## Section 12.4: The Cross Product

**Problem 1.** Let $\mathbf{a} = \mathbf{i} + 2\mathbf{j} - 3\mathbf{k}$ and $\mathbf{b} = -\mathbf{i} + 2\mathbf{j} + 5\mathbf{k}$. Determine each of the following:
(a) $\mathbf{a} \times \mathbf{b}$ (b) $|\mathbf{a} \times \mathbf{b}|$ (c) two unit vectors that are orthogonal to $\mathbf{a}$ and $\mathbf{b}$

**Problem 2.**
(a) Find a nonzero vector orthogonal to the plane through the points $P = (-2, 0, 4)$, $Q = (1, 3, -2)$, and $R = (0, 3, 5)$.
(b) Find the area of the triangle $PQR$.

**Problem 3.** Find the volume of the parallelepiped with adjacent edges $PQ$, $PR$, and $PS$ if $P = (-2, 1, 0)$, $Q = (2, 3, 2)$, and $R = (1, 4, -1)$, and $S = (3, 6, 1)$.

## Section 12.5: Equations of Lines and Planes

**Problem 4.** Find the parametric equations of the line $L$ through the point $(6, 0, -2)$ and parallel to the line

$$x = 4 - 3t, \quad y = -1 + 4t, \quad z = 6 + 5t.$$

**HINT:** Determine the direction vector $\mathbf{v}$ of the line whose parametric equations are given.

**Problem 5.** Find the symmetric equations of the line $L$ through the point $(2, 1, 0)$ that is perpendicular to the vectors $\mathbf{i} + \mathbf{j}$ and $\mathbf{j} + \mathbf{k}$.

**HINT:** The direction vector the the line should be perpendicular to both $\mathbf{i} + \mathbf{j}$ and $\mathbf{j} + \mathbf{k}$.

**Problem 6.**
(a) Find the point of intersection of the line in Problem 4 and the $yz$-plane.
(b) Find the point of intersection of the line in Problem 5 and the plane $x + y = 1$.

**Problem 7.** Show that the lines $L_1$ and $L_2$ with parametric equations

$$L_1: \quad x = 1 + t, \quad y = -2 + 3t, \quad z = 4 - t,$$

$$L_2: \quad x = 2s, \quad y = 3 + s, \quad z = -3 + 4s,$$

are **skew lines**; that is, they are not parallel and do not intersect (and therefore do not lie on the same plane).

**HINT:** If the lines are parallel, then their direction vectors are parallel. If the lines intersect, then they have a point $(x, y, z)$ in common (the given parametric equations give you formulas for the entries of any point on the lines).

**Problem 8.** Find a vector equation for the line segment from the point $(6, -1, 9)$ to the point $(7, 6, 0)$.

**HINT:** Remember that the vector equation through the vectors $\mathbf{r}_0$ and $\mathbf{r}_1$ is $\mathbf{r} = (1 - t)\mathbf{r}_0 + t\mathbf{r}_1$, where $0 \leq t \leq 1$.

**Problem 9.** Find an equation of the plane that contains the line $x = 1 + t$, $y = 2 - t$, $z = 4 - 3t$ and is parallel to the plane $5x + 2y + z = 1$

**Problem 10.** Find an equation of the plane that passes through the point $(3, 5, -1)$ and contains the line $x = 4 - t$, $y = -1 + 2t$, $z = -3t$.