Questions for chapter 8 and 12 in "Antennas" by Kraus

1. The diameter of an helix antenna is D and the distance between two turns is S. Then the circumference is $C = \pi D$ (see page 229). If the helix antenna is in "axial mode" (also called "beam mode") it is radiating in the direction in which the spiral points (see page 240 and page 262). To achieve "axial mode" a good choice of circumference C is one wavelenght. Within which limits must the spacing S be chosen in order to achieve "axial mode" ? Use the diagram on page 230.

2. Who discovered the helix antenna? Where was he when he made the experiment? What circumference C did he choose? When came the first publication? (page 222-223)

3. The helixantenna is often used in space applications. List four advantages of a helix antenna. (page 225)

4. What type of antenna is used by a GPS satellite? (page 226)

5. An array of four helix antennas is constructed according to the example on pages 241-242. The impedance of each separate helix is 50Ω and the directivity of the array is 113. Suppose that the number of helix antennas is increased to 16. Determine the impedance of each separate helix and the directivity of the new bigger array.

6. Write down the radar equation. (page 418)

7. What is the radar cross section σ of a metal sphere of radius a. The sphere is much bigger than the wavelenght. (page 418)

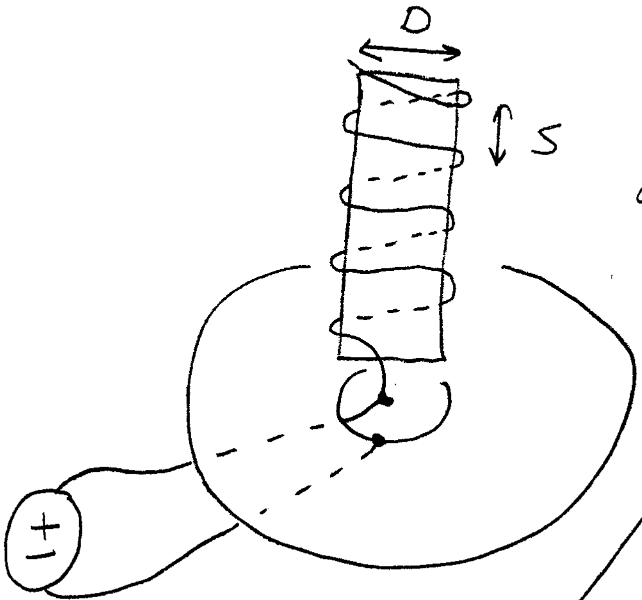
8. Why is the radar cross section of the moon only 10% of the moon´s physical cross section when the wavelength is approximately one meter? (page 418)

9. An electromagnetic wave is incident at right angle on a quadratic metallic plate with sidelenght a. The wavelenght 0.1 a. Determine the radar cross section σ using the table on page 419.

10. The radar cross section of a metallic plate is much bigger than the plate´s physical area when the wave impinges at right angle and the wavelength is much smaller than the plate. Should not the radar cross section in this case be approximately equal to the physical area? Explain.

Answers to questions on chapter 8 and 12, Kraus

(1)



circumference = $C = \pi D$

this is from the enclosed (= next page) Figure 8-10

Suppose that $C = \lambda$ then $C_\lambda = 1$ and

axial mode (= beam mode) is achieved if

$0.06 < S_\lambda < 0.5 \Rightarrow \underline{\underline{0.06\lambda < S < 0.5\lambda}}$

(2) Kraus, at home, $C = 1\lambda$, 1947.

(3) 1. Nearly uniform resistive impedance over a wide bandwidth.

2. High directivity over a wide bandwidth.

3. Wire size and turn spacing is noncritical.

4. Almost negligible mutual inductance (when used as antenna elements in an array).

(4) An antenna array with helix antennas as antenna elements.

