Candidate Name	Centre Number	Candidate Number

GCE AS/A level

1322/01

PHYSICS

ASSESSMENT UNIT PH2: WAVES AND PARTICLES

P.M. MONDAY, 17 January 2011

1½ hours

For Examiner's use only.		
1.	10	
2.	7	
3.	8	
4.	10	
5.	12	
6.	13	
7.	9	
8.	11	
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 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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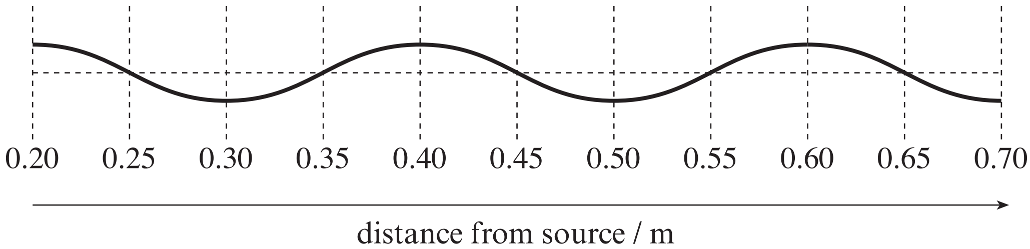
1. *(a)* A transverse progressive wave is travelling from left to right along a stretched string. The diagram shows part of the string at one instant.



(i) Write down the *wavelength*. .... [1]

(ii) The *frequency* is 50 Hz.

(I) Calculate the *speed* of the waves. [1]

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(II) Calculate the time taken for 1 cycle of oscillation. [1]

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(III) **On the diagram above**, draw the string at a time of 0.005 s later. [2]

(iii) Explain why the waves are called *transverse*. [2]

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(b) It is also possible to set up a *stationary wave* on a stretched string. Describe how progressive waves and stationary waves differ in regard to

(i) transfer of energy along the string, [1]

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(ii) **variation** of *amplitude* with distance along the string. [2]

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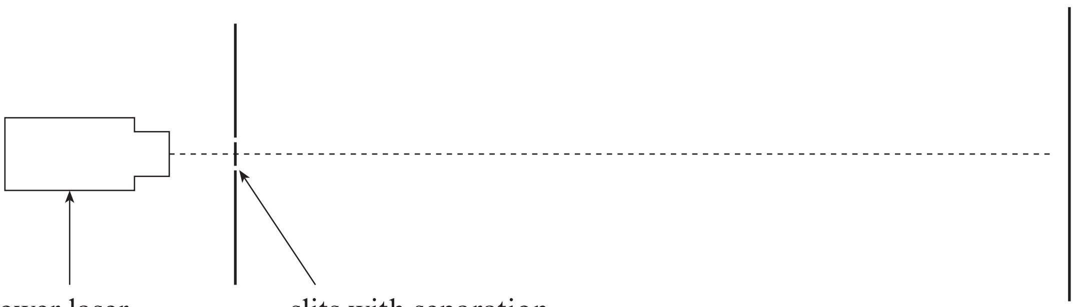
2. A student sets up the apparatus shown, in order to demonstrate two-source interference (Young's fringes).



(a) State what is meant by the following statements.

(i) Light *diffracts* at each slit. [1]

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(ii) The slits act as *coherent* sources. [1]

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(b) The separation of the centres of neighbouring bright fringes on the screen is 2.0 mm. Calculate the distance between the slits and the screen. [3]

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(c) If one of the slits is covered, the dark fringes become brighter. Explain this observation. [2]

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 Turn over.

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3. *(a)* The label indicating slit separation on a *diffraction grating* has been removed. A student decides to determine the slit separation (the separation between the centres of its slits) by shining a laser normally at the grating. The wavelength of the laser light is 5.32×10^{-7} m.

He measures the angle between a ***second order*** emerging beam and the central (*zero order*) beam to be 28.9°.

(i) Show clearly that the slit separation is approximately 2×10^{-6} m. [3]

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(ii) Suggest an advantage of choosing a second order, rather than a first order, beam. [1]

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(b) The student now uses the grating to determine the wavelength of the light from another laser. He measures the second order beam to be at an angle of 35.1°.

(i) Calculate the wavelength of the light. [2]

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(ii) Determine the highest order that the grating will produce with this wavelength. Show your working. [2]

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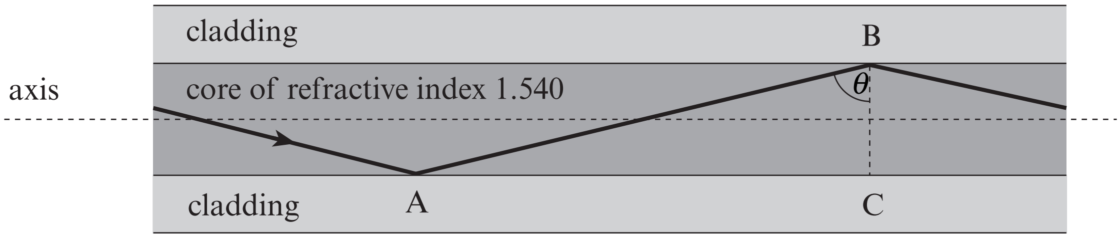
4. The diagram shows a path which light can take along a 'thick' (multimode) optical fibre.



