Example Candidate Responses

Cambridge International AS & A Level

# Cambridge International AS and A Level Physics

## 9702

## Paper 2 – AS Level Structured Questions

Cambridge Advanced

CAMBRIDGE International Examinations

In order to help us develop the highest quality Curriculum Support resources, we are undertaking a continuous programme of review; not only to measure the success of our resources but also to highlight areas for improvement and to identify new development needs.

We invite you to complete our survey by visiting the website below. Your comments on the quality and relevance of Cambridge Curriculum Support resources are very important to us.

**https://www.surveymonkey.co.uk/r/GL6ZNJB**

Do you want to become a Cambridge consultant and help us develop support materials?

Please follow the link below to register your interest.

**http://www.cie.org.uk/cambridge-for/teachers/teacherconsultants/**

# Contents

# Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge International AS & A Level Physics (9702), and to show how different levels of candidates' performance (high, middle and low) relate to the subject's curriculum and assessment objectives.

In this booklet candidate responses have been chosen to exemplify a range of answers. Each response is accompanied by a brief commentary explaining the strengths and weaknesses of the answers.

For each question, each response is annotated with a clear explanation of where and why marks were awarded or omitted. This, in turn, is followed by examiner comments on how the answer could have been improved. In this way it is possible for you to understand what candidates have done to gain their marks and what they will have to do to improve their answers. At the end there is a list of common mistakes candidates made in their answers for each question.

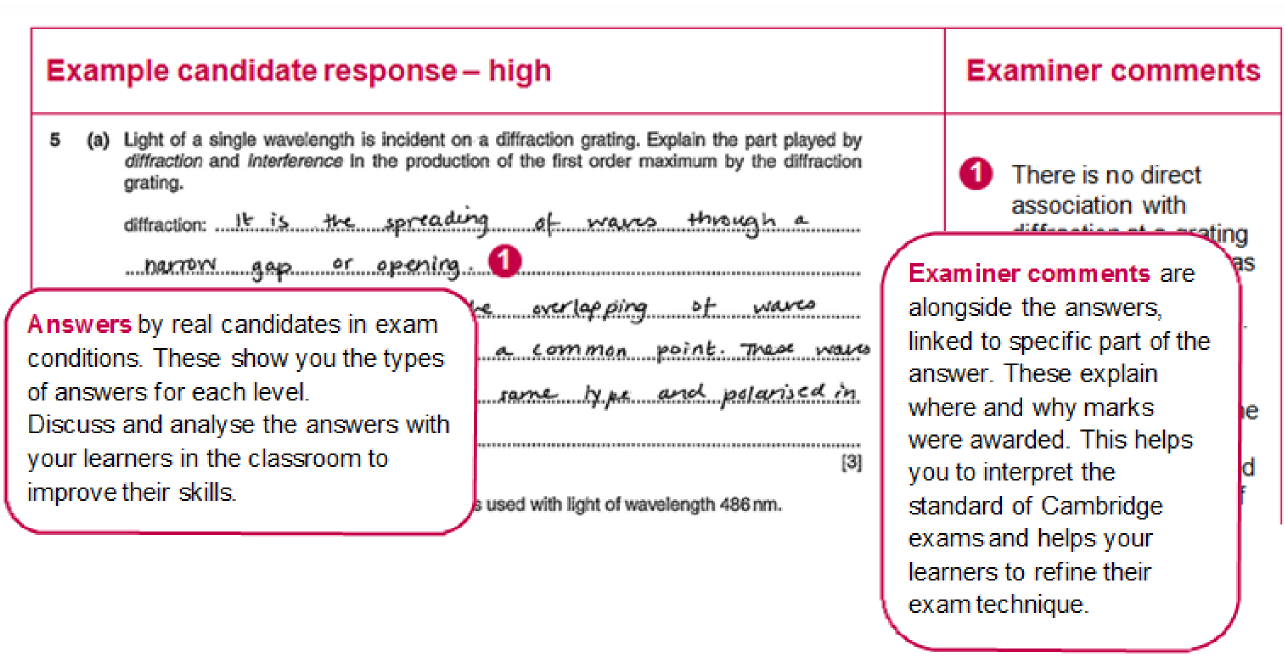
This document provides illustrative examples of candidate work. These help teachers to assess the standard required to achieve marks, beyond the guidance of the mark scheme. Some question types where the answer is clear from the mark scheme, such as short answers and multiple choice, have therefore been omitted.

The questions, mark schemes and pre-release material used here are available to download as a zip file from Teacher Support as the Example Candidate Responses Files. These files are:

| **Question Paper 22, June 2016** | |
|---|---|
| Question paper | 9702_s16_qp_22.pdf |
| Mark scheme | 9702_s16_ms_22.pdf |
| **Question Paper 33, June 2016** | |
| Question paper | 9702_s16_qp_33.pdf |
| Mark scheme | 9702_s16_ms_33.pdf |
| **Question Paper 42, June 2016** | |
| Question paper | 9702_s16_qp_42.pdf |
| Mark scheme | 9702_s16_ms_42.pdf |
| **Question Paper 52, June 2016** | |
| Question paper | 9702_s16_qp_52.pdf |
| Mark scheme | 9702_s16_ms_52.pdf |

Past papers, Examiner Reports and other teacher support materials are available on Teacher Support at **https://teachers.cie.org.uk**

# How to use this booklet



**Example candidate response – high**

**Examiner comments**

5 (a) Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction: It is the spreading of waves through a narrow gap or opening. 1

... overlapping of waves ... a common point. These waves ... same type and polarised in ...

[3]

... used with light of wavelength 486 nm.

1 There is no direct association with diffraction at a grating ...

**Answers** by real candidates in exam conditions. These show you the types of answers for each level.
Discuss and analyse the answers with your learners in the classroom to improve their skills.

**Examiner comments** are alongside the answers, linked to specific part of the answer. These explain where and why marks were awarded. This helps you to interpret the standard of Cambridge exams and helps your learners to refine their exam technique.

## How the candidate could have improved their answer

**(a)** The question was an application of diffraction a... needed to apply their knowledge to the application... interference needed to be applied to the productio... applications as well as learning basic theory is req...

This explains how the candidate could have improved their answer and helps you to interpret the standard of Cambridge exams and helps your learners to refine exam technique.

**(b)** The diffraction grating equation was used and the given data interpreted correctly. There was a mathematical error in the calculation and the final answer was not realistic. The candidate needed to be more familiar with likely values for applications of basic theory.

## Common mistakes candidates made in this question

**(a)** Diffraction was described as the bending of light. ... diffraction is a wave property and hence diffraction a... have passed through the diffraction element. The ef... was not described for this specific example.

This lists the common mistakes candidates made in answering each question. This will help your learners to avoid these mistakes at the exam and give them the best chance of achieving a high mark.

**(b)** The angle given on the diagram was used as the angle θ in the diffraction grating equation. The distance *d* was quoted as the number of lines per mm *N*. There were power of ten errors converting *d* in metres to *N* in $mm^{-1}$.

# Assessment at a glance

Candidates for Advanced Subsidiary (AS) certification take Papers 1, 2 and 3 in a single examination series.

Candidates who, having received AS certification, wish to continue their studies to the full Advanced Level qualification may carry their AS marks forward and take Papers 4 and 5 in the examination series in which they require certification.

Candidates taking the full Advanced Level qualification at the end of the course take all five papers in a single examination series.

