

國立臺灣海洋大學 101 學年度研究所碩士班暨碩士在職專班入學考試試題

考試科目：電磁學

系所名稱：光電科學研究所碩士班不分組

* 可使用計算器

1. 答案以橫式由左至右書寫。2. 請依題號順序作答。

1. (15%) A plane harmonic, linearly polarized, light wave has an electric field intensity given by $E_z = E_0 \cos \pi \times 10^{15} \left(t - \frac{x}{0.65c} \right)$, c is the magnitude of velocity of light, while traveling in a piece

of glass. Find

- (a) (5%) the frequency of the light, and
- (b) (5%) its wavelength, and
- (c) (5%) the refractive index of the glass.

2. (10%) (a) (5%) The current in a coil (with inductance of 8.00 H) is equal to 3.00 A. Find the magnetic flux through the coil.

(b) (5%) If the current is increasing at a rate of 200 A/s, find the induced emf, ε , in the coil.

3. (10%) The natural separation between Na^+ and Cl^- ions in the NaCl crystal is 0.276 nm. What is the interaction energy (potential energy) of the pair of ions in joules and in terms of thermal energy, $k_B T$? (Note that $1 k_B T = 4.14 \times 10^{-21} \text{ J}$, where k_B is the Boltzmann constant ($1.381 \times 10^{-23} \text{ J K}^{-1}$) and T is the absolute temperature in Kelvin. The dielectric permittivity of free space, ε_0 , is $8.854 \times 10^{-12} \text{ C}^2 \text{ J}^{-1} \text{ m}^{-1}$.)

4. (15%) An electromagnetic wave has a frequency of 100 MHz and is traveling in a vacuum. The magnetic field is given by, $\vec{B}(z,t) = (1.00 \times 10^{-8} \text{ T}) \cos(kz - \omega t) \hat{i}$.

(a) (5%) Find the wavelength and the direction of propagation of this wave.

(b) (5%) Find the electric field vector, $\vec{E}(z,t)$.

(c) (5%) Determine the Poynting vector, and use it to find the intensity of the wave.

5. (16%) In the Bohr model of the hydrogen atom, an electron orbits a proton at a radius, R , with a speed of v , and neglecting any motion of the proton. That is, the electron moves in a circle around the proton and so it behaves like a ring of current, generating a magnetic field. Assume that the mass of the electron is m , and the electron charge is e . ε_0 is the permittivity and μ_0 is the permeability of the vacuum. According to this model,

(a) (4%) what is the period, T , the electron takes to orbit a proton?

(b) (4%) what is the speed v in terms R , m , and e ?

(c) (4%) what is the magnetic field at the proton due to the orbital motion of the electron in terms of R , m , and e ?

(d) (4%) if $R = 5.29 \times 10^{-11}$ meters, what is the magnitude of the magnetic field at the proton due to the orbital motion of the electron in Tesla?

6. (15%) (a) (8%) Write down the Maxwell equations in differential forms in a vacuum where there are no currents or charges.

(b) (7%) Show that in a medium in which there is *no* free charge and *no* free current, electromagnetic waves propagate with a velocity of propagation, $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$, where ϵ_0 is the permittivity and μ_0 the permeability of the vacuum.

7. (19%) An air-filled rectangular waveguide is operating in the TM_{21} mode at a frequency f that is 27 percent above the cutoff frequency. The wave-guide dimensions are $a = 11.5$ cm and $b = 6$ cm.

(a) (10%) Calculate the cutoff and operating frequencies.

(b) (9%) Calculate the phase constant and the intrinsic impedance.