9.16 (a) The current density can be written as $\vec{J}(\vec{x}) = I \sin\left(\frac{2\pi}{d} z\right) \delta(x)\delta(y)\hat{z}$, and the vector potential can be exactly calculated

$$\vec{A}(\vec{x}) = \hat{z}\,\frac{\mu_0 I}{4\pi}\frac{e^{ikr}}{r}\int_{-d/2}^{d/2} \sin(kz)\, e^{-ikz\cos\theta}\, dz = \hat{z}\,\frac{\mu_0 I}{4\pi}\frac{e^{ikr}}{kr}\int_{-\pi}^{\pi} \sin(\phi)\, e^{-i\phi\cos\theta}\, d\phi$$

$$= \hat{z}\,\frac{-i\mu_0 I}{2\pi}\,\frac{e^{ikr}}{kr}\,\frac{\sin(\pi\cos\theta)}{\sin^2\theta}, \quad \text{with } k = 2\pi/d.$$

Following the same argument from Eq. (9.55) to Eq. (9.56), we can see that

$$\frac{dP}{d\Omega} = \frac{Z_0 I^2}{8\pi^2}\left[\frac{\sin(\pi\cos\theta)}{\sin\theta}\right]^2.$$

(b) $$P = \int d\Omega\,\frac{dP}{d\Omega} = \frac{Z_0 I^2}{4\pi}\int_0^{\pi}\frac{\sin^2(\pi\cos\theta)}{\sin\theta}\,d\theta = \frac{Z_0 I^2}{4\pi}\times\frac{1}{2}\left[-C_i(4\pi) + \gamma + \log(4\pi)\right]$$

$$= \frac{Z_0 I^2}{4\pi}\times 1.55718,$$

where $C_i(x)$ is the cosine integral function. The radiation resistance is

$$R_{rad} = \frac{Z_0}{2\pi}\times 1.55718 = 93.366061$$