WAVES

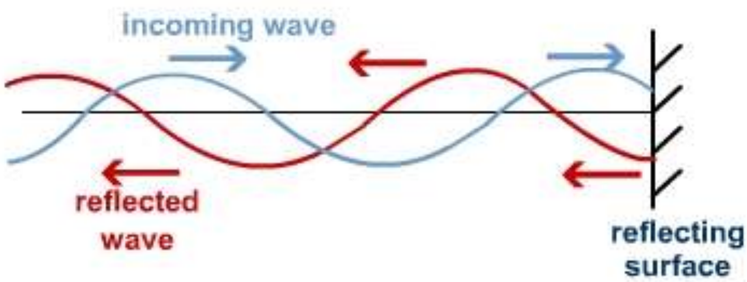
A LEVEL PHYSICS

EXAMINATION PREPARATION BOOK

STUDENT BOOK

TOPIC BOOK

NAME	
PHYSICS CLASS	
MODULE TEACHER	
ALPS GRADE	



Please complete all of these questions in this book and store this work in your student files.

This will provide a useful resource for revision.

In the following booklet there are several questions based on the module '3.3 Waves'. These questions are additional to the work which you must do on your A-Level course.

To gain the highest grade possible in your A-Level examinations it is recommended that you complete these questions in the supervised study sessions carried out in school.

This will both familiarise yourself with both the concepts found in the A-Level syllabus and the examination technique found in examinations.

The mark scheme to the questions is integrated in the book for you to use independently.

To improve competency in answering questions on mechanics and materials and achieve mastery in this module, answer all of these questions independently.

When you have completed your work in this book, please store this work in your student files.

Many thanks for all of your hard work in A-Level Physics.

Mr. Turnbull

QUESTION ONE

1.1 In an experiment to investigate microwaves, a microwave detector **D** is placed between a microwave transmitter **T** and a flat metal sheet.

The detected signal at **D** shows regions of maximum and minimum intensity as **D** is moved towards the metal sheet as shown in **Fig. 7.1**. The distance between adjacent regions of maximum and minimum intensities is 72 mm.

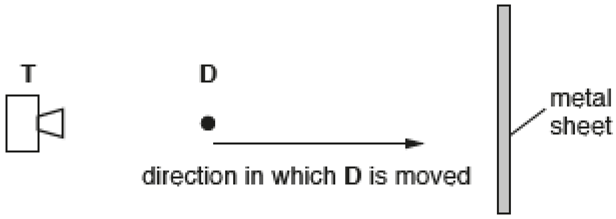


Fig. 7.1

Explain the presence of the regions of maximum and minimum intensity and determine the frequency of the microwaves.

The speed of microwaves in air is 3.0×10^8 m s^{-1}.

[6 Marks]

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1.2 In another experiment using microwaves, a metal grille **G** consisting of a series of long metal rods is placed between the transmitter **T** and the detector **D** as shown in **Fig. 7.2.**

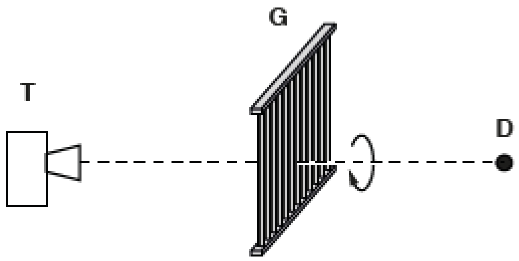

Fig. 7.2

The grille is slowly rotated through 180° about the line joining **T** and **D**. The detected signal **at D** varies from zero to maximum and back to zero again.

Explain why the detected signal behaves in this way.

[2 Marks]

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Reference: OCR AS Level Physics Paper 2 June 2018 Examination

MARK SCHEME

Question	Answer	Marks	Guidance
1.1	**Level 3 (5–6 marks)** Clear explanation of observations **and** correct determination of frequency. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Clear explanation of observations **or** correct method to determine the frequency **or** some explanation of observations and some method for the determination of the frequency *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Has limited explanation of observations **or** limited evidence of method to determine the frequency *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	B1 x6	**Indicative scientific points may include:** Explanation of observations • Metal sheet reflects microwaves • Idea/description of superposition • Constructive/destructive interference • Standing wave pattern between T and plate • Maxima are antinodes and and minima are nodes. • Phase difference at nodes and antinodes • Distance between successive maxima/minima is $\lambda/2$ • Distance between adjacent regions of maximum and minimum intensities is $\lambda/4$ Determination of frequency • $f = \frac{v}{\lambda}$ • $\lambda = 4 \times 72$ mm = 288 mm • $f = \frac{3\times10^8}{288\times10^{-3}} = 1.04 \times 10^9\text{Hz}$
1.2	Microwaves from **T** are transverse/polarised wtte At 0° or 180° the grille blocks (all) the (polarised) waves and at 90° the grille allows all the microwaves to pass.	B1 B1	**Allow** E field perpendicular to direction of motion **Allow** explanation in terms of $I = I_0 \cos^2\theta$
	Total	8	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TWO

(a) When used to describe stationary (standing) waves explain the terms

(i) node ....

.... **[1]**

(ii) antinode. ....

.... **[1]**

(b) Fig. 5.1 shows a string fixed at one end under tension. The frequency of the mechanical oscillator close to the fixed end is varied until a stationary wave is formed on the string.

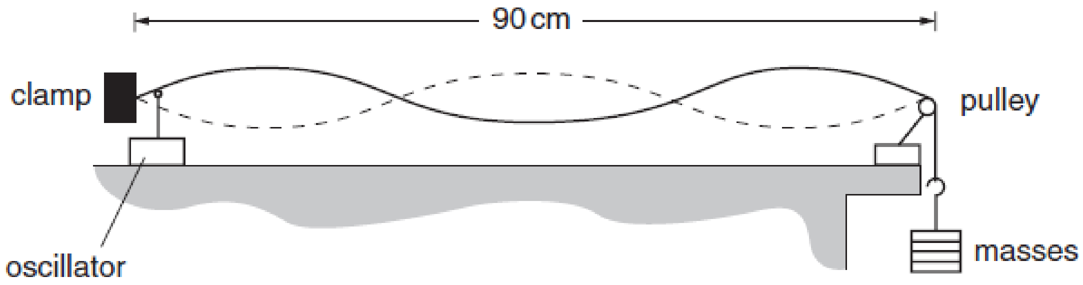

Fig. 5.1

(i) Explain with reference to a progressive wave on the string how the stationary wave is formed.

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.... **[3]**

(ii) On Fig. 5.1 label one node with the letter **N** and one antinode with the letter **A**. **[1]**

(iii) State the number of antinodes on the string in Fig. 5.1.

number of antinodes = ... **[1]**

(iv) The frequency of the oscillator causing the stationary wave shown in Fig. 5.1 is 120 Hz.

The length of the string between the fixed end and the pulley is 90 cm.

Calculate the speed of the progressive wave on the string.

speed = ... $m\,s^{-1}$ **[3]**

(c) The speed *v* of a progressive wave on a stretched string is given by the formula

$$v = k\sqrt{W}$$

where *k* is a constant for that string. *W* is the tension in the string which is equal to the weight of the mass hanging from the end of the string.

In **(b)** the weight of the mass on the end of the string is 4.0 N. The oscillator continues to vibrate the string at 120 Hz. Explain whether or not you would expect to observe a stationary wave on the string when the weight of the suspended mass is changed to 9.0 N.

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.... **[3]**

[Total: 13]

Reference: OCR Physics Unit 2 June 2009 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
5	(a)	(i)	node occurs where the amplitude/displacement is (always) zero	B1	**accept** displacement for amplitude for **(i)** only
		(ii)	antinode occurs where the amplitude (of the standing wave) takes the maximum (possible) value	B1	
	(b)	(i)	wave travels to end and is reflected reflected wave interferes/superposes with incident wave always destructively at certain points to produce nodes **or** always constructively at certain points to produce antinodes	B1 B1 B1	**accept** 2 waves of same f travelling in opposite directions interfere with no reference to reflection
		(ii)	A and N points labelled correctly	B1	
		(iii)	3	B1	
		(iv)	30 cm = $\lambda/2$ or λ = 60 cm $v = f\lambda = 120 \times 0.6$ $v = 72$ (m s^{-1})	C1 C1 A1	**allow** 1 mark for correct calculation using $v = f\lambda$ with wrong wavelength if method/reasoning clear
	(c)		v = 2k becomes v = 3k (k = 36) wavelength increases by 3/2 (as frequency unchanged) 2 half wavelengths fit on the string so standing wave is set up/AW	B1 B1 B1	**accept** v increases by 3/2 or v = 108 m s^{-1} **accept** wavelength becomes 90 cm **allow ecf** correct conclusion with wrong λ
			Total question 5	**13**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION THREE

(a) A parallel beam of red light of wavelength 6.3×10^{-7} m from a laser is incident normally on a diffraction grating as shown in Fig. 6.1.

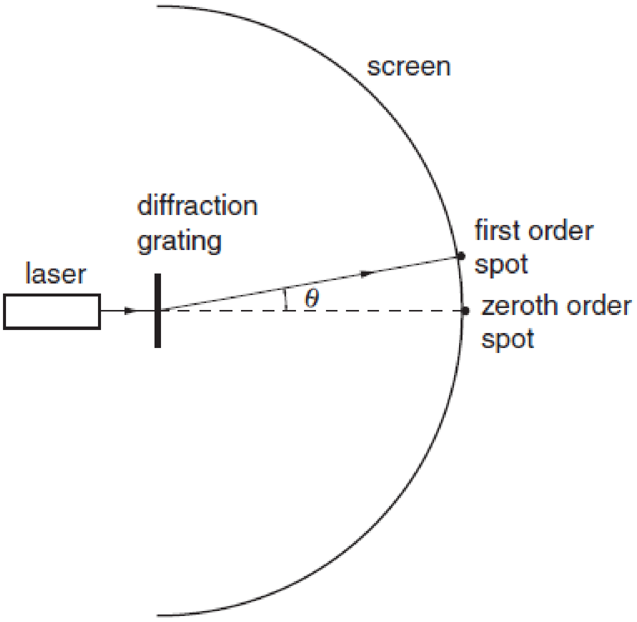

Fig. 6.1

Bright red spots are observed on the curved screen placed beyond the grating.

(i) The diffraction grating has 300 lines per millimetre. Show that the separation d between adjacent lines of the grating is 3.3×10^{-6} m.

[1]

(ii) Calculate the angle θ at which the first order red spot is seen. This is the first spot away from the straight through position.

θ = ... degrees **[3]**

(iii) The screen curves around the full 180° in front of the grating. Explain why there are eleven bright red spots on the screen.