**Candidates may only enter for the papers in the combinations indicated above.**

**Candidates may not enter for single papers either on the first occasion or for resit purposes.**

All components are externally assessed.

| Component | Weighting | |
|---|---|---|
| | AS Level | A Level |
| **Paper 1 Multiple Choice** **1 hour 15 minutes**<br><br>This paper consists of 40 multiple choice questions, all with four options. All questions will be based on the AS Level syllabus content. Candidates will answer all questions.<br><br>Candidates will answer on an answer sheet. [40 marks] | 31% | 15.5% |
| **Paper 2 AS Level Structured Questions** **1 hour 15 minutes**<br><br>This paper consists of a variable number of questions of variable mark value. All questions will be based on the AS Level syllabus content. Candidates will answer all questions.<br><br>Candidates will answer on the question paper. [60 marks] | 46% | 23% |
| **Paper 3 Advanced Practical Skills** **2 hours**<br><br>This paper requires candidates to carry out practical work in timed conditions. The paper will consist of two experiments drawn from different areas of physics. The experiments may be based on physics not included in the syllabus content, but candidates will be assessed on their practical skills rather than their knowledge of theory. Candidates will answer both questions.<br><br>Candidates will answer on the question paper. [40 marks] | 23% | 11.5% |
| **Paper 4 A Level Structured Questions** **2 hours**<br><br>This paper consists of a variable number of questions of variable mark value. All questions will be based on the A Level syllabus but may require knowledge of material first encountered in the AS Level syllabus. Candidates will answer all questions.<br><br>Candidates will answer on the question paper. [100 marks] | – | 38.5% |

| Component | Weighting | |
|---|---|---|
| | AS Level | A Level |
| **Paper 5 Planning, Analysis and Evaluation** **1 hour 15 minutes**<br><br>This paper consists of two questions of equal mark value based on the practical skills of planning, analysis and evaluation. The context of the questions may be outside the syllabus content, but candidates will be assessed on their practical skills of planning, analysis and evaluation rather than their knowledge of theory. Candidates will answer both questions.<br><br>Candidates will answer on the question paper. [30 marks] | – | 11.5% |

Teachers are reminded that the latest syllabus is available on our public website at **www.cie.org.uk** and Teacher Support at **https://teachers.cie.org.uk**

# Paper 2 – AS Level Structured Questions

## Question 1

### Example candidate response – high

1 (a) Define *acceleration*.

rate of change of velocity **1**

[1]

(b) A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.

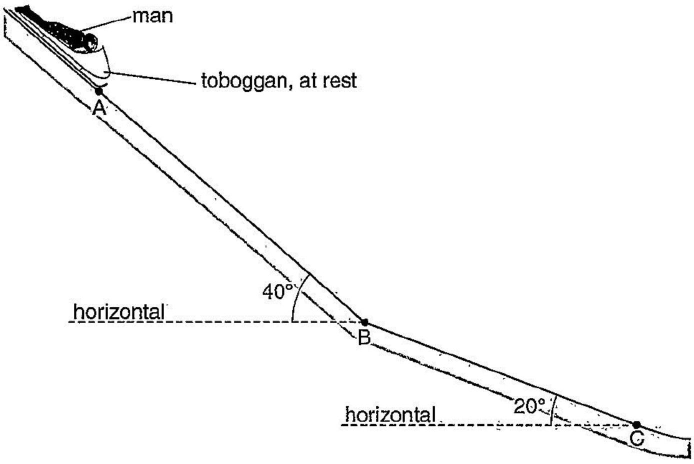



**Fig. 1.1** (not to scale)

The slope AB makes an angle of 40° with the horizontal and the slope BC makes an angle of 20° with the horizontal. Friction is not negligible.

The man and toboggan have a combined mass of 95 kg.

The man starts from rest at A and has constant acceleration between A and B. The man takes 19 s to reach B. His speed is 36 m $s^{-1}$ at B.

(i) Calculate the acceleration from A to B.

~~$v^2 = u^2 + 2as$~~

~~$36^2 = 0 + 2a(19)$~~

~~$a = 34$~~

$v = u + at$

$36 = a(19)$

$a = 1.9$ **2**

acceleration = ~~34~~ 1.9 m $s^{-2}$ [2]

(ii) Show that the distance moved from A to B is 340 m.

$v^2 = u^2 + 2as$

$36^2 = 2(1.9)s$

$s = 342$ **3**

$\approx 340$ m

[1]

### Examiner comments

**1** The answer is concise and in an acceptable form.

Mark for (a) = 1/1

**2** A complete answer showing the equation to be used (in symbols), the substitution and a final correct answer.

Mark for (b) (i) = 2/2

**3** A complete answer showing the equation to be used (in symbols), the substitution and final correct answer to three significant figures, and the correct reduction to the answer required by the question.

Mark for (b) (ii) = 1/1

## Example candidate response – high, continued

**(iii)** For the man and toboggan moving from A to B, calculate

**1.** the change in kinetic energy,

$\frac{1}{2}mv^2$

$= \frac{1}{2}(95)(36^2)$

$\approx 62\,000$

$= 61560$

change in kinetic energy = 62 000 J [2]

**2.** the change in potential energy.

~~change in KE~~ = change in PE

= mgh

= 95 × 9.81 × 342 (5)

= 318727

≈ 319 000

change in potential energy = 319 000 J [2]

**(iv)** Use your answers in **(iii)** to determine the average frictional force that acts on the toboggan between A and B.

318727 − 61560 (6)

$= 257 \times 10^3$ J

W = Fs

$F = \frac{257 \times 10^3}{342}$

= 752 (7)

frictional force = 750 N [2]

**(v)** A parachute opens on the toboggan as it passes point B. There is a constant deceleration of 3.0 m s$^{-2}$ from B to C.

Calculate the frictional force that produces this deceleration between B and C.

F = ma

= 95 × −3

= −285

$F_f - F = ma$

$F_f = -285 + F$

= −285 − 750 (8)

= −1035

frictional force = 1035 N [2]

[Total: 12]

## Examiner comments

**4** This is not really the *change* in kinetic energy but the final kinetic energy. The answer would have been more convincing if the initial kinetic energy had been shown (as zero).

Mark for (b) (iii) 1. = 2/2

**5** The value used for the height is the distance moved down the slope. This is incorrect physics and is not awarded any marks.

Mark for (b) (iii) 2. = 0/2

**6** The energy changes determined in (b) (iii) are shown here; an error which is carried forward is allowed.

**7** The working is shown with the energy difference from the candidate's answers for (b) (iii) so full marks are awarded here. A final answer of this value with no working would not have been awarded any marks.

Mark for (b) (iv) = 2/2

**8** The frictional force used from (b) (iv) is not valid. The component of the weight of the man and toboggan has been ignored and the frictional force for this section is what is asked for.

Mark for (b) (iv) = 0/2

**Total marks awarded = 8 out of 12**

## How the candidate could have improved their answer

**(b) (iii) 1.** The change in the kinetic energy was asked for here. In this case the initial kinetic energy was zero and hence did not contribute to the final answer. It would have been a complete answer if the candidate had commented on this.

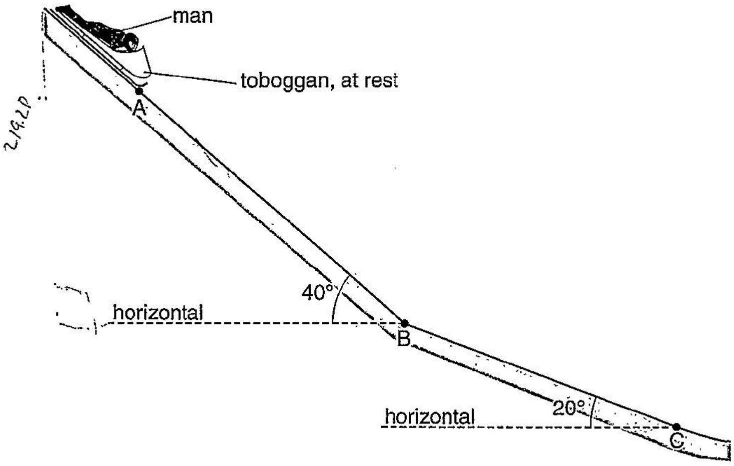
**(b) (iii) 2.** This answer was determined using incorrect physics. The *h* in the formula for gravitational potential energy is the height dropped by the toboggan. The candidate used the distance moved down the slope, clearly identified as such a distance in (b) (ii). The candidate might have been able to see this if they had marked the various distances involved on the diagram.

