Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1322/01

PHYSICS
PH2: WAVES AND PARTICLES

A.M. FRIDAY, 20 January 2012

1½ hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**13**	
3.	**13**	
4.	**10**	
5.	**11**	
6.	**10**	
7.	**10**	
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.

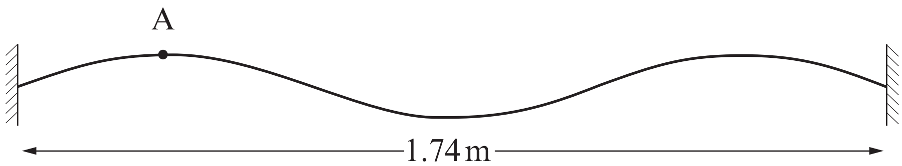
You are reminded of the necessity for good English and orderly presentation in your answers.

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

Examiner only

1. *(a)* A string is stretched between two fixed supports, 1.74 m apart, and is set vibrating in a stationary wave with a periodic time of 0.020 s.

The diagram shows the string at time $t = 0$, when its displacement is at a maximum.



(i) **On the same diagram** draw the string at times

(I) $t = 0.010$ s, [Label it 'I'.] [1]

(II) $t = 0.015$ s. [Label it 'II'.] [1]

(ii) Show that the speed of waves in the string is approximately 60 m s^{-1}. [3]

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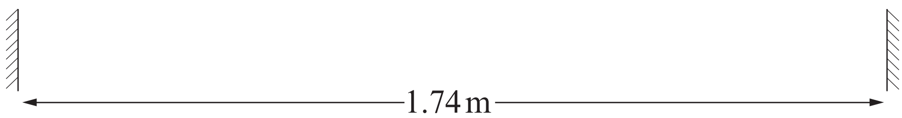
(iii) Use 'N' to show on the diagram the positions of **all** nodes. [1]

(iv) Use crosses to mark on the diagram two points on the string which are vibrating *in phase* with point **A** on the string. **One of your crosses must be on the left hand half of the string, the other on the right hand half.** [1]

(b) (i) Show the lowest frequency mode of vibration of the same string, by drawing the string (at a time of maximum displacement) in the diagram below. [1]



(ii) Calculate this lowest frequency, giving your reasoning. [2]

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(c) (i) State the *Principle of Superposition.* [1]

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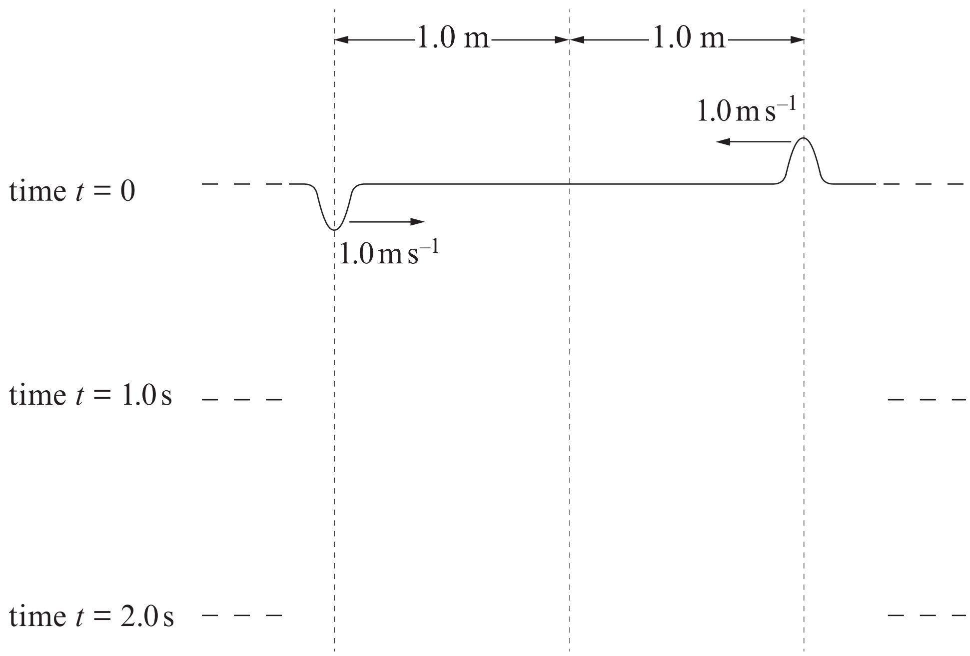
(ii) Waves in the form of single pulses are sent along a string from both ends, and travel in opposite directions at a speed of $1.0\,\text{ms}^{-1}$.