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.... **[3]**

(b) Calculate

(i) the energy of each photon of light emitted by the laser at a wavelength of 6.3×10^{-7} m

energy = ... J **[2]**

(ii) the number of photons emitted each second to produce a power of 0.50 mW.

number = ... **[2]**

(c) **(i)** A beam of electrons in a vacuum can travel through a thin sheet of graphite perpendicular to the beam to produce a diffraction pattern of rings on a fluorescent screen beyond the graphite sheet. Explain why this pattern is produced.

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.... **[3]**

(ii) Calculate

1 the speed v of electrons with a de Broglie wavelength of 5.0×10^{-11} m

v = ... $m\,s^{-1}$ **[2]**

2 the potential difference V required to accelerate the electrons to this speed.

V = ... V **[3]**

[Total: 19]

Reference: OCR Physics Unit 2 June 2009 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
6	(a)	(i)	line spacing d = 1/(300 x 1000) (= 3.3 x 10^{-6} (m))	B1	look for clear reasoning to award mark
		(ii)	sin θ = λ/d = 6.3 x 10^{-7}/3.3 x 10^{-6} = 0.19 θ = 11 degrees	C1 C1 A1	rounding error of 0.2 here gives 11.9° 11.9° gets 2 marks
		(iii)	spots can be seen where n = d sin θ/λ maximum n when sin θ = 1 (giving n = 5.3) so n =5 can be seen thus 5 spots on either side of straight through + straight through = 11	B1 B1 B1	**accept** basic idea of orders for first mark N.B. calculation not necessary
	(b)	(i) (ii)	ε = hc/λ = 6.6 x 10^{-34} x 3.0 x 10^{8}/6.3 x 10^{-7} = 3.14 x 10^{-19} (J) 5.0 x 10^{-4}/3.14 x 10^{-19} = 1.6 x 10^{15}	C1 A1 C1 A1	**accept** 3.2 x 10^{-19} (J) **ecf** from **b(i)1**
	(c)	(i)	Electrons behave as waves/have a wavelength diffraction observable because gaps/atoms are similar to wavelength of electrons regular pattern of atoms acts as a grating allowing constructive interference to produce pattern on screen/AW rings occur because atomic 'crystals' at all possible orientations to beam/AW	B1 B1 B1 B1 B1	max 2 out of next 4 marking points **can** gain first 'waves' mark here as well as second mark if first line not written explicitly
		(ii) 1 2	λ = h/mv = 6.63 x 10^{-34}/9.1 x 10^{-31}v v = 6.63 x 10^{-34}/9.1 x 10^{-31} x 5.0 x 10^{-11} v = 1.5 x 10^{7} (m s^{-1}) ½mv^2 = eV ½ x 9.1 x 10^{-31} x 2.25 x 10^{14} = 1.6 x 10^{-19}V V = 6.4 x 10^{2} (V)	C1 A1 C1 C1 A1	using 6.6 instead of 6.63 gives 1.45 x 10^{7} using v =1.45 x 10^{7} gives 600 V
			Total question 6	**19**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FOUR

4. A refractometer can be used to measure refractive index. A refractometer makes use of the total internal reflection of light at a boundary between two materials.

4.1 Describe the conditions required for total internal reflection to take place at a boundary.

[2 Marks]

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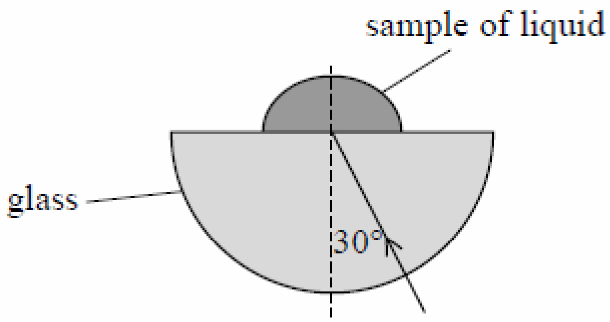
4.2 One type of refractometer is shown.

A sample of liquid is placed on one side of a semi-circular glass prism. A ray of light is shown passing into the prism.



Determine whether this ray will be totally internally reflected from the boundary between the prism and the liquid.

$_{liquid}\mu_{glass} = 1.15$

[3 Marks]

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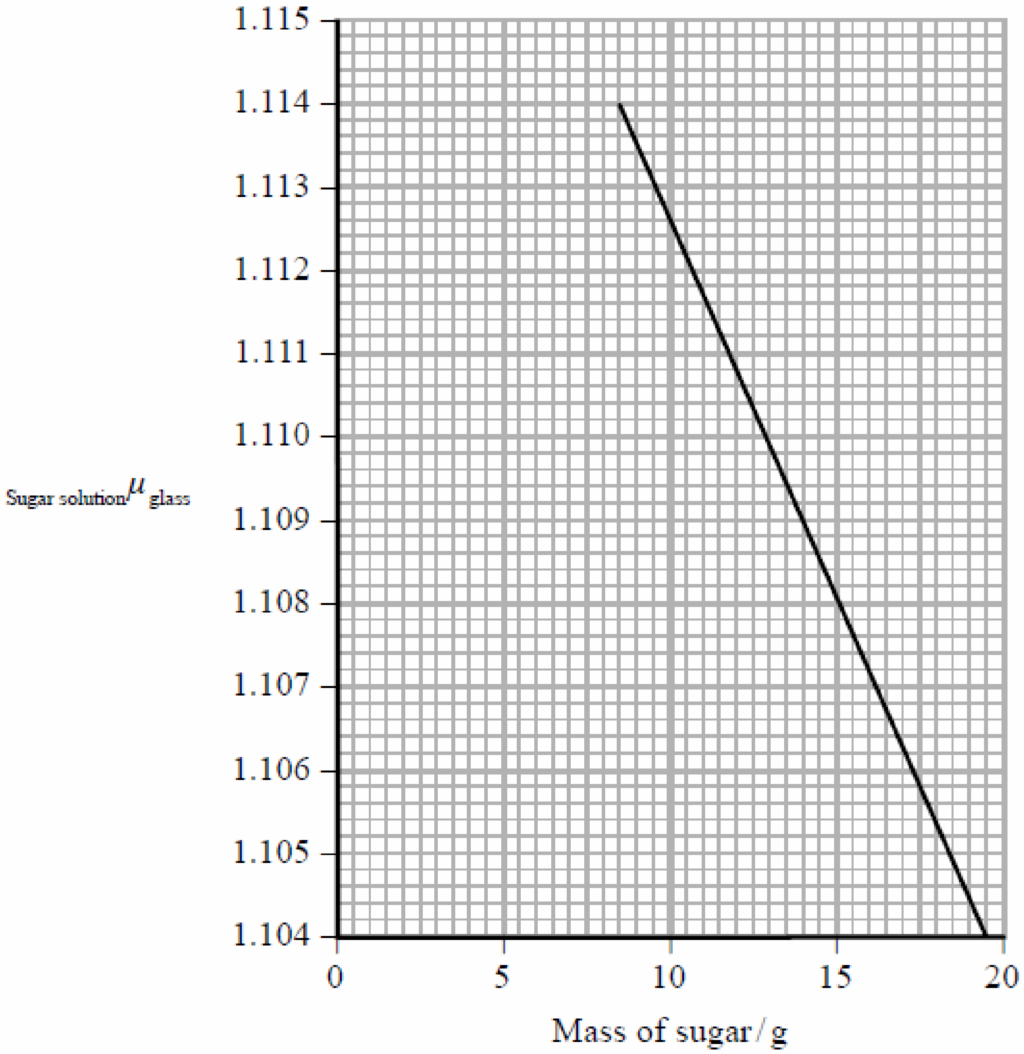
4.3 The graph shows how the refractive index $_{sugar\ solution}\mu_{glass}$ varies with the mass of sugar dissolved in a fixed volume of water.



Explain why the critical angle would have to be measured to a precision of more than two significant figures in order to determine the sugar content to the nearest gram.

[2 Marks]

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Reference: EdExcel International A Level Physics Paper 2 January 2019 Examination

MARK SCHEME

Question Number			Mark
4.1	Light must reach a boundary travelling in a medium of higher refractive index towards one of lower refractive index **Or** light must reach a boundary at which velocity would increase in the second medium **Or** light travelling in more dense medium towards a less dense [rarer] medium	(1)	
	Angle of incidence must be greater than (or equal to) the critical angle	(1)	2
4.2	Use of ${}_1\mu_2 = \sin i / \sin r$	(1)	
	Either Critical angle = 60(°)	(1)	
	The ray will not totally internally reflect as the angle of incidence is smaller than the critical angle	(1)	
	Or Refracted angle = 35(°)	(1)	
	The ray does not totally internally reflect as the ray has refracted into the liquid	(1)	3
	Example of calculation $\frac{1}{1.15} = \frac{\sin i}{\sin 90} = 60.4°$ So not TIR as this is more than 30°		

4.3	Clear link between a mass change and a change in refractive index e.g. A 1 gram change corresponds to (~)0.001 change in refractive index **Or** a calculation of gradient	(1)	
	Comment that (to two sig figs) the refractive index values do not change across the range of the graph **Or** Data used in the graph (for refractive index values) are given to more than two sig figs.	(1)	2
	Total for question 14		7

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FIVE

5. Scientists have succeeded in levitating droplets of liquid. A standing wave is created using ultrasound generated by two sources, one above and one below the liquid. The droplets of liquid are trapped at positions corresponding to nodes as shown.

5.1 Explain how a standing wave is formed.

[3 Marks]

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5.2 Describe the motion of the air at a node and at an antinode.

[3 Marks]

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5.3 The scale of the photograph is half full-size.

Determine the frequency of the ultrasound wave.

Speed of ultrasound in air = 320 m s^{-1}

[5 Marks]

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Reference: EdExcel International A Level Physics Paper 2 January 2019 Examination

MARK SCHEME

Question Number	Answer		Mark
5.1	(Two or more waves meet) travelling in opposite directions **Or** A wave and its reflected wave and superpose / interfere Creating points where the waves are in phase and points where they are in antiphase **Or** creating points of zero/min amplitude and points of maximum amplitude	(1) (1) (1)	**3**
5.2	The particles (of air) are stationary **Or** the particles have minimum/0 amplitude/displacement at a node The particles (of air) oscillate/vibrate with maximum amplitude at an antinode The particles move in a direction that is parallel to the direction of the (original) wave at an antinode	(1) (1) (1)	**3**
5.3	Measures distance across a minimum of 3 spaces Scales x2 Wavelength = 2 × distance between droplets Use of $v = f\lambda$ Frequency = 40000 - 44000 Hz <u>Example of calculation</u> Distance across 6 spaces = 11.5 mm distance between droplets = 1.9 mm scaled distance between droplets = 2×1.9 =3.8 mm wavelength = 2×3.8 mm = 7.6 mm $320 = f \times 7.6 \times 10^{-3}$ $f = 41700$ Hz	(1) (1) (1) (1) (1)	**5**
	Total for question 15		**11**

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SIX

In 1927 it was shown by experiment that electrons can produce a diffraction pattern.

