Electromagnetic Waves

Basic Problems

1. Calculate the wavelength of the radio station DRS 3, which transmits on 88.75 MHz.
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 two neighbouring nodes of the electric and magnetic field of 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. What would be the magnitude of the electric field vector in an electromagnetic wave whose magnetic field has the same magnitude as the horizontal component of the terrestrial magnetic field in Zurich?
8. Calculate the speed of low frequency electromagnetic waves in water. (Hint: Look up the value for the dielectric constant of water). Compare the result with the value for visible light.
9. What is the wavelength of red light (650 nm) in acrylic glass (Plexiglas M222)?
10. A laser beam with a power of 3.5 mW has a diameter of 1.3 mm. Calculate the magnitudes of the electric and the magnetic field vector.
11. 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.
12. Before passing a polarisation filter, an electromagnetic wave's electric field has an amplitude of 30 V/m. The angle between the directions of the incoming wave and the filter's polarisation is 30°. Calculate the transmitted wave's amplitude. To what fraction of its initial value does the intensity decrease?

Supplementary Problems

13. 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.
14. Totally unpolarised light passes through a polarisation filter. For the amplitude of the fields and the intensity of the wave, calculate the ratio of the values before and after the filter.
    (Hint: Integrate over all possible angles and calculate the average.)
15. Light reflected from a surface is totally polarised when the reflected ray is perpendicular to the refracted ray (*Brewster's angle*). Calculate this angle for glass.
16. The antennas of a transmitter and of a corresponding receiver are placed at a right angle. 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.

Numerical Solutions: 1. 3.4 m; 3. 400 nm — 800 nm, 375 — 750 THz; 4. 750 MHz; 5. wavelength 12 cm, yes; 6. 8.3 cm, 4.2 cm; 7. 6.4 kV/m; 8. c/8.9, c/1.33; 9. 440 nm; 10. 1.0 kV/m, 3.3 μT; 11. 750 V/m, 1.5 kW/m²; 12. 26 V, 75 %;