AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



MARK SCHEME

4.6.2 ELECTROMAGNETIC WAVES (PACK 3)

SCORE	PERCENTAGE
/204	%

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Q1.

(a) (i) plane

accept any unambiguous indication

1

(ii) inverted

1

virtual

accept any unambiguous indication

1

(b) reflection takes place at the surface of the pond and angle of incidence = angle of reflection

as judged by eye

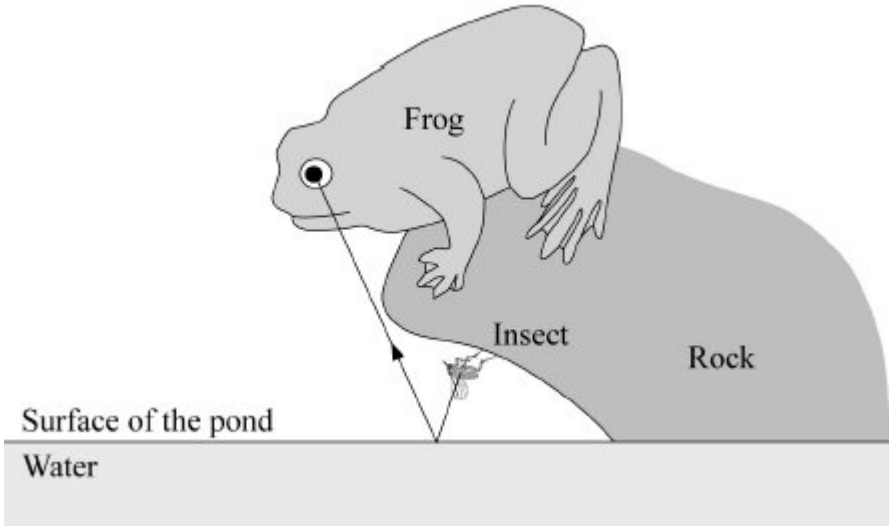
1

reflected ray is a straight line to frog's eye through the air

1

correct direction arrow **either** from insect **or** to frog's eye

only one arrow essential but
*do **not** accept if either arrow contradicted example of a fully correct response*



1

[6]

Q2.

(a) the normal

1

(b) v

1

(c) any **one** from:

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- light has moved from glass to air / from air to glass

  accept light has changed medium

- speed of light has changed

  beware of contradictions for this marking point eg light has moved from glass to air and slowed down gets zero

- angle of incidence is less than the critical angle

  ***or** (angle) i < (angle) c **or** (angle) y is less than the critical angle*

- change in density (of medium)

  eg glass is more (optically) dense than air

1

(d) (i) ratio of v to y does not give the same answer (in every case)

or value of v doubles value of y does not double

1

or increments for v are the same but increments for y are not the same

*allow for **1** mark a calculation but no conclusion*
eg 30 → 60 19 → 35 (38)

1

(ii) as (angle) v increases, angle y increases

accept as the angle of incidence increases, the angle of refraction increases

***or** there is a (strong) positive(non-linear) relationship between the variables*

***or** ratio of sines is constant*

*do **not** accept angle y is not directly proportional to angle v*

1

(iii) no evidence outside this range

OWTTE

or when angle y is greater than the critical angle total internal reflection occurs

1

[7]

Q3.

(a) (i) 25 (%)

*do **not** accept ¼*

1

(ii) increases

1

(b) tick (✓) in top and bottom box

both required

1

(c) SHINY surfaces are good reflectors of infra-red radiation

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accept white for shiny

or black surfaces are POOR reflectors of infra-red radiation

accept bad for poor
accept insertion of 'not' before 'good' in statement

or black surfaces are good EMITTERS of infra-red radiation

or black surfaces are good ABSORBERS of infra red radiation

1

[4]

Q4.

