Rewarding Learning

**ADVANCED SUBSIDIARY (AS)**
**General Certificate of Education**
**2025**

# Physics

## Assessment Unit AS 2

*assessing*

## Module 2: Waves, Photons and Astronomy

**[SPH21]**

**WEDNESDAY 21 MAY, AFTERNOON**

# MARK SCHEME

## Physics Subject Specific Instructions

It is essential that, before using the mark scheme, markers familiarise themselves with the following guidance.

### General

To ensure that all candidates receive the same treatment, the mark scheme must be applied consistently.

The mark scheme for each question shows typical intermediate steps, the answer expected and the marks available for each part of the question.

In cases where a candidate has responded with a seemingly correct response which has not been anticipated in the mark scheme, the marker must make a professional judgement of the correct physics/validity of the response when awarding marks.

Brackets (...) are used to indicate information which is not essential for the mark to be awarded. Alternative answers are indicated by ‘or’, or the symbol for or, ‘/’.

### Multiple/Cancelled Responses

If a candidate provides multiple responses, the general principle to be followed is that ‘right + wrong = wrong’.

Responses considered to be neutral are not penalised. For example, if additional irrelevant information is given in an explanation that does not contradict the correct information given, the mark(s) can be awarded.

In a numerical problem if two different solutions are presented without a definitive answer on the answer line, credit should not be given. If an answer is given on the answer line, then the solution that has led to the answer given should be marked according to the mark scheme.

If a candidate clearly cancels their working by scoring it out, then this should not be marked. It is not the role of the marker to select from the candidate’s response what should or should not be marked.

**Marking Numerical Problems**

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer.

A correct answer, if obtained from a valid starting point, gets full credit, even if all the intermediate steps are not shown.

This “correct answer” rule does not apply in situations where candidates have been asked to ‘show your working’ or ‘show that’. These answers must be valid in all stages to obtain full credit.

The answer to a ‘show that’ question should be quoted to one more significant figure than that given in the question.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation.

The normal penalty for an arithmetical error is to lose the mark(s) for the answer/unit line. An arithmetic error should be penalised for one mark only. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value of a quantity given in a question.

$10^n$ errors count as arithmetical slips and incur a penalty of one mark.

If a candidate rounds a value incorrectly this should be penalised one mark. However, care must be taken not to penalise a candidate for rounding correctly in parts leading up to their final answer in an unstructured numerical problem.

Answers should be given in decimal form. Fractional answers will not be credited with the answer mark.

**Error Carried Forward**

An ECF can occur between parts of a question or, in more unstructured numerical problems, within a part.

When an incorrect answer is carried forward from one question to the next, full credit should be awarded in the part where the incorrect answer is used, provided all the working is correct.

Within a part, ECF is applied where a candidate does an incorrect calculation, for example calculates a value for R incorrectly using V/I and then goes on to use their calculated value for R to calculate a resistivity value. The penalty is applied in the V/I calculation but then the value of R can be carried forward so that the remainder of the marks are available to the candidate provided all the remainder of their working is correct.

The ECF within a part will only apply in numerical problems where more than one calculation is required in a part.

**Significant Figures**

Candidates should show an awareness of using a sensible number of significant figures in their answers, based on the values given in the question. In SPH11, SPH21, APH11 and APH21, unless specifically asked for in the question, candidates will not be penalised for incorrect significant figures.

In SPH31, SPH32, APH31 and APH32, all answers should be given to a suitable number of significant figures and penalties will be applied in these papers unless otherwise stated in the mark schemes.

**Units**

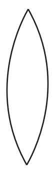
In the majority of questions, the unit will be stated on the answer line.

When the unit is omitted, candidates will be clearly asked to state an appropriate unit and this will be credited in the mark scheme.

Where there is a final calculation required to get from the unit of the answer calculated to the unit on the answer line the required unit will be stated in the question. For example, if wavelength was calculated and the answer line was in nm a statement 'Give your answer in nanometres' would be included.