(a) **(i)** Explain the meaning of the term *diffraction*.

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.... **[1]**

(ii) State the condition necessary for electrons to produce observable diffraction when passing through matter, e.g. a thin sheet of graphite in an evacuated chamber.

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.... **[2]**

(b) Show that the speed of an electron with a de Broglie wavelength of 1.2×10^{-10} m is 6.0×10^{6} m s^{-1}.

[3]

(c) The electrons in **(b)** are accelerated to a speed of 6.0×10^6 m s^{-1} using an electron gun shown diagrammatically in Fig. 8.1.

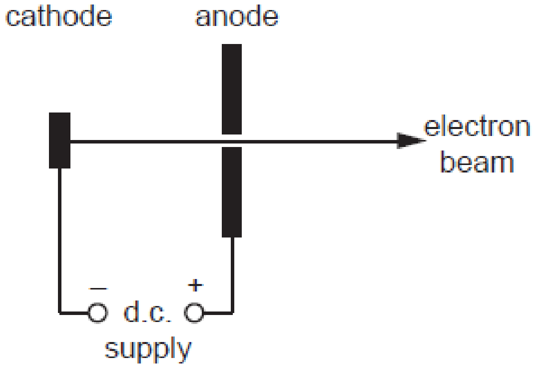

Fig. 8.1

(i) Calculate the potential difference *V* across the d.c. supply between the cathode and the anode.

V = ... V **[3]**

(ii) Suggest why, in an electron gun, the cathode is connected to the negative terminal of the supply rather than the positive terminal.

....

....

.... **[1]**

[Total: 10]

Reference: OCR Physics Unit 2 January 2010 Examination

MARK SCHEME

Question			Expected Answers	Marks	Additional Guidance
8					
	a	i	paths spread out after passing through a gap or around an obstacle/AW	B1	
		ii	wavelength of electrons must be comparable/of the order of magnitude of the atomic spacing	M1 A1	**allow** electrons behave as waves/AW **allow** must be about 10^{-10} m
	b		$\lambda = h/mv$ $v = 6.6(3) \times 10^{-34} / 9.1(1) \times 10^{-31} \times 1.2 \times 10^{-10}$ $= 6.0$ or 6.1×10^{6} (m s^{-1})	C1 M1 A1	mark for selecting formula correct manipulation and subs. shown **give** all 3 marks for answers to 3 figs or more: i.e. 6.04, 6.06 or 6.07
	c	i	$eV = ½mv^2$ $V = mv^2/2e = 9.1 \times 10^{-31} \times (6.0 \times 10^6)^2/2 \times 1.6 \times 10^{-19}$ $= 1.0(2) \times 10^2$ (V)	C1 C1 A1	mark for algebraic equation mark for correct substitution **give** 1 mark max for k.e. = $1.6(4) \times 10^{-17}$ J using 6.1 gives 104 (V)
		ii	electrons should be repelled by cathode and/or attracted by anode **or** they will be attracted back to the cathode/slowed down if cathode positive	B1	**award** mark if answer indicates this idea
			Total question 8	**10**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SEVEN

(a) Name one common property of electromagnetic waves not shared by other waves.

.... **[1]**

(b) Fig. 5.1 shows a block diagram of the seven regions of the electromagnetic spectrum, labelled **A** to **G**.

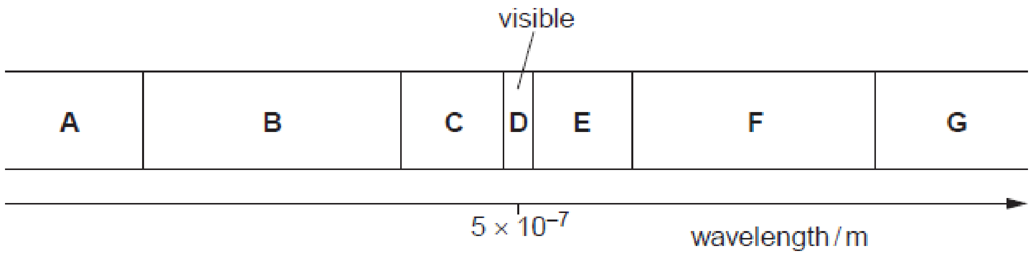

Fig. 5.1

Name the principal radiation in each of the regions **A**, **C** and **F**.

A .... **C** ....

F .... **[3]**

(c) An aerial mounted vertically transmits vertically polarised radio waves of frequency 1.0×10^9 Hz. The waves are detected by a receiving aerial some distance away. Initially the receiving aerial is also mounted vertically as shown in Fig. 5.2.

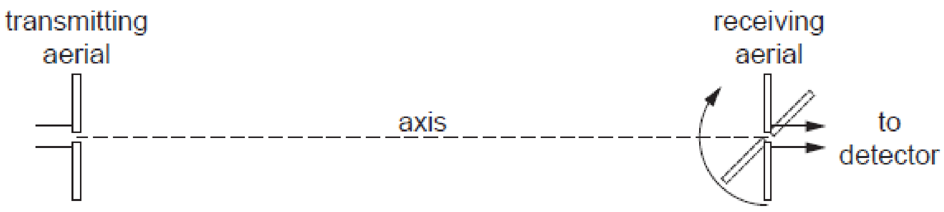

Fig. 5.2

The length of each aerial is half the wavelength of the radio waves.

(i) Calculate the wavelength of the waves.

wavelength = ... m **[2]**

(ii) Calculate the length of an aerial.

length = ... m **[1]**

(iii) The receiving aerial is rotated through 180° about the axis joining the centres of the two aerials. See Fig. 5.2. Describe and explain how the output signal from the receiving aerial changes with the angle of rotation.

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.... **[3]**

(d) Ultra-violet radiation from the Sun is often divided into three regions UV-A, UV-B and UV-C.

(i) Describe the characteristics and dangers of UV-A, UV-B and UV-C radiations.

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.... **[3]**

(ii) Explain how sunscreen protects the human skin.

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.... **[1]**

(e) Explain why electrons can be emitted from a clean metal surface illuminated with bright ultra-violet light but never when infra-red light is used, however intense.

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.... **[2]**

[Total: 16]

Reference: OCR Physics Unit 2 January 2010 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
5					
	a	**i**	travel through a vacuum	B1	**allow** travel at c (in a vacuum)
	b	**ii**	A gamma; C uv; F microwave	B3	**allow** 1 mark for A radio; C ir; F X-ray
	c	**i** **ii**	$3.0 \times 10^8 = 1.0 \times 10^9\ \lambda$ $\lambda = 0.30$ m aerial length = $\lambda/2 = 0.15$ m	C1 A1 A1	 **allow** 0.3 no SF error **ecf (c)(i)**
		iii	emitted wave is (plane) polarised detecting aerial will receive weaker signal/cos θ component when it is rotated (through angle θ)/AW signal falls to zero at 90° and then rises to max again at 180°	B1 B1 B1	**allow** max signal initially/at 0° **max 3 marks** from 4 marking points
	d	**i**	UV-A causes tanning or skin ageing ; most of (99%) uv light; 400-315 nm UV-B causes damage or sunburn or skin cancer; 315-260 nm UV-C is filtered out by atmosphere/ozone layer; 260-100 nm	B1 B1 B1	accept values within ranges with tolerance of 20 nm **allow** $\lambda_A > \lambda_B > \lambda_C$ for 1 mark **max 3 marks** from 7 marking points
		ii	filters out/blocks/reflects/absorbs UV(-B)	B1	**allow** chemicals prevent sunburn/skin cancer **not** stops UV penetrating skin
	e		energy of the infra-red photon is less than the work function of the metal surface	B1 B1	**accept** frequency and threshold frequency **or** wavelength and threshold wavelength used correctly in place of energy and work function **1 mark** only: energy of the uv photon greater than work function with no mention of ir
			Total question 5	**16**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION EIGHT

(a) Describe, in terms of vibrations, the difference between a longitudinal and a transverse wave. Give one example of each wave.

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.... **[4]**

(b) Fig. 6.1 shows a loudspeaker fixed near the end of a tube of length 0.6 m.

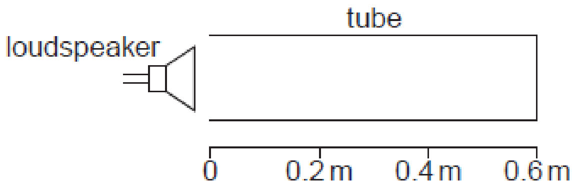

Fig. 6.1

The far end of the tube is closed. The frequency of the sound emitted from the loudspeaker is increased from zero. At a particular frequency a stationary wave is set up in the tube and the sound heard is much louder.

Explain how a stationary wave is formed in the tube.

In your answer, you should make clear how the stationary wave arises.

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.... **[3]**

(c) Figs. 6.2 and 6.3 show stationary wave patterns of amplitude against position along the tube at the fundamental frequency f_0 and the next possible harmonic at frequency $3f_0$.

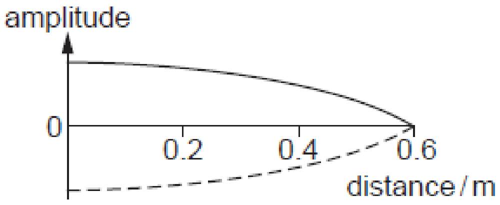

Fig. 6.2

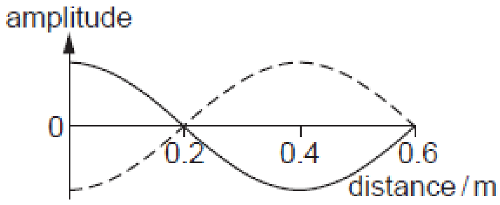

Fig. 6.3

Describe the motion of the air in the tube containing the stationary wave

(i) at points 0 m, 0.2 m and 0.6 m in Fig. 6.2

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....

.... **[2]**

(ii) at points 0 m, 0.2 m and 0.4 m in Fig. 6.3.

....

....

.... **[2]**

(d) The end of the tube at 0.6 m from the loudspeaker is now opened.

(i) On Fig. 6.4 sketch the stationary wave pattern of amplitude against position along the tube at the new fundamental frequency. **[2]**

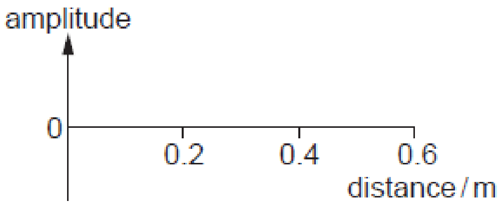

Fig. 6.4

(ii) State how the frequency of this stationary wave is related to the frequency f_0 of Fig. 6.2.

