

Physics 31B 2nd Midterm (200 pts Max.)
Fall 2004

Show your works with diagrams, explanations, and clear writings. No credit will be given for answers without diagrams, explanations, and clear writings.

1. (a) Use Balmer's formula to compute the wavelength of the red line in the hydrogen spectrum.

(b) A beam of quasimonochromatic X-rays with a wavelength of 0.15 nm is incident on a crystal. What is the space between atomic planes if the first-order diffraction maximum between occurs at $\theta_1=16.0^\circ$?
2. (a) State the two postulates of Einstein's principle of relativity.

(b) A starship (some time in the very distant future) is headed for a galaxy that, according to human astronomy texts, is 200 light-years away from Earth. Flying a direct course, the ship reaches a cruising speed of 0.999c. What will be the Earth-galaxy distance as then determined by the navigator?
3. (a) Two galaxies are speeding away from the Earth along a line in opposite directions, each with a speed of 0.75c with respect to the planet. At what speed are they moving apart with respect to each other?

(b) A helium-neon laser puts out a beam of red light containing a very narrow range of frequencies centered at 4.74×10^{14} Hz. Determine the energy of each photon at that frequency.
4. (a) A laser that emits pulses of UV lasting 2.00 ns has a beam diameter of 2.5 mm. If each burst contains an energy of 3.0 J, (a) What is the length in space of each pulse? (b) What is the average energy per unit volume (J/m^3), the energy density, in one of these pulses?

(b) In 1982, workers at Bell Labs produced optical pulses lasting 30.0 femtoseconds. How many wavelengths of the 620-nm red light correspond to one of these little wavetrains?
5. (a) A series circuit contains a 240- Ω resistor, a 3.80- μF capacitor, and a 550-mH inductor. It's placed across the terminals of an ac generator set to 100 Hz. If an ammeter in the circuit reads 250 mA effective, what is the maximum voltage of the generator?

(b) An L - C - R series circuit contains a 500- Ω resistor, a 5.0-H choke coil, and a capacitor. What value of capacitance will cause the circuit to resonate at 1000 Hz? What can you say about the practicality of your result?
6. (a) A capacitor with a reactance of 0.20 k Ω is placed in series with a 100- Ω resistor, and the combination is attached to the terminals of an ac source. What is the phase angle between the instantaneous current and the instantaneous voltage across the combination?

(b) A typical neon sign operates at a voltage of about 11.5 kV. If a transformer is to raise the 115-V line voltage up to that level, what should be its turn ratio?
7. An air-filled coaxial cable of length l consists of a central copper wire of radius r_a surrounded by metal cylindrical sheath with an inner radius of r_b . Determine the self-inductance per unit length of the cable when the two conductors are attached and a steady current I passes up one and back through the other.
8. (a) A helicopter hovering in the air has its 5.0-m rotor blades revolving at 240 rpm in a plane that intersects the local B -field of the Earth (0.050 mT) at an angle (with the normal to the plane) of 40° . Determine the induced emf between the hub and tip of each rotor blade.

(b) Derive the Transient current $I(t)$ in the DC R - L circuits.