(a) The smallest angle θ at which *total internal reflection* can take place is 77°. Calculate the *refractive index* of the cladding. [2]

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(b) (i) Calculate the time it takes light to travel along 2.0 km of the fibre if it travels through the core **in a straight line parallel to the axis of the fibre**. [3]

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(ii) (I) Show that for $\theta = 77°$, the length of AB is 1.026 times greater than the length of AC (see diagram). [1]

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(II) Hence calculate the **extra** time it takes for light to travel 2.0 km along the fibre via the zigzag path (i.e. for $\theta = 77°$). [2]

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(iii) Without further calculation explain how this difference in times limits the rate at which data (encoded in the light) can be sent through 2.0 km of the fibre. [2]

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Turn over.

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5. *(a)* Define the *work function* of a metal surface. [1]

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(b) The work function of sodium is 3.8×10^{-19} J. Use Einstein's photoelectric equation to find

(i) the lowest frequency of light which will eject electrons from a sodium surface, [2]

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(ii) the maximum kinetic energy of electrons emitted from a sodium surface when light of frequency 7.0×10^{14} Hz is shone on to the surface. [2]

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(c) (i) The answer to *(b)*(ii) is unaffected if the *intensity* of light is increased. Explain, in terms of *photons*, why this should be the case. [2]

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(ii) What aspect of photo-electric emission *is* affected by the light intensity? [1]

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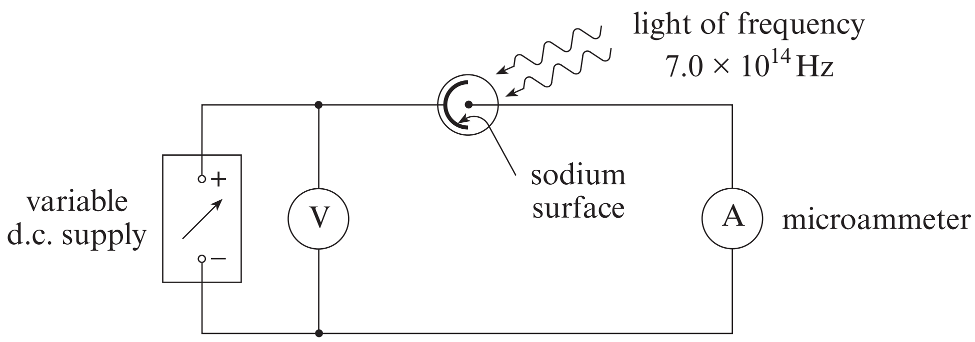
(d) The diagram shows apparatus set up to check experimentally the answer to *(b)*(ii). Describe how you would make this check. [4]



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6. *(a)* A laser emits light with a photon energy of 3.14×10^{-19} J.

(i) Calculate the wavelength of the light. [2]

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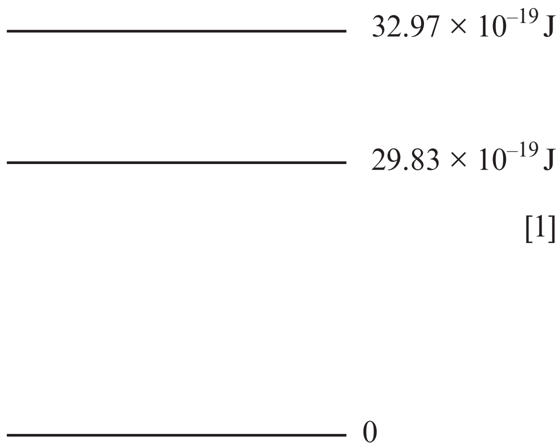
(ii) What is the colour of the light? .... [1]

(iii) A simplified energy level diagram for the amplifying medium of the laser is given.

Add an arrow to show the transition giving rise to these photons.



[1]

(b) Almost all these photons are emitted by the process of *stimulated emission.*

(i) State what triggers an atom to emit a photon by stimulated emission. [2]

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(ii) The light from the laser may be more intense than that from a light-emitting diode (LED), which emits by *spontaneous emission*. State **two** other ways in which the light emitted by the laser differs from that emitted by the LED. [2]