At time $t = 0$, the pulses are 2.0 m apart, as shown below in the top diagram.

In the labelled gaps directly below this diagram, sketch the string at times of 1.0 s and 2.0 s. [2]



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Turn over.

Examiner only

2. *(a)* (i) (I) Light is a transverse wave. Explain what is meant by a *transverse* wave. [1]

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(II) What is meant by *polarised* light? [1]

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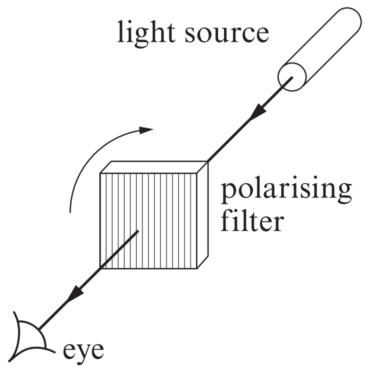
(ii) 

Describe what is seen when a source of **polarised** light is viewed through a polarising filter (polaroid) which is rotated slowly as shown through 360°. [2]

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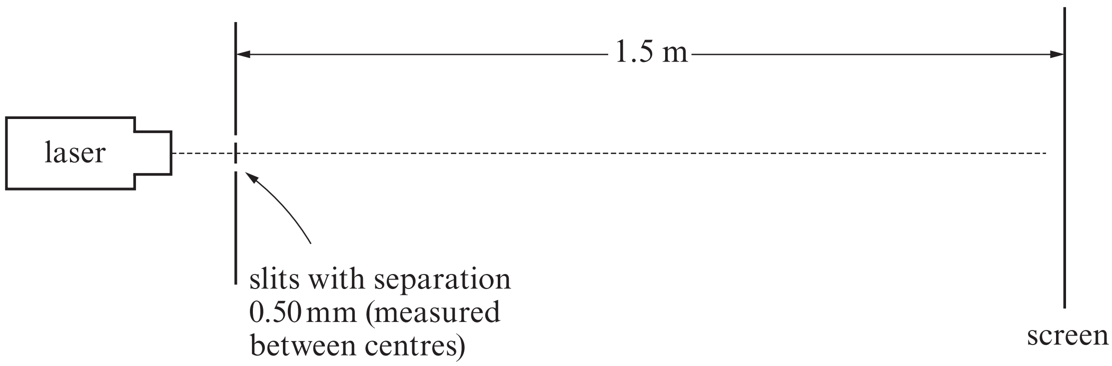
(b) A modern version of Young's *double slit* experiment is set up as shown.



(i) Light *diffracts* at each slit.

(I) What does this statement mean? [1]

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(II) Explain why diffraction at the slits is essential to produce interference fringes. [1]

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(ii) The fringe separation (the separation of the centres of adjacent bright fringes) is 2.0 mm.

(I) Calculate a value for the wavelength of light from the laser. [2]

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(II) The distance from the double slits to the screen is increased to 7.5 m. State **two** ways in which the appearance of the fringes on the screen is changed. [2]

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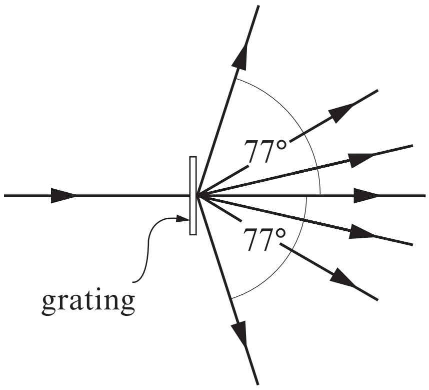
(c)



A diffraction grating with 5.00×10^5 slits per metre is used to measure the wavelength of the laser light, which is shone normally on to the grating. The emerging beams (see diagram) are found to leave the grating as shown.

