PRESTON MANOR

Physics Exam Pack

Waves 2

Name: | Date:

Question / Paper	Mark

5 This question is about the superposition of electromagnetic waves.

(a) **(i)** State the *principle of superposition of waves.*

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.... **[2]**

(ii) State **one** property of electromagnetic waves that distinguishes them from **all** other waves.

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.... **[1]**

(iii) State why electromagnetic waves can be polarised but sound waves cannot be polarised.

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.... **[1]**

(b) In Fig. 5.1 $\mathbf{T_1}$ and $\mathbf{T_2}$ are two adjacent transmitters 1.0 m apart with a receiving aerial **R** halfway between them. The transmitters are set up to emit coherent electromagnetic waves of wavelength 3.0 cm.

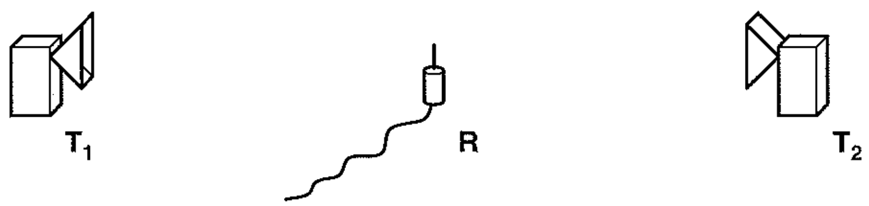

Fig. 5.1

(i) The student finds that the signal at the receiver **R** falls from maximum to zero when **R** is moved 0.75 cm towards a transmitter. Explain this observation.

In your answer you should make clear how the signal can be zero and why the distance moved should be 0.75 cm.

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.... **[4]**

(ii) With **R** at the mid-point between $\mathbf{T_1}$ and $\mathbf{T_2}$, the student rotates $\mathbf{T_2}$ through 90° about an axis through $\mathbf{T_1}$ and $\mathbf{T_2}$. See Fig. 5.2.

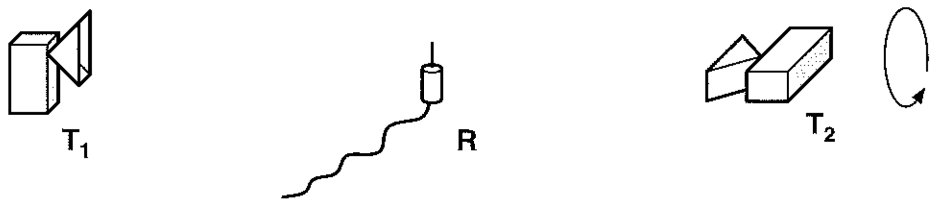

Fig. 5.2

The student finds that the amplitude of the signal at **R** falls to about one half. The detected signal now remains the same when **R** is moved 0.75 cm. Explain these observations.

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.... **[3]**

[Total: 11]

Question			Answer	Marks	Guidance
5	(a)	(i)	when 2 or more waves <u>meet</u> (at a point) the (resultant) <u>displacement</u> is equal to the (vector) <u>sum</u> of the <u>displacements</u> of each wave	B1 B1	**accept** alternative words which mean *meet* **not** *collide, interfere* or *superpose* **not** amplitude
		(ii)	travel through a vacuum/ at c (in a vacuum)	B1	**allow** caused by oscillating charges; consist of electric and magnetic fields/oscillations
		(iii)	only transverse waves can be polarised	B1	**accept** sound waves are longitudinal/not transverse
A A A	(b)	(i)	the waves interfere/superpose producing a stationary wave (with nodes and antinodes) **the resultant signal is zero at a node** distance from max (antinode) to zero (node) is <u>λ/4 = 0.75 cm</u>	B1 B1 B1 B1	 constructive interference produces maximum (at R) **or** signals in phase/zero path diff. of waves (at R) **destructive interference produces minimum/zero signal or out of phase/ ½λ** **or** phase difference of <u>π/2</u> is caused by 0.75 cm shift maximum of 3/4 if nodes and antinodes interchanged QWC mark in bold
A A A		(ii)	emitted waves are polarised (in vertical plane) detected signal from T_2 falls to zero (when T_2 is rotated by 90°) aerial only receives signal from one transmitter (T_1 , signal is halved) (no change in detected signal as) no interference/signals at right angles to each other/AW	B1 B1 B1 B1	 plane of oscillation of waves from T_2 changes/AW **max** 3 marks from 4 marking points
			Total	**11**	

5 **(a)** Name one common property of electromagnetic waves not shared by other waves.

