Candidate Name	Centre Number	Candidate Number

WJEC CBAC

GCE AS/A level

1322/01

PHYSICS

ASSESSMENT UNIT PH2: WAVES AND PARTICLES

P.M. MONDAY, 6 June 2011

1½ hours

For Examiner's use only.		
1.	10	
2.	13	
3.	13	
4.	12	
5.	14	
6.	9	
7.	9	
Total	80	

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ADDITIONAL MATERIALS

In addition to this paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer is incorrect.

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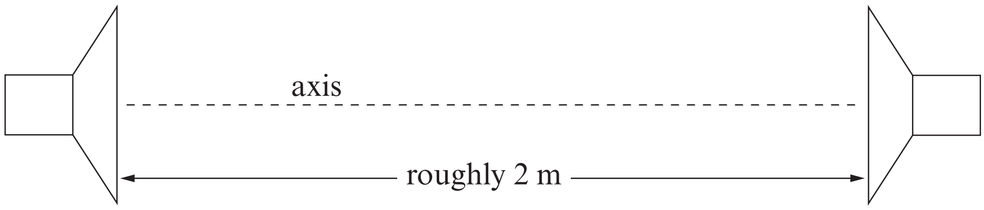
1. *(a)* (i) Sound waves in air are *longitudinal*. Explain what this means. [2]

(ii) What is meant by the *wavelength* of a progressive sound wave? [1]



(b) In the set-up shown, both loudspeakers are connected to the same signal generator.

(i) Explain briefly why a stationary wave is produced. [2]

(ii) With the signal generator set to 750 Hz, the quietest points on the axis are found to be 0.22 m apart. Calculate a value for the speed of sound, giving your reasoning. [3]

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(iii) Show that it would not be possible to use this method, with the set-up just as shown, if the signal generator were set to 50 Hz. [2]

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2. *(a)* (i) Insert the correct symbol (< or = or >) to compare the *speeds (v)*, *frequencies (f)* and *wavelengths (λ)* of a monochromatic light beam as it passes from air to glass.

v_{air} .... v_{glass}, f_{air} .... f_{glass}, λ_{air} .... λ_{glass}. [2]

(ii) Justify your choice of symbol for the case of the frequencies. [Your justification should not require use of the equation $v = f\lambda$.] [1]

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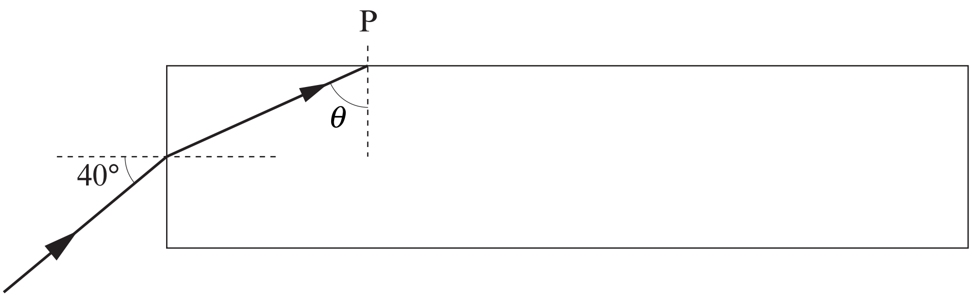
(b) The diagram shows a narrow beam of light entering a solid cuboid (block) of glass of refractive index 1.52, surrounded by air (of refractive index 1.00).



(i) Show clearly that $\theta = 65°$. [3]

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(ii) Show that the beam will not emerge into the air at point P. [2]

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(iii) (I) Carefully complete the path of the beam, showing it eventually emerging into the air and travelling through the air. [1]

(II) Indicate clearly on the diagram sections of the **whole** path which are parallel to each other. [2]

(c) In a multimode fibre, light travels at a range of angles **to the fibre axis**. Explain why, for clear communication of rapid streams of data, the range of angles should be restricted so that even the greatest value of the angle is very small. [2]

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3. *(a)* When ultraviolet radiation of high enough frequency falls on a tin plate (held by an insulating support) the plate acquires a charge. Explain, in terms of electrons and photons, why this happens, and whether the charge is positive or negative. [3]

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(b) The *work function* of tin is 7.1×10^{-19} J.

