Candidate Name	Centre Number	Candidate Number

GCE AS/A level

1322/01

PHYSICS
PH2: WAVES AND PARTICLES

P.M. MONDAY, 18 January 2010

1½ hours

W10 1322 01 1

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**14**	
2.	**14**	
3.	**10**	
4.	**11**	
5.	**11**	
6.	**9**	
7.	**11**	
Total	**80**	

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator, a ruler 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 given is incorrect.

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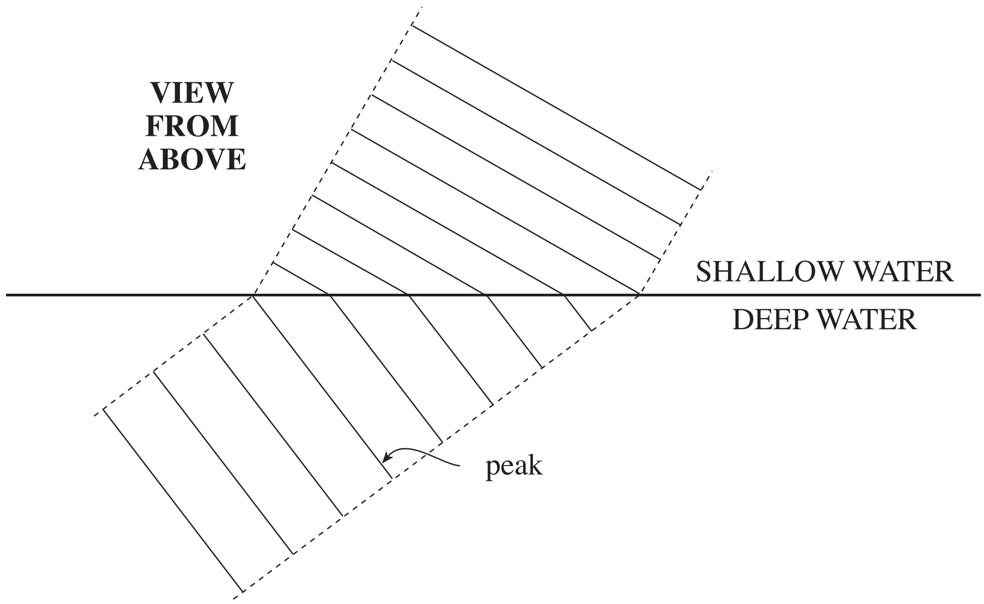
1. *(a)* Water waves are travelling into shallow water from deeper water. The actual positions of the wave peaks at one instant are shown on the diagram, **which is full size**.



(i) (I) Add two arrows to the diagram to show the directions of travel of the waves in the deep water and in the shallow water. [1]

(II) Deduce **from the change in direction** whether the waves travel faster or slower in shallow water. Give a reason. Calculations are not wanted. [2]

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(ii) (I) Measure the *wavelength* of the waves in the deep water. [1]

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(II) The *speed* of the waves in the deep water is $0.33\ \text{ms}^{-1}$. Calculate the frequency of the waves. [2]

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(III) Determine the speed of the waves in the shallow water. [2]

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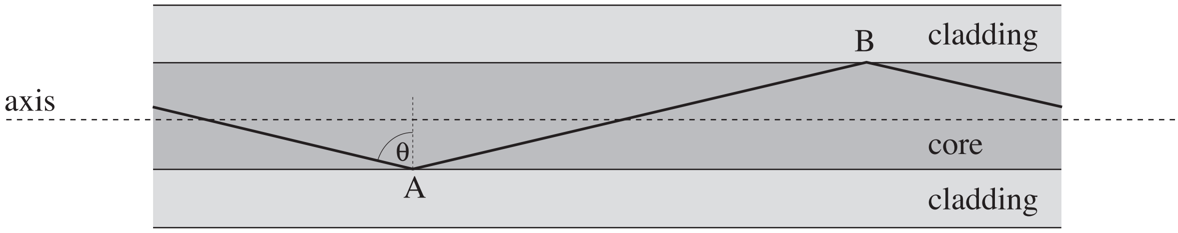
(b) The diagram shows a path by which light can travel through the core of a 'thick' glass fibre.