.... **[1]**

[Total: 14]

Reference: OCR Physics Unit 2 June 2010 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
6					
	a		oscillation/vibration of particles/medium in direction of travel of the wave example: sound wave, etc. oscillation/vibration of particles/medium (in the plane) at right angles to direction of travel of the wave example: surface water waves, string, electromagnetic, etc	B1 B1 B1 B1	**allow** direction of energy transfer of the wave **not** direction of wave motion **allow** direction of energy transfer of the wave **allow** RE mark for weaker descriptions with same omissions as in longitudinal wave
	b		the incident wave is reflected at the end of the pipe reflected wave interferes/superposes with the incident wave to produce (a resultant wave with) nodes and/or antinodes	B1 B1 B1	 **QWC mark** **accept** resultant wave with no energy transfer
	c	i	at 0 oscillation with max amplitude along tube at 0.2 m (oscillation along tube with) smaller amplitude at 0.6 m no motion/node	B1 B1	**not** displacement (penalise only once) all 4 correct for 2 marks; 2 correct for 1 mark
		ii	oscillation at 3 times the frequency of c(i) at 0 (oscillation with) max amplitude (along tube)/antinode at 0.2 m no motion/node at 0.4 m motion as at 0 (but in antiphase/opposite direction)	B1 B1	 3 correct for 2 marks; 2 correct for 1 mark
	d	i	$\lambda/2$ sketch with zero at 0.3 m	M1 A1	**accept** 1 or 2 lines, solid or dotted
		ii	$2f_0$	B1	**no ecf from d(i)**
			Total question 6	**14**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION NINE

(a) When a glowing gas discharge tube is viewed through a diffraction grating an emission line spectrum is observed.

(i) Explain what is meant by a *line spectrum*.

....

....

.... **[2]**

(ii) Describe how an absorption line spectrum differs from an emission line spectrum.

....

.... **[1]**

(b) A fluorescent tube used for commercial lighting contains excited mercury atoms. Two bright lines in the visible spectrum of mercury are at wavelengths 436 nm and 546 nm.

$1\,\text{nm} = 10^{-9}\,\text{m}$

Calculate

(i) the energy of a photon of violet light of wavelength 436 nm

energy = ... J **[3]**

(ii) the energy of a photon of green light of wavelength 546 nm.

energy = ... J **[1]**

(c) Electron transitions between the three levels **A**, **B** and **C** in the energy level diagram for a mercury atom (Fig. 7.1) produce photons at 436 nm and 546 nm. The energy E of an electron bound to an atom is negative. The ionisation level, not shown on the diagram, defines the zero of the vertical energy scale.

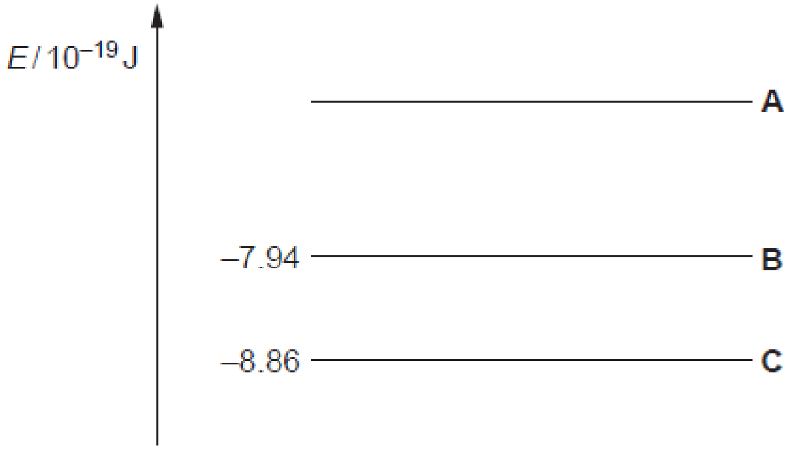

Fig. 7.1

(i) Draw two arrows on Fig. 7.1 to represent the transitions which give rise to these photons. Label each arrow with its emitted photon wavelength. **[3]**

(ii) Use your values for the energy of the photons from **(b)** to calculate the value of the energy level **A**.

E = ... J **[2]**

(d) The light from a distant fluorescent tube is viewed through a diffraction grating aligned so that the tube and the lines on the grating are parallel. The light from the tube is incident as a parallel beam at right angles to the diffraction grating.

The line separation on the grating is 3.3×10^{-6} m.

Calculate the angle to the straight through direction of the first order green (546 nm) image of the tube seen through the grating.

angle = ... ° **[3]**

[Total: 15]

Reference: OCR Physics Unit 2 June 2010 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
7					
	a	i	light emitted from (excited isolated) atoms produces a line spectrum a series of (sharp/bright/coloured) lines against a dark background	B1 B1	**max 2 marks** from 3 marking points
		ii	in an absorption spectrum a series of <u>dark</u> lines (appears against a bright background/within a continuous spectrum)	B1	**accept** black
	b	i	$\varepsilon = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.00 \times 10^{8} / 436 \times 10^{-9}$ $= 4.56 \times 10^{-19}$ (J)	C1 C1 A1	**apply** SF error if all numbers not to 3+ figures 4.54 if use 6.6
		ii	3.64×10^{-19} (J)	A1	**allow** mark if repeated error from **b(i)**
	c	i	correct vertical lines; correct labels arrow(s) downwards	B1 B1 B1	**1 mark** for 1 vertical line + correct label
		ii	$- 8.86 + 4.56 = - 4.3 \times 10^{-19}$ (J) $- 7.94 + 3.64 = - 4.3 \times 10^{-19}$ (J)	B1 B1	**ecf b(i)** **do** calculation for one line only correctly scores 2 marks; give answer as 4.3×10^{-19} **or** -4.3 scores 1 mark **do** calculation for both lines and give answer as 4.3×10^{-19} **or** -4.3 scores both marks
N.B. Before marking 7d check pages 18, 19 and 20 for additional answers by scrolling down. Extra answers MUST be annotated to show that they have been seen and credited back in the relevant question when appropriate. ✓ = 1 extra mark x = incorrect; scores 0 NBOD = no added value or no further action needed; scores 0 CON = if reference is made to the additional answer in the main text and this answer contradicts the other then deduct the original mark; = if NO reference is made to the additional answer in the main text and this answer contradicts the other then do NOT change the original mark					
	d		($d \sin \theta = \lambda$) $3.3 \times 10^{-6} \sin \theta = 546 \times 10^{-9}$ $\sin \theta = 0.165$ $\theta = 9.5°$	C1 C1 A1	
			Total question 7	**15**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TEN

Fig. 4.1 shows the variation with time t of the displacements x_S and x_T at a point **P** of two sound waves **S** and **T**.

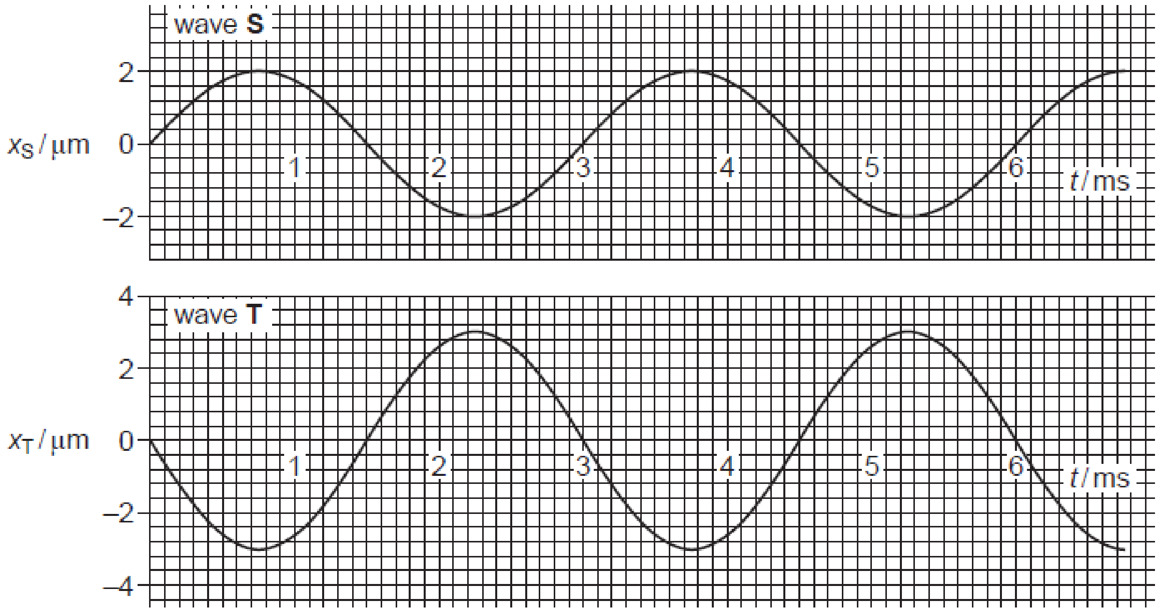

Fig. 4.1

(a) By reference to Fig. 4.1, state one similarity and one difference between these two waves.

similarity ....

difference .... **[2]**

(b) Explain whether or not the two waves are coherent.

....

....

.... **[2]**

(c) The speed of the sound waves is $340\,\text{m}\,\text{s}^{-1}$. Determine the frequency of wave **S** and hence its wavelength.

frequency = ... Hz

wavelength = ... m **[4]**

(d) At point **P** the two sound waves superpose (combine). By reference to Fig. 4.1 determine the resultant displacement *x* of the two waves at time

(i) $t_1 = 1.5\,\text{ms}$

x_1 = ... µm **[1]**

(ii) $t_2 = 2.25\,\text{ms}$.

x_2 = ... µm **[1]**

(e) The intensity of wave **S** alone at point **P** is I.

(i) Show that the intensity of wave **T** alone at point **P** is $2.25I$.

[2]

(ii) Calculate the intensity of the resultant wave at point **P** in terms of I.

intensity = ... I **[2]**

(f) The sound waves shown in Fig. 4.1 are emitted from the loudspeakers labelled **S** and **T** in Fig. 4.2 and detected by the microphone at point **P**.

Fig. 4.2

(i) Calculate the distance that loudspeaker **S** must be moved towards **P** to bring the two waves into phase at **P**. State your reasoning clearly.

distance = ... m **[2]**

(ii) Describe how the intensity of the sound wave detected at **P** varies as loudspeaker **S** is moved as in **(i)**.

....

....

