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Electromagnetic Field Theory: A Problem Solving Approach

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chapter 1

review of vector analysis

Electromagnetic field theory is the study of forces between charged particles resulting in energy conversion or signal transmission and reception. These forces vary in magnitude and direction with time and throughout space so that the theory is a heavy user of vector, differential, and integral calculus. This chapter presents a brief review that highlights the essential mathematical tools needed throughout the text. We isolate the mathematical details here so that in later chapters most of our attention can be devoted to the applications of the mathematics rather than to its development. Additional mathematical material will be presented as needed throughout the text.

1-1 COORDINATE SYSTEMS

A coordinate system is a way of uniquely specifying the location of any position in space with respect to a reference origin. Any point is defined by the intersection of three mutually perpendicular surfaces. The coordinate axes are then defined by the normals to these surfaces at the point. Of course the solution to any problem is always independent of the choice of coordinate system used, but by taking advantage of symmetry, computation can often be simplified by proper choice of coordinate description. In this text we only use the familiar rectangular (Cartesian), circular cylindrical, and spherical coordinate systems.

1-1-1 Rectangular (Cartesian) Coordinates

The most common and often preferred coordinate system is defined by the intersection of three mutually perpendicular planes as shown in Figure 1-1*a*. Lines parallel to the lines of intersection between planes define the coordinate axes (x, y, z), where the x axis lies perpendicular to the plane of constant x, the y axis is perpendicular to the plane of constant y, and the z axis is perpendicular to the plane of constant z. Once an origin is selected with coordinate $(0, 0, 0)$, any other point in the plane is found by specifying its x-directed, y-directed, and z-directed distances from this origin as shown for the coordinate points located in Figure 1-1*b*.