**(b) (iv)** The working clearly showed the use of the energy changes from (b) (iii). The correct substitution was made and the correct answer was obtained for the answers the candidate gave for (b) (iii). This answer would not have been awarded any marks if the working had not been shown.

**(b) (v)** The candidate did not relate the forces acting during this stage of the motion to the acceleration given in the question. A sketch diagram of the forces acting drawn by the candidate might have helped with their analysis of this part. The use of the frictional force from (b) (iv) showed a misconception for this part.

Mark awarded = **(a) 1/1**
Mark awarded = **(b) (i) 2/2, (ii) 1/1, (iii)1 2/2, (iii)2 0/2, (iv) 2/2, (v) 0 /2**

**Total marks awarded = 8 out of 12**

| Example candidate response – middle | Examiner comments |
|---|---|
| 1 (a) Define *acceleration*.<br>~~##~~ final velocity – initial velocity / time. **1** [1] | **1** A correct equation given in words is accepted as a definition.<br><br>Mark for (a) = 1/1 |
| (b) A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.<br><br><br>**Fig. 1.1** (not to scale)<br><br>The slope AB makes an angle of 40° with the horizontal and the slope BC makes an angle of 20° with the horizontal. Friction is not negligible.<br><br>The man and toboggan have a combined mass of 95 kg.<br><br>The man starts from rest at A and has constant acceleration between A and B. The man takes 19 s to reach B. His speed is 36 m s$^{-1}$ at B.<br><br>(i) Calculate the acceleration from A to B.<br>$a = \frac{36-0}{19}$ **2**<br>$a = \frac{36}{19}$<br>$a = 1.89$<br>acceleration = 1.89 m s$^{-2}$ [2] | **2** The substitution shows the correct equation is used for acceleration. The three significant figures answer is acceptable as it would reduce to the answer required if reduced to two significant figures.<br><br>Mark for (b) (i) = 2/2 |
| (ii) Show that the distance moved from A to B is 340 m.<br>~~$s \times t = d$~~ $s = ut + \frac{1}{2}at^2$<br>$s = \frac{1}{2}at^2$ $s = \frac{1}{2} \times 1.89 \times (19)^2$ **3**<br>$s = 341.145$ m. [1] | **3** The initial velocity is not stated as zero. The second line suggests that the candidate has taken this value as zero, but, as this is a 'show that' question, it would have been better if this had been clearly stated by the candidate.<br><br>Mark for (b) (ii) = 1/1 |

## Example candidate response – middle, continued

(iii) For the man and toboggan moving from A to B, calculate

1. the change in kinetic energy,

$v = \frac{d}{t}$ $v = \frac{341.145}{19}$ **4**

$v = 17.955$

$E_K = \frac{1}{2} mv^2$

$E_K = \frac{1}{2} \times 95 \times 17.955$

$E_K = 852.86$ J **5**

change in kinetic energy = ......852.86...... J [2]

2. the change in potential energy.

$\frac{341.145}{\sin 90} = \frac{x}{\sin 40}$

$x = 219.28$

$95 \times 9.81 \times 340 \sin 40$ **6**

$E_p = mgh$

$E_p = 95 \times 9.81 \times 341 \sin 40$

$= 204274$

$= 204274$

change in potential energy = ......204274...... J [2]

(iv) Use your answers in **(iii)** to determine the average frictional force that acts on the toboggan between A and B.

$E_p - E_k$ = friction force **7**

$204274 - 852.86$

$203421.79$

$2.03 \times 10^5$

frictional force = ......$2.03 \times 10^5$...... N [2]

(v) A parachute opens on the toboggan as it passes point B. There is a constant deceleration of 3.0 m s$^{-2}$ from B to C.

Calculate the frictional force that produces this deceleration between B and C.

$F = ma$ $F = 95 \times 3$ **8**

$F = 285$ N.

frictional force = ......285...... N [2]

[Total: 12]

## Examiner comments

**4** The calculation of the average velocity shows a misconception by the candidate.

**5** The candidate also makes an arithmetic error by not squaring the velocity. However, this is of no consequence as the incorrect physics in calculating the average velocity means that no marks are awarded.

Mark for (b) (iii) 1. = 0/2

**6** The correct height has been calculated and used in the correct equation for potential energy. The answer is given to more than two significant figures, but this is allowed as the answer is correct if reduced to two significant figures.

Mark for (b) (iii) 2. = 2/2

**7** The energy change is equated to a force. This is incorrect physics and the calculation of the difference in energy changes is not awarded any marks.

Mark for (b) (iv) = 0/2

**8** This is a calculation of the resultant force and therefore does not answer the question. The expression $F = ma$ needs to be used as the resultant force $F$ causes the acceleration $a$.

Mark for (b) (v) = 0/2

**Total marks awarded = 6 out of 12**

## How the candidate could have improved their answer

**(a) (i)** A correctly stated equation in words was acceptable here.

**(b) (i)** The initial equation in symbols was not given but the subsequent substitution showed that the correct equation was used. The answer to three significant figures was allowed as this would give the correct answer if reduced to two significant figures.

**(b) (ii)** The initial value of the velocity was not shown as being zero; the equation given by the candidate just took the value to be zero. An explanatory comment or the statement $u = 0$ would have been helpful here. The answer for the distance was given to more than two significant figures, which helped the examiner to know that the calculation had been completed.

**(b) (iii) 1.** The candidate did not determine the change in the kinetic energy. Using *the change* = *final - initial* would have helped the candidate arrive at the correct answer. The 'average' kinetic energy calculated by the candidate was not what was asked for and might have been due to not reading the question carefully.

**(b) (iii) 2.** The correct height was calculated and substituted into the correct equation, as required.

**(b) (iv)** The candidate equated the energy changes with a force and this showed a lack of understanding of the problem. This kind of question needs practice with situations that involve work done being equated with energy change rather than using equations of uniform acceleration.

**(b) (v)** The equation used was for the resultant force and did not answer the specific question, where more than one force acts. A sketch diagram of the forces acting might have helped the candidate see into the complexity of this question.

Mark awarded = **(a) 1/1**
Mark awarded = **(b) (i) 2/2, (ii) 1/1, (iii)1 0/2, (iii)2 2/2, (iv) 0/2, (v) 0 /2**

**Total marks awarded = 6 out of 12**

## Example candidate response – low

**1 (a)** Define *acceleration*.

acceleration = change in ~~velocity~~ speed / time taken **[1]** ❶

**(b)** A man travels on a toboggan down a slope covered with snow from point A to point B and then to point C. The path is illustrated in Fig. 1.1.

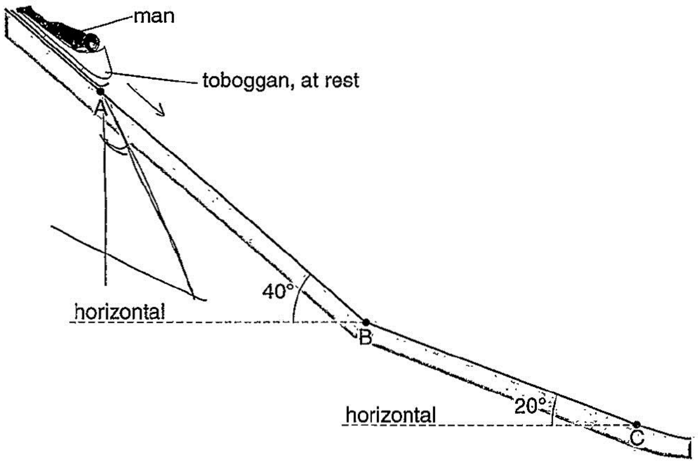



**Fig. 1.1** (not to scale)

The slope AB makes an angle of 40° with the horizontal and the slope BC makes an angle of 20° with the horizontal. Friction is not negligible.

The man and toboggan have a combined mass of 95 kg.

The man starts from rest at A and has constant acceleration between A and B. The man takes 19 s to reach B. His speed is $36\,\text{m}\,\text{s}^{-1}$ at B.