.... **[2]**

[Total: 18]

Reference: OCR Physics Unit 2 January 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
4					
	a		same frequency / period different amplitude / phase	B1 B1	**accept** wavelength / sinusoidal /AW **accept** + sine and – sine for 2 marks
	b		because the waves have a constant phase relationship **or** are continuous and have the same f/period/λ they are coherent	M1 A1	**accept** same phase relationship for 1 mark only
	c		use of 3 ms as period $f = 1/3.0 \times 10^{-3} = 330$ (Hz) using $v = f\lambda$ $340 = 330\lambda$ $\lambda = 1.0(2)$ (m)	C1 A1 C1 A1	 **ecf** for f possible e.g. λ = 1020 (m) **accept** 1.03 (m) **no** SF error here
	d	i	0	B1	
		ii	1.0 (μm)	B1	**look for** SF error i.e. zero for 1 (μm)
	e	i	Intensity α $(\text{amplitude})^2$ so ratio is $(3/2)^2 = 9/4$ (giving 2.25 I)	C1 A1	**allow** I α A^2
		ii	resultant $A = A_S + A_T = (\pm)\ 1$ so ratio is $(1/2)^2$ giving 0.25 I	C1 A1	**ecf** from **(d)(ii)**
	f	i	phase shift of π or 180° required **or** movement of λ/2 1.02/2 = 0.51 (m)	B1 B1	**ecf** from **(c)**; **accept** (2n + 1)/2 λ **accept** 0.50 m
		ii	intensity increases to the maximum value	B1 B1	**accept** quantitative answers, i.e. from 0.25 I to 6.25 I
			Total question 4	**18**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION ELEVEN

In Fig. 5.1 the solid line on the graph represents the displacement *y* against position *x* of a **progressive** transverse wave on a stretched wire at time t = 0. The dotted line shows the displacement at a later time t = 0.75 ms, where the wave has moved to the right.

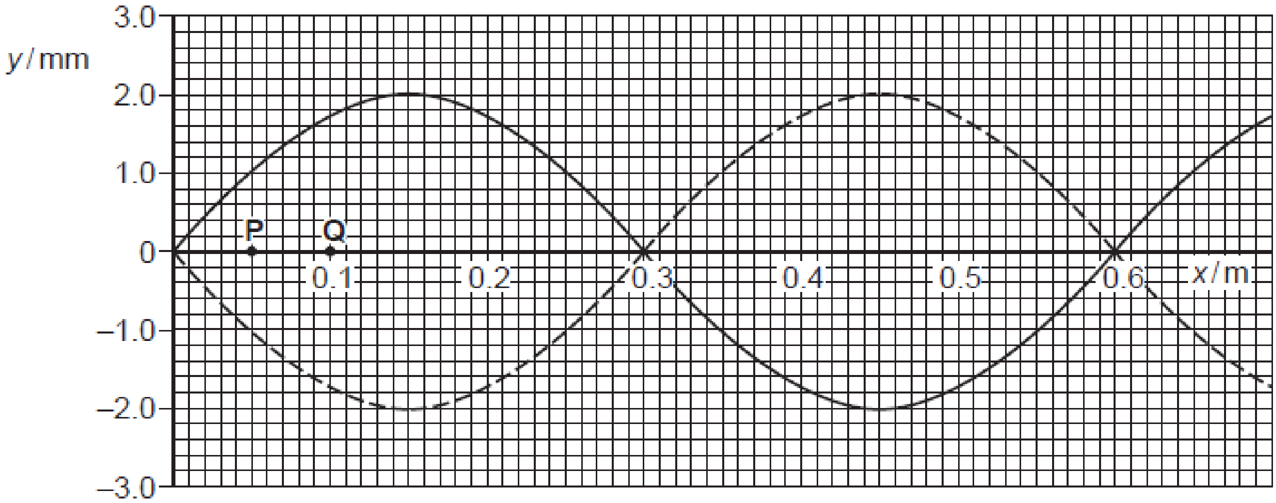

Fig. 5.1

(a) **(i)** Determine the wavelength of the wave.

wavelength = ... m **[1]**

(ii) **1** Explain how Fig. 5.1 shows that the period of the wave is 1.5 ms.

....

.... **[1]**

2 Calculate the speed of the wave along the wire.

speed = ... m s^{-1} **[2]**

(b) Consider the oscillations of the wire at positions **P** (x = 0.05 m) and **Q** (x = 0.10 m). See Fig. 5.1. For the **progressive** wave on the wire state the difference, if any, in **amplitude** of the oscillations of the wave at **P** and **Q**.

difference = ... mm **[1]**

(c) **(i)** Describe the diference between the *displacement* and the *amplitude* of a wave.

....

....

....

....

....

.... **[2]**

(ii) Describe how a *stationary* wave is different from a *progressive* wave.

....

....

....

....

....

.... **[2]**

(d) Fig. 5.2 shows the wire of Fig. 5.1 under tension fixed at points $x = 0$ and 0.60 m. The frequency of the mechanical oscillator close to one end is varied so that a **stationary** wave is set up on the wire.

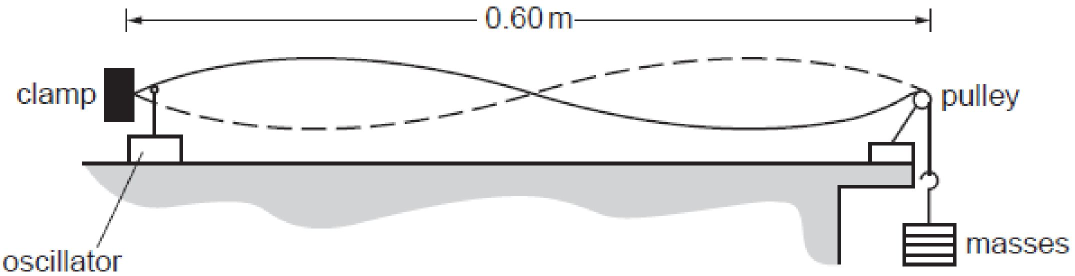

Fig. 5.2

(i) By considering the motion of progressive waves on the wire, explain how the stationary wave is produced.

In your answer you should make clear how the stationary wave arises.

....

....

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.... **[3]**

(ii) In Fig. 5.3 the solid line on the graph represents the displacement *y* against position *x* of the **stationary** wave on the stretched wire at time $t = 0$. The dotted line shows the displacement at a later time $t = 0.75\,\text{ms}$.

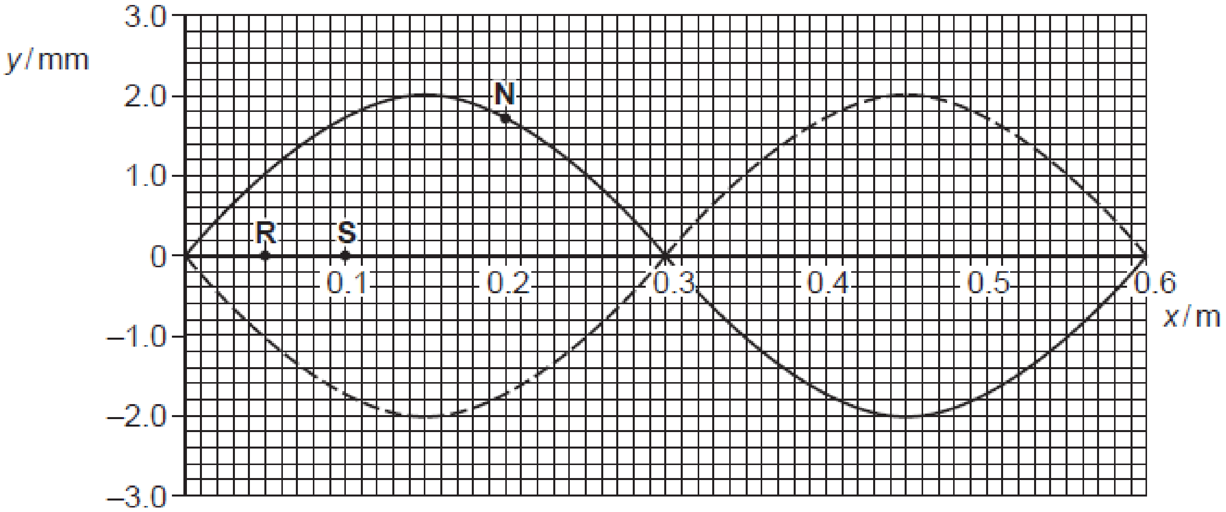

Fig. 5.3

For the **stationary** wave on the wire

1 state the difference, if any, in **amplitude** of the oscillations at **R** and **S**

difference = ... mm **[1]**

2 mark with an **X** the position of one antinode **[1]**

3 mark with a **Y** on the dotted line on Fig. 5.3 where the point **N** on the wave is at $t = 0.75\,\text{ms}$. **[1]**

[Total: 15]

Reference: OCR Physics Unit 2 June 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
5					
	a	i	0.60 m	B1	**allow** 0.6 another example of SF comment Q2
		ii1 ii2	the wave has moved along 0.5 wavelengths in 0.75 ms so will move one wavelength in 1.5 ms which is the period/AW f = 670 Hz so v = fλ = 670 x 0.60 = 400 (m s^{-1})	B1 C1 A1	can be answered in terms of phase **ecf(a)(i)** **accept** v = λ/T = 0.60/1.5 x 10^{-3}
	b		0	B1	
	c	i	*displacement* any distance moved from equilibrium of a point/particle (on a wave) *amplitude* maximum possible displacement (caused by wave motion)	B1 B1	**allow** alternatives for equilibrium, e.g. mean/rest/undisturbed position
		ii	*progressive* a wave which transfers energy *stationary* a wave which traps/stores energy (in pockets) **OR** *progressive* : transfers shape/information from one place to another *stationary* where the shape does not move along/which has nodes and antinodes/AW	B1 B1 B1 B1	**accept** phase relationship descriptions between different points on wave; must be a comparison for same property to score both marks
	d	i	the incident wave is reflected at the fixed ends of the wire reflected wave interferes/superposes with the incident wave to produce a resultant wave with nodes and antinodes/no energy transfer	B1 B1 B1	must have reference to an end of the wire QWC mark
		ii1 ii2 ii3	0.70 (mm) 0.15 (m)/0.45 (m) x = 0.2, y = -1.7	B1 B1 B1	**allow** 0.60 to 0.80 mm anywhere on vertical line x = 0.15 or 0.45
			Total question 5	**15**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION TWELVE

This question is about measuring the wavelength of the yellow light from a sodium lamp.

(a) A beam of light from a sodium lamp passes through a pair of narrow slits $\mathbf{S_1}$ and $\mathbf{S_2}$ producing a pattern on a screen. See Fig. 6.1. The pattern on the screen consists of regularly spaced bright and dark lines, called fringes. See Fig. 6.2.

