TURNING POINTS

2-2 The discovery of electromagnetic waves

1. Diagram:

oscillating electric field

direction of travel

oscillating magnetic field
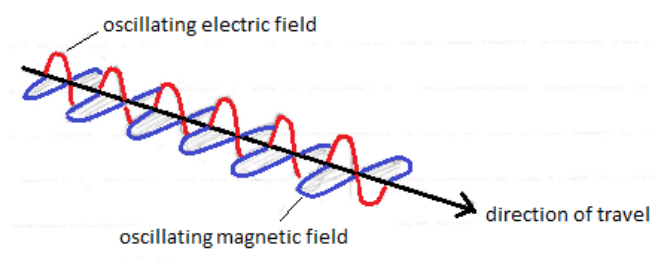
An electromagnetic wave consists of an oscillating electric field and an oscillating magnetic field. The two fields are perpendicular to each other and perpendicular to the direction of travel of the wave.

2. Maxwell's equation $c = \dfrac{1}{\sqrt{\mu_0 \varepsilon_0}}$ enabled the speed of electromagnetic waves, c, to be calculated from the value of μ_0 obtained from magnetic field measurements and the value of ε_0 obtained from electric field measurements.

3. (a) The stationary wave pattern was set up between a radio wave transmitter and a flat metal sheet.

detector

flat metal reflector sheet

transmitter at focus of curved sheet
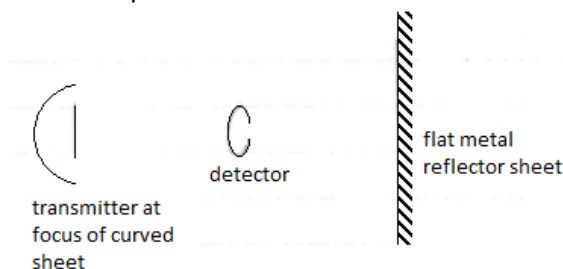
Hertz detected a set of nodes and antinodes in the stationary wave pattern. By measuring the inter-nodal distance and doubling it he calculated the wavelength.

$\qquad\qquad$ λ = 2 x node-to-node distance

(b) The dependence on orientation is because unless the detector is in the correct orientation there is no p.d. induced and hence no signal received. The conclusion drawn from this was that radio waves must be plane-polarised.

(A dipole detector needs to be parallel to the oscillations of the electric field component for maximum received signal strength. A loop detector needs to be perpendicular to the oscillations of the magnetic field and thus parallel to the electric field for maximum received signal strength).

4. (a) N = 720, f =12.6 Hz, c = 3.00 x 10^8 ms^{-1}

$\qquad$ $t = \dfrac{1}{2 f_0 N} = \dfrac{1}{2 \times 12.6 \times 720}$ = 5.511….x 10^{-5} s = 5.511….x 10^{-5} s

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ = 5.51 .x 10^{-5} s to 3 sf or 55.1 μs

(b) (i) The reflected light can't be seen at 37.8 Hz, which is 37.8/12.6 = 3 times the original frequency because the wheel will have turned such that a tooth will still be in the way of the light's path to the reflector. (It would have to turn through n/2N of a rotation where n is an odd number for a gap to replace the tooth).

(ii) The next highest frequency will be at 5f$_0$

$\qquad$ f = 5 x 12.6 = 63.0 Hz to 3 sf