Solution to Problem 1) a) An optical medium is linear when it responds linearly to the local electric and magnetic fields. For instance, in the case of monochromatic excitation with frequency ω, a linear material's polarization and magnetization at $(\boldsymbol{r},t)$ are given by $\boldsymbol{P}(\boldsymbol{r})e^{-\mathrm{i}\omega t} = \varepsilon_0\chi_\mathrm{e}(\omega)\boldsymbol{E}(\boldsymbol{r})e^{-\mathrm{i}\omega t}$ and $\boldsymbol{M}(\boldsymbol{r})e^{-\mathrm{i}\omega t} = \mu_0\chi_\mathrm{m}(\omega)\boldsymbol{H}(\boldsymbol{r})e^{-\mathrm{i}\omega t}$, while $\rho_\mathrm{free}(\boldsymbol{r},t) = 0$ and $\boldsymbol{J}_\mathrm{free}(\boldsymbol{r},t) = 0$. It is seen that the relation between $\boldsymbol{P}(\boldsymbol{r})$ and $\boldsymbol{E}(\boldsymbol{r})$ is one of proportionality, and so is the relation between $\boldsymbol{M}(\boldsymbol{r})$ and $\boldsymbol{H}(\boldsymbol{r})$.

The material is said to be isotropic when its response to the local $\boldsymbol{E}$ and $\boldsymbol{H}$ fields does not depend on the direction of these fields. For instance, the aforementioned linear medium is also isotropic if $\chi_\mathrm{e}(\omega)$ as well as $\chi_\mathrm{m}(\omega)$ remain the same irrespective of whether the $\boldsymbol{E}$ and $\boldsymbol{H}$ fields happen to be along the x, or y, or z directions or, for that matter, along any direction in space.

The material medium is homogeneous if its optical properties, such as electric and magnetic susceptibilities $\chi_\mathrm{e}(\omega)$ and $\chi_\mathrm{m}(\omega)$, are independent of the location $\boldsymbol{r}$ within the medium.

b) The plane of incidence is the geometric plane defined by the vector $\boldsymbol{k}^{(\mathrm{inc})}$ and the surface normal, which, in the present problem, is the z-axis. In the case of normal incidence, where the incident k-vector is aligned with the z-axis, the plane of incidence is not unique. Stated differently, in the case of normal incidence, any plane that is perpendicular to the interfacial xy-plane can be considered to be the plane of incidence.

c) The incident plane-wave is p-polarized (p stands for parallel) if its state of polarization is linear, with the E-field vector residing entirely in the plane of incidence. The plane-wave is s-polarized (s stands for senkrecht, which is German for perpendicular) if its state of polarization is also linear, but the E-field is perpendicular to the plane of incidence. At normal incidence, one cannot distinguish between p- and s-polarization states; consequently, when a normally-incident plane-wave is linearly polarized, it is equally valid to treat it as either p- or s-polarized light.

d) The incident plane-wave is linearly polarized if $E_p = 0$, or $E_s = 0$, or when neither E_p nor E_s is zero but $\varphi_p - \varphi_s = 0°$ or $180°$. The plane-wave is circularly polarized if $|E_p| = |E_s| \neq 0$ and $\varphi_p - \varphi_s = 90°$ or $-90°$. When a monochromatic plane-wave is neither linearly nor circularly polarized, it is said to be elliptically polarized. With the passage of time, the tip of the E-field vector in the latter case describes an ellipse, which is known as the ellipse of polarization.