Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1322/01

PHYSICS – PH2
Waves and Particles

A.M. FRIDAY, 18 January 2013

1½ hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**12**	
2.	**13**	
3.	**13**	
4.	**11**	
5.	**11**	
6.	**11**	
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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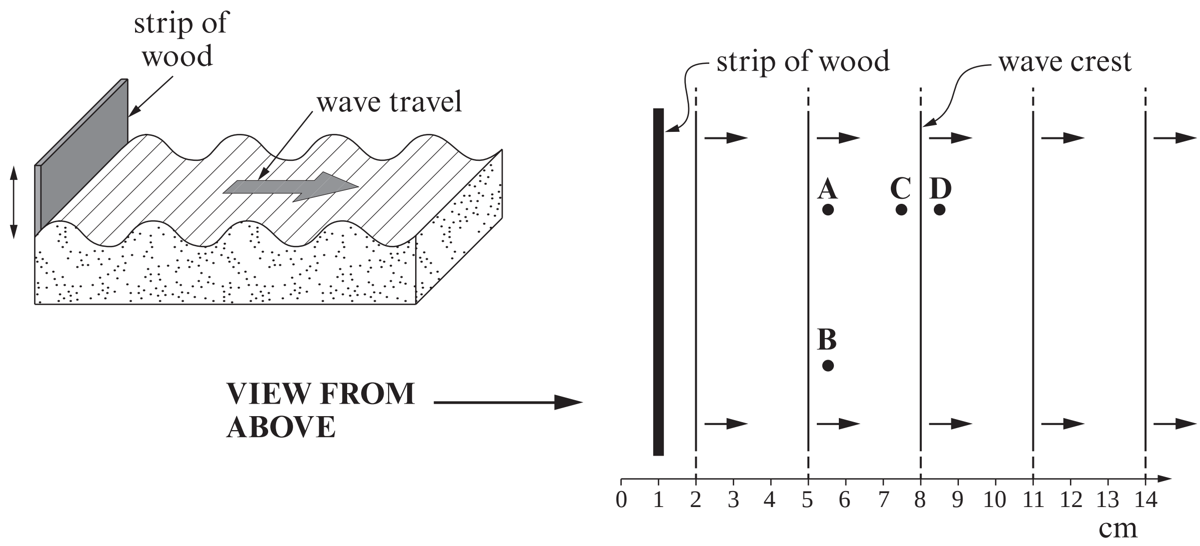
1. *(a)* A strip of wood, in contact with the surface of water in a tank, oscillates up and down at a frequency of 5.0 Hz. The view from above shows the positions of wave crests (where the water height is a maximum) at one instant.



(i) Determine the wavelength of the wave. [1]

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(ii) Calculate the time it takes for a wave crest to travel a distance of 10.5 cm. [3]

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(iii) State whether or not the oscillations at points **B**, **C** and **D** are *in phase* with the oscillations at **A**. Justify your answers. [3]

Point **B** ....

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Point **C** ....

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Point **D** ....

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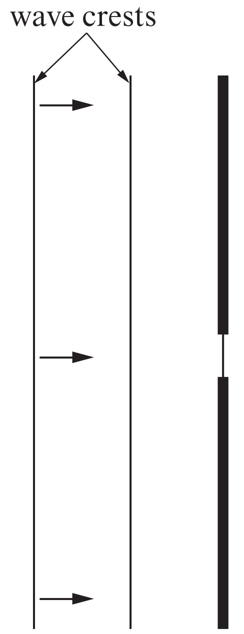
(b) The waves of frequency 5.0 Hz approach a barrier with a gap in it (see diagram below). The waves that pass through the gap spread out.