The unit on the answer line will generally be the SI unit but may in some cases be a more appropriate unit. For example, if values of mass in g and momentum in g cm $s^{-1}$ were given, the unit on the answer line for speed could reasonably be cm $s^{-1}$ without prompt.

| | | | | | | AVAILABLE MARKS |
|---|---|---|---|---|---|---|
| 1 | (a) | | Transverse | | [1] | |
| | (b) | (i) | V = l × b × h or subs | [1] | | |
| | | | 1.8 m | [1] | [2] | |
| | | (ii) | Amplitude | | [1] | |
| | | (iii) | 3 cycles drawn | [1] | | |
| | | | Amplitude = 0.2 m | [1] | | |
| | | | $\lambda = \frac{25}{5}$ | [1] | | |
| | | | 5 m | [1] | | |
| | | | 5, 10, 15 m in correct position on x-axis (ecf $\lambda$) | [1] | [5] | |
| | (c) | | $v = f\lambda$ or subs or $T = \frac{1}{f}$ | [1] | | |
| | | | 23 m $s^{-1}$ / T = 0.22 | [1] | | |
| | | | $v = \frac{d}{t}$ or subs / 25m in 5T | [1] | | |
| | | | 1.1 s / 1.1s | [1] | [4] | 13 |
| 2 | (a) | | Change in direction | [1] | | |
| | | | When wave passes from one medium into another | [1] | [2] | |
| | (b) | | Correct normal at all boundaries | [1] | | |
| | | | Away from normal at boundary 1 | [1] | | |
| | | | Towards normal at boundary 2 | [1] | | |
| | | | Away from normal at boundary 3 | [1] | [4] | |
| | (c) | | Speed of light in glass = $1.95 \times 10^8$ | [1] | | |
| | | | $n = \frac{c}{v}$ | [1] | | |
| | | | 1.54 | [1] | [3] | 9 |
| 3 | (a) | | resonance tube in water or tube if signal generator + speaker | [1] | | |
| | | | tuning fork/signal generator & speaker | [1] | | |
| | | | Metre rule | [1] | [3] | |
| | (b) | | Hold tuning fork/speaker above tube and lift tube and fork | [1] | | |
| | | | From L = 0 until loudest sound heard for first time | [1] | | |
| | | | Measure the length from water surface to top of tube | [1] | | |
| | | | Repeat for 5 frequency values | [1] | | |
| | | | Alternative: speaker above tube + adjust freq | | | |
| | | | 2nd mark: from f = 0 until loud sound heard for 1st time | | | |
| | | | length of tube measured | | | |
| | | | Repeat 5 lengths/5 positions of resonance | | [4] | |
| | (c) | | v = 4Lf or plot f against $\frac{1}{L}$ or correct alternative | [1] | | |
| | | | Average for all f values or v = 4 × gradient or correct from alternative plot | [1] | | |
| | | | Alternative: if 1st + 2nd positions used | | | |
| | | | $v = 2f(L_2 - L_1)$ gets [1] | | [2] | 9 |

| | | | | | | AVAILABLE MARKS |
|---|---|---|---|---|---|---|
| **4** | **(a)** | | Glass core and cladding | [1] | | |
| | | | n of cladding less than core | [1] | | |
| | | | TIR occurs | [1] | | |
| | | | 2 bundles of fibre, coherent & incoherent | [1] | | |
| | | | Incoherent used for illumination, fibres don't need to be aligned | [1] | | |
| | | | Coherent used for image, ends of fibres must be aligned | [1] | [6] | |
| | **(b)** | | Sin C = $\frac{1}{n}$ | [1] | | |
| | | | C in air = 43.2° | [1] | | |
| | | | $\frac{1}{n_{core}} \times n_{cladding}$ or subs $\frac{1}{1.46} \times 1.43$ | [1] | | |
| | | | 0.98 | [1] | | |
| | | | C in cladding = 78.4° | [1] | | |
| | | | Difference = 35.2° | [1] | [6] | 12 |
| **5** | **(a)** | | In phase | [1] | | |
| | | | Single wavelength/frequency/colour | [1] | [2] | |
| | **(b)** | **(i)** | $E = \frac{hc}{\lambda}$ or $E = hf$ and $c = f\lambda$ | [1] | | |
| | | | Nano conversion | [1] | | |
| | | | $3.14 \times 10^{-19}$ J | [1] | | |
| | | | 1.96 eV | [1] | | |
| | | | −[1] 22.62 eV [1] | [2] | [6] | |
| | | **(ii)** | ultraviolet | | [1] | 9 |
| **6** | **(a)** | **(i)** | 1.8 ± 0.1 cm | [1] | | |
| | | | M = 3 | [1] | [2] | |
| | | **(ii)** |  | | [1] | |
| | **(b)** | **(i)** | Ray through centre of lens from top of object | [1] | | |
| | | | Extended back until h = 18mm and image h = 18mm | [1] | | |
| | | | Ray parallel to p axis converging | [1] | | |
| | | | As if from top of image | [1] | | |
| | | | Image in where virtual rays intersect | [1] | | |
| | | | Dashed lines for virtual rays | [1] | | |
| | | | [penalty −1 if no arrows on rays] | | [6] | |
| | | **(ii)** | Value from their diagram | | [1] | 10 |