THE HELIX CHART
BOUNDED BY LOOPS AND LINEAR CONDUCTORS

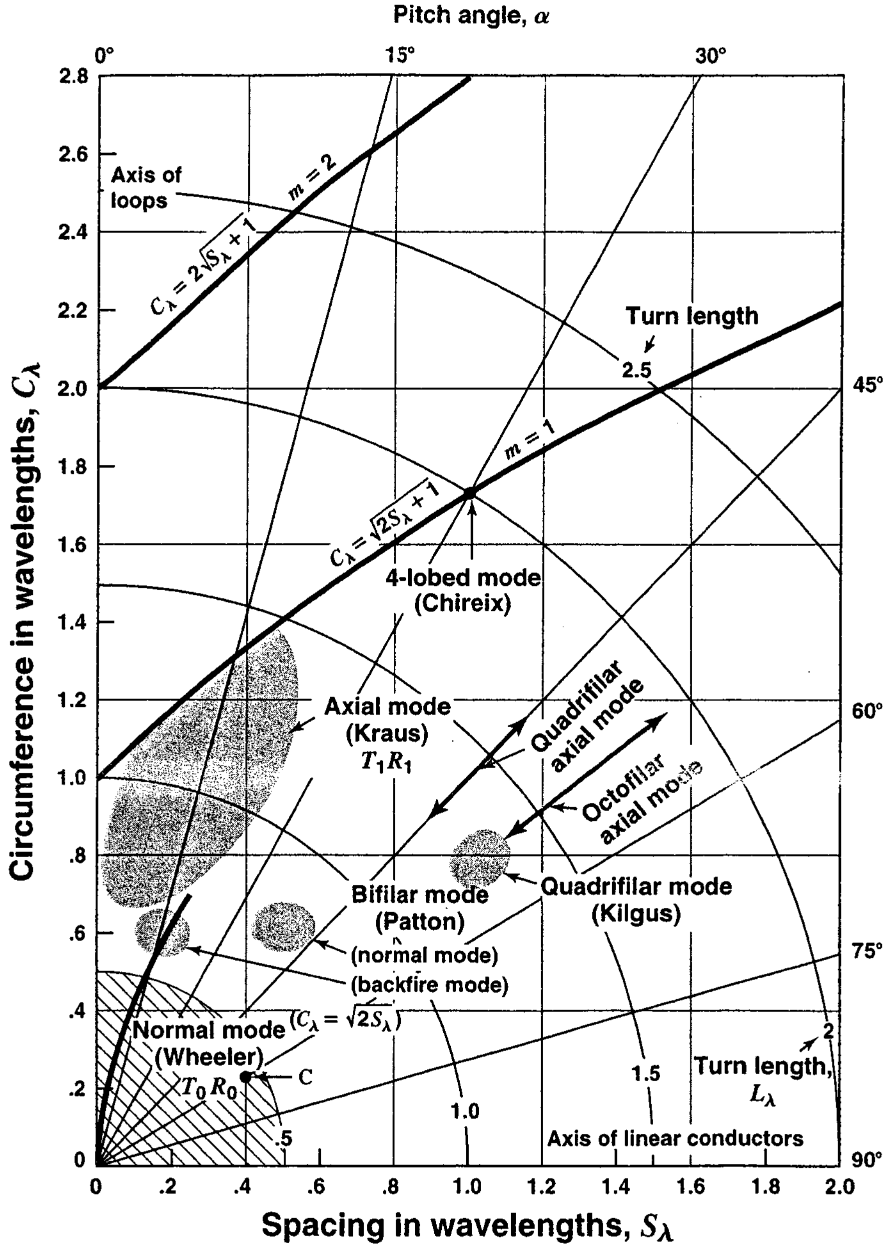


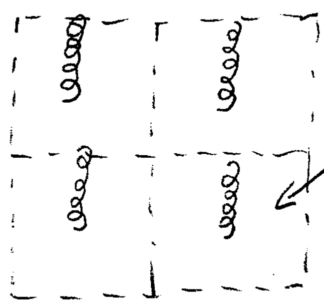
Figure 8–10
Helix chart showing the location of different modes of operation as a function of the helix dimensions (diameter, spacing and pitch angle). As a function of frequency the helix moves along a line of constant pitch angle. *Along the vertical axis the helices become loops and along the horizontal axis they become linear conductors.* The 4-lobed, quadrifilar, bifilar and normal modes are discussed in Chap. 8, Part II. Point *C* is a bifilar mode location (see Sec. 8–25).

