June '05 PH2 Past Paper 2

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3. The diffraction grating formula is given below.

$$n\lambda = d \sin\theta$$

(a) State the meaning of

(i) *n*, [1]

....

(ii) *d*. [1]

....

(b) White light containing a spread of wavelengths ranging from 450 nm (violet) to 700 nm (red) is incident normally on a diffraction grating. It is observed that the **first-order violet** line occurs at $\theta = 22°$.

(i) Calculate *d*. [2]

....

....

....

(ii) Calculate the angular separation between first order red and first-order violet. [2]

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....

(c) Show that the second order spectrum for red (700 nm), will **not** be present. [3]

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(d) State what would be seen at $\theta = 0$. [1]

....

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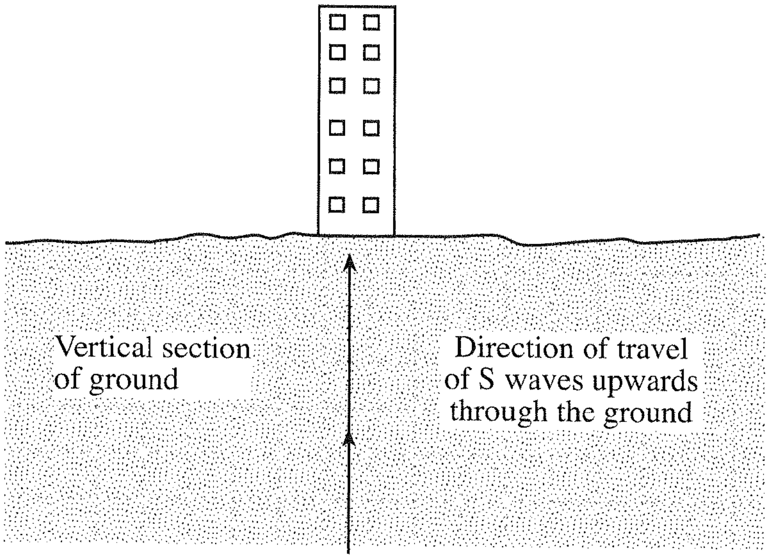
5. This question is about the physics of seismic waves.

When an earthquake occurs two kinds of seismic wave travel from their source through the body of the Earth. Primary or P waves have the greater speed and are *longitudinal*. The slower Secondary or S waves are *transverse*.

(a) The diagram shows a Secondary wave approaching a tall building from underneath. Indicate, with a double-headed arrow, in which direction you would expect the building to vibrate when the wave reaches it. Explain your reasoning.



Explanation: ....

.... [2]

(b) P waves travel with a speed of $7{\cdot}8\,\text{km s}^{-1}$, and S waves with a speed of $5{\cdot}2\,\text{km s}^{-1}$ near the surface. Assume that these speeds are constant for this part of the question. Following a particular earthquake a seismological station observed that P waves were first detected after time **t**, and S waves were detected 58 seconds **later**.

(i) Use the formula speed = distance/time to write an expression for the distance, in km, travelled by the P waves, d_p, from the source to the seismological station. [1]

....

(ii) Hence write an expression for the distance travelled by the S waves, d_s, from the source to the seismological station. [1]

....

(iii) Given that $d_p = d_s$, calculate the time taken for the P waves to travel from the source to the seismological station. [1]

....