.... **[1]**

(b) Fig. 5.1 shows a block diagram of the seven regions of the electromagnetic spectrum, labelled **A** to **G**.

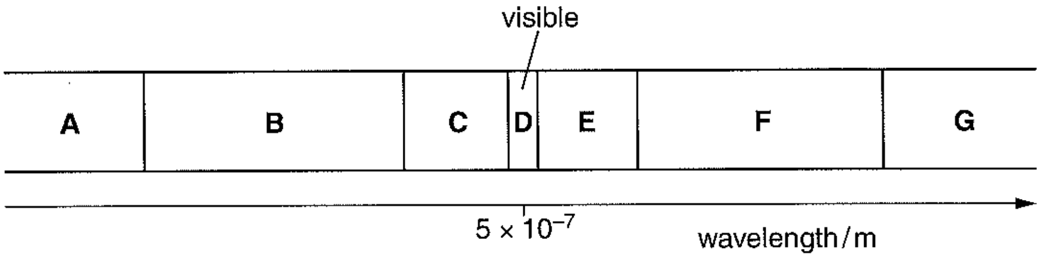

Fig. 5.1

Name the principal radiation in each of the regions **A**, **C** and **F**.

A .... **C** ....

F .... **[3]**

(c) An aerial mounted vertically transmits vertically polarised radio waves of frequency 1.0×10^9 Hz. The waves are detected by a receiving aerial some distance away. Initially the receiving aerial is also mounted vertically as shown in Fig. 5.2.

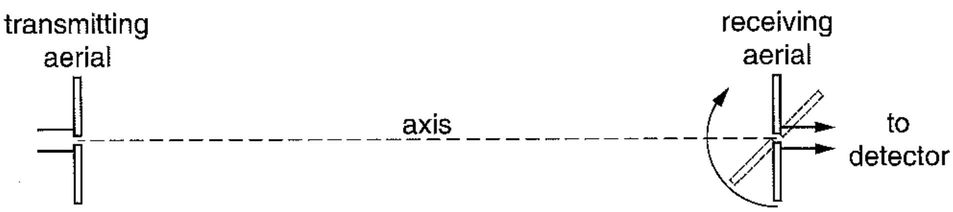

Fig. 5.2

The length of each aerial is half the wavelength of the radio waves.

(i) Calculate the wavelength of the waves.

wavelength = ... m **[2]**

(ii) Calculate the length of an aerial.

length = ... m **[1]**

(iii) The receiving aerial is rotated through 180° about the axis joining the centres of the two aerials. See Fig. 5.2. Describe and explain how the output signal from the receiving aerial changes with the angle of rotation.

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.... **[3]**

(d) Ultra-violet radiation from the Sun is often divided into three regions UV-A, UV-B and UV-C.

(i) Describe the characteristics and dangers of UV-A, UV-B and UV-C radiations.

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.... **[3]**

(ii) Explain how sunscreen protects the human skin.

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(e) Explain why electrons can be emitted from a clean metal surface illuminated with bright ultra-violet light but never when infra-red light is used, however intense.

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.... **[2]**

[Total: 16]