(5) The impedance is still 50 Ω since the mutual inductances are neglible.

$D = \frac{4\pi}{\lambda^2} A_e$ and A_e is increased by a factor 4,

$D_{16} = 4 D_4 = 4 \cdot 113 = 452$

array with four antenna elements



this area should be equal to A_e for a single helix antenna

(6) $P_r = \frac{P_t}{4\pi R^2} D \sigma \frac{1}{4\pi R^2} A_e$

(7) $\sigma = \pi a^2$

(8) The moon is not a conducting sphere.

(9) $\sigma = 4\pi \frac{A^2}{\lambda^2} = \left[A = a^2,\ \lambda = 0.1a \right] =$

$= 4\pi \frac{a^4}{0.01 \cdot a^2} = 400\pi a^2$

{this is from enclosed (=next page) Table II-1

(10) In the radar equation it is "imagined" that the power is scattered isotropically. This is of course not true for a metallic plate (or any other object).

distance. A solution is to use a parabola to convert the spherical wave front from the radar to a plane wave. This greatly reduces the distance required and results in what is called a "compact range." The Ohio State University 110-m radio telescope doubled as a compact range for RCS measurements of large objects. See Figs. 20–6 and 20–8.

Notice in (3) that the backscattered power at the radar receiver is inversely proportional to the fourth power of the distance. This means that if you have a receiver as sensitive and an antenna as large as the radar's, you should be able to detect the radar at greater distances than it can detect you. The signal needs to cover the path to you only once ($1/r^2$ attenuation), but it must cover it twice to get back to the radar ($1/r^4$ attenuation).

In *pulse radar* the antenna is connected to the transmitter while the pulse is sent. It is then switched to the receiver which listens for the echoes. The greater the range being observed, the longer the time needed between pulses. In *doppler radar* the antenna is connected continuously to both transmitter and receiver through a circulator which isolates the receiver from the transmitter, and the transmitter is on all the time. The term CW (continuous wave) *doppler* is used to describe this mode of operation, which measures only velocity. By measuring both time delay and frequency shift of the echoes from a pulse radar, we have what is called *pulse doppler radar* which measures both distance and velocity.

Radars have wide application for ship and aircraft navigation; for harbor, airport and highway surveillance; for weather forecasting (storms, rain, hail, etc.); for terrain mapping; for measuring the distance to the moon or the rotation of Venus (whose surface is hidden by clouds); for monitoring the speed of a pitcher's fast ball; or determining the velocity of a hummingbird.

The radar cross sections of several objects are listed in Table 12–1 where it is assumed that the objects are large compared to the wavelength. Note that, whereas the RCS of a sphere is equal to its cross-sectional area, the RCS of a plate or sheet is larger than its area (see Prob. 12–5–7). See also the RCS data in Fig. 12–9.

In *pulse radar* the time Δt between the transmission of the pulse and reception of its echo gives the *distance d* of the object as

$$d = \frac{1}{2} c \Delta t \qquad \text{(m)} \tag{6}$$

where $c = 300$ Mm s^{-1} (for air) and Δt = delay time of echo, s.

Table 12–1 Radar cross sections†

Object	Radar cross section σ
Sphere, radius a	πa^2
Flat plate, area A	$4\pi A^2/\lambda^2$
Cylinder, radius a, length L	$2\pi a L^2/\lambda$

†Objects perfectly conducting and large compared to the wavelength (a and $L \gg \lambda$). Plate and cylinder at normal incidence. Cylinder length L parallel to plane of polarization of radar wave. For the general case where the object's dimensions may also be smaller than the wavelength, see R. J. Kouyoumjian (1).