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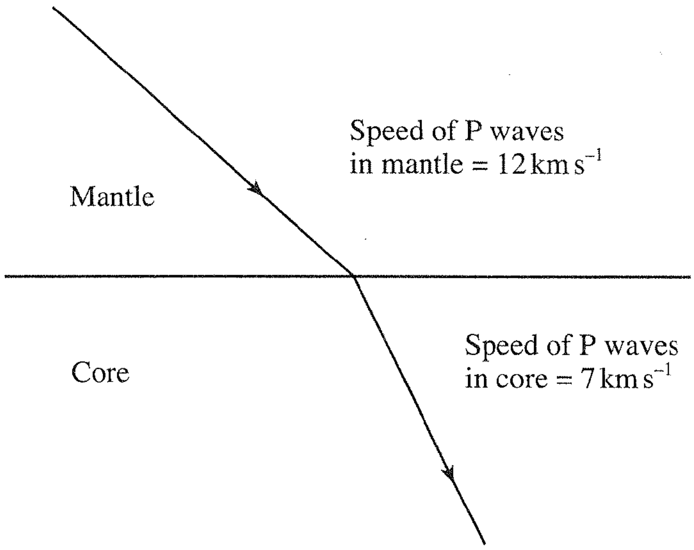
(iv) Hence determine the distance from the source to the seismological station. [1]

....

....

(c) The study of seismic waves provides evidence about the internal structure of the Earth because they are refracted in a similar way to light. The diagram shows how the speed of P waves, now travelling deep inside the Earth, changes as they travel from the mantle to the core.



(i) Use the information given in the diagram to calculate a value for the refractive index of the core with respect to the mantle at the core-mantle boundary. [2]

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....

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(ii) Calculate the critical angle for P waves, which are travelling in the core and are incident at the core-mantle boundary. [2]

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....

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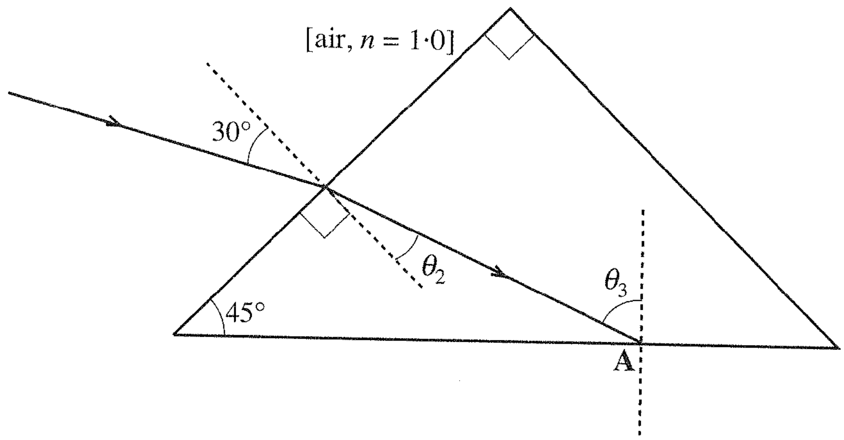
5. The *refractive index* of crown glass is 1·5.

(a) Explain what is meant by refractive index. [1]

....

....

(b) The diagram shows a ray of light entering and travelling through a prism made from crown glass.



(i) Calculate the angle of refraction, θ_2. [2]

....

....

(ii) Calculate the critical angle for crown glass. [2]

....

....

(iii) Find θ_3 and hence show clearly **on the diagram** what happens to the light ray at **A**.[3]

....

....

(c) Complete the following table, which shows some of the properties of the light ray used in part *(b)*. [2]

Medium	Speed of the light/ms^{-1}	Frequency of the light/ terahertz
air	$3{\cdot}0 \times 10^8$	
crown glass		500

Turn over.

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4. *(a)* Write down Young's double-slit formula for interference and state the meaning of **each** of the symbols. [3]

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(b) (i) Describe an experiment that demonstrates two-source interference for microwaves. Draw a labelled diagram of the apparatus. Your description should include an explanation of how the interference pattern is detected given a suitable probe. [5]

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(ii) Young's double-slit formula may be applied to your experimental arrangement (provided the probe is far enough away). State **two** adjustments that can be made to the experimental set-up described in part *(b)*(i) that would increase the separation between points of constructive interference i.e. increase the fringe separation.

Adjustment 1: [1]

....

....

Adjustment 2: [1]

....

....