(a) C or 0.18 mm

1

(b) 0.6 m

*allow **1** mark for correct transformation and substitution*
*allow **1** mark for changing frequency to Hz*
*answer 600 gains **1** mark*

2

(c) creates an alternating current

accept 'ac' for alternating current
accept alternating voltage

1

with the same frequency as the radio wave

accept signal for radio wave

or it gets hotter

1

(d) X-rays cannot penetrate the atmosphere

accept atmosphere stops X-rays
*do **not** accept atmosphere in the way*

or X-rays are absorbed *(*by the atmosphere*)*

before reaching Earth
ignore explanations

1

[6]

Q5.

(a) converging

or convex

1

(b) (principal) focus

or focal point

1

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(c) **either** (×)1.5 **or** (×)1½ **or** 150%

*unambiguous evidence of appropriate measurements for **1** mark only eg 4 and 6 **or** 8 and 12 **or** 0.8 and 1.2*

2

(d) real rays cross to form it / formed at the intersection of real rays

accept 'image on the opposite side of the lens to the object'
accept 'can be put onto a screen'

1

[5]

Q6.

(a) (i) (angle of) refraction

*take care **not** to credit 'angle of reflection'*

1

(ii) normal

*do **not** credit 'horizontal'*

1

(b) **either**

(photographic) film

or CCD(s) (charge-coupled device(s)) / CMOS(s) (sensor(s)) / (active) pixel sensor(s)

accept 'LDR(s)' / 'light dependent resistor(s)'
***not** lux meter*
*do **not** accept light sensor(s)*

1

(c) (i) converging

***or** 'convex'*

1

(ii) **either**

(0).35

or (0).4(1...)

*do **not** give any credit for an answer greater than 1*
or
*7 ÷ 20 for **1** mark*
or
*clear evidence that appropriate measuring / counting, has been made for **1** mark*

2

(d) otherwise it will have no effect on the light detector

or otherwise no (real) light will fall on the light detector

***or** 'a virtual / imaginary image will have no effect on the light detector'*
allow error carried forwards for 'light detector'

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allow so it can be formed on the film

1

[7]

Q7.

(a) B

1

(b) G

1

(c) D

1

(d) A

1

[4]

Q8.

(a) (i) microwave

1

(b) (i) identical

1

(ii) • increased risk of cancerous growth (between ear and brain)

1

• complaints of headaches and tiredness

1

(iii) any **two** from:

• tests in a laboratory did not give effects of tiredness or headaches

• waves not strong enough to cause long term heat damage to cells

• evidence to link mobile phones and ill health is not reliable

2

[6]

Q9.

(i) all electromagnetic waves travel at the same speed through a vacuum, (so assume same speed in air)

accept 'all parts of spectrum' for electromagnetic waves

1

(ii) 1500 (m)

allow 1 mark for correct transformation and substitution
allow 1 mark for using 200 000 Hz
*answers 1 500 000 = **1** mark*

2

(iii) line drawn at correct position

anywhere between 1000 and next section (10 000)

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accept their value for (a)(ii) drawn in the correct position

1

[4]

Q10.

(a) stars / galaxies / sources emit all / different types of electromagnetic waves / radiation

accept two or more named electromagnetic waves

accept answers in terms of frequencies / wavelengths

1

(b) (i) wavelength (of light) increases

accept frequency decreases

or

light moves to red end of spectrum

*accept redder but do **not** accept red alone*

1

(ii) it is the star (detected) <u>furthest</u> from the Earth

accept galaxy for stars

or

it is moving <u>away</u> the fast<u>est</u>

ignore reference to universe expanding

1

(c) (i) all matter compressed to / starts at / comes from a single point

*do **not** accept increasing gravitational pull*

accept everything / the universe for all matter

1

(massive) <u>explosion</u> sends matter outwards

accept <u>explosion</u> causes universe to expand

*ignore explosion creates the universe **or** further reference to star / Earth formation*

1

(ii) check validity / reliability of the evidence

or

change the theory to match the new evidence

accept comparison of new and old evidence

1

[6]

Q11.