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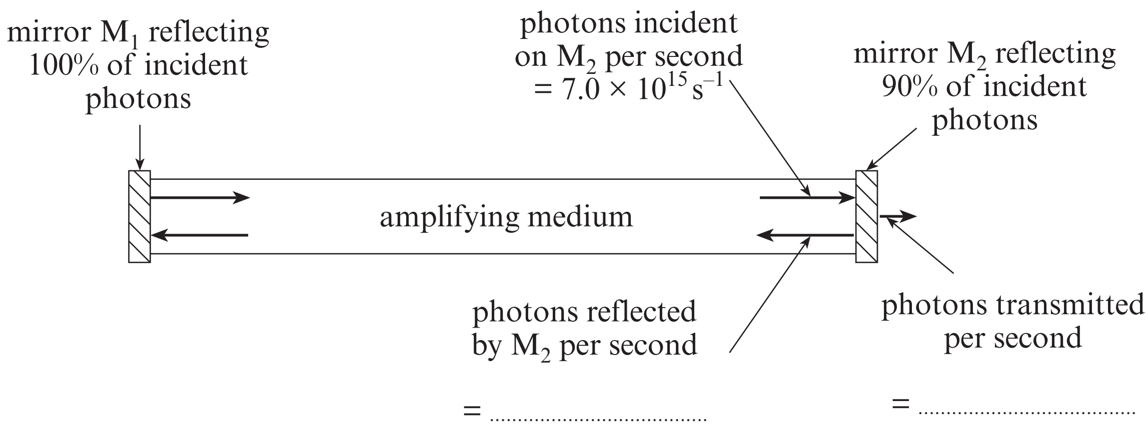
(c) The (simplified) diagram shows the cavity of the laser.

(i) Mirror M_2 is only partially reflecting. The light that it does not reflect is transmitted through it.



Fill in the numbers of photons per second reflected and transmitted. [1]

(ii) Calculate the ***power output*** of the laser. [2]

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(iii) Photons reflected from M_2 travel to M_1 and are reflected from it. Explain, using the concept of stimulated emission, why more photons arrive back at M_2 than are reflected from it. [2]

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7. When protons with high enough kinetic energies collide, they occasionally interact thus:

$$p + p \rightarrow {}^2_1H^+ + e^+ + \nu_e$$

[${}^2_1H^+$ stands for a *deuteron*, that is the nucleus of a ${}^2_1H$ atom.]

(a) (i) Show how *lepton number conservation* applies in this interaction. [2]

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(ii) Compare the initial and final numbers of

(I) u-quarks, [1]

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(II) d-quarks. [1]

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

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(c) Explain why this interaction is vital for life on Earth. [2]

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(d) Deuterons from this interaction may interact with protons according to

$${}^2_1H^+ + p \rightarrow {}^3_2He^{++} + \gamma$$

Which force is involved in the γ emission? [1]

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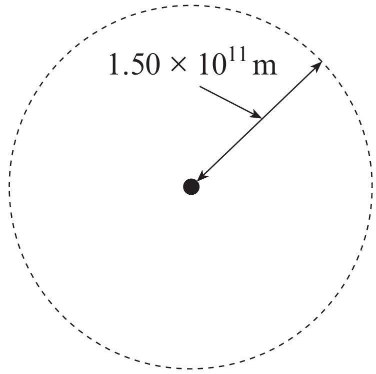
8. *(a)* (i) The *intensity* of the Sun's electromagnetic radiation at a distance of 1.50×10^{11} m from its centre is $1.36\,kW\,m^{-2}$.

Show that the power the Sun emits is approximately 4×10^{26} W. Give your answer to 3 significant figures. [2]



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(ii) 1.50×10^{11} m is the radius of the Earth's orbit. Suggest why the intensity of radiation, as measured on the Earth's surface, is less than $1.36\,kW\,m^{-2}$. [1]

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(b) The temperature of the Sun's surface is 5780 K.

(i) Use Stefan's Law to calculate the *surface area* of the Sun. [2]

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(ii) The Sun's ***diameter*** is measured, by optical methods, to be 1.4×10^{9} m. Show clearly whether or not your answer to *(b)*(i) is consistent with this. [2]

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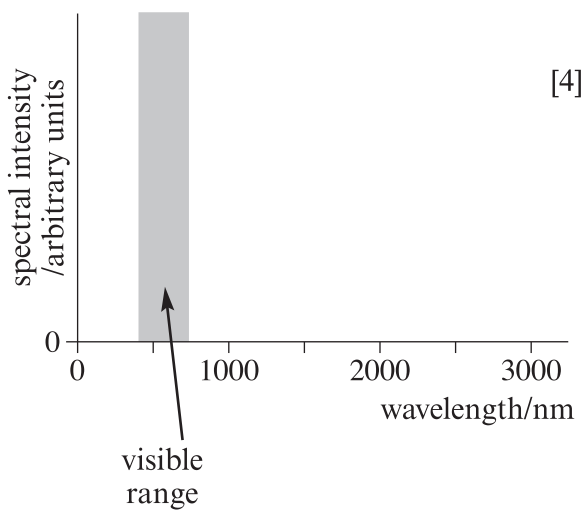
(c) A biologist claims that our eyes are sensitive to the region of the Sun's spectrum of greatest intensity. Use Wien's law to support this claim, and sketch the Sun's spectrum on the axes provided. [4]



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