ELEC2212 Electromagnetism for Communications
Coursework 2

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This coursework will contribute 5% of the marks for ELEC2212 Electromagnetism for Communications. Submit your answers via handin.ecs.soton.ac.uk by 5 pm on Monday 12 November 2018. On the top of the first page of your answer, specify your name, student number and university user name, or you will risk of getting no mark. The answers will be discussed in the tutorial on Wednesday 14 November 2018, and the marked answer sheets will be returned within two weeks.

Consider a plane wave propagating in free space with an electric field of
\[ \vec{E} = E_0 (\hat{x} + i \hat{y}) \exp[i(kz - \omega t)] \] [Equation #1].

(1) We filter the wave by using a linear polarizer. The polarizer only allows the x-polarised component of the electric field to pass. Calculate the percentage of energy that passes through the polarizer.
[1 mark]

(2) If we rotate the linear polarizer by 90°, it only allows the y-polarised component of the electric field in Equation #1 to pass. Calculate the percentage of energy that passes through the polarizer.
[1 mark]

(3) We attenuate the wave in Equation #1 by sending it into an attenuator. Inside the attenuator the electric field of the wave is
\[ \vec{E} = E_1 (\hat{x} + i \hat{y}) \exp[i(kz - \omega t)] \exp[\beta z] \]
where \( \beta \) is a real number that determines the attenuation. After propagating inside the attenuator for a distance of \( d \), the energy of the wave drops to 1%. Derive the expression of \( d \) using \( \beta \).
[1 mark]

(4) The magnetic field associated with the electric field in Equation #1 has the form of \( \vec{B} = B_0 (a \hat{x} + b \hat{y}) \exp[i(kz - \omega t)] \). Use Faraday’s law
\[ \nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \]
to derive the expression of \( B_0 \) and the values of \( a \) and \( b \). Note that \( a \) and \( b \) may be complex numbers.
[1 mark]

(5) The real, x component of the electric field in Equation #1 at \( z = 0 \) is \( \vec{E} = E_0 \cos(\omega t) \hat{x} \). It interacts with an electric dipole \( \vec{p} \), which is also at \( z = 0 \). We know that \( \vec{p} = p_0 \cos(\omega t + \theta) \hat{x} \), where \( \theta \) is the phase difference between the dipole and the electric field. If \( \theta = 0 \), we say that the electric field and the dipole are oscillating in phase. The energy dissipation of the dipole in the electric field is the time average of the dot product
\[ \vec{E} \cdot \frac{\partial \vec{p}}{\partial t} \]
over an extremely large number of oscillation cycles. Calculate the value of the energy dissipation if \( \theta = 0 \).
[1 mark]