(i) What name is given to the spreading of the waves? .... [1]

(ii) Carefully sketch the **two** wave crests to the right of, and nearest to, the gap. [2]



(iii) What changes would occur to the diagram above if the **frequency** of the wave were increased by a factor of 4? No calculations are needed. [2]

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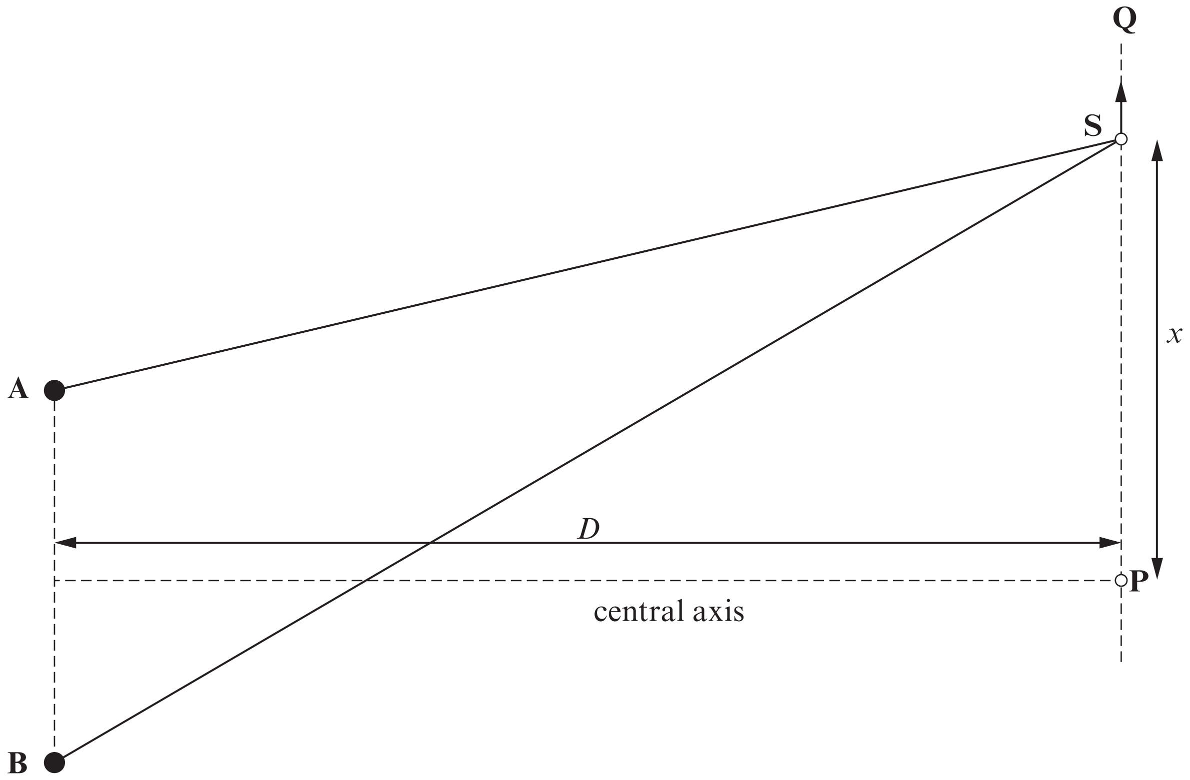
2. *(a)* Two in-phase sources, **A** and **B**, emit microwaves.



As a microwave sensor, **S**, is moved from **P** towards **Q**, the intensity is found to vary, with the first three maxima when $x = 0$, when $x = 10.0$ cm and when $x = 22.0$ cm.

(i) Explain why there is a maximum at point **P**. [2]