(i) Give the full name for the process which must occur at A and B if the light is to travel a large distance through the fibre along this path. [1]

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(ii) The smallest value of angle θ for which the process can take place is 72°. Calculate the refractive index of the cladding if that of the core is 1.58. [3]

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(iii) Thick glass fibres allow light to travel in zigzag paths, with a range of angles, and also in straight paths parallel to the fibre axis. Explain why these fibres are unsuitable for the transmission of rapid streams of data encoded in the light. [2]

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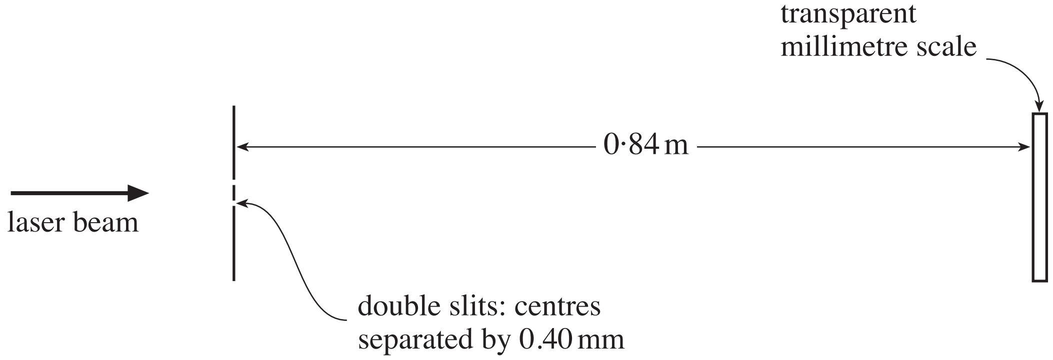
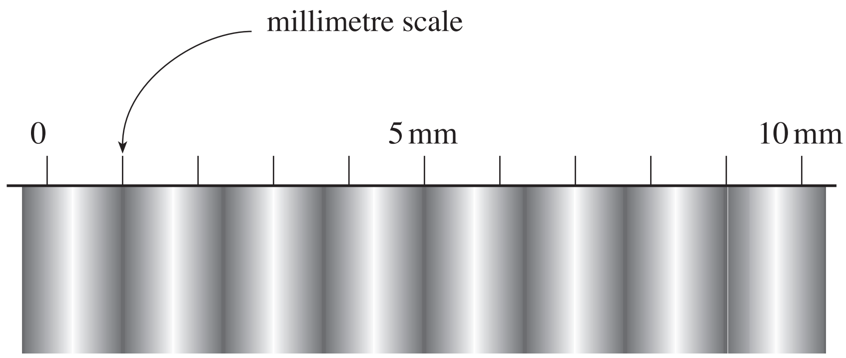
2. *(a)* Young's fringes are produced using light from a laser.



A transparent millimetre scale is placed 0.84 m from the double slits, as shown. When a camera is used to take a close-up picture of the scale, a series of equally-spaced bright and dark fringes is seen, as shown in the diagram below.



(i) Explain, in terms of *interference, phase* and *path difference*, how the **bright** fringes arise. [4]

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(ii) Using data from the diagrams calculate the wavelength of the light. [3]

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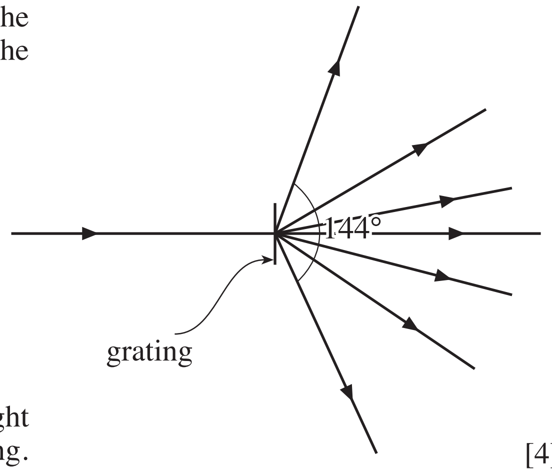
(b) The laser beam is now shone normally (i.e. at 90°) at a diffraction grating with 5.00×10^5 'slits' per metre of length.