**(i)** Calculate the acceleration from A to B.

$a = \frac{36}{19} \rightarrow 1.89$ ❷

acceleration = 1.89 $\text{m}\,\text{s}^{-2}$ **[2]**

**(ii)** Show that the distance moved from A to B is 340 m.

$s = ut + \frac{1}{2}at^2$ $\quad s = 0 + \frac{1}{2} \times 1.89 \times 19^2$ ❸

$= 341.~~445~~\,145\,\text{m} \simeq 340\,\text{m}$

**[1]**

## Examiner comments

❶ The use of speed in the definition is not acceptable.

Mark for (a) = 0/1

❷ The candidate would have done better to write out the information given for each term and then the equation that fitted the information for the answer required. A brief statement such as this can lead to errors.

Mark for (b) (i) = 2/2

❸ The full equation is given here, along with the correct substitution and calculation.

Mark for (b) (ii) = 1/1

| Example candidate response – low, continued | Examiner comments |
| --- | --- |
| **(iii)** For the man and toboggan moving from A to B, calculate<br><br>**1.** the change in kinetic energy,<br><br>KE = ½mv² (4)<br>= ½ × 95 × 30 (5)<br>= 1710<br><br>change in kinetic energy = 1710 J [2]<br><br>**2.** the change in potential energy.<br><br>GPE = mgh<br>~~= 95 × 9.81 × h~~<br>= ~~95 × 9.81 × 219.8283~~<br>= 95 × 9.81 ×<br>~~sin 40° = 0/341.145 ∴ 0 = 341.145 sin 40° = 219.283~~<br>(6) 1710 = 95 × 9.81 × h<br>h = 1.83<br>GPE = 95 × 9.81 × 1.83 = 1705.47<br><br>change in potential energy = 1705 J [2]<br><br>**(iv)** Use your answers in **(iii)** to determine the average frictional force that acts on the toboggan between A and B.<br><br>~~F = ma~~ ~~We~~ W = mg (7)<br>= 95 × 9.81 → 931.95<br><br>frictional force = .................... N [2]<br><br>**(v)** A parachute opens on the toboggan as it passes point B. There is a constant deceleration of 3.0 m s⁻² from B to C.<br><br>Calculate the frictional force that produces this deceleration between B and C.<br><br>W – F = ma (8)<br>W – F = 95 × 3.0<br>~~931.9~~<br>932 – F = 285<br>F = 1217<br>W = mg<br>= 95 × 9.81 → 931.95<br><br>frictional force = 1217 N [2]<br><br>[Total: 12] | **4** The equation for kinetic energy is given but not the expression for the change in kinetic energy. This might have led to errors if the initial velocity had not been zero.<br><br>**5** The error of not squaring the velocity is treated as an arithmetic error, as the correct equation is given for the kinetic energy. If the correct formula had not been given, this would have been treated as incorrect physics. (K E would then have been given as 1/2 *m v*.)<br><br>Mark for (b) (iii) 1. = 1/2<br><br>**6** Equating the kinetic energy to the potential energy is a misconception of the physics of the situation. The value obtained for the height should have made the candidate think that an error had been made as it is an unrealistic value.<br><br>Mark for (b) (iii) 2. = 0/2<br><br>**7** There is no evidence of the answers to (b) (iii) being used by the candidate here. The link between the difference in energies and work done has not been established.<br><br>Mark for (b) (iv) = 0/2<br><br>**8** There is evidence of a good start here but the component of the weight is required. This leads to incorrect physics at this point.<br><br>Mark for (b) (v) = 0/2<br><br>**Total marks awarded = 4 out of 12** |

## How the candidate could have improved their answer

**(a) (i)** This candidate gave an unacceptable answer and should have learned the correct definition.

**(b) (i)** The full equation should have been the starting point here. The candidate should have written out the values of the data given and related them to the correct symbols, for example $u = 0$, $t = 19$ s. The correct answer was obtained but full working was not clearly shown.

**(b) (ii)** The full details were given here and full marks were awarded.

**(b) (iii) 1.** The equation for kinetic energy was stated but the arithmetic error suggested that the candidate did not fully check their answer.

**(b) (iii) 2.** The height used was not sensible for the situation involved. A sketch diagram of the motion down the slope and the height fallen would have helped the candidate see how to calculate the height.

**(b) (iv)** The question was not followed and the answers to (b) (iii) were not used. Practice with questions equating work done to change in energy would have helped for these more complex questions.

**(b) (v)** The component of the weight down the slope was not included in the candidate's answer. A sketch of the force diagram for the situation in the last section might have helped the candidate see the relationship between the forces acting and the acceleration of the man on the toboggan. This was a complex situation and a diagram often helps with finding a solution.

Mark awarded = **(a) 0/1**
Mark awarded = **(b) (i) 2/2, (ii) 1/1, (iii) 1 1/2, (iii) 2 0/2, (iv) 0/2, (v) 0/2**

**Total marks awarded = 4 out of 12**

## Common mistakes candidates made in this question

**(a) (i)** Some candidates gave *change in speed* instead of *change in velocity*. Some gave acceleration as *velocity / time* or acceleration = *change in velocity over time* and acceleration = *rate of change in velocity per unit time* (stating two rates here is incorrect). None of these versions was accepted.

**(b) (i) & (ii)** The answers here were generally correct, particularly where the equations and terms were written out in full before the calculation was completed.

**(b) (iii) 1.** Some candidates used the calculation $1/2\ m\ (\Delta v)^2$ instead of $1/2\ m\ (v^2 – u^2)$ for the change in kinetic energy.

**(b) (iii) 2.** The distance down the slope was used instead of the height. A simple triangle sketch would have helped candidates see that there was a trig function required.

**(b) (iv)** The difference in energy was equated with a force (the frictional force).

**(b) (v)** The equation $F = ma$ was used. The $F$ (the resultant force) was equated to the frictional force. The component of the weight of the man and the toboggan was ignored by some candidates.

# Question 4

## Example candidate response – high

**4 (a)** By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal: Waves that travel parralel to direction of proporgation of energy. **1**

transverse: Waves that travel at right angles to direction **2** of proporgation of energy. [2]

**(b)** The intensity of a sound wave passing through air is given by

$$I = Kv\rho f^2 A^2$$

where $I$ is the intensity (power per unit area),
$K$ is a constant without units,
$v$ is the speed of sound,
$\rho$ is the density of air,
$f$ is the frequency of the wave
and $A$ is the amplitude of the wave.

Show that both sides of the equation have the same SI base units.

$I = \frac{P}{A}$ $P = \frac{F \times d}{t} \rightarrow \frac{kg\,m\,s^{-2} \times m\,s^{-1}}{} \rightarrow kg\,m^2\,s^{-3}$ / $m^2$ **3**

$\therefore I = kg\,s^{-3}$

$v\rho f^2 A^2 \rightarrow (m\,s^{-1})(kg\,m^{-3}) \times (s^{-1})^2 (m)^2$

$\rightarrow kg\,m^{-2}\,s^{-1} \times s^{-2} \times m^2$ **4**

$\rightarrow kg\,s^{-3}$

$\therefore$ LHS = RHS. [3]

## Examiner comments

**1** There is no description of the direction of vibration or oscillation of the particles that allow the propagation of the energy.

**2** The description in terms of wave motion / travel is incorrect physics. The direction of the particle's vibrations with reference to the direction of energy propagation defines the type of wave motion.

