Answers to Further Questions
in GCSE Physics for You (5th Edition)

On the following pages we show the detailed Answers and Mark Schemes for the Further Questions on Waves: light and sound. The answers have been prepared by an Examiner using the mark schemes published by each Examination Board. They are laid out in the same way as the pages of Further Questions in the Students’ Book.

For the Student:

● It is very important that you are able to answer the questions on your own, using your own knowledge of Physics.
So it is important that you have a go at the questions first, and then afterwards you can check your answers using these pages.
If you get a question wrong, try to work out where you have made an error. Discuss it with your teacher if you are not sure.

● Be aware that in some answers the mark is for the idea in your own words (not necessarily the exact words shown), whereas in other answers the number and unit must be exactly correct.

For the Teacher:

● You will find these sheets useful when marking the students’ homework, or when going over the Further Questions in class.
The Answer Sheet will also enable you to assess how much work is involved in answering the questions when planning how much homework to set.

● The PDFs are available for you to hand out to the students if you wish (perhaps as part of a Revision Programme).
As with all mark schemes there may be alternative credit-worthy statements for qualitative answers (for the idea) and this may need to be explained to your students. Quantitative answers, however, are generally more prescriptive and your students may need to be encouraged to show the exact numerical value and the appropriate unit.

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Further questions on waves: light and sound

**Waves**

1. (a) 1 mark for each of the following labelled features shown on the diagram:
   - reflected waves B and C drawn parallel;
   - same distance apart as incident rays;
   - normal drawn;
   - angle of incidence = angle of reflection.

   (b) (i) 1 mark for 1.5 cm

   (ii) 1 mark for each of the following **steps**:
   - recall of equation speed = frequency × wavelength
   - substitute values speed = 10 Hz × 0.15 m
   - arithmetic correct 0.15 m/s (= 15 cm/s)


2. (a) 1 mark for speed decreases.

   (b) 1 mark for showing waves bent towards the normal.

   (c) 1 mark for the speed decreases.

   **Total 3 marks**

3. (a) 1 mark for each of the following **steps**:
   - recall of equation speed = frequency × wavelength
   - substitute values speed = 200 kHz × 1500 m
   - arithmetic correct 300 000 km/s (3 x 10^8 m/s)

   (b) 1 mark for each of the following **steps**:
   - substitute values frequency = 300 000 km/s ÷ 250 m
   - arithmetic correct 1200 kHz

   1 mark for each of the following **ideas**:
   - the wavelength of the waves is comparatively long;
   - they diffract (pass round) objects which are narrower than their wavelength;
   - radio waves are reflected;
   - by some layers in atmosphere (ionosphere).

   **Total 9 marks**

**Mirrors**

4. 1 mark for C

   **Total 1 mark**

5. 1 mark for A

   **Total 1 mark**

6. (a) 1 mark for each of the following labelled features shown on the diagram:
   - (i) angle of reflection for ray 1 equal to its angle of incidence;
   - angle of reflection for ray 2 equal to its angle of incidence.
   - (ii) reflected rays extended to meet behind the mirror, the position where they meet labelled I.

   (b) 1 mark for each of the following **ideas**:
   - no; because the image is **virtual**.

   **Total 5 marks**

7. 1 mark for each of the following features on the diagram:
   - reflection at first mirror (angle i = angle r);
   - reflection at second mirror (angle i = angle r);
   - continuous ray entering pupil or would enter pupil if continued and straight lines (judge by eye).
   - A maximum of 2 marks if any incorrect arrows.

   **Total 3 marks**

8. 1 mark for each of the following **ideas**:
   - eg. electric fire;
   - reflects infra-red;
   - eg. satellite dish;
   - reflects microwaves (or radio waves).

   **Total 4 marks**
**Refraction**

9 (a) 1 mark for each of the following labelled features shown on the diagram:
- ray bent towards normal at A inside the block;
- ray bent away from normal as it emerges from the block;
- ray reflected at A at the correct angle (i.e. angle of incidence = angle of reflection).
(b) 1 mark for wavelength decreases.

Total 4 marks

10 (a) 1 mark for each of the following labelled features shown on the diagram:
- incident ray reflected from hypotenuse at 45°;
- emerges from base at 90°.
(b) 1 mark for each of the following labelled features shown on the diagram:
- incident ray refracted towards normal on entering prism;
- ray refracted away from normal as it emerges from the opposite side of the prism.
(c) 1 mark for a spectrum would be produced.

Total 5 marks

11 (a) 1 mark for showing the refracted ray coming out of the block along the edge.
(b) 1 mark for showing the ray being refracted away from the normal.
(c) 1 mark for showing each of the following:
- ray continuing until it meets far side of fibre;
- total internal reflection;
- angles of incidence and reflection being equal.
(d) 1 mark each for three examples eg.
- communications – carrying telephone communications;
- medicine – looking inside the stomach; decorative objects;
- illuminating dials.