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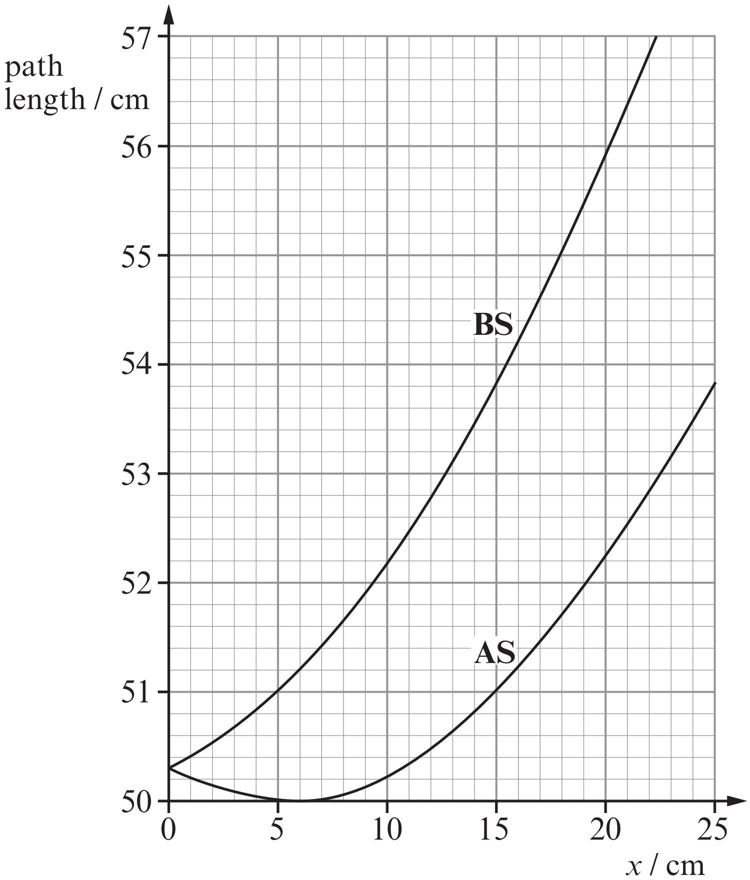
(ii) The graphs show how the *path lengths*, **BS** and **AS** depend on the distance x of the sensor from **P**.



Use these graphs to determine the wavelength of the microwaves, showing your working. [2]

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(iii) (I) The distance marked D on the diagram on the page opposite is 50.0 cm. The distance **AB** between the sources is 10.0 cm. Use the Young's fringes formula to obtain a value for the wavelength. [Make use of the distance from the central maximum at **P** to the next maximum.] [2]

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(II) Give one reason, based on the set-up, or on the positions of the maxima, why it is not strictly appropriate to use the Young's fringes formula here. [1]

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(b) A diffraction grating has 5.0×10^5 slits per metre. When a laser beam is shone normally at the grating, the third order beams emerge at angles of 72.3° to the normal.

(i) Determine the wavelength of the light. [3]

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(ii) Show that 7 (but no more than 7) beams of light emerge from the grating. [3]

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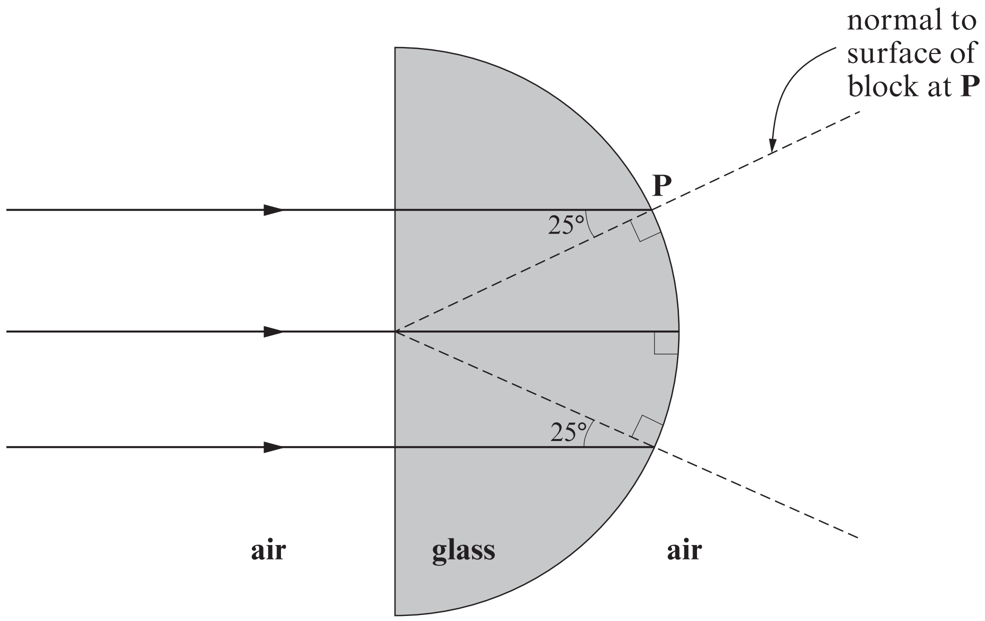
3. *(a)* (i) The diagram shows three beams of light travelling through a glass block of semicircular cross-section and refractive index, *n,* of 1.58. The block is surrounded by air (refractive index 1.00).



