L2 Foundation of Physics 2B Optics 2018-19

O.WP.1 Harmonic waves

January 17, 2020

(a) 1. What are $\underline{k}$ and ω? [2 marks]
$\underline{k}$ is the **wave vector**.[1] ω is the **angular frequency**.[1]

2. Write expressions for $\underline{k}$ and ω in terms of the wavelength of light λ. [2 marks]
The modulus of $\underline{k}$, $k = 2\pi/\lambda$.[1] $\omega = 2\pi c/\lambda$.[1]

3. For the case where $\underline{\mathcal{E}}_0$ is a constant, sketch the magnitude of the electric field as a function of position for a harmonic wave with wavelength $\lambda = 0.45$ μm. Include a scale on both axes. [Hint: Assume that $\underline{k}$ is parallel the z axis.] [2 marks] The plot is the cosine wave [1] with the maxima at multiples of 0.45 μm.[1] See Fig. 1(a).

4. Now plot the magnitude of the field as a function of time. Include a scale on both axes. [2 marks] The plot is similar[1] except that now the x-axis has units of time and the maxima are at multiples of 1.5 fs.[1] See Fig. 1(b).

5. Now plot the intensity as a function of time and show the time-averaged intensity $\mathcal{I}_0 = \frac{1}{2}c\epsilon_0\mathcal{E}_0$. Include a scale on both axes with the vertical axis in units of $\mathcal{I}_0$. [2 marks] The plot is a cosine squared.[1] The time-averaged intensity is equal to $\frac{1}{2}$ of the maximum.[1] See Fig. 1(d).

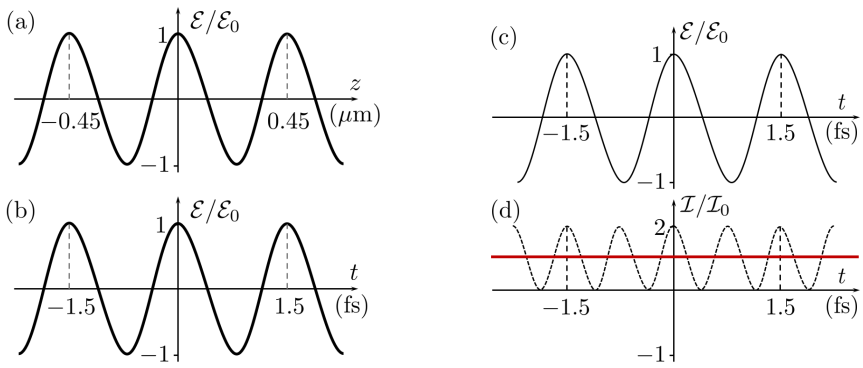
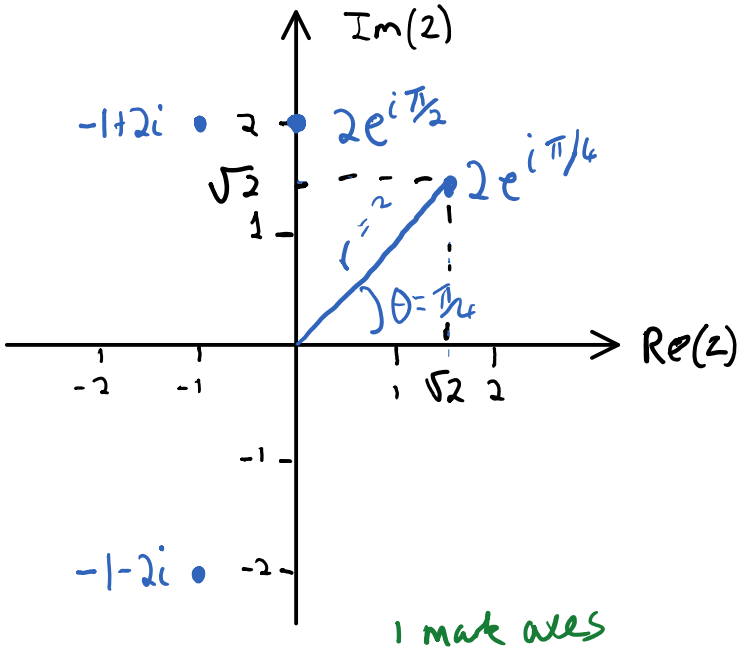


Figure 1: Harmonic wave in space (a) and time (b). The intensity (c) and time averaged intensity (red) (d).

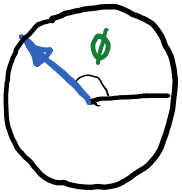


1 mark axes
1 mark each number

(b) 5 marks

1 mark direction
1 mark label

$\phi = 3\pi/4$



(c)

(b and c)