EETE 4231	Antennas & Propagation	3 Credit Hours
Prerequisites:	EETE 4130	
Goal	To introduce the principal radio antennas and the nature of the propagation of radio waves.	

Objectives	Outcomes
The course should enable the student to: 1. discuss the sources of noise in radio systems 2. explain the principles behind signal-to-noise degradation in a radio system 3. describe the parameters which characterize the operation of an antenna 4. illustrate the operation of a dipole antenna and an array of dipole antennas by their application to systems such as broadcasting and airport aids.	The students should be able to: 1. Recognize and represent monochromatic uniform and non-uniform plane EM waves in phasor notation, and use refractive index to relate wave properties in material media (isotropic) to wave properties in free space (a). 2. Recognize orthogonal polarized wave pairs, synthesize arbitrarily polarized waves and perform Poynting flux calculations in terms of linear and circular orthogonal pair components (a). 3. Perform 1- and 2-D spatial Fourier transforms of scalar functions defined on planar surfaces, and recognize the Fourier spectrum of tangential field components or surface currents as the amplitude spectrum of propagating and evanescent waves in the half-space bounded by the surface (a). 4. Calculate the far-field radiation due to a localized source on a surface in terms of the angular spectrum function of the source (a). 5. Perform near field calculations using the Fresnel diffraction formula, and examine the transition from near to far-field in the case of localized source distributions (a). 6. Describe the operation of radio imaging systems (radio camera) in terms of fields detected on a reception plane, and design reception systems to meet specified resolution requirements and source configurations (a,b,c). 7. Understand transmission properties (directivity, gain pattern, solid angle) of short line antennas and antenna arrays, and design 1- and 2-D antenna arrays to meet specified directivity and pointing requirements (a,c). 8. Understand the sampling (reception) properties of antennas and the relationship between antenna gain and effective antenna area, and re-interpret array design issues from the viewpoint

	of reception (a,c). 9. Construct the power budget equations for communication and remote sensing systems (Friis transmission formula, hard- and soft-target radar equations), and design systems (choice of average transmitted power, transmission and reception antenna gains, bandwidth and pulse length) to meet specified SNR and resolution goals under operation constraints (e.g., link or target distance, target backscatter cross-section, sky temperature) (a,c). 10. Calculate radar backscatter cross-section for simple targets (free electron, planar reflector) (a,b). 11. Do ray tracing and phase path calculations in plane and spherical stratified inhomogeneous geometries (a). 12. Understand the standard tropospheric refractive index model and its implications for tropospheric refraction including curvature (spherical Earth) effects (a). 13. Calculate space-gain factor for tropospheric space wave links, and design link parameters (antenna heights, gains) to meet specified constraints (a,c). 14. Derive the refractive index for collisionless plasma and recognize propagation and evanescence conditions in ionospheric plasma in terms of plasma and radiowave frequencies (a). 15. Calculate phase and group velocities from specified dispersion relations and/or refractive index formulae, and perform group path calculations in homogeneous dispersive media (a). 16. Understand the average morphology and causes of formation of the ionosphere (a,j). 17. Perform ionospheric ray tracing calculations, and local ionosphere description in terms of ionograms, and determine ionospheric sky-wave link parameters such as virtual reflection height, ground distance, skip zone, and maximum usable frequency (a,c). 18. Understand the effect of free electron collisions in the D-region ionosphere on the propagation of radio waves in different frequency bands (in particular MF and HF) (a, j). 19. Derive refractive indices for normal modes of propagation in a collisionless but magnetized plasma neglecting the heavy ion effects (for parallel and

perpendicular propagation), and perform phase and group velocity as well as phase and group path calculations associated with the normal modes (a).

20. Identify the conditions when quasi-longitudinal approximation is applicable and perform Faraday rotation computations, and design simple remote sensing experiments exploiting the Faraday rotation phenomenon (a, c).
21. Design simple experiments exploiting group delay variations for whistler mode propagation (a,c).
22. Understand the scintillation effect of ionospheric plasma density irregularities on waves propagating through the ionosphere (the simplest weak scintillation/single screen description) (a,j).
23. Understand atmospheric and ionospheric Doppler wind and electric field measurement techniques (a simplified multiple point-target description) (a, b, c).