(I) **Sketch, on the diagram above, the paths** of all three beams when they emerge into the air from the curved surface of the block. [2]

(II) Calculate the angle to the normal at which the top beam emerges into the air at **P**. [2]

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(ii) (I) Show by calculation that a beam of light striking the curved surface at **Q** (see diagram alongside) will not re-enter the air at **Q**. [2]

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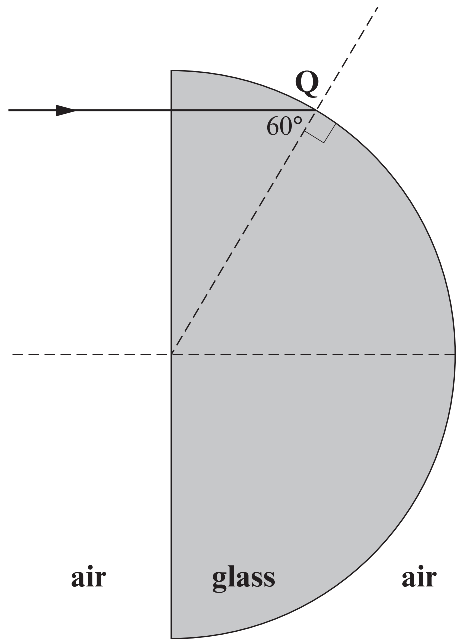

(II) **Continue** carefully on the diagram the path of the beam until it re-emerges into the air. [2]

(b) (i) State how the core of a *monomode* optical fibre differs from that in a multimode fibre. [1]

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(ii) How do the paths of light in monomode and multimode fibres differ? [1]

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(iii) Explain the advantage of monomode fibres over multimode fibres for communicating a rapid sequence of data encoded as light pulses. [3]

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4. *(a)* Here is a summary of a theory (now considered incorrect) to account for the photoelectric effect:

"The electrons in a surface gradually gain energy from light waves falling on the surface. After a time they will have gained enough energy to escape. The greater the intensity of the light waves the greater the maximum kinetic energy of the emitted electrons."

State some ways in which Einstein's explanation (in terms of photons) of the photoelectric effect differs from the theory above. [4]

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(b) The work function of sodium is 3.8×10^{-19} J.

(i) Calculate the maximum kinetic energy of electrons emitted from a sodium surface irradiated with ultraviolet radiation of frequency 8.7×10^{14} Hz. [2]

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(ii) Discuss whether or not this maximum kinetic energy would change if the surface were also irradiated **at the same time** with radiation of frequency 8.5×10^{14} Hz. [2]

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(iii) Determine whether or not visible light can cause the emission of electrons from a sodium surface, giving your reasoning and conclusion. Take the range of visible wavelengths to be 400 nm to 700 nm. [3]

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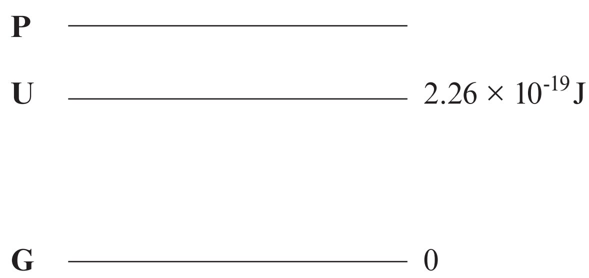
5. A simplified diagram of the energy levels in a 3-level laser system is given alongside.