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6. *(a)* What is the *photoelectric effect*? [2]

....

....

(b) Einstein's photoelectric equation is an example of energy conservation. It may be written

$$hf = \frac{1}{2}mv^2_{max} + \phi$$

(i) What is the meaning of $\frac{1}{2}mv^2_{max}$? [1]

....

(ii) According to the equation $\frac{1}{2}mv^2_{max}$ is less than the photon energy, hf, by an amount ϕ. Explain, in terms of energy, why this is so. [2]

....

....

....

(c) When light of frequency $6{\cdot}0 \times 10^{14}$ Hz falls on a caesium surface, $\frac{1}{2}mv^2_{max}$ is $9{\cdot}6 \times 10^{-20}$ J.

(i) Calculate ϕ for caesium. [Refer to the data on page 2.] [2]

....

....

....

(ii) Explain whether or not photoelectric emission would take place if light of frequency $4{\cdot}4 \times 10^{14}$ Hz were shone on to a caesium surface. [3]

....

....

....

(iii) $\frac{1}{2}mv^2_{max}$ is found by measuring the 'stopping voltage', V_s (the p.d. that has to be applied between the caesium surface and a nearby electrode, in order to stop emitted electrons reaching the electrode). Calculate V_s for light of frequency $6{\cdot}0 \times 10^{14}$ Hz. [Refer to the data on page 2.] [2]

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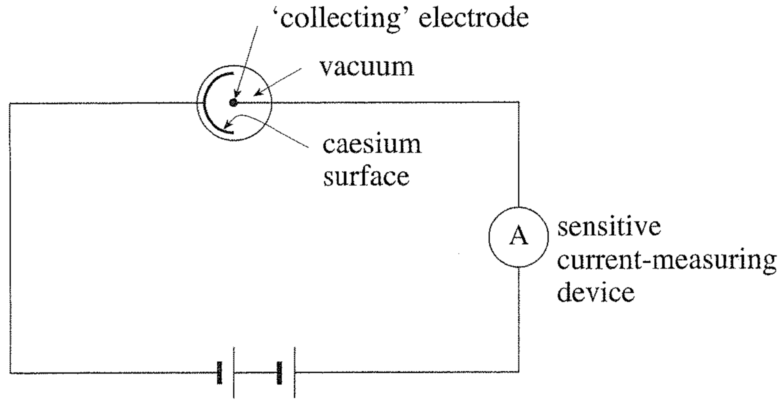
(d) The circuit shown below is set up.



(i) Give **three** reasons why the circuit, as shown, would **not** enable one to measure the stopping voltage, V_S. [3]

....

....

....

(ii) The current indicated is $4{\cdot}8 \times 10^{-8}$ A.

(I) Calculate the number of electrons emitted per second from the caesium surface. [Refer to the data on page 2.] [1]

....

....

....

(II) What assumption are you making? [1]

....

(iii) In order to produce this current, $9{\cdot}5 \times 10^{-6}$ J of light energy of frequency $6{\cdot}0 \times 10^{14}$ Hz must arrive at the caesium surface each second.

(I) Calculate the number of photons striking the surface per second. [Refer to the data on page 2.] [2]

....

....

....

(II) Calculate the fraction of these photons which cause electron emission. [1]

....

....

....

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6. *(a)* When one end of a length of rope is moved from side to side in a direction perpendicular to its length a progressive wave is produced.