(i) Calculate the separation of the centres of adjacent slits in the grating. [1]

(ii) Seven beams emerge from the grating. The central lines of the beams are shown in the diagram.



Calculate the wavelength of the laser light using the angle given. Show your working. [4]

(c) Suppose that you have to make your own measurements to find the wavelength of light from a laser. Discuss whether you would choose the Young's fringes method, or the diffraction grating method, if you wanted an accurate value for the wavelength. [2]

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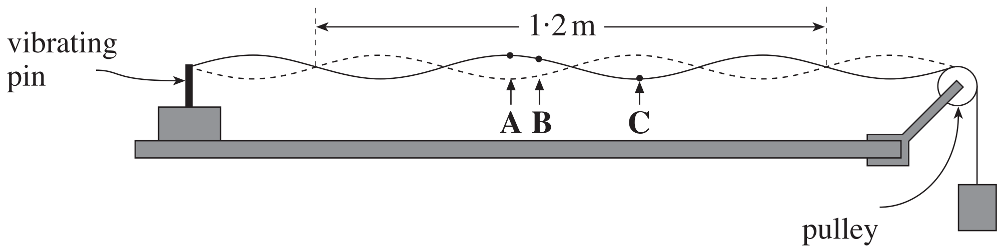
3. The diagram shows a demonstration of a *stationary wave* on a string.



(a) (i) State whether the following pairs of points on the string are vibrating *in phase, in antiphase*, or neither in phase nor in antiphase. [2]

A and **B** ....

A and **C** ....

(ii) Describe briefly how you could check this experimentally. [2]

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(b) (i) Progressive waves transfer energy through the medium; stationary waves do not do this. Describe **one** other difference between progressive and stationary waves. [2]

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(ii) Explain how, in the set-up above, the stationary wave can be thought of as arising from progressive waves. [2]

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(c) (i) From the diagram deduce a value for the wavelength. [1]

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(ii) The pin is vibrating at a frequency of 50 Hz. Calculate the wave speed. [1]

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4. *(a)* Einstein's *photoelectric equation* may be written

$$E_{k\,max} = hf - \phi .$$

(i) What quantity of energy does hf represent? [1]

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(ii) A student mistakenly thinks that the 'minus' sign should be a 'plus' sign. Explain, in terms of electrons and photons, why the equation must be correct as written above. [3]

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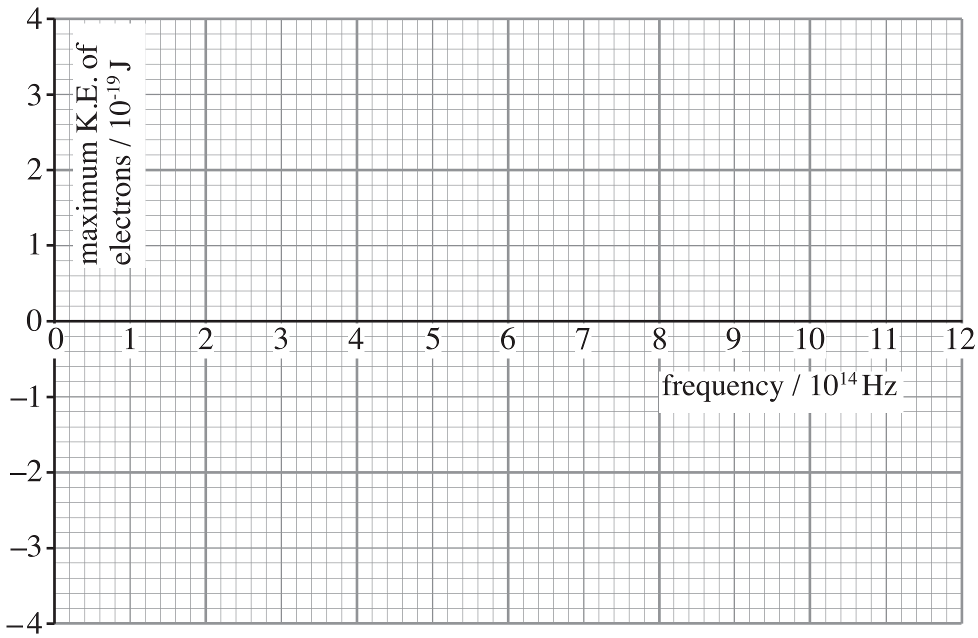
(b) In an experiment in which a sodium surface is exposed to electromagnetic radiation, these results are obtained.