Total 8 marks

12 (a) 1 mark for less danger to the patient (or to the doctor).
(b) 1 mark each for the following (shown correctly on a diagram):
- core and cladding;
- total internal reflection.
(c) 1 mark for each of the following ideas:
- using lots of fibres gives a clearer image;
- some of the fibres carry light into the patient for illumination.

Total 5 marks

13 (a) 1 mark for glass or plastic.
(b) 1 mark for transparent core.
(c) 1 mark for surrounded by cladding.
(d) 1 mark for infra-red beam is modulated or is switched on and off.
1 mark for using a digital signal.

Total 7 marks

14 (a) 1 mark for total internal reflection.
(b) 1 mark for each of two of the following ideas:
- all of the light is reflected back; at the boundary between the core and the cladding;
- because the angle of incidence is greater than the critical angle.
(c) 1 mark for each of two of the following ideas:
- electrical signals lose energy quickly; because of the resistance of the metal cables;
- no energy is lost when the light is totally internally reflected;
- very little energy is lost when the light travels along the optical fibre.
(d) 1 mark for any of the following:
- in endoscopes or in decorations or for illumination or in lasers.

Total 6 marks

15 (a) 1 mark for each of the following features on the diagram:
- ray drawn from the object parallel to the principal axis and refracted at the lens through the principal focus;
- ray drawn from the object passing through the centre of the lens unrefracted;
- virtual rays constructed and intersecting on the same side of the lens as the object;
- image drawn and labelled at 15 cm from the lens (accept 14.8–15.2).
(b) 1 mark for virtual.
(c) 1 mark for 5 cm (accept 4.9–5.1)
(d) 1 mark for magnification = height of image ÷ height of object
1 mark for 2.5 (5 ÷ 2) (accept 2.4–2.6)

Total 8 marks

16 (a) 1 mark for each of the following features on the diagram:
- ray drawn from the object parallel to the principal axis and refracted at the lens as if it came from the principal focus;
- ray drawn from the object passing through the centre of the lens unrefracted;
- virtual rays constructed and intersecting between the object and the lens;
- image drawn and labelled between object and lens, at 3.75 cm from lens (accept 3.6–3.9 cm).
(b) 1 mark for virtual.
(c) 1 mark for 1.25 cm (accept 1.1–1.4)
(d) 1 mark for magnification = height of image ÷ height of object
1 mark for 0.625 (1.25 ÷ 2) (accept 0.55–0.7)

Total 8 marks
The electromagnetic spectrum

17 (a) 1 mark each for infra-red; X-rays.
(b) 1 mark each for (i) radio; (ii) gamma; (iii) ultra-violet; (iv) infra-red.
Total 6 marks

18 (a) 1 mark for each of three of the following ideas:
they have the same speed (in vacuo);
you can be reflected;
you can be refracted;
you can be diffracted;
you are transverse waves.
(b) 1 mark for each of ultra-violet; microwave or infra-red; gamma or X-ray; infra-red.
Total 7 marks

19 1 mark for each of:
(a) radio
(b) gamma
(c) gamma
(d) use a fluorescent substance
(e) 1 mark for each of two of the following ideas:
they have the same speed (in vacuo);
you can be reflected;
you can be refracted;
you can be diffracted;
you are transverse waves.
Total 6 marks

20 1 mark for each of the following steps:
substitute values in the equation
speed = frequency × wavelength
3 × 10^8 (m/s) = f × 2.5 × 10^2 (m)
arithmetic correct 1.2 × 10^6 (Hz) [2 sig. figs.]
unit correct 1.2 × 10^6 Hz or 1.2 × 10^8 hertz
Total 3 marks

21 (a) 1 mark for the idea that absorption of short wavelength radiation (UV or X-rays or gamma rays) by the atmosphere is to the benefit to people. 
1 mark for each of two of the following reasons:
a benefit because these radiations are ionising;
a benefit because exposure to these radiations can cause cancer or cell damage;
a benefit because absorption in the atmosphere reduces the intensity of radiation that reaches us.
(b) 1 mark for each of the following steps:
recall of equations velocity = frequency × wavelength
substitute values f × 670 × 10^-9 (m) = 1.50 × 10^11 (m) ÷ 500 (s)
rearrange frequency = 1.50 × 10^11 ÷ (670 × 10^-9 × 500)
arithmetic correct 4.48 × 10^14 Hz
Total 7 marks

22 (a) (i) 1 mark for each of the following steps:

wavelength of greatest intensity read from graph as 220 nm.
convert nm to m 220 nm = 220 × 10^-9 (m)
substitute values in
velocity = frequency × wavelength
3 × 10^8 (m/s) = f (Hz) × 220 × 10^-9 (m)
rearrange f = 3 × 10^8 (m/s) ÷ 220 × 10^-9 (m)
correct arithmetic 1.36 × 10^15 Hz
(ii) 1 mark for 220 nm = 0.220 μm, which is less than 0.4 μm so shorter wavelength than visible light.
1 mark for ultraviolet.
(b) (i) 1 mark for graph drawn with similar shape.
1 mark for peak moved to the right (longer wavelengths)
1 mark for lower peak showing lower intensity.
(ii) 1 mark for each of the following ideas:
the outward force of radiation pressure (resulting from nuclear fusion) and inward force of gravitation are balanced.
Total 12 marks

