Candidate Name	Centre Number	Candidate Number

GCE AS/A level

1322/01 **New AS**

PHYSICS
ASSESSMENT UNIT PH2: WAVES AND PARTICLES

P.M. THURSDAY, 21 May 2009

$1\frac{1}{4}$ hours

For Examiner's use only.		
1.	9	
2.	15	
3.	12	
4.	12	
5.	12	
6.	8	
7.	12	
Total	80	

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

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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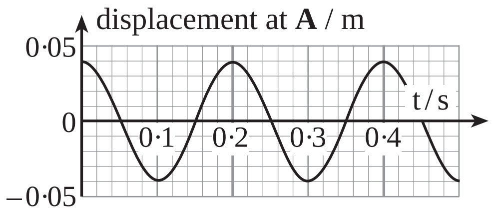
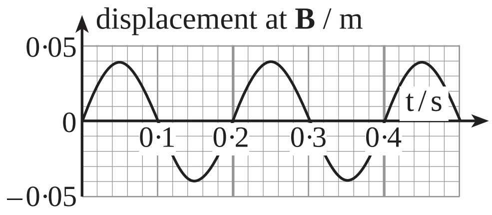
1. A progressive wave is travelling from left to right. Displacement – time graphs are given for the same time interval for two points, **A** and **B**, in the path of the wave. **B** is 0·30 m to the right of **A**.





(a) (i) Write down the value of the *amplitude* of the wave. .... [1]

(ii) Calculate the *frequency*. [3]

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(b) Show that $6{\cdot}0\ \mathrm{m\,s^{-1}}$ is a possible *speed* for the waves, explaining your reasoning carefully. [2]

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(c) (i) Explain what is meant by the *wavelength* of the waves. [2]

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(ii) Taking the wave speed as $6{\cdot}0\ \mathrm{m\,s^{-1}}$, calculate the wavelength of the waves. [1]

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Turn over.

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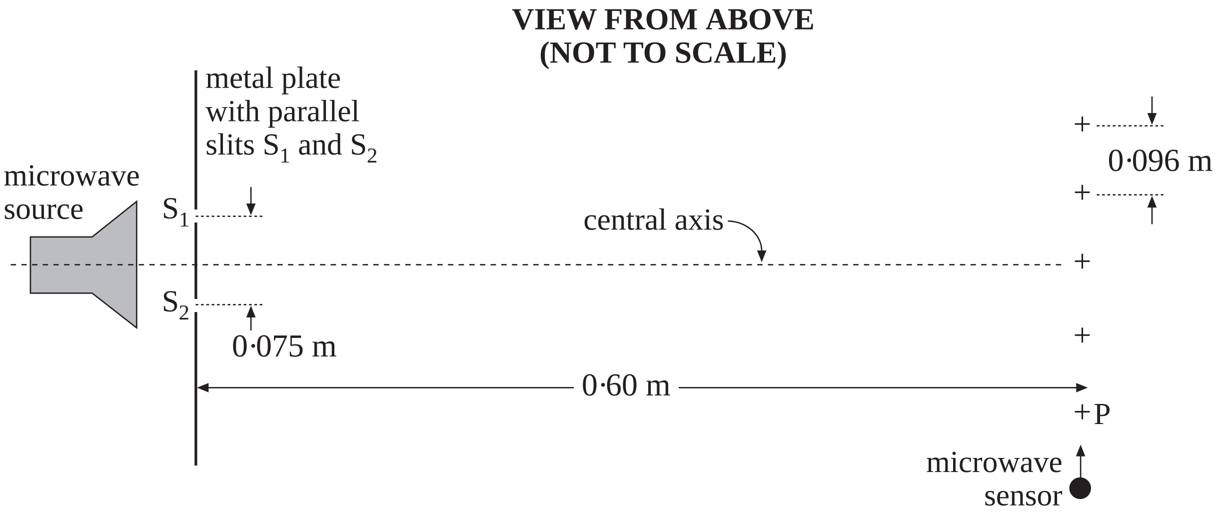
2. *(a)* In the set-up below, a microwave sensor is moved slowly in a straight line at right angles to the central axis. Successive maxima of microwave intensity are found at the points marked by crosses.



(i) Explain what part *diffraction* plays in the formation of this pattern. [2]

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(ii) The slits S_1 and S_2 act as *in-phase sources*.