(a) 400 000 000

or

correct equivalent

*allow **1** mark for correct transformation **and** substitution (of 75)*

*answer 4 000 000 gains **1** mark only*

2

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(b) (i)

*any mention of alpha, beta, gamma waves scores **0** marks*

emit / uses / transmit / receive micro<u></u>waves
accept radiation for microwaves throughout
ignore radio waves

1

some microwave / energy absorbed by / enters the body
ecf for their given electromagnetic wave
*do **not** accept goes <u>through</u> the body*

1

raises temperature of (body) cells / tissue / water
accept reference to water molecules vibrating fast<u>er</u>
accept it could cause mutation / harm / kill cells
*do **not** accept answers in terms of ionisation*
ignore references to cancer

1

(ii) any **two** from:

- research (may be) biased
  or may have been misled in the past
  accept not independent
  ***or** may be lying*
- some research suggests a link
- long-term effect not proven / studied
  accept not studied for long enough
- residents may not have seen the research

2

[7]

Q12.

(i) B

1

(ii) A

1

[2]

Q13.

(a) (i) point where the rays cross
do not credit if ambiguous

1

(ii) converging (lens)
*do **not** accept convex*

1

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(b) (i) point where the rays appear to diverge from

this should appear to be within 10mm in front of the back of the arrows on the approximate centre line

need not be accurately constructed using a ruler

1

(ii) diverging (lens)

*do **not** accept concave*

1

(c) converging

1

film

1

smaller than

nearer to

accept any clear indication of the response e.g. ticking, ringing, writing in after a mistake

1

(d) (i) (image) bigger than object enlarge

accept just 'made bigger'

1

(ii) it / real image can be put on a screen **or** real image on the opposite side of the lens to the object

accept 'not an imaginary or virtual image'

assume 'it' refers to a real image

*do **not** credit 'it can be seen'*

1

(e) **either** (the converging lens is) thick in the middle thin(ner) at the edge

1

*thick<u>est</u> in the middle gains **2** marks*

1

or (both) sides bend outwards (1) in the middle (1)

*convex gains **2** marks*

*suitable diagrams gains **2** marks*

or one side bends in the middle (1) more than the other side bends inwards (in the middle) (1)

1

[12]

Q14.

silver is a (good) reflector of <u>heat</u> (radiation) **or**
silver reflects the heat (radiation)

fact
heat = infra red
ignore references to light

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accept shiny for silver
good radiator negates the mark
ignore references to good conductor
*do **not** accept bounce back*

1

less heat is lost through the board **or** more heat is retained by the shirt

explanation
accept both sides of shirt heated
*reflects heat back up gets **1** mark only*
ignore mention of friction

1

[2]

Q15.

(a) (i) converging / convex / biconvex

1

(ii) focal (points) **or** foci

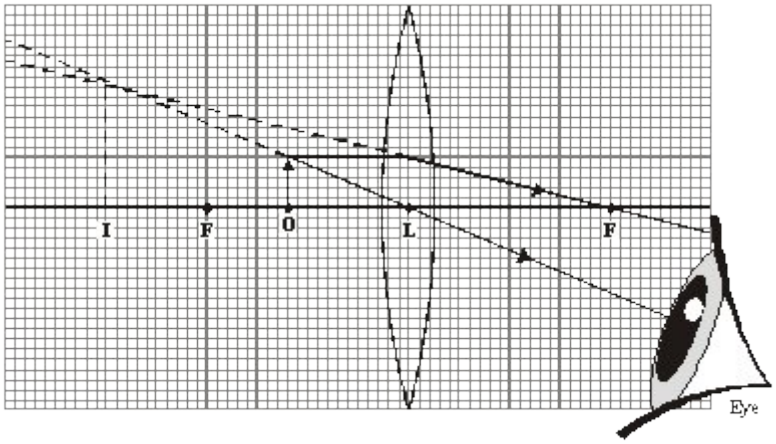
*accept focuses **or** focus (point)*

1

(iii) (principal) axis

1

(iv)



all lines drawn with a ruler for full marks

no ruler, penalise **1** mark from first four

last mark can still be awarded

double refraction drawn could get **4** out of 5 marks

ray that continues from the top of the object through L to the eye

1

horizontal ray from the top of the object, refracted by the lens and continued through F on the r.h.s. to the eye

