4.3 Wave Characteristics

Question Paper

Course	DP IB Physics
Section	4. Waves
Topic	4.3 Wave Characteristics
Difficulty	Hard

Time allowed: 50

Score: /39

Percentage: /100

Question 1a

When electromagnetic waves are reflected from a shiny surface, such as a road sign, they often become polarised.

(a)
Suggest how to determine experimentally if visible light reflected from a road sign is polarised.

[2]

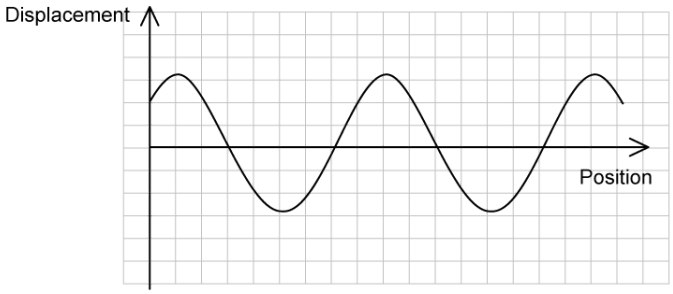
[2 marks]

Question 1b

Changes in phase can occur when electromagnetic waves are reflected from a surface.

If an electromagnetic wave is reflected at the boundary between a medium with a higher refractive index than the medium it is travelling in, the oscillating electric field undergoes a phase change of π radians.

Light is incident on an air-water boundary. A displacement-position sketch of the amplitude of the incident electric field is shown. The origin represents the boundary.



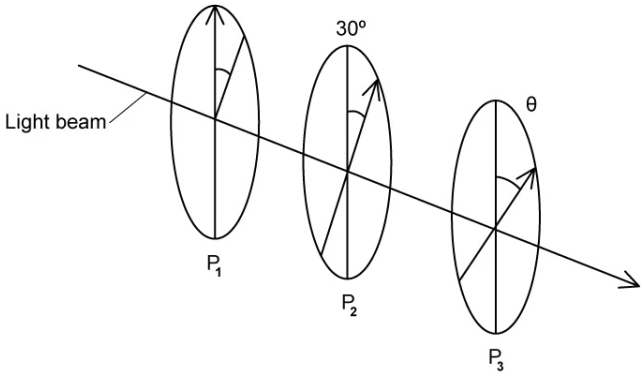
(b)
Sketch the amplitude of the reflected electric field on the graph.

[2]

[2 marks]

Question 1c

Three polaroid filters P_1, P_2 and P_3 are aligned as follows:



Unpolarised light is incident on P_1 and subsequently passes through each of the three polaroid filters. P_1 and P_2 are in fixed positions, but P_3 can be rotated to any angle θ to P_1.

(c)
Determine the angles of θ at which minima and maxima of emergent light intensity occur.

[3]

[3 marks]

Question 1d

(d)
Complete the missing spaces in the table to show whether the waves listed are polarised or unpolarised, and to give a reason for your answer.

Wave	Polarised or unpolarised	Reason
Light from the sun		
Compression waves caused by an earthquake	Unpolarised	Longitudinal waves cannot be polarised
Electromagnetic waves emitted from a dipole aerial		
Ultrasonic waves from an echo sounder		

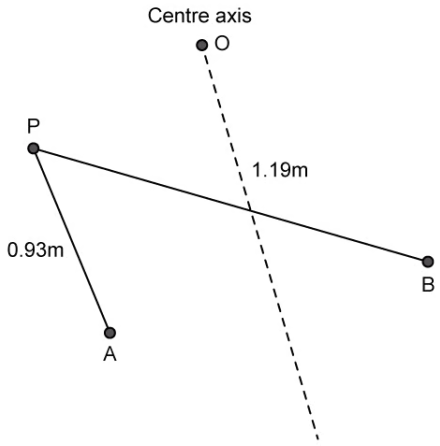
[3]

[3 marks]

Question 2a

Two coherent sources, A and B, which are in phase with each other, emit microwaves of wavelength 40.0 mm. The amplitude of waves from source B is twice that of source A.

A detector is placed at the point P where it is 0.93 m from A and 1.19 m from B. The centre axis is normal and a bisector to the straight line joining A and B.



(a)
With reference to the phase of the microwaves, deduce the magnitude of the detected signal at P and explain your reasoning.

[3]

[3 marks]

Question 2b

(b)
Determine the ratio of the intensity at P to the intensity at O.