| | | | | | | AVAILABLE MARKS |
|---|---|---|---|---|---|---|
| **7** | **(a)** | **(i)** | 1.2 × 2 | [1] | | |
| | | | mm and cm conversion | [1] | | |
| | | | $0.4 \times 10^{-3}(0.024)/0.8$ | [1] | | |
| | | | $1.2 \times 10^{-5}$ m | [1] | [4] | |
| | | **(ii)** | Minimum so path diff = $(n + \frac{1}{2})\lambda$ | [1] | | |
| | | | $2.5\lambda$ | [1] | | |
| | | | $3 \times 10^{-5}$ m ecf **(i)** | [1] | [3] | |
| | **(b)** | **(i)** | $1.93 \times 10^{4}$ lines $m^{-1}$ | [1] | | |
| | | | 19.3 lines $mm^{-1}$ | [1] | [2] | |
| | | **(ii)** | Correct subs of d and n $5.18 \times 10^{-5} \sin\theta$ = **3(a)(i)** ans | [1] | | |
| | | | $\sin\theta = 0.695$ | [1] | | |
| | | | $\theta = 44°$ ecf **(a)(i)** | [1] | [3] | 12 |
| **8** | **(a)** | **(i)** | A – arrow down | [1] | | |
| | | | B – arrow down | [1] | [2] | |
| | | **(ii)** | 0°, 90°, 450°, $\frac{\pi}{2}$ or $\frac{5\pi}{2}$ rad | [1] | | |
| | | | Unit consistent | [1] | [2] | |
| | **(b)** | **(i)** | $L = 1.5\lambda$ | [1] | | |
| | | | $\lambda = 0.44$ m | [1] | [2] | |
| | | **(ii)** | $v = 11$ m $s^{-1}$     $f = 4f°$ | [1] | | |
| | | | New wavelength = 0.33 m **or** $f° = \frac{25}{3} = 8.3$ Hz | [1] | | |
| | | | f = 33.3 Hz     = 33.3 Hz | [1] | [3] | 9 |
| **9** | **(a)** | | Electrons released from metal surface | [1] | | |
| | | | When em radiation incident (accept photons) | [1] | | |
| | | | With energy > work function or equivalent | [1] | [3] | |
| | **(b)** | **(i)** | E of light = $6.63 \times 10^{-34}(3.72 \times 10^{14})$ | [1] | | |
| | | | $2.47 \times 10^{-19}$ J | [1] | | |
| | | | $2.47 \times 10^{-19} - 2.30 \times 10^{-19}$ | [1] | | |
| | | | $1.70 \times 10^{-20}$ | [1] | | |
| | | | $1.70 \times 10^{-20} = 0.5(9.11 \times 10^{-31})\, v^2$ | [1] | | |
| | | | $v = 1.93 \times 10^{5}$ m $s^{-1}$ | [1] | [6] | |
| | | **(ii)** | W = qV or subs | [1] | | |
| | | | k conversion 23,000V | [1] | | |
| | | | $3.68 \times 10^{-15}$ J | [1] | [3] | 12 |
| **10** | **(a)** | | Spectrum A | [1] | | |
| | | | Longer wavelength red shifted | [1] | [2] | |
| | **(b)** | | $\Delta\lambda = 90.2$ or 90.9 | [1] | | |
| | | | Subs into $\frac{\Delta\lambda}{\lambda}$ of a correct pair or z = 0.203 | [1] | | |
| | | | $6.1 \times 10^{7}$ m $s^{-1}$ (ecf z value) | [1] | [3] | 5 |
| | | | | | **Total** | **100** |