Calculate the wavelength of the light. [3]

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Turn over.

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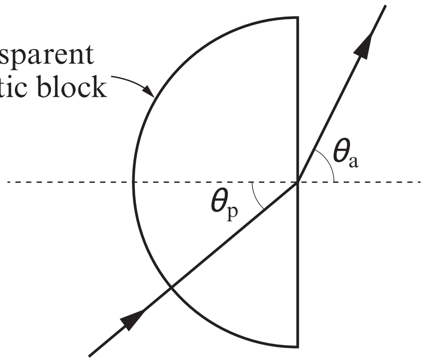
3. *(a)*

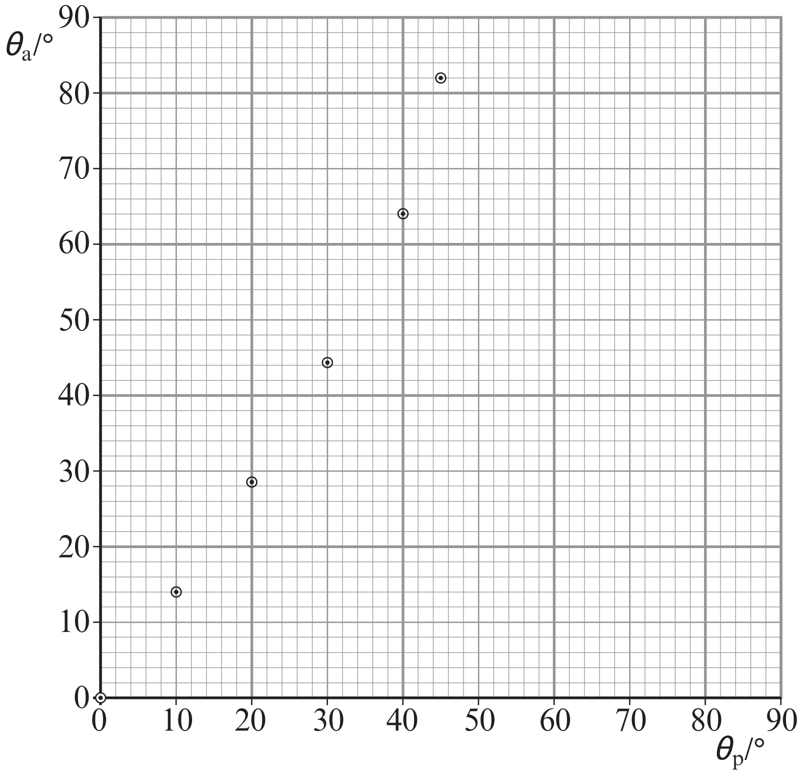


A student traces the path of a narrow beam of light through a transparent plastic block, and measures the angles θ_a and θ_p (see diagram). She repeats the measurements for various chosen values of θ_p, and her results are plotted below.

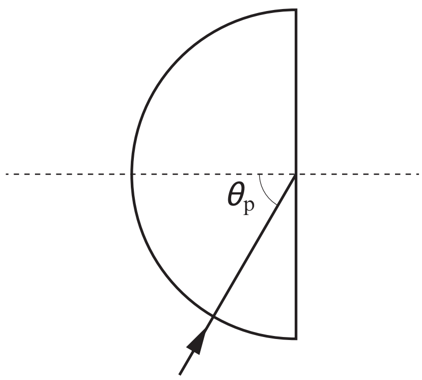
(i) Draw a curve of best fit. [1]

(ii) Without calculation, use the graph to obtain a value for the *critical angle* of the plastic.

