation $m = \frac{0.75\text{ m}}{0.09\text{ m}} = 8.3$	
	• Use of $m = \frac{\text{image height}}{\text{object height}}$ to calculate distance between dots on screen	(1)	Image height = 8.3 x 0.005 m = 0.042 (m)	
	• Uses tan/sin **or** small angle approximation to calculate the angle	(1)	$\tan(\frac{\theta}{2}) = \frac{0.042/_2\text{ m}}{4.5\text{ m}}$ $\theta = 0.5° = \frac{0.5\pi}{180}$ rads = 0.0092radians	
	• Answer consistent with their calculation	(1)	0.009 radians > 0.0003 radians so student can distinguish between the dots	
	• Comparison with 0.0003 radians **or** 0.017° and conclusion consistent with their value for θ	(1)		**5**

Q11.

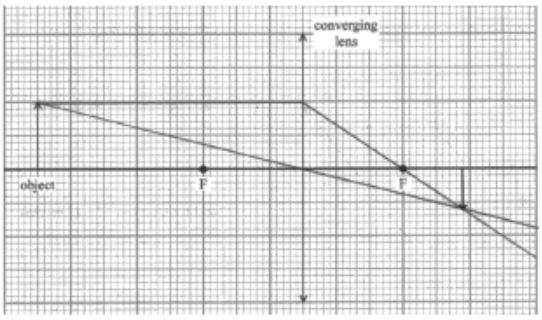
Question Number	Acceptable Answers	Additional guidance	Mark
	• Use of $m = \frac{image\ height}{object\ height}$ • Use of $m = \frac{v}{u}$ (1) • Use of $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ (1) • Use of $P = \frac{1}{f}$ (1) • 21 D (1)	Example of Calculation $m = \frac{3.5\times10^{-3}\ m}{2.0\times10^{-4}\ m} = 17.5$ $v = 17.5 \times 5.0 \times 10^{-2} m = 0.875$ (m) $\frac{1}{f} = \frac{1}{5.0\times10^{-2}\ m} + \frac{1}{0.875\ m}$ $f = 0.047$ m $P = \frac{1}{0.047\ m} = 21.1$ D	5

Q12.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	A ray diagram including: • ray from top of object through centre of lens to retina (1) • ray parallel to axis on one side of lens and through focal point on other side (1) • distance to near point = 6.0 cm (1)	Correct calculation scores MP3 only	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• use of $M = v/u$ (1) • M = 0.33 (2/3 sf) ecf u from (i) (1)	Example of calculation M = 2 cm / 6 cm = 0.33	**(2)**

Q13.

Question Number	Answer	Additional Guidance	Mark
	• two rays correctly drawn (1) • image drawn in correct position ±half square (1) • use of $m = \frac{v}{u}$ or $m = \frac{image\ height}{object\ height}$ (1) • m = 0.6 (1)	 Example of calculation $m = \frac{4.8\ \text{cm}}{8.0\ \text{cm}} = 0.6$	4

Q14.

Question Number	Acceptable Answers	Additional guidance	Mark
	• An image formed from the apparent divergence of light rays from a single point **Or** an image that cannot be projected on to a screen (1)		1