f / 10^{14} Hz	6.9	9.6	11.8
$E_{k\,max}$ / 10^{-19} J	0.79	2.58	4.04

(i) Plot these data points on the grid, and hence draw the graph line. [2]



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(ii) Use the data, or your graph, to determine values for

(I) the *work function* of sodium, [1]

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(II) the *Planck constant*. Show your working. [2]

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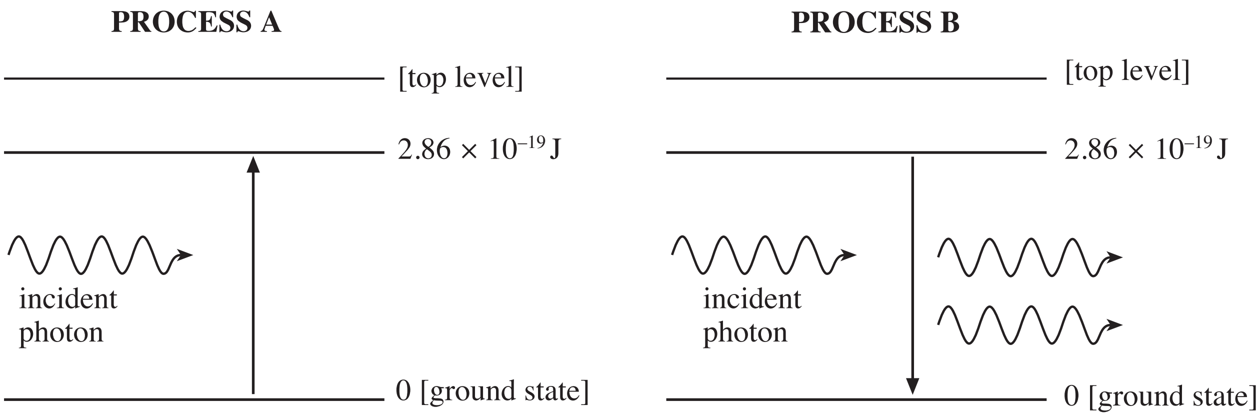
(iii) Draw on the grid a line, labelled (iii), which might be obtained if a metal with a **lower** work function were used in the experiment. [2]

Examiner only

5. A *ruby laser* is classed as a *3-level system*. The amplifying medium is a ruby, which is a crystal containing chromium ions. The diagram shows two processes, **A** and **B**, which could occur when a photon of a certain wavelength is incident on a chromium ion.



(a) Calculate the *wavelength* of the incident photon. [2]

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(b) (i) What name is given to process **A**? .... [1]

(ii) State what happens to the energy of the incident photon in process **A**. [1]

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(c) (i) What name is given to process **B**? .... [1]

(ii) State **two** things which the emerging photons in process **B** have in common. [2]

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(d) For the laser to work, process **B** must happen more often than process **A**. This requires a *population inversion*.

(i) Explain what is meant by a *population inversion*. [1]

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(ii) The population inversion is achieved in the ruby laser by *optical pumping* (shining a very bright light on the ruby). **Draw an arrow** on the right hand diagram on page 10 to represent the energy level transition associated with the pumping. [1]

(iii) How must the typical time an electron spends at the top level compare with the typical time it spends at the middle level? Give a reason for your answer. [2]

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Examiner only

6. *(a)* The quark make-up of a neutron is udd. Explain why only this combination of u and d quarks is possible for a neutron. [1]

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(b) The π^-particle has quark make-up $d\bar{u}$. There is a particle called Δ^- which has quark make-up ddd.