1

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back projections of these rays (shown as dotted lines)

1

image 25 mm high at 61 mm left of L
(tolerance 1 mm ± vertically, 2 mm ± horizontally)

1

at least one arrow shown on real ray and towards the eye
*but do **not** credit if contradicted by other arrow(s)*

1

(v) formed where imaginary rays intersect / cross **or** not formed by real rays

accept (virtual image) is imaginary
accept cannot be put on screen
*do **not** credit just '… is not real'*

1

(b) (the image) needs to fall on film / sensors / LDRs / CCDs

accept just 'charged couples'
*do **not** credit '… solar cells'*
*do **not** accept virtual image cannot be stored*

1

either to cause a (chemical) reaction **or** to be digitalised

for credit response must be appropriate to camera type

1

object (should be) on the far side of F / the focus (from the lens)

***or** … more than the focal length (away from the lens)*
allow 'beyond the focus'

or object should be more than twice the distance / 2F (from the lens) (2 marks)

***or** … more than twice the focal length (away from the lens)*
*(**2** marks)*

1

[12]

Q16.

Quality of written communication

*award for a sensible sequence of **two** points*

1

X-rays do not go through lead

accept lead protects them from the X-rays
accept not exposed to X-rays

1

lead stops / reduces risk of X-rays harming / damaging / killing (persons) <u>cells</u>

accept X-rays (may) cause cancer
accept organs for cell
*do **not** accept references to electric shock*
*do **not** accept stops bones of people showing on X-ray*
answers involving the horse wearing an apron are incorrect
references to gamma rays are incorrect

1

[3]

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Q17.

(a) (i) rays continued to meet on the right hand side of the lens and beyond

must be straight lines from the right hand side of the lens
ignore details through the lens
allow if no arrows

1

meet exactly on the axis

negate mark if contradictory arrow(s) added
do not need to go beyond the focus for this mark

1

(ii) (principal) focus

or *focal (point)*

1

(iii) converging

or *convex*

1

(b) (i) **A**

1

(ii) rays seem to come from this point

or *words to this effect*
or *shows this on the diagram*

1

(iii) diverging

or *concave*

1

(c) film

accept any unambiguous method of showing the correct response

1

smaller than

1

further away from

1

(d) any **three** from:

- real image can be put on a screen

  allow film

- virtual image cannot be put on a screen / film
- virtual image is imaginary
- real image is formed where (real) rays cross / converge

  allow real image has light travelling through it

- virtual image is where virtual / imaginary rays (seem to) come from

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or *virtual image is where rays seem to come from*

- virtual image formed where virtual rays intersect / cross

3

[13]

Q18.

(a) (i) L

1

(ii) N

1

(b) the answer should be in the form:

not *inside the eye*

either for **both** marks an arrangement which could demonstrate visibly light travels in straight lines

full credit should be given for answer presented as a diagram

and
an explanation of how it shows the straightness

or for one mark

named device which uses principle of light travelling in straight lines to work

examples
light (from a street lamp) strikes an object producing a shadow
laser light travelling through (fine) dust shows a straight beam
three pieces of card with central holes need to be lined up to be able to see through the third hole from the first
ray box type experiment using mirrors/prisms, etc
beams on paper or in smoke
torch beams through smoke
example devices:–
–pinhole camera (qualification may get second mark)
–periscope
–optical fibre
–reflection 'in a ***mirror***

2

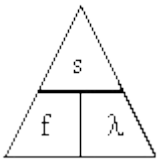
[4]

Q19.

(i) speed = frequency × wavelength

accept the equation rearranged
accept v ***or*** *s = f × λ*
do not allow w for wavelength
do not accept

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unless subsequent calculation correct

1

(ii) 330 (m)

allow 1 mark for

$$\lambda = \frac{300\,000\,000}{909\,000}$$

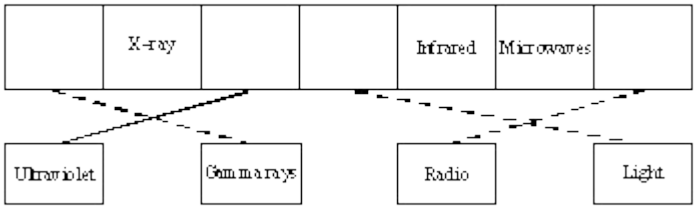
or *300 000 000 = 909 000 × λ*
or *answer of 330000(m)* ***or*** *330033(m)*

2

[3]

Q20.