(I) Explain what is meant by *in-phase sources*. [1]

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(II) State one feature of the diagram which confirms that S_1 and S_2 are in-phase. [1]

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(iii) Assuming that the *Young's double slits* formula is applicable, use the data in the diagram to show that the *wavelength* of the microwaves is approximately 0·01 m. [2]

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(iv) (I) What can be said about the *phase* of the waves from S_1 and S_2 when they arrive at point P? Justify your answer. [2]

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(II) Calculate the *path difference*, $S_1P - S_2P$, explaining your reasoning. [3]

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(b) The microwave source of part *(a)* emits *polarised* waves. Describe how you would demonstrate this. [2]

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(c) Potatoes can be heated quickly in a microwave oven. Which properties of the microwave radiation account for this? [2]

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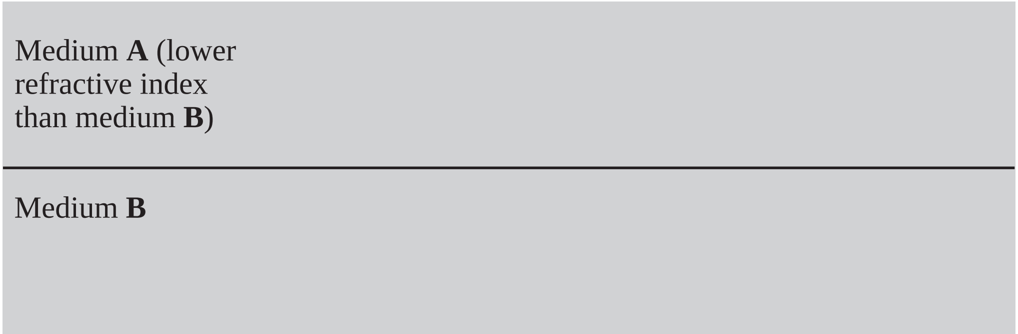
3. *(a)* Add to the diagram to show clearly what is meant by *critical angle*. [2]



(b) If **A** is glass of refractive index 1·520, and **B** is glass of refractive index 1·550, show clearly that the critical angle is approximately 80°. [3]

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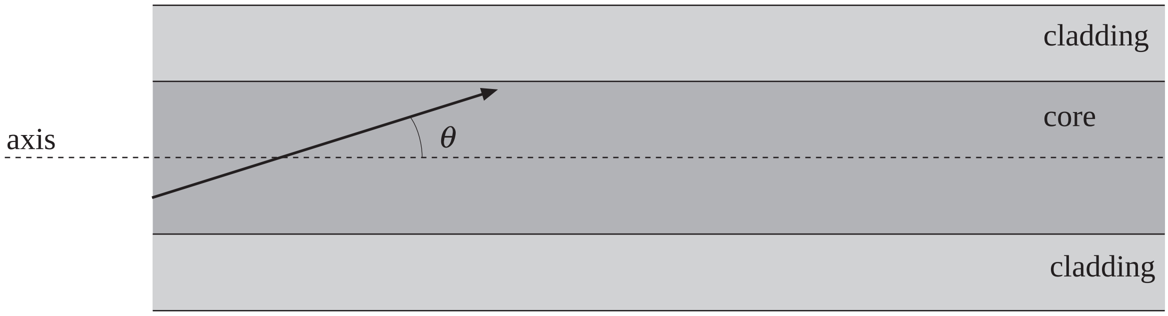
(c) A step-index optical fibre has a core of glass **B**, and cladding of glass **A**. [See part *(b)*.]



(i) What is the largest angle, θ, **to the axis**, at which light can propagate along the fibre with successive total internal reflections? .... [1]

(ii) Explain why light initially travelling at an angle to the axis greater than θ will not reach the end of the fibre. [3]

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(d) Modern communications systems require very high data transmission rates, for which *mono-mode* optical fibres are needed. Explain why optical fibres with thick cores (*multi-mode* fibres) are not suitable. [3]

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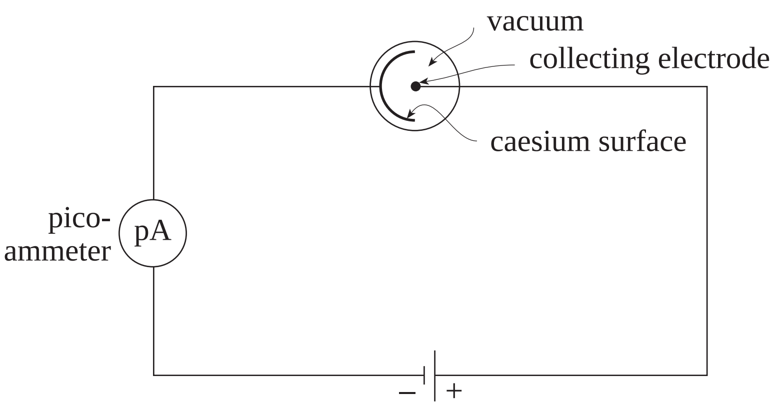
4. The circuit shown below is set up in a darkened room with the blinds drawn.