Mark for (a) = 0/2

**3** The base units of power and area for intensity are clearly shown.

**4** The base units of the terms on the right-hand side of the equation are clear.

Mark for (b) = 3/3

| Example candidate response – high, continued | Examiner comments |
|---|---|
| **(c)** **(i)** Describe the *Doppler effect*.<br>Where the observed frequency is different from the emitted frequency, when there is motion between the observer & source. **5** [1]<br>**(ii)** A distant star is moving away from a stationary observer.<br>State the effect of the motion on the light observed from the star.<br>The light becomes less brighter since frequency decreases (observed), ~~and~~ **6** [1] | **5** A clear reference to the frequency being observed rather than changed at source due to relative motion here.<br>**6** Benefit of the doubt is given here as the link between the motion of the star and the observed frequency is not clearly stated.<br>Mark for (c) = 2/2 |
| **(d)** A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is $340\,\mathrm{m\,s^{-1}}$.<br>Calculate the speed of the car.<br>$f_o = \frac{f_s \times V}{V - V_s}$<br>$550 = \frac{510 \times 330}{(330 - x)}$ **7**<br>$181{,}500 - 550x = 168{,}300$<br>$550x = 13{,}200$<br>$x = 24\,\mathrm{ms^{-1}}$<br>speed = 24 ms⁻¹ $\mathrm{m\,s^{-1}}$ [3]<br>[Total: 10] | **7** The use of 330 is incorrect since the value for the speed of sound is given in the question as 340.<br>Mark for (d) = 2/3<br>**Total marks awarded = 7 out of 10** |

## How the candidate could have improved their answer

**(a)** The candidate referred to the wave's direction of travel, but the term 'wave' is not appropriate here. The description in terms of wave motion / travel is incorrect physics. The definition of wave motion should have been more specific and required the description of the direction of vibration or oscillation of the particles that allow the propagation of the energy. The direction of the particle's vibrations with reference to the direction of energy propagation defines the type of wave motion.

**(c) (ii)** The description of the effect on intensity was ignored. This is considered to be due to the distance changing and not the motion of the star.

**(d)** The candidate did not gain full marks as not all the data given in the question were used. The candidate should not use remembered data when a value is clearly included in the question.

Mark awarded = **(a) 0/2**
Mark awarded = **(b) 3/3**
Mark awarded = **(c) (i) 1/1, (ii) 1/1**
Mark awarded = **(d) 2/3**

**Total marks awarded = 7 out of 10**

## Example candidate response – middle

**4** **(a)** By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal: A wave in which the particle moves parallel to the propagation of energy is known as longitudinal wave. **1**

transverse: A wave in which the particle of the motion moves perpendicular to the direction of motion is known as a transverse wave. **2**

[2]

**(b)** The intensity of a sound wave passing through air is given by

$$I = Kv\rho f^2 A^2$$

where $I$ is the intensity (power per unit area),
$K$ is a constant without units,
$v$ is the speed of sound,
$\rho$ is the density of air,
$f$ is the frequency of the wave
and $A$ is the amplitude of the wave.

$\frac{\text{mass}}{\text{vol}} = \text{kg m}^{-3}$

Show that both sides of the equation have the same SI base units.

→ $\frac{\text{kg} \times \text{m s}^{-2} \times \text{m}^{-1}}{\text{s}}$ = K × m s$^{-1}$ × kg m$^{-3}$ × **3**

kg × s$^{-3}$ = K × m s$^{-1}$ × kg m$^{-3}$ × s$^{-2}$ × m$^{2}$

kg s$^{-3}$ = K × m$^{0}$ × kg × s$^{-3}$

kg s$^{-3}$ = K kg s$^{-3}$

Hz = f = $\frac{1}{T}$

= s$^{-1}$

E = P × t

P = $\frac{W}{t}$

f × d  m s$^{-2}$

= $\frac{\text{kg} \times a \times \text{m}}{\text{s}}$

[3]

## Examiner comments

**1** There is a clear link between the particle movement and the direction of the energy propagation here.

**2** The required link is missing here, and the description of the motion of particles and the direction of motion of something undefined makes no sense.

Mark for (a) = 1/2

**3** The base units of power and area have not been used to determine the base units of intensity. The units have been made to agree with those obtained for the right-hand side.

Mark for (b) = 2/3

| Example candidate response – middle, continued | Examiner comments |
|---|---|
| **(c) (i)** Describe the *Dopplèr effect.*<br>~~It~~ The observed frequency is always different to the frequency emmitted when source and sound are in a relative motion. **4** [1]<br>**(ii)** A distant star is moving away from a stationary observer.<br>State the effect of the motion on the light observed from the star.<br>The wavelenght and the frequency has now been changed so the motion will also change. **5** [1]<br>**(d)** A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is 340 m s$^{-1}$.<br>Calculate the speed of the car.<br>$f = 510$<br>$510 = 550 \times \left(\frac{340}{340 - V_{car}}\right)$ **6**<br>$0.927(340 - V_{car}) = 340$<br>$340 - V_{car} = 366.67$<br>$V_{car} = 26.67$ **7**<br>speed = ~~266~~ 26.67 m s$^{-1}$ [3]<br>[Total: 10] | **4** This makes a correct link between the observed frequency and relative motion, although it is not completely clear in terms of the source and the observer.<br>Mark for (c) (i) = 1/1<br>**5** Insufficient detail given. The direction of the change is required here.<br>Mark for (c) (ii) = 0/1<br>**6** There is an error in the substitution of the values for the source and observer frequencies.<br>**7** The answer should be negative from this working but this has been ignored or an arithmetic error made. Either way, the candidate is not awarded any marks for this answer as they have not provided any comment regarding how their answer is positive.<br>Mark for (d) = 1/3<br>**Total marks awarded = 5 out of 10** |

## How the candidate could have improved their answer

**(a)** The candidate needed to read through both their answers and check them against the question asked. The first definition gave the required detail. The second definition was disjointed and not consistent with the first answer.

**(b)** The candidate needed to read the question more carefully. The information needed for intensity was given in the question but not used by the candidate. This was compounded by an arithmetic error in the cancelling for the left-hand side of the equation. The working for the right-hand side should have been done independently and not made to agree with the left-hand side. The subsequent errors meant that both sides were incorrect. Checking of working is essential in such questions.

**(c) (i)** The Doppler effect was described correctly.

**(c) (ii)** The question gave a specific direction of motion for the star. This required a specific answer, and just suggesting the frequency would change was not sufficient. The candidate should have given either an increase or a decrease.

**(d)** The candidate should have written out the given formula from the formula page. The terms in the question could then have been attributed to the symbols in that equation more carefully. The candidate confused the two given frequencies and obtained an incorrect answer. The negative sign obtained should have signalled to the candidate that something was wrong, but the negative sign was ignored.

Mark awarded = **(a) 1/2**
Mark awarded = **(b) 2/3**
Mark awarded = **(c) (i) 1/1, (ii) 0/1**
Mark awarded = **(d) 1/3**

**Total marks awarded = 5 out of 10**

## Example candidate response – low

**4 (a)** By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal: The energy is ~~...~~ parallel to The direction of The propagation, such as a sound wave.

(1)

transverse: The energy is perpendicular to the direction of the propagation, such as in a guitar string.

[2]

**(b)** The intensity of a sound wave passing through air is given by

$$I = Kv\rho f^2 A^2$$

where $I$ is the intensity (power per unit area),
$K$ is a constant without units,
$v$ is the speed of sound,
$\rho$ is the density of air,
$f$ is the frequency of the wave
and $A$ is the amplitude of the wave.

Show that both sides of the equation have the same SI base units.

power = f × d / t

− power = mad / t

= kgms⁻²m / s

= kgm²s⁻³ / t (2)

= kgm²s⁻⁴

− v = ~~...~~ ms⁻¹

− ρ = m / v = kg / m³ = kgm⁻³

− f = ~~...~~ s⁻³

− A = m²

I = ~~K~~vρ f² A²

kgm²s⁻⁴ / m² = m~~s~~⁻¹ kgm⁻³ s⁻³ ~~m²~~ (3)

~~kgs~~⁻⁴ = ~~kgs~~⁻⁴

Thus proved

[3]

## Examiner comments

(1) These definitions make no sense and do not describe the waves in the detail required.

Mark for (a) = 0/2

(2) The correct equation for power here, but mathematical error made in analysis.

(3) There is an apparent change in the frequency base units to make units on each side of the equation equal. This means that no marks can be awarded.