(a) all **three** correct



one *only correct,* ***1*** *mark only*
allow names in boxes
there should be only ***one*** *line from* ***or*** *to each box*

2

(b) the same as

1

(c) any **two** from:

- bones absorb X-rays
- so film not exposed
- X-rays pass through flesh or skin or
- body or tissue (to expose film)

allow X-rays cannot pass through bones

2

[5]

Q21.

(a) (i) 3

1

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(ii) 1

accept a definition of frequency ignore units

1

(iii) hertz

1

(b) straight line in correct direction

judge by eye (from 'a' of waves to 's' of across) ignore arrow
accept equal angles shown on waves

1

(c) (i) gets smaller

1

(ii) kinetic

accept movement

1

(iii) renewable

1

[7]

Q22.

(i) wave speed = frequency × wavelength

accept correct transformation
accept v = f × λ
accept s for speed
accept m/s = Hz x m

accept  *if subsequent use of*  *is correct*

1

(ii) 500 000 000

*credit for **1** mark correct transformation in words **or** numbers **or** correct substitution*

2

Hertz

***3** marks for 500 000k Hz **or** 500 MHz*
numerical answer **and** *unit must be consistent for full credit*

1

[4]

Q23.

(i) 0.5

1

(ii) wave speed = frequency × wavelength

accept v = f × λ
accept s for v
accept m/s = Hz × m
accept

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providing subsequent method correct

1

(iii) 15.2 km

both numerical answer and unit are required for both marks
numerical answer and unit must be consistent
*allow **1** mark for 15.2 with incorrect or no unit*
*allow **2** marks for an answer of 1.52 km if the answer to (b)(i) was given as 5*
***r** 1 mark for correct transformation*
***or** 1 mark for correct use of speed = distance/time*
unit on its own gains no credit

2

[4]

Q24.

(i) X-rays or gamma rays

for 1 mark

1

(ii) passes through flesh;
stopped by bone/absorbed

for 1 mark each

2

[3]

Q25.

(a) Reflection correct
Normal incidence correct in and out
Correct refraction in
Parallel ray out

each for 1 mark

4

(b) (i) Each ray correctly refracted in

1 + 1 = 2

7

(ii) Wavefronts perp sides
Wavefronts closer

(Cannot score wavefront marks if refracted rays clearly wrong)

(iii) Speed reduces
Starting at B
Then D

each for 1 mark

(c) TIR correct

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gets 2 marks

Else rough reflection

gets 1 mark

2

[13]

Q26.

(a) (i) Image distance increases
Image size increases
Remains inverted
Remains real

for 1 mark each

2

(ii) Image distance decreases
Image size decreases
Becomes upright
Becomes virtual

for 1 mark each

2

(b) Move lens with respect to film
Closer for distant objects
Further for near objects

for 1 mark each

3

[7]

Q27.

(a) (i) Ignore arrows on rays
perpendicular rays goes straight in and out
other ray refracts towards normal (not along)
emerges parallel incident ray (by sight) if refraction correct (ignore reflections)

for 1 mark each

3

(ii) emergent angle marked Y if emerges parallel to right of normal

for 1 mark

1

(b) straight ray to water surface refracts/bends
straight to eye/towards surface on right image correctly shown
or states the same mark prose only of diagram incomplete

any 3 for 1 mark each

3

[7]

Q28.

Eye – Diminished/smaller than object
Nearer the lens than object or on the retina

for 1 mark each

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2

Projector – real
Further from lens than object

for 1 mark each

2

Camera – real
Smaller (than object)

for 1 mark each

2

[6]

Q29.