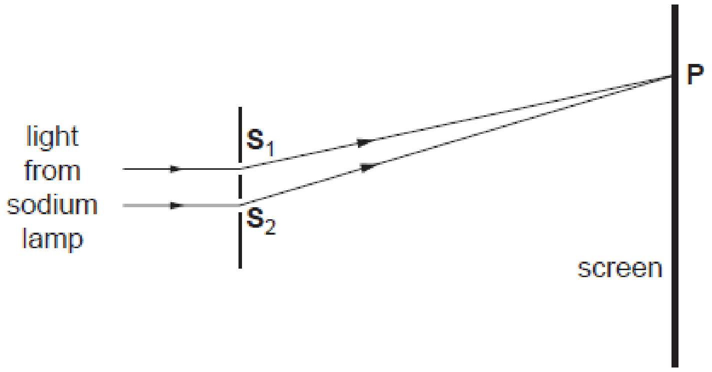

Fig. 6.1

(i) State and explain the conditions necessary for the light from the two slits $\mathbf{S_1}$ and $\mathbf{S_2}$ to produce a visible pattern on the screen.

....

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....

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....

....

.... **[3]**

(ii) Using the ideas of wave superposition, explain the existence of the bright and the dark fringes. In your answer state the condition for a bright fringe to appear on the screen at **P** in Fig. 6.1 and the condition for a dark fringe to appear at **P**.

....

....

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....

.... **[4]**

(b) Fig. 6.2 shows the central part of the fringe pattern on the screen at 1.5 m from the slits $\mathbf{S}_1$ and $\mathbf{S}_2$ which are 0.60 mm apart.

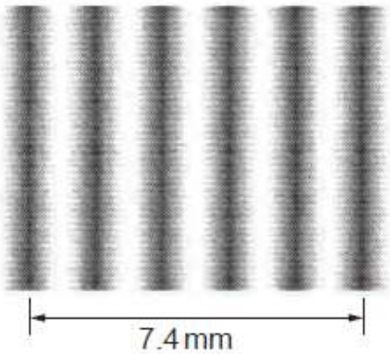

Fig. 6.2

Calculate

(i) the fringe separation, that is, the separation x between adjacent dark lines

x = ... m **[1]**

(ii) the wavelength λ of the yellow light.

λ = ... m **[3]**

(c) One of the two slits is covered up. Describe and explain how the pattern of light on the screen is different from that of Fig. 6.2.

....

....

....

....

....

.... **[3]**

[Total: 14]

Reference: OCR Physics Unit 2 June 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
6					
	a	i	method of producing coherent sources at S_1 and S_2 light (waves) from the two slits/sources must be coherent; that is, they must have a constant phase relationship/difference slits must be narrow/close together (so that diffraction patterns overlap) light (waves) from two slits must have similar amplitudes/intensities	B1 B1 B1 B1 B1	e.g. initial single slit **max 3 marks** from 5 marking points
		ii	*bright*: constructive interference occurs/waves add to give a maximum amplitude at the screen path difference between slits and screen is a whole/integer number of wavelengths/waves arrive in phase at screen *dark*: destructive interference occurs/waves add to give a minimum amplitude/zero at the screen path difference between slits and screen is an odd half number of wavelengths/waves arrive out of/in antiphase at screen	B1 B1 B1 B1	 **accept** explanation in terms of distance or phase **accept** explanation in terms of distance or phase
	b	i	$7.4/5 = 1.48 \times 10^{-3}$ (m)	B1	**accept** 1.5 mm
		ii	$\lambda = xd/L$ $= 1.48 \times 10^{-3} \times 0.6 \times 10^{-3}/1.5$ $= 5.9(2) \times 10^{-7}$ (m)	C1 C1 A1	using 1.5 mm gives 600 nm **ecf(b)(i)** e.g. 4.92×10^{-7} for 1.23 mm **accept** 590 nm
	c		pattern/fringes vanish because there is now no interference from light from the two slits/AW light spreads out over whole/similar region light intensity (at screen) is less diffraction spreads light simple description of single slit pattern further features of single slit pattern	B1 B1 B1 B1 B1 B1 B2	 e.g. bright in middle and dim at edges/sketch of bell shape **max 3 marks** from 8 marking points
			Total question 6	**14**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION THIRTEEN

(a) Describe a *plane polarised wave*.

....

....

....

.... **[2]**

(b) Light reflected from the surface of water is partially plane polarised in the horizontal direction. The reflected light is totally plane polarised when the angle of reflection is about 53°.

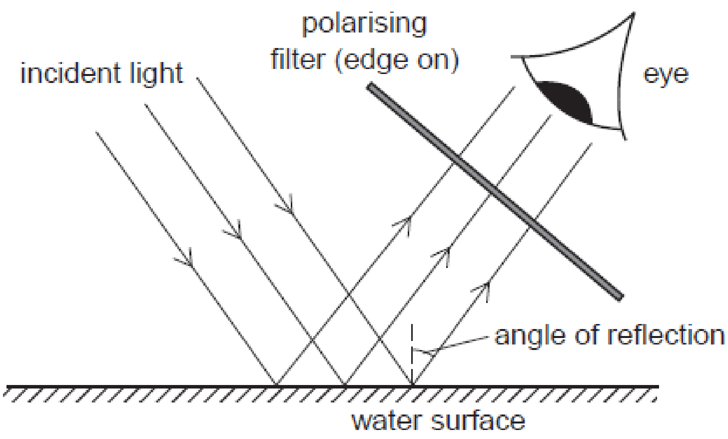

Fig. 7.1

Describe, referring to Fig. 7.1, the experiment that you would perform using a polarising filter (a sheet of Polaroid) to determine whether this statement is correct. Describe what you expect to observe.

In your answer you should make clear how you would use any apparatus to make observations or take suitable measurements.

....

....

....

....

....

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....

.... **[4]**

(c) State Malus' law for the intensity I of a beam of plane polarised light transmitted through a polarising sheet with its transmission axis at an angle θ to the plane of polarisation. Explain the meaning of any other symbols that you use.
Use Malus' law to explain the observations in the experiment of part **(b)**.

....

....

....

....

....

....

....

....

.... **[4]**

[Total: 10]

Reference: OCR Physics Unit 2 June 2011 Examination

MARK SCHEME

Question			Expected Answers	M	Additional Guidance
7					
	a		reference to a transverse wave or to vibrations in plane normal to the direction of (energy) propagation	B1	can be answered with suitable diagram(s)
			oscillations/vibrations in one direction only/confined to single plane (containing the direction of propagation)	B1	NOT the wave oscillating in one plane
	b		set up apparatus, e.g. tray of water on table with lamp/light from window	B1	
			rotate the filter	B1	QWC mark essential for full marks
			rotation of filter changes the image intensity/brightness/AW	B1	**allow** from bright to zero or vice versa
			correct orientation for maximum and minimum intensities of image	B1	transmission axis parallel to water surface for maximum and perpendicular for minimum
			move head up or down to change angle of reflected light observed	B1	can hold head still and move lamp
			use of protractor to measure angles	B1	
			image/reflection becomes partially plane polarised/ image changes from bright to dim but does not disappear	B1	**max 3** from 6 marking points **+ QWC mark**
	c		$I = I_0 \cos^2\theta$	B1	
			where I_0 is the maximum intensity (of the polarised beam)	B1	**allow** incident/original/initial for maximum
			when θ is zero maximum intensity transmitted/ image bright	B1	
			when θ is 90° minimum/zero intensity transmitted/image dim/vanished	B1	
			Total question 7	**10**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FOURTEEN

(a) Explain what is meant by a *progressive wave*.

....

....

....

.... **[2]**

(b) Describe how a *transverse* wave differs from a *longitudinal* wave.

....

....

....

.... **[2]**

(c) **(i)** Explain what is meant by *diffraction* of a wave.

....

....

.... **[1]**

(ii) Describe how you would demonstrate that a sound wave of wavelength 0.10 m emitted from a loudspeaker can be diffracted.

In your answer you should make clear how your observations show that diffraction is occurring.

....

....

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....

.... **[4]**

(d) Fig. 4.1 shows two loudspeakers connected to a signal generator, set to a frequency of 1.2 kHz. A person walks in the direction **P** to **Q** at a distance of 3.0 m from the loudspeakers.

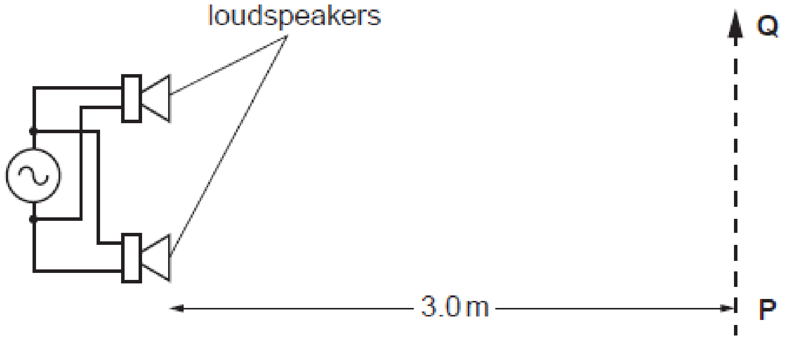

Fig. 4.1

(i) Calculate the wavelength λ of the sound waves emitted from the loudspeakers.

speed of sound in air = $340\,\text{m}\,\text{s}^{-1}$

λ = ... m **[2]**

(ii) Explain, either in terms of path difference or phase difference, why the intensity of the sound heard varies as the person moves along **PQ**.

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.... **[3]**

(iii) The distance x between adjacent positions of maximum sound is 0.50 m. Calculate the separation a between the loudspeakers. Assume that the equation used for the interference of light also applies to sound.

a = ... m **[2]**

(iv) The connections to one of the loudspeakers are reversed. Describe the similarities and differences in what the person hears.

....

....

....

....

....

