556.

Problem 41.25 (RHK)

An airplane flying at a distance of 11.3 km *from a radio transmitter receives a signal of* $7.83\ \mu\text{W m}^{-2}$. *We have to calculate* (a) *the amplitude of the electric field at the airplane due to the signal*; (b) *the amplitude of the magnetic field at the airplane*; (c) *the total power radiated by the transmitter, assuming the transmitter to radiate uniformly in all directions*.

Solution:

(a)

Recall that in problem **554. 41.20** (RHK) we have shown that the amplitude of the electric field of a plane wave and intensity of the wave are related as

$$I = \overline{S} = \frac{1}{\mu_0 c}\overline{E}^2 = \frac{1}{2\mu_0 c}E_m^2.$$

It is given that the intensity of the signal received by the aeroplane when it is at a distance of 11.3 km from a radio transmitter is $7.83\ \mu\text{W m}^{-2}$. Therefore,

$$E_m(r) = \left(2\mu_0 c I(r)\right)^{1/2} = \left(2 \times 4\pi \times 10^{-7} \times 3 \times 10^8 \times 7.83 \times 10^{-6}\right)^{1/2} \text{ V m}^{-1}$$

$$= 7.68 \times 10^{-2} \text{ V m}^{-1} = 76.8 \text{ mV m}^{-1}.$$

(b)

And the amplitude of the magnetic field will be

$$B_m = \frac{E_m}{c} = \frac{7.68 \times 10^{-2}}{3 \times 10^8} \text{ T} = 2.56 \times 10^{-10} \text{ T} = 256 \text{ pT}.$$

(c)

The total power radiated by the radio transmitter, assuming that it is radiating uniformly in all directions, will be

$$P = 4\pi r^2 I = 4\pi \times \left(11.3 \times 10^3\right)^2 \times 7.83 \times 10^{-6} \text{ W}$$

$$= 12.56 \text{ kW}.$$