Mark for (b) = 0/3

| Example candidate response – low, continued | Examiner comments |
|---|---|
| **(c) (i)** Describe the *Doppler effect*.<br>The change in apparent frequency due to the ~~change in~~ movement of the source or observer [1] **4** | **4** A clear description is given here. |
| **(ii)** A distant star is moving away from a stationary observer.<br>State the effect of the motion on the light observed from the star.<br>The apparent frequency would decrease **5** [1] | **5** A correct statement is made here.<br>Mark for (c) = 2/2 |
| **(d)** A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is 340 m s$^{-1}$.<br>Calculate the speed of the car.<br>$f_o = \left(\frac{V_w}{V_w - V_s}\right) f_s$<br>$550 = \left(\frac{340}{340 - V_s}\right) 510$<br>$40 = \frac{340}{340 - V_s}$<br>$340 = 13600 - 40V_s$<br>$-13260 = -40V_s$<br>$V_s = 331.5$ **6**<br>speed = 331.5 m s$^{-1}$ [3]<br>[Total: 10] | **6** Good presentation of equation and correct substitution of values. A mathematical error is made in the third line, leading to an incorrect final answer and one mark not awarded.<br>Mark for (d) = 2/3<br>**Total marks awarded = 4 out of 10** |

## How the candidate could have improved their answer

**(a)** The definitions of the two wave motions required specific detail. The descriptions given were far from the correct versions.

**(b)** The candidate needs to practise this kind of analysis of base units. Errors were made in the determination of the base units of power, and these were not linked to the base units of intensity. The right-hand side should have been completed independently and not influenced by the answer on the left-hand side. If there was no agreement, then both sides should have been checked for errors, instead of one side being 'made' to agree with the other. The working and result here were therefore not awarded any marks.

**(d)** The use of the given formula and correct substitution was well presented. The candidate needs to practise rearranging equations of this type.

Mark awarded = **(a) 0/2**
Mark awarded = **(b) 0/3**
Mark awarded = **(c) (i) 1/1, (ii) 1/1**
Mark awarded = **(d) 2/3**

**Total marks awarded = 4 out of 10**

## Common mistakes candidates made in this question

**(a)** Many answers did not follow the specific requirements of the question. The question was often not read carefully and the key reference to the direction of the propagation of energy was missed. Use of the terms ‘wave motion’ or ‘wave travel’ was not accepted as these terms did not answer the question and are used to describe the phenomena of waves in general.

**(b)** The candidates did not always use the information for intensity given in the question. There were mathematical errors when cancelling power terms. The two sides of the equation were often made to agree with each other in terms of base units and this introduced more mistakes**.**

**(c) (i)** The frequency heard or measured was not described as being different from the source’s frequency but a change in the frequency emitted from the source was implied. The need to have relative motion between the source and the observer was also omitted. A change of distance between the source and observer was also incorrectly suggested as a reason for the change in observed frequency.

**(c) (ii)** Many candidates merely mentioned the intensity change that would be observed. The effect of the motion of the star was required. Some answers were not specific with the direction of the change in the wavelength or frequency.

**(d)** Some answers did not use the formula given on the formula page. Many candidates did not fully understand the meaning of the symbols and did not link the symbols to the data given in the question correctly. There were mathematical errors in rearranging the equation and these often led to a negative value for the speed. Some candidates then gave a positive answer without any comment.

# Question 5

## Example candidate response – high

**5 (a)** Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction: It is the spreading of waves through a narrow gap or opening. **1**

interference: Interference is the overlapping of waves when they meet at a common point. These waves must be coherent, of the same type and polarised in the same plane. **2**

[3]

**(b)** The diffraction grating illustrated in Fig. 5.1 is used with light of wavelength 486 nm.

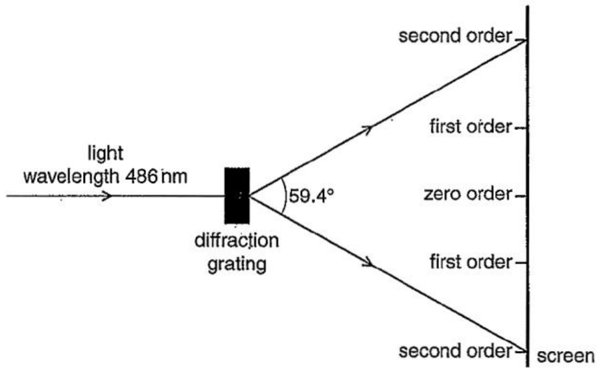



**Fig. 5.1** (not to scale)

The orders of the maxima produced are shown on the screen in Fig. 5.1. The angle between the two second order maxima is 59.4°.

Calculate the number of lines per millimetre of the grating.

$\frac{59.4}{2} = 29.7°$

$d \sin\theta = n\lambda$

$d \sin 29.7° = 2(4.86 \times 10^{-7})$

$\therefore d = 1.96 \times 10^{-6}$ m

$d = \frac{1}{N}$

$1.96 \times 10^{-6} = \frac{1}{N}$ **3**

$\therefore N = 509731$ lines (m)

$\therefore N = 509731140$ (mm)

number of lines per millimetre = 509731140 mm$^{-1}$ [3]

[Total: 6]

## Examiner comments

**1** There is no direct association with diffraction at a grating element but there is sufficient detail for marks to be awarded.

**2** There is no explanation of how the second order maximum is formed by the interference of waves overlapping from each diffraction element.

Mark for (a) = 2/3

**3** The value of *d* is correct. The conversion from m$^{-1}$ to mm$^{-1}$ is incorrect and gives a rather inappropriate answer.

Mark for (b) = 2/3

**Total marks awarded = 4 out of 6**

## How the candidate could have improved their answer

**(a)** The question was an application of diffraction and interference with a diffraction grating. The candidate needed to apply their knowledge to the application and not give just the basic theory. The basic theory of interference needed to be applied to the production of the first order maximum. Practice with questions on applications as well as learning basic theory is required.

**(b)** The diffraction grating equation was used and the given data interpreted correctly. There was a mathematical error in the calculation and the final answer was not realistic. The candidate needed to be more familiar with likely values for applications of basic theory.

## Example candidate response – middle

**5** **(a)** Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction: The wave experience a bending due to meeting an apertune or obstacle **1**

interference: When two or more waves meet at a point, ~~the~~ the displacements add up, and there is a change in displacement. **2**

[3]

**(b)** The diffraction grating illustrated in Fig. 5.1 is used with light of wavelength 486 nm.

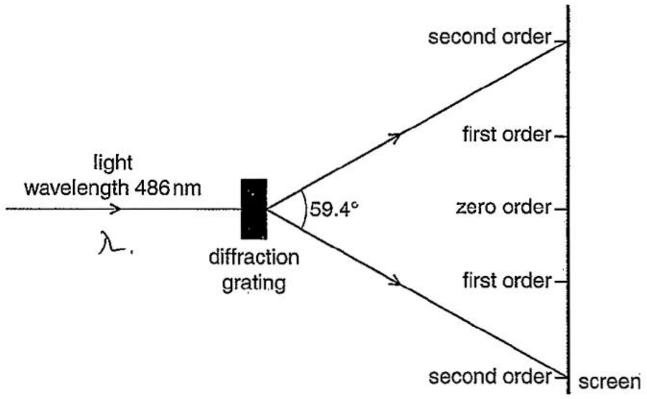



**Fig. 5.1** (not to scale)

The orders of the maxima produced are shown on the screen in Fig. 5.1. The angle between the two second order maxima is 59.4°.

Calculate the number of lines per millimetre of the grating.

$D \sin\theta = n\lambda$

$D = \frac{2 \times 486 \times 10^{-9}}{\sin(\frac{59.4°}{2})}$

$D =$ ~~1.13 No~~ $1.96 \times 10^{-6}$ **3**

number of lines per millimetre = .................................... $mm^{-1}$ [3]

[Total: 6]

## Examiner comments

**1** Bending is inappropriate for diffraction and there is no application to the diffraction grating.

**2** Interference in general is described but there is no answer to the formation of the second order maximum as asked for in the question.

Mark for (a) = 1/3

**3** There is complete substitution of the correct values in the diffraction grating equation. The use of *D* rather than *d* is allowed. The final conversion of *d* to *N* is not shown.