(a) Calculate the wavelength of a photon associated with a transition between levels **U** and **G** (the ground state). [2]

(b) Explain in terms of electrons and photons what happens in the three possible processes listed below, in which photons are involved in transitions between levels **U** and **G** (or **G** and **U**). [Assume in each case that the levels are suitably populated.]

(i) absorption [1]

(ii) stimulated emission [4]

(iii) spontaneous emission [1]

Examiner only

(c) (i) Explain what is meant by *pumping* in a laser. [1]

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(ii) Explain why pumping is essential to the operation of the laser. [2]

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6. *(a)* A table of astronomical data includes the following about the star *Alpha Centauri A*: Radius = 8.54×10^8 m, Temperature = 5790 K, Luminosity = 5.83×10^{26} W.

(i) Investigate whether the data above is consistent with the star radiating as a black body. Show your working clearly, and give your conclusion. [3]

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(ii) The star is 4.1×10^{16} m from the Earth. Calculate the intensity (energy per second per m^2) of electromagnetic radiation reaching the Earth from the star. [2]

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(iii) Calculate the wavelength of the star's peak spectral intensity, and sketch the spectrum on the axes provided. [4]

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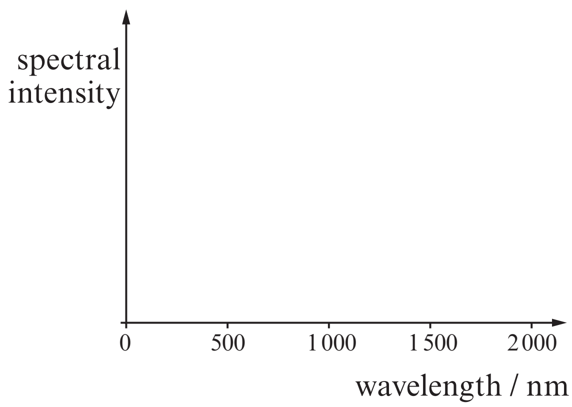

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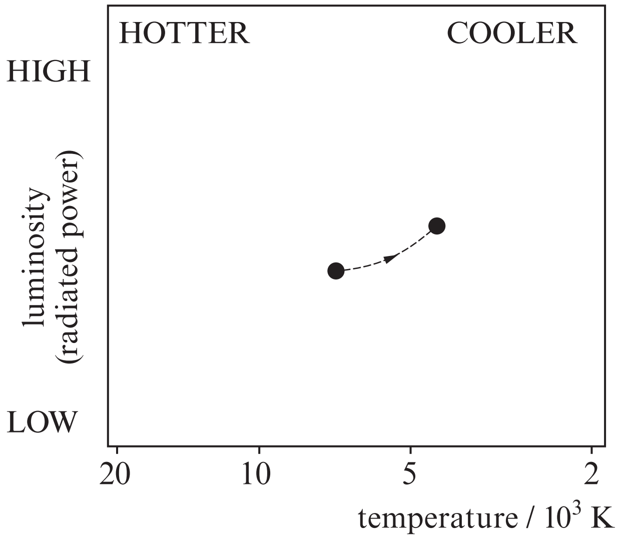
(b) Astronomers assign to each star a position on a chart, according to the star's luminosity and temperature.

During one stage in the life of *Alpha Centauri A*, its position on the chart will move as shown by the dotted line.

Use Stefan's law to show clearly what happens to the *size* of the star during this stage. [**Numerical calculations are not needed.**] [2]



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7. *(a)* A law of Physics is that the baryon number is always conserved.

[Baryon number = number of baryons – number of antibaryons.]

Name one antibaryon, giving its quark make-up. [2]

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(b) (i) A gamma ray photon of high enough energy can interact with a proton to produce a neutron and a particle x in the following interaction:

$$p + \gamma \rightarrow n + e^{+} + x$$

Identify x, giving your reasoning. [2]

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(ii) Another possible interaction is:

$$p + \gamma \rightarrow n + y$$

Identify y, giving your reasoning. [3]

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(iii) For each of the above interactions (*(b)*(i) and *(b)*(ii)) discuss whether the *weak force* is involved. [2]

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