Electromagnetic Waves

Basic Problems

1. Wirless networks (WLAN) operate in the 2.4 GHz band. Calculate the corresponding wavelength. What type of electromagnetic waves does this correspond to?
2. Give five different examples of electromagnetic waves and order them by increasing wavelength.
3. What are the wavelength and frequency ranges for visible light?
4. The distance between the respective nodes of the electric and magnetic field in a standing electromagnetic wave is 10 cm. Calculate the oscillation's frequency.
5. A microwave oven works with electromagnetic waves of 2.45 GHz. Is there any danger of standing waves in the appliance?
6. The antennas used in mobile phones usually have a length of a quarter of a wavelength. How long are the antennas for the two frequency bands used in Europe (900 MHz and 1'800 MHz)?
7. Calculate the refractive index for radio waves in glass. Compare the result with the value for visible light.
8. Calculate the wavelength of the hydrogen spectral line H_α („Formeln und Tafeln", T 176) in water.
9. A typical laser beam has an intensity of 2.5 kW/m². Calculate the magnitudes of the electric and magnetic fields.
10. Before passing a polarisation filter, the amplitude of an electromagnetic wave's electric field is 30 V/m. The angle between the incoming wave's and the filter's polarisation directions is 30°. Calculate the transmitted wave's amplitude. What fraction of the initial intensity passes the filter?
11. Calculate Brewster's angle for the reflexion on water.

Additional Problems

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12. Two 50 cm long wires run parallel to each other. They are connected on one end. When brought close to a radio transmitter, a voltage antinode can be found at 10 cm from the connected ends.
    a) Sketch the voltage and current amplitudes along the wires.
    b) Calculate the transmitter's frequency.
13. The high-frequency LC oscillator of a radio transmitter consists of a capacitor with capacitance 4.8 pF and a coil with inductance 0.3 µH.
    a) Calculate the length of an appropriate dipole antenna.
    b) The receiver's dipole antenna is placed in a tank filled with alcohol. Its length of 22 cm is perfectly matched to the transmitter's frequency. Calculate the dielectric constant for alcohol at this frequency. Compare the value to the other values you can derive from tables in „Formeln und Tafeln".
14. The magnetic field's amplitude of an electromagnetic wave propagating along the positive y-axis can be described by the vector (2.5|0|0) µT. Calculate the electric field's magnitude and the Poynting vector.
15. Totally unpolarised light passes through a polarisation filter. Calculate the rms value of the electric field and the average intensity after the filter in terms of the respective initial values.
    Hint: Integrate the square of the electric field over all possible angles and take the square root of the average value.
16. The antennas of a transmitter and of a corresponding receiver are placed at right angles. A polarisation filter is placed between them. Graph the receiver's signal as a function of the angle between the emitted wave's polarisation and the filter's polarisation direction.

Solutions to Basic Problems: 1. 12.5 cm; ; 4. 750 MHz; 6. 8.3 cm, 4.2 cm; 7. 2, 1.46; 8. 493 nm; 9. 970 V/m, 3.2 µT; 10. 26 V, 75 %; 11. 53 °