# 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. 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.
4. A light bulb connected to the central part of a 34 cm long wire lights up when the arrangement is brought close to a radio transmitter. Sketch the nodes and antinodes of current and voltage along the wire for the first few harmonics. 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 speed of low frequency electromagnetic waves in glass.
8. 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.
9. A pedestrian observes the red LED backlight of a bicycle moving away at 27 km/h. The LEDs' wavelength in their rest system is 630 nm. Calculate the change in wavelength as seen by the observer.
10. Before passing a polarisation filter, an electromagnetic wave's electric field has the amplitude 30 V/m. The angle between the incoming wave's and the filter's polarisation directions is 30°. Calculate the transmitted wave's amplitude. To what fraction of its initial value does the intensity decrease?

**Additional Problems**

11. 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.
12. The capacitor in a high frequency oscillator has a capacitance of 4.8 pF, the coil an inductance of 0.3 μH.
    a) Calculate the length of an appropriate antenna ($\lambda/2$ dipole).
    b) A 22 cm long dipole antenna is placed in a tank filled with alcohol. The antenna is perfectly adapted to receiving the waves emitted by the transmitter. Calculate the speed of the waves in alcohol.
    c) Calculate the dielectric constant for alcohol from the speed of propagation.
13. The police use radar guns to measure the speed of driving cars. Explain the idea of this way of speed measurements and make an estimate for the frequency measurements' required precision.
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. 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.

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Solutions to Basic Problems: 1. 3.4 m; 3. 750 MHz; 4. 440 MHz; 5. 12 cm; 6. 8.3 cm bzw. 4.2 cm; 7. $c_0/2$; 8. 750 V/m, 1.5 kW/m²; 9. $+1.6 \cdot 10^{-5}$ nm; 10. 26 V, 75 %;