EE 483/583 Antennas for Wireless Communications Quiz #9 (Spring 2026)

Name **KEY A**

Instructions: Open book & notes. Place answers in indicated spaces and **show all** work for credit.

In free space, a 6 cm diameter circular loop antenna, located on the *x*-*y* plane and centered on the *z*-axis, is driven by a phasor input current of $8.3\angle 168^\circ$ A at 8 MHz. Is the loop small, smallish w/ constant current, or electrically large? Why? What is *ka*? If the wire has a diameter of 4 mm and an electrical conductivity of 6.1×10^7 S/m, find the radiation and loss resistance as well as the radiation efficiency (%) of this antenna.

Wavelength $\lambda = c/f = 2.9979\times10^8 / 8\times10^6 = 37.47375$ m.

$C = 2\pi a = \pi D = \pi\,(0.06 \text{ m}) = 0.18849556$ m.

$ka = C/\lambda = 0.18849556/37.47375 \Rightarrow$ **$ka = 0.00503$** $< 0.1 \ll 1 \Rightarrow$ **electrically small**

Radiation resistance, per (5-24), $R_r = \eta(\pi/6)(ka)^4 = 376.7303\,(\pi/6)[0.00503]^4$

$\Rightarrow$ **$R_r = 1.26277\times10^{-7}\ \Omega = 0.126277\ \mu\Omega$.**

Loss resistance, per (2-90b),

$$R_L = \frac{\ell}{P}\sqrt{\frac{\omega\mu_0}{2\sigma}} = \frac{2\pi a}{2\pi b}\sqrt{\frac{\omega\mu_0}{2\sigma}} = \frac{a}{b}\sqrt{\frac{\omega\,\mu_0}{2\sigma}} = \frac{0.06/2}{0.004/2}\sqrt{\frac{2\pi(8\times10^6)4\pi\times10^{-7}}{2(6.1\times10^7)}}$$

$\Rightarrow$ **$R_L = 0.010793224\ \Omega = 10.7932\ \text{m}\Omega$**

Radiation efficiency (%), per (2-90)

$$e_{cd} = \left(\frac{R_r}{R_L + R_r}\right)100\% = \left(\frac{1.26277\times10^{-7}}{0.010793224 + 1.26277\times10^{-7}}\right)100\%$$

$\Rightarrow$ **$e_{cd} = 0.00117\ \%$.**

Loop is: **[small]**, smallish w/ constant current, or electrically large (Circle one)

Why? **$ka = C/\lambda = 0.005 < 1/10$** $\qquad$ $ka =$ **0.00503**

Rad. res. = **$R_r = 1.26277\times10^{-7}\ \Omega = 0.126277\ \mu\Omega$** $\qquad$ Loss res. = **$R_L = 0.010793\ \Omega = 10.7932\ \text{m}\Omega$**

Radiation efficiency = **$e_{cd} = 0.00117\ \%$**