the transmission frequency so that we operate in the high-frequency regime, signals are not filtered as they propagate along the transmission line: The characteristic impedance is real-valued the transmission line's equivalent impedance is a resistor and all the signal's components at various frequencies propagate at the same speed. Transmitted signal amplitude does decay exponentially along the transmission line. Note that in the high- frequency regime the space constant is approximately zero, which means the attenuation is quite small.

###### Exercise 6.3.3

What is the limiting value of the space constant in the high frequency regime?

### Wireless Channels

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Wireless channels exploit the prediction made by Maxwell's equation that electromagnetic felds propagate in free space like light. When a voltage is applied to an antenna, it creates an electromagnetic feld that propagates in all directions (although antenna geometry afects how much power fows in any given direction) that induces electric currents in the receiver's antenna. Antenna geometry determines how energetic a feld a voltage of a given frequency creates. In general terms, the dominant factor is the relation of the antenna's size to the feld's wavelength. The fundamental equation relating frequency and wavelength for a propagating wave is

λ*f = c*

Thus, wavelength and frequency are inversely related: High frequency corresponds to small wavelengths. For example, a 1 MHz electromagnetic feld has a wavelength of 300 m. Antennas having a size or distance from the ground comparable to the wavelength radiate felds most efciently. Consequently, the lower the frequency the bigger the antenna must be. Because most information signals are baseband signals, having spectral energy at low frequencies, they must be modulated to higher frequencies to be transmitted over wireless channels.

For most antenna-based wireless systems, how the signal diminishes as the receiver moves further from the transmitter derives by considering how radiated power changes with distance from the transmitting antenna. An antenna radiates a given amount of power into free space, and ideally this power propagates without loss in all directions. Considering a sphere centered at the transmitter, the total power, which is found by integrating the radiated power over the surface of the sphere, must be constant regardless of the sphere's radius. This requirement results from the conservation of energy. Thus, if ***p (d)*** represents the power integrated with respect to

direction at a distance d from the antenna, the total power will be ***p (d)4πd2*** . For this quantity to be a constant, we must have