(a) (i) When the blinds are opened a little, so that sunlight falls on the caesium surface, the ammeter registers a continuous current. Explain, in terms of photons and electrons, why this happens. [3]

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(ii) What difference, if any, would be observed if the blinds were adjusted so that a greater intensity of light fell on the caesium surface? Give your reasoning. [2]

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(b) (i) State **two** ways in which the apparatus would need to be modified in order to measure the *maximum kinetic energy* of the emitted electrons. [2]

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(ii) The *work function* of caesium is $3{\cdot}1 \times 10^{-19}$ J. The highest frequency of electro-magnetic radiation in the sunlight passing through the window may be assumed to be $8{\cdot}6 \times 10^{14}$ Hz. Use Einstein's photoelectric equation to calculate the maximum kinetic energy of the electrons emitted from the caesium surface. [2]

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(iii) Show that this corresponds to a maximum *speed* of $7{\cdot}5 \times 10^{5}$ ms^{-1} for electrons leaving the caesium surface. [2]

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(iv) According to Einstein's equation the maximum kinetic energy of the emitted electrons does not depend on the *intensity* of the light (for a given frequency). Explain in terms of photons, why this non-dependence is to be expected. [1]

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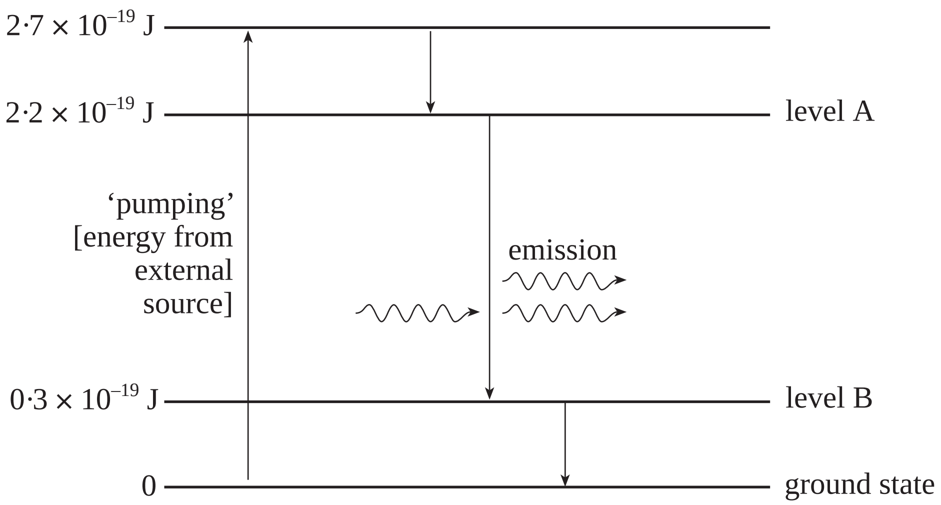
5. A simplified energy level diagram is given for the amplifying medium in a type of laser (the Nd-YAG laser).



(a) The useful output of the laser results from the transition between level A and level B.

(i) Calculate the *wavelength* of the radiation emitted. [3]

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(ii) Name the region of the electromagnetic spectrum in which the radiation lies. [1]

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(iii) This radiation is produced by *stimulated emission*. Explain what is meant by *stimulated emission*. [Your answer should include statements about *photon energy* and *phase*.] [3]

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(iv) Explain briefly, in terms of photons, why stimulated emission gives rise to 'light amplification'. [1]

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(b) (i) Referring to levels A and B, explain what is meant by a *population inversion*. [1]

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(ii) Explain why a population inversion is needed for the laser to work. [1]

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(iii) In this *4-level* laser system, level B is above the ground state. How does this make the population inversion easier to establish than in a *3-level* system? [2]