Question			Expected Answers	M	Additional Guidance
5					
	a	i	travel through a vacuum	B1	**allow** travel at c (in a vacuum)
	b	ii	A gamma; C uv; F microwave	B3	**allow** 1 mark for A radio; C ir; F X-ray
	c	i	$3.0 \times 10^8 = 1.0 \times 10^9\ \lambda$ $\lambda = 0.30$ m	C1 A1	 **allow** 0.3 no SF error
		ii	aerial length = $\lambda/2 = 0.15$ m	A1	**ecf (c)(i)**
		iii	emitted wave is (plane) polarised detecting aerial will receive weaker signal/cos θ component when it is rotated (through angle θ)/AW signal falls to zero at 90° and then rises to max again at 180°	B1 B1 B1	**allow** max signal initially/at 0° **max 3 marks** from 4 marking points
	d	i	UV-A causes tanning or skin ageing ; most of (99%) uv light; 400-315 nm UV-B causes damage or sunburn or skin cancer; 315-260 nm UV-C is filtered out by atmosphere/ozone layer; 260-100 nm	B1 B1 B1	accept values within ranges with tolerance of 20 nm **allow** $\lambda_A > \lambda_B > \lambda_C$ for 1 mark **max 3 marks** from 7 marking points
		ii	filters out/blocks/reflects/absorbs UV(-B)	B1	**allow** chemicals prevent sunburn/skin cancer **not** stops UV penetrating skin
	e		<u>energy</u> of the infra-red photon is less than the <u>work function</u> of the metal surface	B1 B1	**accept** frequency and threshold frequency **or** wavelength and threshold wavelength used correctly in place of energy and work function **1 mark** only: energy of the uv photon greater than work function with no mention of ir
			Total question 5	**16**	

7 **(a)** Describe a *plane polarised wave.*

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.... **[2]**

(b) Light reflected from the surface of water is partially plane polarised in the horizontal direction. The reflected light is totally plane polarised when the angle of reflection is about 53°.

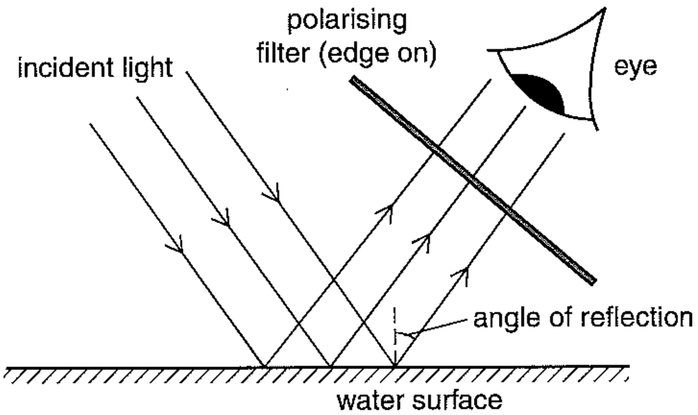

Fig. 7.1

Describe, referring to Fig. 7.1, the experiment that you would perform using a polarising filter (a sheet of Polaroid) to determine whether this statement is correct. Describe what you expect to observe.

In your answer you should make clear how you would use any apparatus to make observations or take suitable measurements.

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(c) State Malus' law for the intensity I of a beam of plane polarised light transmitted through a polarising sheet with its transmission axis at an angle θ to the plane of polarisation. Explain the meaning of any other symbols that you use.
Use Malus' law to explain the observations in the experiment of part **(b)**.

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.... **[4]**

[Total: 10]

END OF QUESTION PAPER

Question			Expected Answers	M	Additional Guidance
7					
	a		reference to a transverse wave or to vibrations in plane normal to the direction of (energy) propagation	B1	can be answered with suitable diagram(s)
			oscillations/vibrations in one direction only/confined to single plane (containing the direction of propagation)	B1	NOT the wave oscillating in one plane
	b		set up apparatus, e.g. tray of water on table with lamp/light from window	B1	
			rotate the filter	B1	QWC mark essential for full marks
			rotation of filter changes the image intensity/brightness/AW	B1	**allow** from bright to zero or vice versa
			correct orientation for maximum and minimum intensities of image	B1	transmission axis parallel to water surface for maximum and perpendicular for minimum
			move head up or down to change angle of reflected light observed	B1	can hold head still and move lamp
			use of protractor to measure angles	B1	
			image/reflection becomes partially plane polarised/ image changes from bright to dim but does not disappear	B1	**max 3** from 6 marking points **+ QWC mark**
	c		$I = I_0 \cos^2\theta$	B1	
			where I_0 is the maximum intensity (of the polarised beam)	B1	**allow** incident/original/initial for maximum
			when θ is zero maximum intensity transmitted/ image bright	B1	
			when θ is 90° minimum/zero intensity transmitted/image dim/vanished	B1	
			Total question 7	**10**	

6 **(a)** State **two** properties which distinguish electromagnetic waves from other transverse waves.