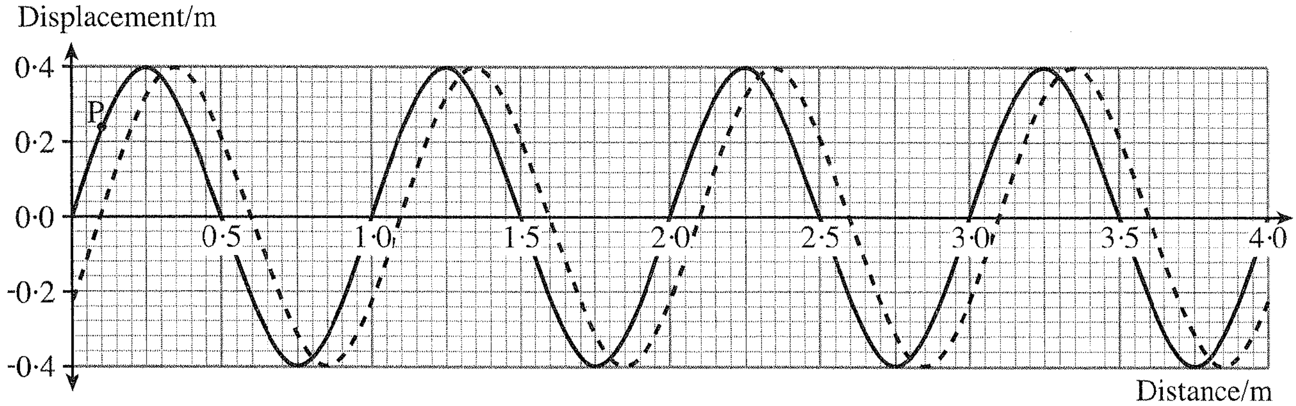
(i) State the type of progressive wave produced. [1]

....

(ii) Give **one** other example of this type of wave. [1]

....

(b) The figure shows a progressive wave travelling **to the right** along a rope. The dark (solid) line represents the position of the wave at t = 0·0s. The dotted line represents the wave a short time later at t = 0·20s. **P** is a particle on the rope.



(i) Draw an arrow on the diagram to show the direction of movement of particle **P** at t = 0·0s. [1]

(ii) Determine the maximum displacement of particle **P**. [1]

....

(iii) Label on the graph with the letter **Q**, the nearest particle that is oscillating in phase with particle **P**. [1]

(iv) Write down the term used to describe the distance **PQ**. [1]

....

(v) Label on the graph with the letter **R**, the particle that is 180° out of phase with particle **P**. [1]

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(vi) Calculate

(I) the speed of the wave, [2]

....

....

(II) the frequency of the wave, [2]

....

....

(III) the period of the wave. [1]

....

(vii) Calculate

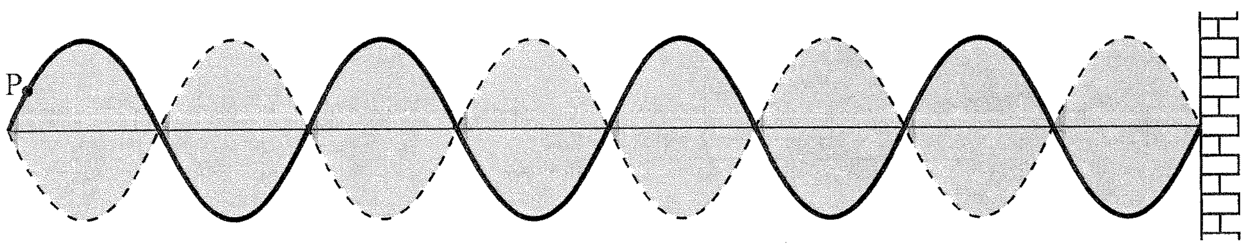
(I) The mean speed of particle **P** over one complete cycle. [2]

....

(II) The mean velocity of particle **P** over one complete cycle. [2]

....

(c) One end of the same rope is now securely attached to a wall as shown. The other end of the rope continues to be moved up and down at the same frequency as before. **Stationary (standing) waves** are set up in the rope as shown. **P** is the same particle as described in part *(b)*.



(i) Label with the letter **S** one particle on the wave that is in phase with **P**. [1]

(ii) Label with the letter **T** one particle on the wave that is out of phase with **P**. [1]

(iii) State how the stationary wave pattern changes when the frequency is doubled. Explain your answer. [2]

....

....