Mark for = 2/3

**Total marks awarded = 3 out of 6**

## How the candidate could have improved their answer

**(a)** The candidate needed to learn the basic theory of diffraction and be able to apply this theory to specific examples. The candidate's knowledge of interference needed to be used in the application in the question.

**(b)** The candidate needed to be aware of the relation between the number of lines per mm and the size of the grating element in order to complete the question.

## Example candidate response – low

**5 (a)** Light of a single wavelength is incident on a diffraction grating. Explain the part played by *diffraction* and *interference* in the production of the first order maximum by the diffraction grating.

diffraction: → This is when the light wave gets spreaded out or we can say when it bends on the edges. **1**

interference: this is when the two waves meet at this point they may form a constructive interference or destructive interference. **2**

[3]

**(b)** The diffraction grating illustrated in Fig. 5.1 is used with light of wavelength 486 nm.

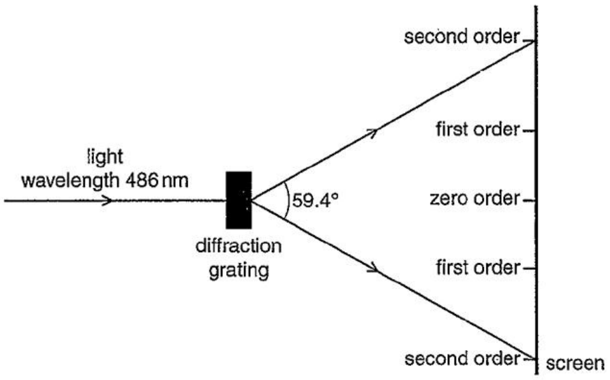



**Fig. 5.1** (not to scale)

The orders of the maxima produced are shown on the screen in Fig. 5.1. The angle between the two second order maxima is 59.4°.

Calculate the number of lines per millimetre of the grating. λ : 486

d sinθ = nλ **3**

d sin 59.4 = 2 × 486 **4** **5**

d = 1129.3

$\frac{1}{1129.3}$ = 8.85 × 10⁻⁴

number of lines per millimetre = 8.85 × 10⁻⁴ mm⁻¹ [3]

[Total: 6]

## Examiner comments

**1** There is no proper explanation of diffraction in general or to this application of the diffraction grating. 'Bending on an edge' is incorrect.

**2** The description of interference is acceptable. There is no description of this application into the production of the first order maximum as asked for in the question.

Mark for (a) = 1/3

**3** The formula is stated correctly.

**4** The angle used is incorrect and so is inappropriate/incorrect physics.

**5** The power of ten for the wavelength is incorrect.

Mark for (b) = 1/3

**Total marks awarded = 2 out of 6**

## How the candidate could have improved their answer

**(a)** The candidate needed to learn the basic theory of diffraction as well as being able to apply the theory to specific examples. Knowledge of the basic theory of interference was given. Practice with applying this knowledge to specific examples is required.

**(b)** The candidate needed to practise the basic diffraction grating formula with many different examples.

## Common mistakes candidates made in this question

**(a)** Diffraction was described as the bending of light. Bending is associated with refraction. The effect of diffraction is a wave property and hence diffraction at a grating should be associated with waves after they have passed through the diffraction element. The effect of interference to produce the first order maximum was not described for this specific example.

**(b)** The angle given on the diagram was used as the angle $\theta$ in the diffraction grating equation. The distance *d* was quoted as the number of lines per mm *N.* There were power of ten errors converting *d* in metres to *N* in $mm^{-1}$.

# Question 7

## Example candidate response – high

**7 (a)** Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*.

It means that charge is divide among the electrons **1** .......[1]

**(b)** A battery of electromotive force (e.m.f.) 9.0V and internal resistance 0.25Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

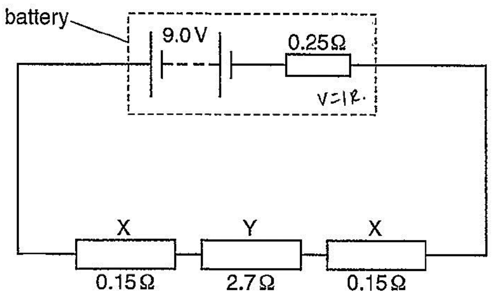



**Fig. 7.1**

The resistance of each resistor X is 0.15Ω and the resistance of resistor Y is 2.7Ω.

**(i)** Show that the current in the circuit is 2.8A.

V = IR.

I = 9/

Vbattery / Rtotal = I

I = 9 / (0.25 + 0.15 + 0.15 + 2.7)

= 2.769 A **2**

= 2.8 A

[3]

**(ii)** Calculate the potential difference across the battery.

V = IR

V = 2.8 × 0.25

= 0.69

9 − 0.69

= 8.307

= 8.31 **3**

potential difference = ....8.31.... V [2]

## Examiner comments

**1** Basic theory requirement of current electricity not given correctly.

Mark for (a) = 0/1

**2** All the correct requirements given for a 'show that' question.

Mark for (b) (i) = 3/3

**3** The working and answer are fully correct showing good knowledge and understanding.

Mark for (b) (ii) = 2/2

## Example candidate response – high, continued

**(c)** Each resistor X connected in the circuit in **(b)** is made from a wire with a cross-sectional area of 2.5 $mm^2$. The number of free electrons per unit volume in the wire is $8.5 \times 10^{29} m^{-3}$.

**(i)** Calculate the average drift speed of the electrons in X.

$I = nAve$

$2.8 = 8.5 \times 10^{29} \times 2.5 \times 10^{6} \times v \times 1.6 \times 10^{-19}$

4

$\frac{2.8}{3.4 \times 10^{17}} = v$

$v = 8.14 \times 10^{-18}$

drift speed = $8.14 \times 10^{-18}$ $ms^{-1}$ [2]

**(ii)** The two resistors X are replaced by two resistors Z made of the same material and length but with half the diameter.

Describe and explain the difference between the average drift speed in Z and that in X.

Since the drift speed is inversely proportional to cross-sectional area the drift speed in Z will be increased by 4 times. It will be four times more than X as the area is four times less than X [2]

5 6

[Total: 10]

## Examiner comments

**4** There is a basic error in the conversion of units. The remainder of the substitution and the calculation are correct following this error.

Mark for (c) (i) = 1/2

**5** The error here is to assume the current is constant (a requirement for the statement made by the candidate).

**6** The dependence of the resistance on area is correct and is awarded one of the marks available.

Mark for (c) (ii) = 1/2

**Total marks awarded = 7 out of 10**

## How the candidate could have improved their answer

**(a)** Basic knowledge of this term needed to be learned.

**(c) (i)** More practice with the conversion of units might have helped the candidate to achieve full credit here.

**(c) (ii)** More practice with the applications of circuit theory might have helped here.

Mark awarded = **(a) 0/1**
Mark awarded = **(b) (i) 3/3, (ii) 2/2**
Mark awarded = **(c) (i) 1/2, (ii) 1/2**

**Total marks awarded = 7 out of 10**

## Example candidate response – middle

**7 (a)** Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*.

'quantised' means expressed as a numerical value. [1]

**1**

**(b)** A battery of electromotive force (e.m.f.) 9.0V and internal resistance 0.25Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

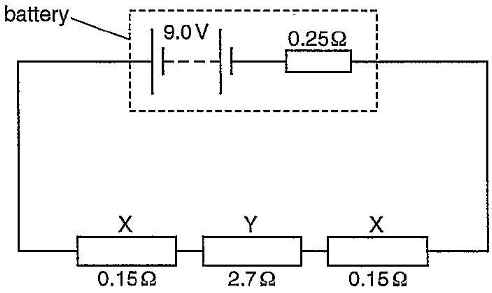



**Fig. 7.1**

The resistance of each resistor X is 0.15Ω and the resistance of resistor Y is 2.7Ω.