Critical angle = ... [1]



(iii) Carefully continue the light path on the diagram, to show what would happen if the student had selected an angle θ_p which was greater than the critical angle. [1]



(iv) Use data from any one of the plotted points to calculate a value for the refractive index, *n*, of the plastic. [2]

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(v) (I) Describe the line of best fit you would expect if sin θ_a were plotted on the vertical, '*y*', axis against sin θ_p. [2]

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(II) Briefly, how would you find *n* from this graph? [1]

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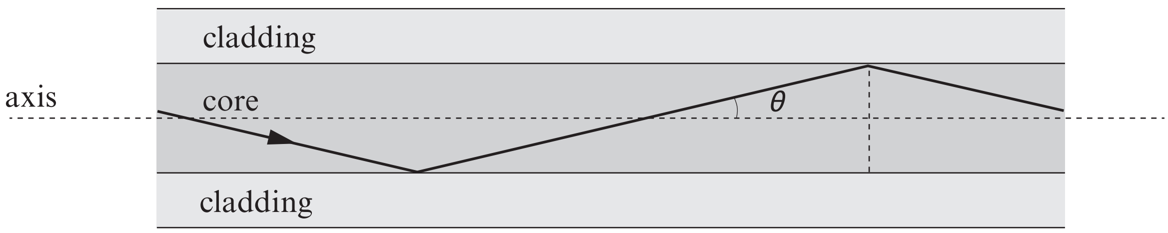
(b) A multimode optical fibre has a core of refractive index 1.530 and a cladding of refractive index 1.520.



(i) Calculate the *critical angle* for the boundary between the core and the cladding. [2]

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(ii) Hence determine the maximum angle, θ, between a light path and the axis of the fibre (see diagram) if the light is to travel for a long distance through the fibre. [1]

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(iii) Explain why it is an advantage for this angle to be small if data are being transmitted. [2]

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Examiner only

4. *(a)* The *work function* of caesium is 3.4×10^{-19} J.

Calculate the lowest *frequency* of light that will cause photo-electric emission from a caesium surface. [2]

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(b) Light of frequency 7.4×10^{14} Hz is shone on to a caesium surface.

(i) Calculate the maximum kinetic energy, KE_{max}, of the emitted electrons for this frequency of light. [2]

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(ii) Explain **in physical terms** why KE_{max} is less than the energy of an incident photon. [2]

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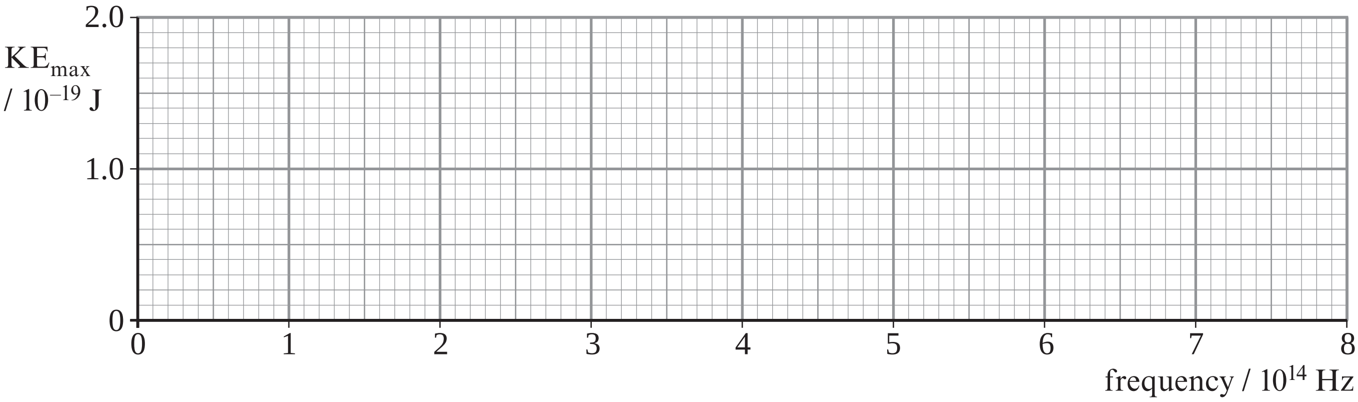
(c) (i) Making use of your answers to *(a)* and *(b)*(i), draw a graph, on the axes provided, to show how KE_{max} would depend on the frequency of incident light. [2]