(i) Show that the magnitudes of the charges of the π^- and the Δ^- are equal. [1]

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(ii) Explain in terms of quarks, why the π^- is classed as a meson but the Δ^- as a baryon. [2]

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(c) The Δ^- has a very short lifetime (about 6×10^{-24}s), almost always decaying into a neutron and a π^- as shown.

$$\Delta^- \rightarrow n + \pi^-$$

(i) Show clearly whether or not the following are separately conserved in this decay:

(I) up-quark number, [1]

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(II) down-quark number. [1]

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(ii) Give **one** reason for believing this decay **not** to be a *weak force* interaction. [1]

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Examiner only

(d) The Δ^{++} particle is a baryon with a charge equal to that of two protons.

(i) Write down the quark make-up which the Δ^{++} must have. [1]

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(ii) The Δ^{++} decays into a proton and a pion (π meson) by a similar mechanism to that in *(c)*. Determine the quark make-up of the pion. [1]

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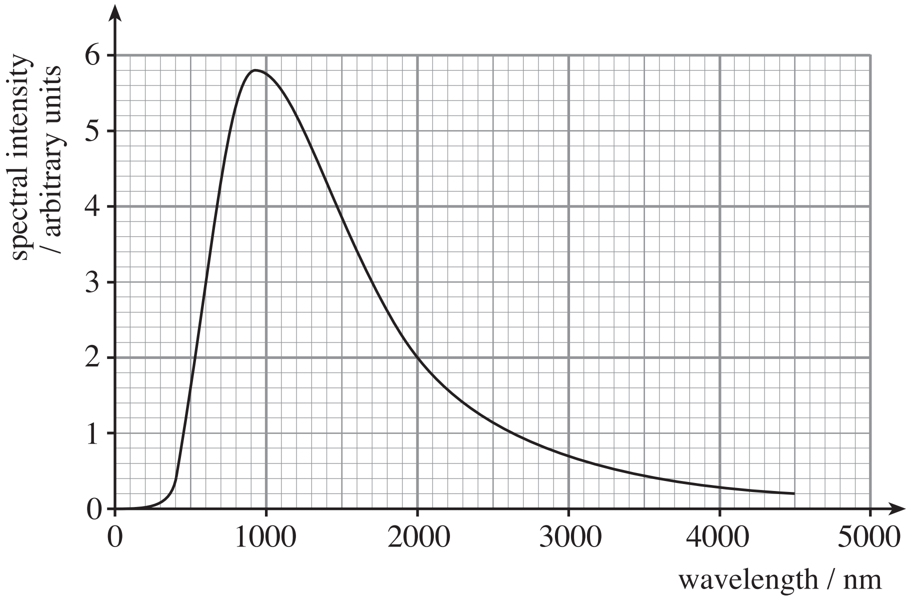
7. The nearest star to the Sun is a 'red dwarf', *Proxima Centauri*. The graph shows its spectrum.



(a) Use *Wien's law* to show clearly that the temperature of the star is about 3000 K. [3]

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(b) The range of visible wavelengths is 400 nm – 700 nm.

(i) Explain why *Proxima Centauri* is described as 'red'. [1]

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(ii) Name the region of the electromagnetic spectrum containing most of the power radiated. [1]

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Examiner only

(iii) (I) Where, apart from at the extremes, is the graph gradient zero? [1]

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(II) Astrophysicists believe that *Proxima Centauri* will become hotter in the distant future. Estimate the temperature it would have to reach in order for the intensity of its radiation to be roughly the same at each end of the **visible** region of the spectrum (so the star appears white). Show your working clearly. [2]

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(c) Use *Stefan's law* to calculate the total power of electromagnetic radiation emitted from *Proxima Centauri* (at its present temperature) if its effective radius is 1.01×10^{8} m. [3]

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Examiner only

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