(a) radio – 1500
ultra violet 3×10^{-8}
visible – 5×10^{-7}
X-rays – 1×10^{-11}

4

(b) 1×10^{10}Hz 10^{10}HzOK

for 4 marks

else 1×10^{10}

for 3 marks

else 3×10^{8}/0.03

for 2 marks

else v = frequency × wavelength or $3 \times 10^{8} = 0.03$f
any answer with unit Hz scores 1, 2 or 3

for 1 mark

4

[8]

Q30.

(a) one mark for each ray correctly drawn straight to glass then bent towards pupil

accept both rays hitting any part of eye
judge straightness by eye
*accept dotted **or** dashed lines*
ignore any arrows

N.B. the rays must reach the eye

2

(b) speed

1

refraction

1

transverse

1

[5]

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Q31.

(a) any two successive peaks labelled **W**

accept any 2 points on same part of adjacent waves
correct by eye

1

half 'height' of wave labelled **A**

correct by eye
N.B. at least one of the answers must be labelled

1

(b) 0.2

correct answer with no working = 2
allow 1 mark for s = f x w or correct working i.e., 2 × 0.1
N.B. correct answer from incorrectly recalled relationship = 0

2

m/s (unit)

*independent mark do **not** allow mps **or** mHz*

1

[5]

Q32.

(ultrasonic) waves **or** vibrations **or** oscillations in fluid

*N.B. must mention fluid **or** liquid*
***or** water*

1

idea of shaking dirt particles off watch

allow cavitation / implosion of small bubbles

1

[2]

Q33.

(a) Quality of written communication:
Correct use of 2 of the words, angle, critical, normal and reflection

1

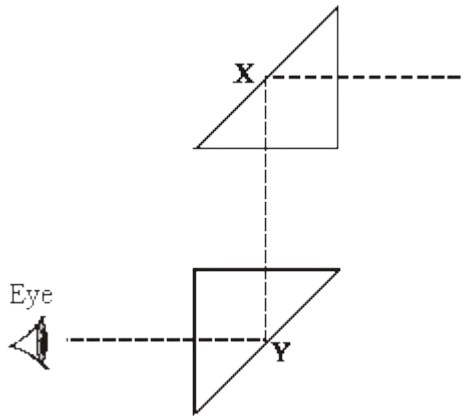
any **two** from

- light is reflected / bounces off
- if angle between ray and normal angle of incidence
- is greater than critical angle
- idea that no refraction bending if ray at 90°

2

(b)

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*1 mark for reflection at **X** if ray would reach the lower prism*
*1 mark for subsequent reflection at **Y***
1 mark for subsequent ray emerging from prism in direction of front of eye
*accept dotted **or** dashed lines*
ignore any arrows

3

[6]

Q34.

(i) absorbed by water / water heated

1

hot water heats (rest of) food / idea of particle vibration

1

(ii) 300 000 000 / 3×10^8

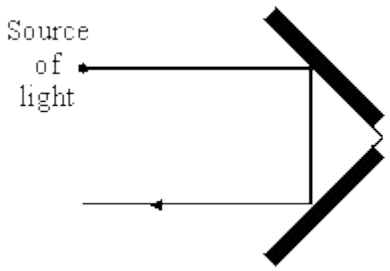
correct answer with no working = 2
*allow 1 mark for s = f x w **or** correct working i.e., 10000 (000000) × 0.03*
N.B. correct answer from incorrectly recalled relationship / substitution = 0

2

[4]

Q35.

(a) first reflection vertically down to the fourth hatch line or just to the left of it reaching mirror (must come from incident ray given)



1

second reflection back parallel to incident ray must be linked to first part of ray

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1

appropriate arrow on a part of the ray (may be given if lines wrong)

(must come from source of light)

maximum of one mark to be lost for poor diagrams not using a ruler for straight lines

first time you come across wavy line, it is penalised

1

(b) ray in block bent downwards, not beyond the normal

do not credit if exactly on normal

1

emergent ray parallel to incident ray

do not credit a continuation of the line straight through the block these are independent

1

[5]

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