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6. Neutrinos (ν_e) from the Sun can be detected by the conversion of chlorine (Cl) into argon (Ar) in the interaction.

$$^{37}_{17}\text{Cl} + \nu_e \longrightarrow {}^{37}_{18}\text{Ar} + e^-$$

(a) State, giving a reason, which force (strong, weak, or electromagnetic) is involved in this interaction. [2]

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(b) Explain how the interaction demonstrates

(i) *charge conservation*, [1]

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(ii) *lepton conservation*. [1]

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(c) Write down the number of *neutrons* in

(i) $^{37}_{17}\text{Cl}$ .... (ii) $^{37}_{18}\text{Ar}$ .... [1]

(d) On the level of *quarks*, the interaction can be written as

$$\text{d} + \nu_e \longrightarrow \text{u} + e^-$$

(i) The quark composition of a proton is uud. Write down the quark composition of a neutron. [1]

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(ii) Hence explain how the quark version of the interaction is equivalent to the version given at the beginning of the question. [2]

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QUESTION 7 IS ON PAGE 14

Turn over.

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7. *(a)* A star's continuous spectrum approximates to that of a *black body*. What is meant by a *black body*? [1]

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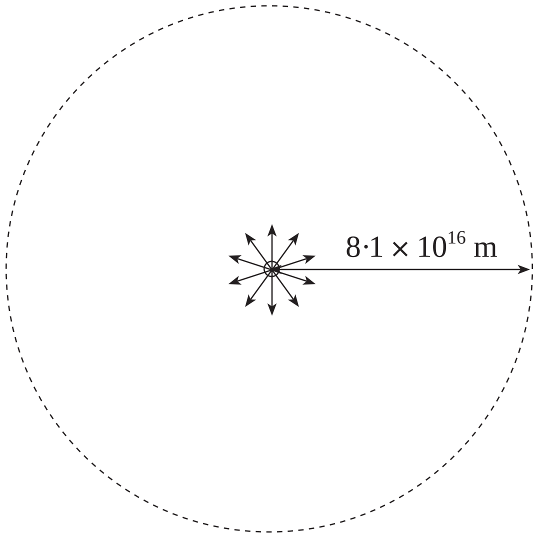
(b) The star *Sirius* is estimated to be $8{\cdot}1 \times 10^{16}$ m away. The *intensity* of its electromagnetic radiation reaching the Earth is measured to be $1{\cdot}2 \times 10^{-7}$ $\mathrm{Wm^{-2}}$.



(i) Sirius emits radiation equally in all directions. Show that the information above leads to a value of $9{\cdot}9 \times 10^{27}$ W for the *power* output from the surface of Sirius. [2]

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(ii) Suggest why the actual emitted power will, in fact, be more than this. [1]

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(iii) The surface temperature of Sirius is measured to be 9900 K. Using *Stefan's Law*, estimate the effective *radius* of Sirius. [3]

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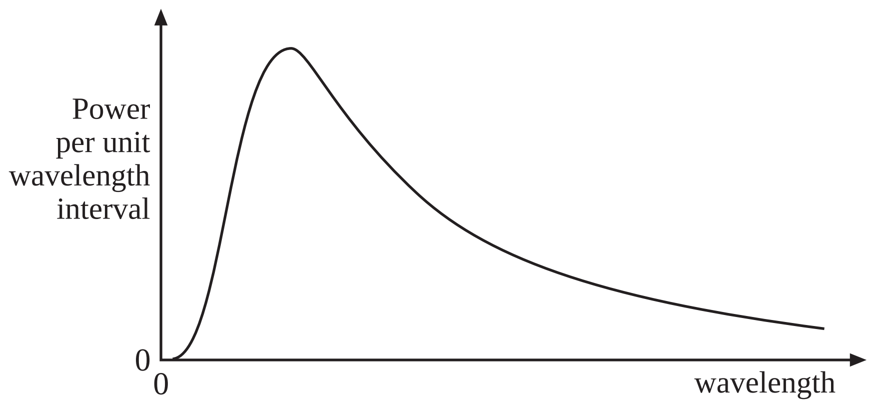
(iv) The (continuous) spectrum of Sirius is sketched below. On the same axes, sketch the spectrum of the Sun. The sun's temperature is 5800 K. [Assume that the surface areas of the Sun and Sirius are approximately equal.] [2]



(c) Dark lines are seen crossing the continuous spectrum of a star. Explain how these lines arise. [3]

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