(i) What is meant by the work function of a metal? [1]

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(ii) Calculate the minimum frequency of ultraviolet radiation needed for photoelectric emission from tin. [2]

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(iii) Calculate the **frequency** of ultraviolet radiation needed for the emitted electrons to have a maximum kinetic energy of 1.5×10^{-19} J. [2]

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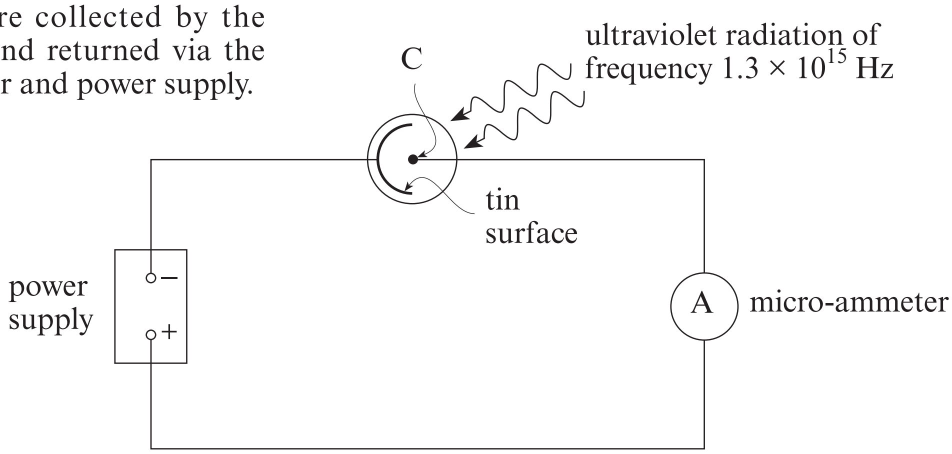
(c) In the set-up shown, assume that all the electrons emitted from the tin surface are collected by the electrode C, and returned via the micro-ammeter and power supply.



(i) The micro-ammeter reads 0.64 μA (0.64×10^{-6} coulombs per second). Show that 4.0×10^{12} electrons are emitted per second. [1]

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(ii) Only 1 in 1200 of the incident photons causes emission of an electron. By considering the energy of an individual photon, calculate the ultraviolet energy per second falling on the tin surface. [4]

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Turn over.

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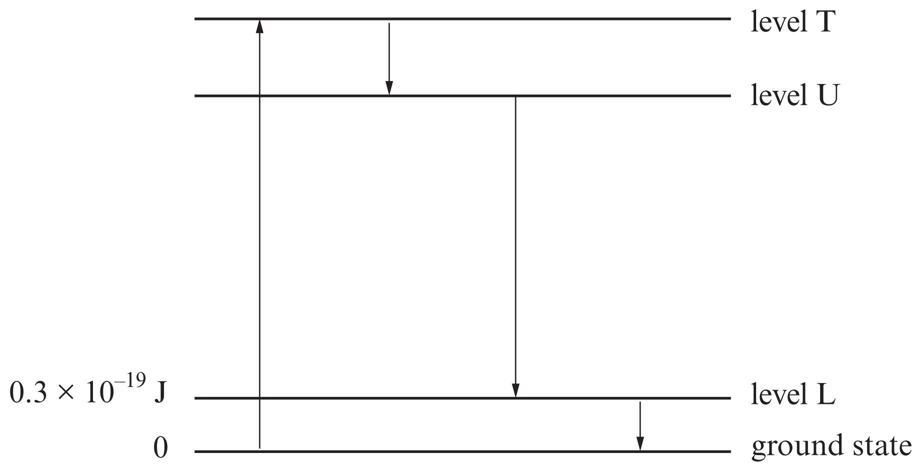
4. *(a)* A simplified energy level diagram for a 4-level laser system is given. The arrows show the sequence of transitions which electrons make between leaving the ground state and returning to it.



(i) Label the transitions associated with (I) *pumping* (II) *stimulated emission*. [2]

(ii) The wavelength of the output radiation from the laser is 1.05×10^{-6}m. Calculate the energy **above the ground state** of level U. [3]

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(iii) (I) What triggers a stimulated emission event? [2]

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(II) How does stimulated emission produce light amplification? [1]

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(III) What feature of stimulated emission makes the laser's output *coherent*? [1]

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(iv) T_U is the typical time spent by an electron in level U before spontaneously 'falling' to a lower level. T_L is the typical time spent by an electron in level L before spontaneously falling to the ground state. Explain why it is an advantage for laser operation for T_U to be much greater than T_L. [2]

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(b) Semiconductor (diode) lasers are much cheaper to make and much more compact than other types of laser. What advantage do they have in terms of *energy* over other types of laser? [1]