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(b) **(i)** Describe what is meant by *a plane polarised wave*.

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(ii) Light from a filament lamp is viewed through two polarising filters, shown in Fig. 6.1. The arrow beside each filter indicates the transmission axis of that polarising filter.

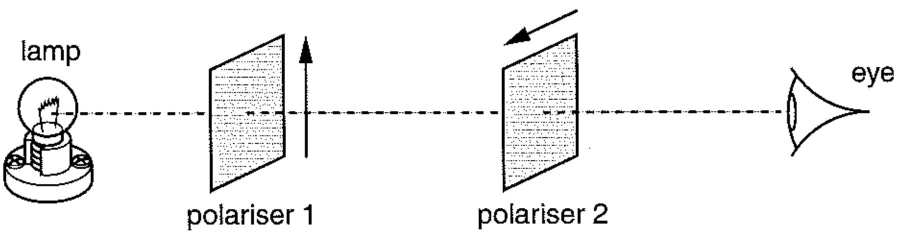

Fig. 6.1

Explain why the lamp cannot be seen by the eye.

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(iii) A third polarising filter is placed between the first two with its transmission axis at 45° to each of the others as shown in Fig. 6.2.

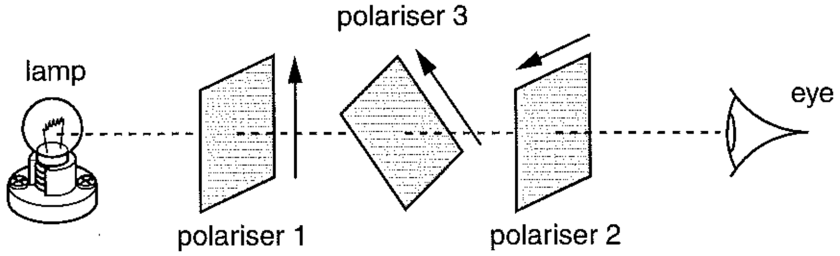

Fig. 6.2

Explain whether or not any light reaches the eye through the three filters.

In your answer you should state clearly the condition for light to be transmitted by a polarising filter.

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[Total: 9]

Question			Answer	Marks	Guidance
6	a		all travel at speed of light through a vacuum are oscillating E and B fields **or** are caused by accelerating charges/AW	B1 B1	**max** 2 marks from 3 marking points if 3 properties are given withhold one mark for each incorrect property so 2 correct and 1 incorrect would score 1 mark ;1 correct and 2 incorrect would score zero, etc
	b	i	oscillations (of particles/e-m fields along the wave) are in one direction only perpendicular to the direction of wave propagation/of travel of the wave/of energy transfer	B1 B1	
		ii	light passing through polariser 1 is <u>vertically</u> polarised/ only vertical oscillations of the light exist beyond the polariser 1/AW only (the component of) light in the <u>horizontal</u> plane can pass through polariser 2 so no light reaches the eye	B1 B1	**allow** any words indicating <u>vertical</u>, e.g. up and down; for <u>horizontal</u>, e.g. at 90° to vertical or crossed polarisers **accept** using Malus' law $I_{trans} = I_{incident}\cos^2\theta$ with $\theta = 90°$ gives $I_{trans} = 0$
		iii	after polariser 1 the component of the vertically polarised light at 45° passes through polariser 3 the polarised light beyond polariser 3 has a component at 45° which passes through polariser 2 so light reaches the eye **or mark a typical answer of the form (max 2) as follows** some of the vertically polarised light passes through polariser 3 and some of this passes through polariser 2 because in each case the polarised light is not at right angles to the transmission axis of the polariser	B1 B1 B1	**QWC** statement to the effect that component of light along polarising axis of filter is transmitted **accept** using Malus' law $I_{trans} = I_{incident}\cos^2\theta$ with $\theta = 45°$ gives $I_{trans} = I_{incident}/2$ same process gives $I_{trans} = I_{incident}/2$ again so ¼ of light after polariser 1 reaches eye (assuming no absorption) accept answers in terms of amplitudes rather than intensities, i.e. $A = A_0 \cos\theta$, etc.
			Total	**9**	