.... **[2]**

[Total: 18]

Reference: OCR Physics Unit 2 January 2012 Examination

MARK SCHEME

Question			Answer	Marks	Guidance
4	(a)		**is a transfer of energy** as a result of oscillations (of the source/medium/particles through which energy is travelling)	M1 A1	**allow** carries **allow** information **accept** without the transfer of the medium/particles/matter
	(b)		displacement/oscillation (of particles) is normal/perpendicular to direction of energy transfer in transverse wave displacement/oscillation (of particles) is parallel to direction of energy transfer in longitudinal wave	B1 B1	**allow** vibrations **allow** to direction of wave motion/propagation/velocity/travel **NOT** transverse wave can travel through a vacuum give max 1 mark for 2 similar poor definitions, e.g. direction of travel, waves oscillate, etc. (two such errors scores zero)
	(c)	(i)	wavefronts/paths spread out after passing through a gap or around an obstacle/AW	B1	**NOT** wave changes direction
		(ii)	use a slit/hole/ barrier width of gap/position beyond barrier comparable to wavelength microphone/observer's ear suitably placed sound detected/heard outside 'geometrical shadow' region (showing diffraction)	B1 B1 B1 B1	**accept** doorway/end of wall **accept** position of detector beyond doorway **N.B.** good diagram can illustrate first 3 marking points **allow** 'hears sound' in suitable context only observation mark which is QWC mark must be in words 2 marks max for double slit experiment(1st and 3rd m.p.)
	(d)	(i)	$v = f\lambda$ giving $340 = 1200 \times \lambda$ $\lambda = 0.28$ (m)	C1 A1	substitution needed to score mark POT error for using 1.2 kHz giving 280 m **N.B.** $\lambda = 0.3$ SF error (remember apply only once)
		(ii)	waves superpose/interfere at points along **PQ** (constructively and destructively) path difference from sources of $n\lambda$ for maximum/loud sound/intensity path difference of $(2n + 1)\lambda/2$ for minimum/quiet sound/intensity	B1 B1 B1	**max** 2/3 for writing phase difference is $n\lambda$ or path difference is 2π i.e. mixing path and phase consistently through answer **allow** waves arrive in phase (0, 2π, 360°, etc) **allow** waves arrive in anti-phase (π, 180°, etc) **do not allow** waves arrive out of phase **or** answers in terms of peaks and troughs for 2nd and 3rd marks
		(iii)	$a = \lambda D/x$ giving $a = 0.28 \times 3.0/0.50$ $a = 1.7$ m	C1 A1	**ecf (d)(i)** substitution needed to score mark
		(iv)	intensity of sound (at maxima) unchanged/AW positions of maxima and minima reversed/AW	B1 B1	**allow** volume or amplitude
			Total	**18**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION FIFTEEN

Fig. 5.1 shows a uniform string which is kept under tension between a clamp and a pulley. The frequency of the mechanical oscillator close to one end is varied so that a stationary wave is set up on the string.

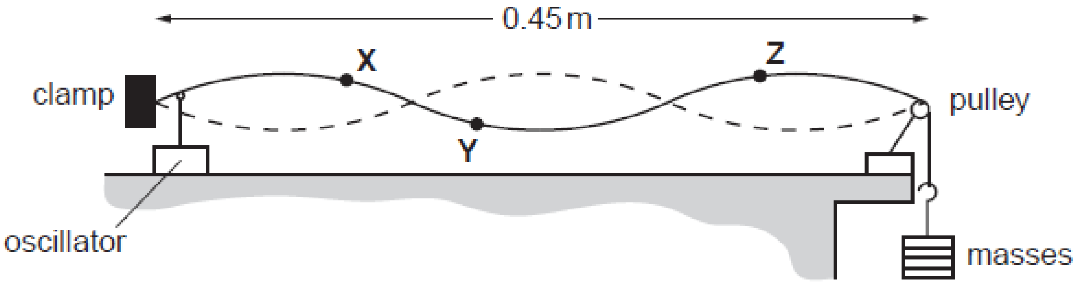

Fig. 5.1

(a) State two features of a stationary wave.

....

....

....

.... **[2]**

(b) Explain how the stationary wave is formed on the string.

....

....

....

....

.... **[2]**

(c) The distance between the clamp and the pulley is 0.45 m. **X**, **Y** and **Z** are three points on the string. **X** and **Y** are each 0.040 m from the nearest node and **Z** is 0.090 m from the pulley. State, giving a reason for your choice, which of the points **Y** or **Z** or both oscillate

(i) with the same amplitude as **X**

....

....

....

.... **[2]**

(ii) with the same frequency as **X**

....

....

....

.... **[2]**

(iii) in phase with **X**.

....

....

....

.... **[2]**

[Total: 10]

Reference: OCR Physics Unit 2 January 2012 Examination

MARK SCHEME

Question			Answer	Marks	Guidance
5	(a)		energy is trapped in pockets/ where the shape or energy does not move along/energy is stored/AW there are nodes/positions of zero amplitude/motion there are positions where there is max. amplitude/antinodes different/adjacent points have different amplitudes/AW all points between nodes in phase/all points in adjacent λ/2's in anti-phase/AW	B1 B1 B1 B1 B1	**accept** any **two** sensible but different features **allow** there are nodes and antinodes as 1 marking point **penalise** displacement for amplitude once only
	(b)		incident wave is reflected (at the fixed end of the string) and the reflected wave (or it) interferes/superposes with the incident wave (to produce the stationary wave)	B1 B1	
	(c)	(i)	**points which are the same distance from the nodes will have the same amplitude** so **Y** (has the same amplitude as **X**)	M1 A1	**N.B.** some will add **Z** stating it is the same distance from the node – these candidates can score the first mark
		(ii)	**all points on the string oscillate with the same frequency** so **Y** and **Z** (have the same f as **X**)	M1 A1	
		(iii)	**all points in alternate segments of the string oscillate in phase/AW** so **Z** (is in phase with **X**)	M1 A1	**accept** e.g. have positive displacement at the same time
			Total	**10**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

QUESTION SIXTEEN

(a) X-rays and radio waves are two examples of electromagnetic waves.

(i) Name **two** other examples of electromagnetic waves.

....

.... **[1]**

(ii) State **one** similarity and **one** difference between X-rays and radio waves.

similarity ....

....

....

difference ....

....

.... **[2]**

(iii) Explain why X-rays are easily diffracted by layers of atoms, about 2×10^{-10} m apart, but radio waves are not.

....

....

....

.... **[2]**

(b) On the Earth, we are all exposed to ultraviolet radiation coming from the Sun.
State **one** advantage and **one** disadvantage of UV-B radiation.

....

....

....

....

.... **[2]**

(c) **(i)** Circle a typical value for the wavelength of an X-ray from the list below.

2×10^{-4} m $\quad$ 2×10^{-7} m $\quad$ 2×10^{-10} m $\quad$ 2×10^{-13} m **[1]**

(ii) Use your answer to **(i)** to determine how many X-ray photons must be collected to produce an energy of 1.0×10^{-6} J.

number of photons = ... **[4]**

(d) A plane polarised radio wave is transmitted from a vertical aerial to a nearby receiving aerial as shown in Fig. 6.1.

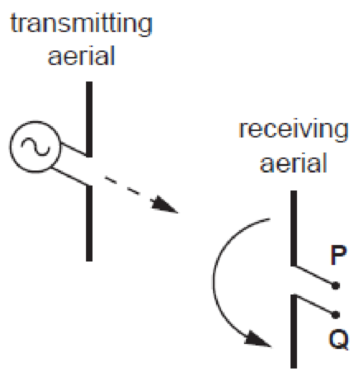

Fig. 6.1

A diode, resistor and ammeter are connected in series across the terminals **P** and **Q**.

(i) Draw the circuit between terminals **P** and **Q** on Fig. 6.1 in the space to the right of **PQ**. **[2]**

(ii) The entire receiving aerial is rotated slowly through 180° in the direction shown by the arrow. Explain clearly what will be observed on the ammeter and how the detected signal varies.

....

....

....

....

....

....

.... **[3]**

[Total: 17]

Reference: OCR Physics Unit 2 January 2012 Examination

MARK SCHEME

Question			Answer	Marks	Guidance
6	(a)	(i)	gamma rays, u.v., visible/light, i.r., microwaves	B1	**two** out of five needed for mark
		(ii)	*similarity*: travel in a vacuum/same speed (in vacuum)/at c/transverse (wave)/can be polarised/caused by accelerating charges/are oscillating electric and magnetic fields *difference*: different λ, f, (photon) energy	B1 B1	any **one** for mark **NOT** can be reflected/refracted/diffracted/interfere,etc. any **one** for mark
		(iii)	wavelength of X-rays is close to atomic spacing/AW **or** wavelength of radio waves many/million times the atomic separation maximum/significant diffraction occurs when radiation wavelength ~ spacing (between diffracting planes) within material	B1 B1	
	(b)		**advantage** produces vitamin D (in skin cells) **disadvantage** damage DNA/cause cancer/sunburn, etc.	B1 B1	**allow** any sensible use, e.g. sterilise equipment, forensic science, disco lighting, etc. **NOT** tanning, photosynthesis
	(c)	(i)	2×10^{-10} m	B1	
		(ii)	$E = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.0 \times 10^{8}/2 \times 10^{-10}$ $= 9.9(5) \times 10^{-16}$ number $= 1 \times 10^{9}$	C1 C1 A1 B1	Select equation and attempt to apply it **ecf (c)(i)** accept 1×10^{-15}, i.e 1 SF mark scored for 1×10^{-6}/value of E
	(d)	(i)	diode symbol all three components in series	B1 B1	**allow** LED symbol; basic requirement is triangle along wire direction with bar, with or without circle and line through **ecf** for diode symbol
		(ii)	maximum ammeter reading when aerials in line/parallel zero signal/current when aerials at 90° to each other at 180° same signal/ammeter reading as at 0° quoting $I = I_0\cos^2\theta$ to indicate variation through 180°	B1 B1 B1 B1	**accept** ammeter reading falls as aerial is rotated **accept** minimum **allow** full marks for answers in terms of only ammeter reading or signal strength max 3 out of 4 marking points
			Total	**17**	

Revision Reflection

A1. Could you answer this question without any help?

A2. Could you answer this question correctly?

A3. Did you encounter any problems with this question?

A4. Do you need to carry out further revision on this topic?

Revision Target

From this question, are there any targets you need to set for revision? What are they?