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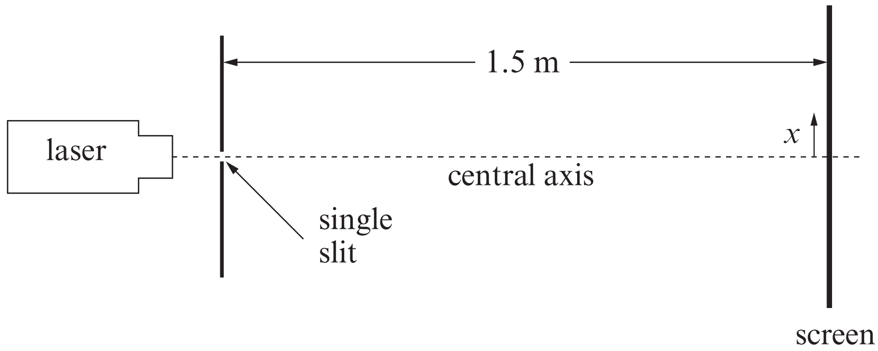
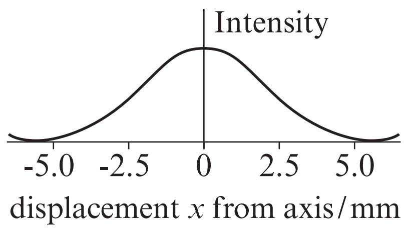
5. *(a)* Apparatus is set up as shown.



The graph shows how the intensity of light on the screen varies with displacement x from the central axis.

[Note the expanded displacement scale.]



(i) Name the wave property being demonstrated. .... [1]

(ii) What can be deduced about the width of the slit compared with the wavelength of the light from the laser? Give your reasoning. Calculations are not needed. [2]

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(iii) What would happen to the graph if the width of the slit were to be increased? [2]

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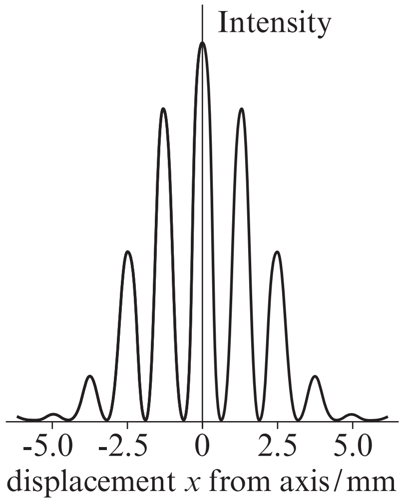
(b) The single slit is now replaced by two parallel slits, each of the same width as the single slit in *(a)*. The centres of the slits are 0.75 mm apart. The intensity of light on the screen near the central axis now varies as shown.



(i) Determine from the graph the separation of the bright interference fringes. [1]

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(ii) Hence find the wavelength of the light. [2]

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(iii) Explain in terms of *interference*, *phase,* and *path difference* how the **bright** fringes arise. Assume that the slits act as in-phase sources. [3]

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(iv) Suggest why the brightness of the bright fringes decreases with displacement x from the central axis, in the region shown on the graph. [1]

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(c) It is easier to obtain clear fringes in the experiment of part *(b)* using a laser rather than an ordinary light source. Give two reasons for this. [2]

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6. *(a)* (i) What is a *meson*? [1]

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(ii) A π^+ particle is a (first generation) meson with a positive charge. Explain why its quark make-up must be $u\bar{d}$. [1]

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(b) An interaction sometimes observed at high energies is

$$\pi^+ + {}^2_1H \longrightarrow p + p$$

[${}^2_1H$ symbolises here the **nucleus** of a ${}^2_1H$ atom.]

(i) Determine whether or not

(I) u quark number is conserved. [1]

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(II) d quark number is conserved. [1]

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(ii) Discuss which force is likely to be responsible for this interaction. [2]

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(c) A similar interaction can be observed between a π^+ particle and a ${}^7_3Li$ nucleus.

$$\pi^+ + {}^7_3Li \longrightarrow {}^A_ZX + p$$

(i) Determine A and Z. [2]

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(ii) What is in common between the nuclei ${}^A_ZX$ and ${}^7_3Li$? [1]

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7. *(a)* (i) The spectrum of the star *Rigel* in the constellation *Orion* peaks at a wavelength of 260 nm. Calculate the temperature of the surface of Rigel. [2]

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(ii) What assumption were you making about the way the star's surface radiates? [1]

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(b) To a good approximation the Kelvin temperature of Rigel's surface is twice that of the Sun, and the **radius** of Rigel is 70 times the radius of the Sun. Use *Stefan's Law* to estimate the ratio

$$\frac{\text{total power of electromagnetic radiation emitted by Rigel}}{\text{total power of electromagnetic radiation emitted by the Sun}}\ .$$ [3]

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(c) We can discover the presence of particular atoms in the atmosphere of a star by measuring the wavelengths of dark lines in the star's spectrum.

Explain how the lines arise, and why they occur at specific wavelengths. [3]

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