[3]

[3 marks]

Question 2c

(c)
Discuss, with suitable calculations, what happens to the detected signal as the detector is moved from P to O.

[5]

[5 marks]

Question 2d

The source B is altered such that it emits waves that are 180° out of phase with source A.

(d)
Deduce the type of interference that now occurs at point P and explain your reasoning.

[2]

[2 marks]

Question 3a

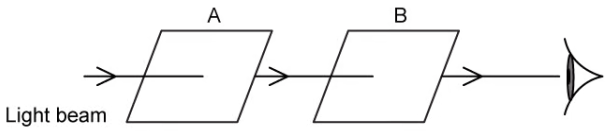
Transverse, sinusoidal progressive waves of wavelength λ have points P and Q which are $\frac{5\lambda}{4}$ apart. The waves travel from P to Q.

(a)
With an appropriate sketch, discuss the motion of Q at the instant when P is displaced upwards but is moving downwards.
[3]

[3 marks]

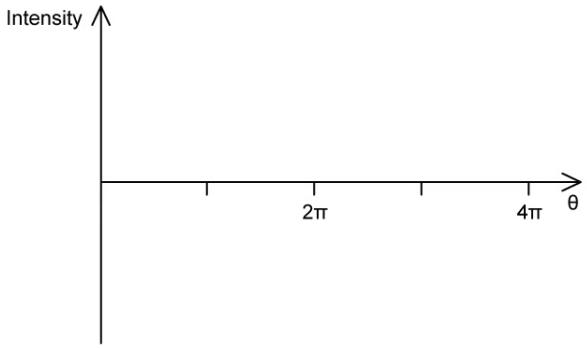
Question 3b

Electromagnetic waves, being transverse, can be polarised. A light source is viewed through two pieces of polarisers, A and B, with their axes initially at $\frac{\pi}{2}$ radians from each other:



(b)

Using the axes below, sketch the variation of intensity of light reaching the eye with angular displacement of B with respect to A when polariser B is rotated.

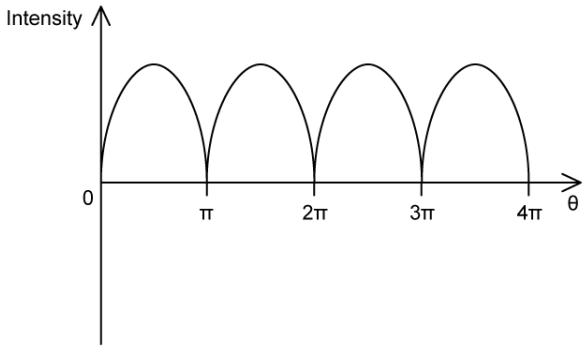


[4]

[4 marks]

Question 3c

A common incorrect way of drawing this graph is as:



(c)

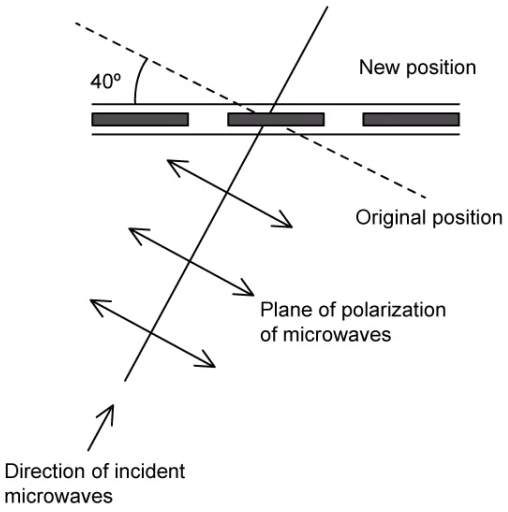
State the differences between the correct graph in part b, and then, through derivation of Malus' Law, explain why the graph above is incorrect.

[3]

[3 marks]

Question 4a

Plane polarised electromagnetic waves are incident on an aerial positioned to give a maximum response. High winds cause the aerial to rotate about the direction of the incident wave until it makes and angle of 40° to the plane of polarisation.



(a)
Calculate the percentage reduction in the amplitude of the signal received by the aerial following the high winds.

[3]

[3 marks]

Question 4b

The intensity of incident radiation is 0.05 mW m^{-2}. When the aerial is repaired, it is found to have a maximum vibration amplitude of 6.3 mm.

(b)
Determine the angle at which the aerial has been set.

[3]

[3 marks]