DATASHEET

DATA - FUNDAMENTAL CONSTANTS AND VALUES

Quantity	Symbol	Value	Units
speed of light in vacuo	c	3.00×10^{8}	$\mathrm{m\,s^{-1}}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$\mathrm{H\,m^{-1}}$
permittivity of free space	ε_0	8.85×10^{-12}	$\mathrm{F\,m^{-1}}$
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$\mathrm{N\,m^{2}\,kg^{-2}}$
the Avogadro constant	N_A	6.02×10^{23}	$\mathrm{mol^{-1}}$
molar gas constant	R	8.31	$\mathrm{J\,K^{-1}\,mol^{-1}}$
the Boltzmann constant	k	1.38×10^{-23}	$\mathrm{J\,K^{-1}}$
the Stefan constant	σ	5.67×10^{-8}	$\mathrm{W\,m^{-2}\,K^{-4}}$
the Wien constant	α	2.90×10^{-3}	m K
electron rest mass (equivalent to 5.5×10^{-4} u)	m_e	9.11×10^{-31}	kg
electron charge/mass ratio	$\frac{e}{m_e}$	1.76×10^{11}	$\mathrm{C\,kg^{-1}}$
proton rest mass (equivalent to 1.00728 u)	m_p	$1.67(3) \times 10^{-27}$	kg
proton charge/mass ratio	$\frac{e}{m_p}$	9.58×10^{7}	$\mathrm{C\,kg^{-1}}$
neutron rest mass (equivalent to 1.00867 u)	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	$\mathrm{N\,kg^{-1}}$
acceleration due to gravity	g	9.81	$\mathrm{m\,s^{-2}}$
atomic mass unit (1u is equivalent to 931.5 MeV)	u	1.661×10^{-27}	kg

ALGEBRAIC EQUATION

quadratic equation $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

ASTRONOMICAL DATA

Body	Mass/kg	Mean radius/m
Sun	1.99×10^{30}	6.96×10^{8}
Earth	5.97×10^{24}	6.37×10^{6}

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
curved surface area of cylinder	$= 2\pi rh$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

Particle Physics

Class	Name	Symbol	Rest energy/MeV
photon	photon	γ	0
lepton	neutrino	ν_e	0
		ν_μ	0
	electron	$e^\pm$	0.510999
	muon	$\mu^\pm$	105.659
mesons	π meson	$\pi^\pm$	139.576
		π^0	134.972
	K meson	$K^\pm$	493.821
		K^0	497.762
baryons	proton	p	938.257
	neutron	n	939.551

Properties of quarks

antiquarks have opposite signs

Type	Charge	Baryon number	Strangeness
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of Leptons

		Lepton number
Particles:	$e^-, \nu_e; \mu^-, \nu_\mu$	$+1$
Antiparticles:	$e^+, \overline{\nu_e}, \mu^+, \overline{\nu_\mu}$	-1

Photons and energy levels

photon energy $E = hf = hc/\lambda$

photoelectricity $hf = \phi + E_{k\,(max)}$

energy levels $hf = E_1 - E_2$

de Broglie wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

Waves

wave speed $c = f\lambda$ *period* $f = \frac{1}{T}$

first harmonic $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

fringe spacing $w = \frac{\lambda D}{s}$ *diffraction grating* $d \sin\theta = n\lambda$

refractive index of a substance s, $n = \frac{c}{c_s}$

for two different substances of refractive indices n_1 *and* n_2,

law of refraction $n_1 \sin\theta_1 = n_2 \sin\theta_2$

critical angle $\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$

Mechanics

moments moment $= Fd$

velocity and acceleration $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

equations of motion $v = u + at$ $s = \left(\frac{u+v}{2}\right)t$

$v^2 = u^2 + 2as$ $s = ut + \frac{at^2}{2}$

force $F = ma$

force $F = \frac{\Delta(mv)}{\Delta t}$

impulse $F\Delta t = \Delta(mv)$

work, energy and power $W = Fs\cos\theta$

$E_k = \frac{1}{2}mv^2$ $\Delta E_p = mg\Delta h$

$P = \frac{\Delta W}{\Delta t}$, $P = Fv$

$efficiency = \frac{useful\ output\ power}{input\ power}$

Materials

density $\rho = \frac{m}{V}$ *Hooke's law* $F = k\Delta L$

Young modulus $= \frac{\text{tensile stress}}{\text{tensile strain}}$ *tensile stress* $= \frac{F}{A}$

tensile strain $= \frac{\Delta L}{L}$

energy stored $E = \frac{1}{2}F\Delta L$

Electricity

current and pd $I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$ $R = \frac{V}{I}$

resistivity $\rho = \frac{RA}{L}$

resistors in series $R_T = R_1 + R_2 + R_3 + \ldots$

resistors in parallel $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

power $P = VI = I^2R = \frac{V^2}{R}$

emf $\varepsilon = \frac{E}{Q}$ $\varepsilon = I(R + r)$

Circular motion

magnitude of angular speed $\omega = \frac{v}{r}$

$\omega = 2\pi f$

centripetal acceleration $a = \frac{v^2}{r} = \omega^2 r$

centripetal force $F = \frac{mv^2}{r} = m\omega^2 r$

Simple harmonic motion

acceleration $a = -\omega^2 x$

displacement $x = A\cos(\omega t)$

speed $v = \pm\omega\sqrt{(A^2 - x^2)}$

maximum speed $v_{max} = \omega A$

maximum acceleration $a_{max} = \omega^2 A$

for a mass-spring system $T = 2\pi\sqrt{\frac{m}{k}}$

for a simple pendulum $T = 2\pi\sqrt{\frac{l}{g}}$

Thermal physics

energy to change temperature $Q = mc\Delta\theta$

energy to change state $Q = m\,l$

gas law $pV = nRT$

$pV = NkT$

kinetic theory model $pV = \frac{1}{3}N\,m\,(c_{rms})^2$

kinetic energy of gas molecule $\frac{1}{2}m\,(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$

Gravitational fields

force between two masses $F = \frac{Gm_1m_2}{r^2}$

gravitational field strength $g = \frac{F}{m}$

magnitude of gravitational field strength in a radial field $g = \frac{GM}{r^2}$

work done $\Delta W = m\Delta V$

gravitational potential $V = -\frac{GM}{r}$

$g = -\frac{\Delta V}{\Delta r}$

Electric fields and capacitors

force between two point charges $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$

force on a charge $F = EQ$

field strength for a uniform field $E = \frac{V}{d}$

work done $\Delta W = Q\Delta V$

field strength for a radial field $E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

electric potential $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

$E = \frac{\Delta V}{\Delta r}$

capacitance $C = \frac{Q}{V}$

$C = \frac{A\varepsilon_0\varepsilon_r}{d}$

capacitor energy stored $E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

capacitor charging $Q = Q_0(1 - e^{-t/RC})$

decay of charge $Q = Q_0e^{-t/RC}$

time constant RC

Magnetic fields

force on a current $F = BIl$

force on a moving charge $F = BQv$

magnetic flux $\Phi = BA$

magnetic flux linkage $N\Phi = BAN\cos\theta$

magnitude of induced emf $\varepsilon = N\frac{\Delta\Phi}{\Delta t}$

$N\Phi = BAN\cos\theta$

emf induced in a rotating coil $\varepsilon = BAN\omega\sin\omega t$

alternating current $I_{rms} = \frac{I_0}{\sqrt{2}}$ $V_{rms} = \frac{V_0}{\sqrt{2}}$

transformer equations $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$efficiency = \frac{I_sV_s}{I_pV_p}$

Nuclear physics

the inverse square law for γ radiation $I = \frac{k}{x^2}$

radioactive decay $\frac{\Delta N}{\Delta t} = -\lambda N,\ N = N_0 e^{-\lambda t}$

activity $A = \lambda N$

half-life $T_{½} = \frac{\ln 2}{\lambda}$

nuclear radius $R = R_0 A^{1/3}$

energy-mass equation $E = mc^2$

OPTIONS

Astrophysics

1 astronomical unit = 1.50×10^{11} m

1 light year = 9.46×10^{15} m

1 parsec = 206265 AU = 3.08×10^{16} m
= 3.26 light year

Hubble constant, H = 65 km s^{-1} Mpc^{-1}

$M = \frac{\text{angle subtended by image at eye}}{\text{angle subtended by object at unaided eye}}$

in normal adjustment $M = \frac{f_o}{f_e}$

Rayleigh criterion $\theta \approx \frac{\lambda}{D}$

magnitude equation $m - M = 5\log\frac{d}{10}$

Wien's law $\lambda_{max}T = 2.9 \times 10^{-3}$ m K

Stefan's law $P = \sigma A T^4$

Schwarzschild radius $R_s \approx \frac{2GM}{c^2}$

Doppler shift for v << c $\frac{\Delta f}{f} = -\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

red shift $z = -\frac{v}{c}$

Hubble's law $v = Hd$

Medical physics

lens equations $P = \frac{1}{f}$

$m = \frac{v}{u}$

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

threshold of hearing $I_0 = 1.0 \times 10^{-12}$ W m^{-2}

intensity level $intensity\ level = 10\log\frac{I}{I_0}$

absorption $I = I_0 e^{-\mu x}$

$\mu_m = \frac{\mu}{\rho}$

ultrasound imaging $Z = \rho c$

$\frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$

half-lives $\frac{1}{T_E} = \frac{1}{T_B} + \frac{1}{T_P}$

Engineering physics

moment of inertia $I = \Sigma mr^2$

angular kinetic energy $E_k = \frac{1}{2} I\omega^2$

equations of angular motion

$\omega_2 = \omega_1 + \alpha t$

$\omega_2^{\,2} = \omega_1^{\,2} + 2\alpha\theta$

$\theta = \omega_1 t + \frac{\alpha t^2}{2}$

$\theta = \frac{(\omega_1 + \omega_2)\,t}{2}$

torque $T = I\,\alpha$

$T = F\,r$

angular momentum $\text{angular momentum} = I\omega$

angular impulse $T\Delta t = \Delta(I\omega)$

work done $W = T\theta$

power $P = T\omega$

thermodynamics $Q = \Delta U + W$

$W = p\Delta V$

adiabatic change $pV^\gamma = \text{constant}$

isothermal change $pV = \text{constant}$

heat engines

efficiency $= \frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H}$

maximum theoretical efficiency $= \frac{T_H - T_C}{T_H}$

work done per cycle = area of loop

input power = calorific value × fuel flow rate

indicated power = (*area of* $p - V$ *loop*) × (*number of cycles per second*) × (*number of cylinders*)

output or brake power $P = T\omega$

friction power = indicated power – brake power

heat pumps and refrigerators

refrigerator: $COP_{ref} = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C}$

heat pump: $COP_{hp} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_C}$

Turning points in physics

electrons in fields $F = \frac{eV}{d}$

$F = Bev$

$r = \frac{mv}{Be}$

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

Millikan's experiment $\frac{QV}{d} = mg$

$F = 6\pi\eta rv$

Maxwell's formula $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$

special relativity $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

$l = l_0 \sqrt{1 - \frac{v^2}{c^2}}$

$E = mc^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$

Electronics

resonant frequency $f_0 = \frac{1}{2\pi\sqrt{LC}}$

Q-factor $Q = \frac{f_0}{f_B}$

operational amplifiers: open loop $V_{out} = A_{OL}(V_+ - V_-)$

inverting amplifier $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$

non-inverting amplifier $\frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_1}$

summing amplifier $V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \cdots\right)$

difference amplifier $V_{out} = (V_+ - V_-)\frac{R_f}{R_1}$

Bandwidth requirement:

for AM $\text{bandwidth} = 2f_M$

for FM $\text{bandwidth} = 2(\Delta f + f_M)$

Acknowledgements

This document has been produced by Mr J Turnbull.

All relevant information has been credited in the document.

This document has been produced for educational purposes only.

This document has been produced for the AQA A Level Physics Specification.

Student Voice

If you when using this document, you believe there is an improvement to made, please state this in the space below….

Only constructive and reasoned feedback will be considered.