**(i)** Show that the current in the circuit is 2.8A.

V = IR

9 = I (0.25 + 0.15 + 0.15 + 2.7)

9 = I (3.25)

∴ I = 2.8 A  shown. **2**

[3]

**(ii)** Calculate the potential difference across the battery.

~~p.d.=~~ V = IR

= 2.8 x 0.25

= 0.7 V **3**

potential difference = 0.7 V [2]

## Examiner comments

**1** The meaning of this term applied to current electricity is clearly not known.

Mark for (a) = 0/1

**2** The equation and full substitution are shown, with the correct final answer. The calculated value for 9 / 3.25 (= 2.77) would have confirmed that this calculation had been completed.

Mark for (b) (i) = 3/3

**3** This is the p.d. across the internal resistance and therefore is a misconception and an incorrect answer.

Mark for (b) (ii) = 0/2

<table>
<tr><th>Example candidate response – middle, continued</th><th>Examiner comments</th></tr>
<tr><td>
(c) Each resistor X connected in the circuit in (b) is made from a wire with a cross-sectional area of 2.5 $mm^2$. The number of free electrons per unit volume in the wire is $8.5 \times 10^{29}\ m^{-3}$.<br><br>
(i) Calculate the average drift speed of the electrons in X.<br><br>
I = nAVq<br>
2.8 = (8.5 × 10^29)·(2.5 × 10^-3)(V)·(1.6 × 10^-19)<br>
∴ V = 8.2 × 10^-9 ms^-1 ❹<br><br>
drift speed = 8.2 × 10^-19 $ms^{-1}$ [2]<br><br>
(ii) The two resistors X are replaced by two resistors Z made of the same material and length but with half the diameter.<br><br>
Describe and explain the difference between the average drift speed in Z and that in X.<br><br>
If the diameter is halved, the area is decreased by four times ❺ According to I = nAVq, if the area decreases by four times, the <s>veloci</s> average drift speed which increase by ❻ four times [2]<br><br>
[Total: 10]<br><br>
I / nAq = V
</td><td>
❹ The conversion to $m^2$ is incorrect. The answer is correct following this error so one mark is awarded.<br><br>
Mark for (c) (i) = 1/2<br><br>
❺ The effect on the area of reducing the diameter is correct.<br><br>
❻ The assumption that the change in area will only affect the drift speed and not the current as well is a misconception.<br><br>
Mark for (c) (ii) = 1/2<br><br>
Total marks awarded = 5 out of 10
</td></tr>
</table>

## How the candidate could have improved their answer

**(a)** Basic knowledge of this term needed to be learned.

**(b) (i)** The calculation of 9 / 3.25 should have been stated before giving the answer to two significant figures, as this answer is given in the question.

**(b) (ii)** The candidate misunderstood this calculation. The potential difference across the battery is not the potential difference across the internal resistance, which is the lost volts.

**(c) (i)** In order to obtain full marks, the candidate needed more practice converting units, in this case $mm^2$ to $m^2$.

**(c) (ii)** The effect of the change in diameter on the resistance was described by the candidate. The effect of the change in the resistance on the current was missed. This type of question can only be completed successfully after having had greater practice with the applications of circuitry.

Mark awarded = **(a) 0/1**
Mark awarded = **(b) (i) 3/3, (ii) 0/2**
Mark awarded = **(c) (i) 1/2, (ii) 1/2**

**Total marks awarded = 5 out of 10**

## Example candidate response – low

7 (a) Electric current is a flow of charge carriers. The charge on the carriers is quantised. Explain what is meant by *quantised*. ❶

Measured how many charge flows per unit time [1]

(b) A battery of electromotive force (e.m.f.) 9.0 V and internal resistance 0.25 Ω is connected in series with two identical resistors X and a resistor Y, as shown in Fig. 7.1.

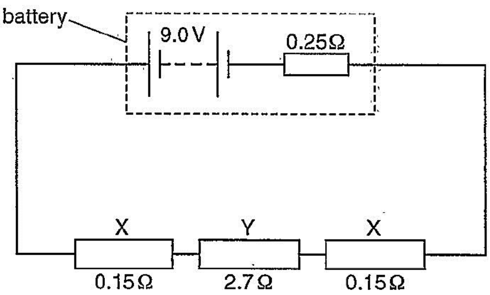



**Fig. 7.1**

The resistance of each resistor X is 0.15 Ω and the resistance of resistor Y is 2.7 Ω.

(i) Show that the current in the circuit is 2.8 A.

$E = I(R + r + r + r)$

$9.0\text{V} = I(0.25 + 0.15 + 2.7 + 0.15)$

$9.0 = I(3.25)$

$I = \frac{9.0}{3.25}$ ❷

$= 2.769$

$\simeq 2.8\text{A}$

shown. [3]

(ii) Calculate the potential difference across the battery.

$V = IR$

$V = 2.769 \times 0.25$

$V = 0.69\text{V}$ ❸

potential difference = 0.69 V [2]

## Examiner comments

❶ The answer shows a lack of knowledge of this term.

Mark for (a) = 0/1

❷ This is a complete answer which is also very well presented.

Mark for (b) (i) = 3/3

❸ This is the calculation of the p.d. across the internal resistance and shows a lack of understanding.

Mark for (b) (ii) = 0/2

| Example candidate response – low, continued | Examiner comments |
|---|---|
| **(c)** Each resistor X connected in the circuit in **(b)** is made from a wire with a cross-sectional area of 2.5 $mm^2$. The number of free electrons per unit volume in the wire is $8.5 \times 10^{29}$ $m^{-3}$.<br>$2.5\times10^{-3}m^2$<br>**(i)** Calculate the average drift speed of the electrons in X.<br>$I = nAve$<br>$2.8 = 8.5\times10^{29} \times 2.5\times10^{-3} \times V \times 1.60\times10^{-19}$<br>$2.8 = 3.4\times10^{8}\ V$ **4**<br>$V = \frac{2.8}{3.4\times10^{8}}$<br>$V = 8.24\times10^{-9}$ drift speed = $8.24\times10^{-9}$ $ms^{-1}$ [2]<br>**(ii)** The two resistors X are replaced by two resistors Z made of the same material and length but with half the diameter.<br>Describe and explain the difference between the average drift speed in Z and that in X.<br>Resistance is doubled **5** therefore the current decreases so the average drift speed in Z is less than in X. It may be halved.<br>[2]<br>[Total: 10] | **4** The conversion of the area to $m^2$ is incorrect. The remaining substitution of values and final answer get one mark as the error has been carried forward.<br><br>Mark for (c) (i) = 1/2<br><br>**5** This is stated with no supporting evidence. This is incorrect and so no marks are awarded.<br><br>Mark for (c) (ii) = 0/2<br><br>**Total marks awarded = 4 out of 10** |

## How the candidate could have improved their answer

**(a)** Basic terms needed to be learned here.

**(b) (ii)** The calculation showed a lack of understanding of lost volts and battery potential difference. Practice with calculating potential differences in many different situations would have helped with this.

**(c) (i)** Practice with converting units would have helped the candidate with this question.

**(c) (ii)** Greater knowledge was required about the effect of changes in diameter / area on the resistance.

Mark awarded = **(a) 0/1**
Mark awarded = **(b) (i) 3/3, (ii) 0/2**
Mark awarded = **(c) (i) 1/2, (ii) 0/2**

**Total marks awarded = 4 out of 10**

## Common mistakes candidates made in this question

**(a)** This basic term of current electricity was not known in sufficient detail.

**(b) (i)** Some calculations omitted one of the resistances in the circuit, generally the internal resistance of the battery.

**(b) (ii)** The potential difference across the internal resistance was given as the potential difference across the battery.

**(c) (i)** The equation given on the formula page was not used, or the symbols in the equation were not associated correctly with the data provided in the question.

**(c) (ii)** The effect of the change of resistance on the current in the circuit was not realised and the drift speed was assumed to be inversely proportional to the cross-sectional area.

Cambridge International Examinations
1 Hills Road, Cambridge, CB1 2EU, United Kingdom
t: +44 1223 553554    f: +44 1223 553558
e: **info@cie.org.uk**    **www.cie.org.uk**


Version 1.0

Cambridge Assessment