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Appendix B: PROBLEM SESSIONS

PROBLEM SESSION I

Part (1): Visualization of surfaces in 3D coordinate systems

Describe the following surfaces separately:

- a) x=-5, z=2.
- b) $\rho = 3$, $\Phi = 3\pi/2$.
- c) $\rho = \sqrt{5}$, z=-2.
- d) r=5, $\Phi = \pi/3$.
- e) $\theta = \pi/2, \Phi = \pi/2.$
- f) $r=2, \Phi=0.$
- g) y=5.

Part (2): Visualization of surfaces in 3D coordinate systems

Describe the intersection of surfaces (1) and (2):

Surface (1) Surface (2)

$$\Phi=45$$
 $z=5$
 $x=-2$ $z=3$
 $\rho=5$ $\Phi=45$
 $r=1$ $\theta=60$

Part (3): Vector Algebra

Problems 1.5 and 1.10 from the text book.

- For $U = U_x \mathbf{a_x} + 5 \mathbf{a_y} \mathbf{a_z}$, $V = 2 \mathbf{a_x} V_y \mathbf{a_y} + 3 \mathbf{a_z}$, and $W = 6 \mathbf{a_x} + \mathbf{a_y} + W_z \mathbf{a_z}$, obtain U_x , V_y , and W_z such that U, V, and W are mutually orthogonal.
- **1.10** Verify that
 - (a) $\mathbf{A} \cdot (\mathbf{A} \times \mathbf{B}) = 0 = \mathbf{B} \cdot (\mathbf{A} \times \mathbf{B})$
 - **(b)** $({\bf A} \cdot {\bf B})^2 + |{\bf A} \cdot {\bf B}|^2 = (AB)^2$
 - (c) If $\mathbf{A} = (\mathbf{A}_x, \mathbf{A}_y, \mathbf{A}_z)$, then $\mathbf{A} = (\mathbf{A} \cdot \mathbf{a}_x) \mathbf{a}_x + (\mathbf{A} \cdot \mathbf{a}_y) \mathbf{a}_y + (\mathbf{A} \cdot \mathbf{a}_z) \mathbf{a}_z$.

Part (4): Coordinate transformations

Problems 2.1, 2.2, 2.3 and 2.15 from the text.

- **2.1** Convert the following points to Cartesian coordinates:
 - (a) $P_1(5, 120^{\circ}, 0)$
 - **(b)** $P_2(1, 30^{\circ}, -10)$
 - (c) P_3 (10, $3\pi/4$, $\pi/2$)
 - (d) $P_4(3, 30^{\circ}, 240^{\circ})$
- **2.2** Express the following points in cylindrical and spherical coordinates:
 - (a) P(1, -4, -3)
 - **(b)** Q(3,0,5)
 - (c) R(-2, 6, 0)
- **2.3** Express the following points in cylindrical and spherical coordinates:
 - (a) $\mathbf{P} = (y + z) \mathbf{a}_{\mathbf{x}}$
 - **(b)** $Q = y a_x + x z a_y + (x + y) a_z$
 - (c) $T = \left[\frac{x^2}{x^2 + y^2} y^2 \right] a_x + \left[\frac{xy}{x^2 + y^2} + xy \right] a_y + a_z$
 - (d) $S = \frac{y}{x^2 + y^2} a_x \frac{x}{x^2 + y^2} a_y + 10 a_z$
- **2.15** If $\mathbf{J} = r \sin \theta \cos \phi \mathbf{a}_r \cos 2\theta \sin \phi \mathbf{a}_\theta + \tan \frac{\theta}{2} \ln r \mathbf{a}_\phi$, determine the vector component of \mathbf{J} at $T(2, \pi/2, 3\pi/2)$ that is
 - (a) Parallel to a_z .
 - **(b)** Normal to the surface $\Phi = 3\pi/2$.
 - (c) Tangential to the spherical surface r = 2.
 - (d) Parallel to the line y = -2, z = 0.