(ii) What does the gradient of this graph represent? [1]

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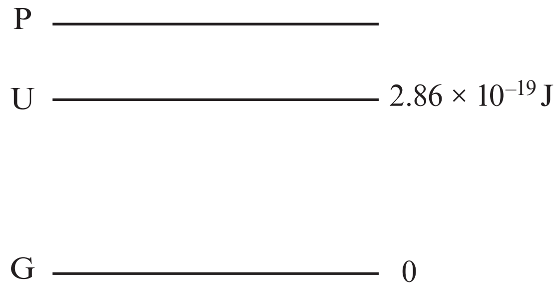
(iii) On the same axes sketch a graph that could be obtained for a metal with a greater work function than caesium. **Label this graph '(iii)'.** [1]

Examiner only

5. The first laser used *ruby*, a crystal containing chromium ions, as its amplifying medium. A simplified energy level diagram is given for the chromium ions.



(a) Calculate the wavelength, λ_{UG}, of radiation associated with transitions between levels U and G. [2]

(b) For the laser to work there needs to be a *population inversion* involving levels U and G.

(i) What does this statement mean? [1]

(ii) What would happen to photons of wavelength λ_{UG} present in the ruby if there were **no** population inversion, and what would become of their energy? [2]

(iii) *Pumping*, involving level P, is used to cause a population inversion. **Add arrows** to the diagram to show the transitions by which the inversion is achieved. [1]

(iv) The population inversion makes possible light amplification by stimulated emission (from the chromium ions). Explain what is meant by *stimulated emission* and explain how this leads to *light amplification*. [3]

(c) State three properties of the **light** from a laser which distinguish it from light from an 'ordinary' source, such as a filament lamp. [2]

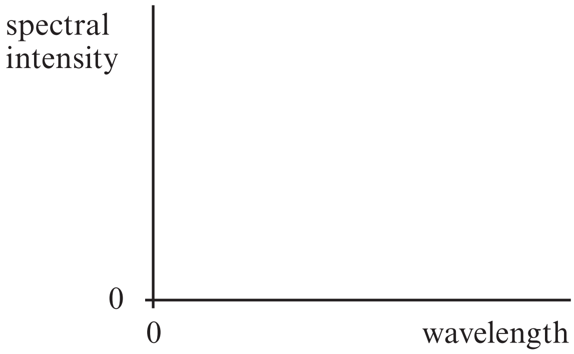
Examiner only

6. *Neutron stars* are very small, dense 'dead' stars. Sometimes they can acquire an outer layer of 'active' material which becomes very hot and radiates as a *black body*. One such star has a **radius** of 11 km, and radiates at a temperature of 2.5×10^7 K.

(a) (i) Show that the wavelength of greatest spectral intensity is approximately 1×10^{-10} m. [2]

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

(iii) Sketch a black body spectrum on the axes provided. [1]



(iv) Discuss briefly whether the star in question emits any **visible** radiation. [1]

(b) Calculate the total *power* emitted as electromagnetic radiation by the star. [3]

(c) The outer layer of the star expands rapidly and cools. The total power emitted remains roughly constant. Estimate the temperature of the outer layer when its **surface area** has doubled. [2]

Examiner only

7. *(a)* (i) State **three** ways in which the properties of down-quarks and electrons differ. [3]

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(ii) The Δ^- ('delta-minus') particle has the quark make-up ddd. Deduce its charge. [1]

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(b) The Δ^- particle decays in a typical time of 6×10^{-24} s into a neutron and a pion (π meson).

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

State **two** features of the decay which point to it being a *strong* interaction. [2]

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(c) The neutron and the pion formed in the decay are themselves unstable. The neutron decays thus:

$$n \rightarrow p + x + y$$

in which p is a proton and x is a charged (first generation) lepton.

(i) Use the laws of conservation of charge and of lepton number to identify x and y, setting out your reasoning clearly. [3]

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(ii) Which force is responsible for this decay? [1]

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THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.

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