23 (a) 1 mark for diagram of a digital signal with sharp on and off pulses.
1 mark for diagram of an analogue signal with a range of amplitudes.
(b) 1 mark for digital signals can carry more information.
1 mark for digital signals are less susceptible to interference.
Total 4 marks

24 (a) 1 mark for each of the following steps:
recall of equation
wavelength = speed × frequency
substitute values 3.00 × 10^8 (m/s) × 1.2 × 10^18 (Hz)
arithmetic correct 0.25 m or 25 cm
(b) (i) 1 mark for the following idea:
the radio waves might be harmful or might damage body tissue.
(ii) 1 mark for each of the following ideas:
the brain tumours in mobile phone users could be caused by chance;
people who do not use mobile phones can get brain tumours;
not everyone who uses a mobile phone gets a brain tumour;
there is not enough evidence yet.
1 mark for the quality of written communication.
Total 7 marks
Sound

25(a) 1 mark for each of the following ideas:
- the air particles vibrate;
- making the particles next to them vibrate.
(b) 1 mark for each of the following ideas:
- directly from the loudspeaker;
- and reflected from the wall (or diffracted).
Total 4 marks

26(a) 1 mark for each of the following ideas:
- the distance from the girl to the wall;
- the time taken for the sound to travel to the wall and back.
(b) 1 mark for each of the following ideas:
- use e.g. a tape to measure the distance;
- a stop-watch for time;
- start the watch when the girl claps;
- stop the watch when the echo is heard.
(c) 1 mark for 200 m
- 1 mark for eg. at 10 m the time delay would be too short to measure;
- 1 mark for eg. at 500 m the echo might be too faint to hear.
Total 9 marks

27(a) 1 mark for 150 m
(b) 1 mark for 75 m
(c) 1 mark for each of the following ideas:
- the fish in the shoal are at varying distances from the boat;
- the pulse will reflect off several of them.
Total 4 marks

28(a) 1 mark for each of the following ideas:
- the sound travels to her both directly from the gun and reflected from the cliff;
- the distances travelled by the sound in each case are different.
(b) 1 mark for 720 m (allow answers between 715 m and 725 m)
(c) 1 mark for each of the following steps:
- difference in distance travelled = (720 − 600) = 120 m (+/− 5 m)
- time difference = (120 m ÷ 340 m/s) = 0.35 s (+/− 0.1 s)
- 1 mark for the idea that it can be reflected or diffracted.
Total 6 marks

29 1 mark for C
Total 1 mark

Further questions on waves: light and sound

30(a) (i) 1 mark for a value above 20 000 Hz.
(ii) 1 mark for a value below 20 Hz.
(b) 1 mark for to and fro or backwards and forwards.
- 1 mark for in the direction of the wave energy transfer.
(c) 1 mark for each of three of the following ideas:
- ultrasound waves (or pulses) can travel deep into the body;
- ultrasound waves transfer energy;
- ultrasound waves make the kidney stone vibrate;
- when there is enough energy in the kidney stone it will shatter.
- 1 mark for the quality of written communication.
(d) 1 mark for any one of the following ideas:
- locating fish in the sea by bouncing ultrasound off a shoal of fish;
- depth sounding by bouncing ultrasound off the sea bed;
- measuring a room by bouncing ultrasound off the far wall;
- using an ultrasound dog whistle that humans cannot hear;
- scaring cats away with a loud ultrasound that humans cannot hear;
- cleaning objects by shaking the dirt off with high frequency waves.
Total 8 marks

31(a) 1 mark for each of the following steps:
recall of equation
wavelength = speed ÷ frequency
substitute values 1500 (m/s) ÷ 3 000 000 (Hz)
- arithmetic correct 5 × 10\(^{-4}\) m or 0.5 mm
- unit correct 5 × 10\(^{-4}\) m or 0.5 mm
(b) 1 mark for each of three of the following ideas:
- ultrasound waves (or pulses) can travel deep into the body;
- some of the ultrasound waves are reflected when they reach a boundary;
- the reflections can be received using a microphone;
- the time taken for the waves to return tells us how far the waves travelled;
- a computer can process the data to make an image of the reflecting surfaces;
- the image of the fetus can be shown on a screen.
(c) 1 mark for each of three of the following ideas:
- X-rays damage cells;
- X-rays would harm the baby or X-rays would harm the mother;
- X-rays would harm the radiographer;
- X-rays do not show soft tissue clearly or X-rays only show bones clearly;
- babies’ cells are dividing quickly so radiation could cause extra damage.
Total 10 marks