

1. Let  $\vec{u} = \langle 1, 4, 2 \rangle$ ,  $\vec{v} = \langle -2, 3, 1 \rangle$ , and  $\vec{w} = \langle 4, -1, -1 \rangle$ . Perform the indicated operations.

(a) Calculate  $(2\vec{u} + 3\vec{v}) \cdot \vec{w}$ .

(b) Compute the angle (in degrees) between  $\vec{u}$  and  $\vec{v}$ .

(c) Calculate  $\vec{v} \times \vec{w}$ .

(d) Find the volume of the parallelepiped determined by  $\vec{u}$ ,  $\vec{v}$ , and  $\vec{w}$ .

2. Let  $\vec{u} = \langle 3, 4 \rangle$  and  $\vec{v} = \langle 5, 12 \rangle$ . We can write  $\vec{u} = \vec{w} + \vec{n}$ , where  $\vec{w}$  is parallel to  $\vec{v}$  and  $\vec{n}$  is perpendicular to  $\vec{v}$ . Find  $\vec{w}$  and  $\vec{n}$ .

3. Find the equation of the plane that passes through the points  $P = (1, 4, 6)$ ,  $Q = (-2, 5, -1)$ , and  $R = (1, -1, 1)$ .

4. A particle P travels in the plane, and its vector position at time  $t$  is given by  $\vec{r}(t) = (1 - t)\vec{i} + \sqrt{1 - t^2}\vec{j}$ .

(a) Find the Cartesian equation for the path of the particle.

(b) Assuming that P starts moving at time  $t = 0$ , how far will it have traveled at  $t = 1/2$  seconds?

5. A small kid who goes by the nickname Triple A is going sledding. It is a quarter-mile (1320 feet) walk from his house to get to the sledding hill. He exerts 15 pounds of force by pulling the sled. The sled is tied to a 5 foot rope, and the hand that he pulls the rope with is 3 feet above the ground. How much work does Triple A do in pulling the sled? Assume that the ground is flat from his house to the sledding hill, and don't worry about friction.

6. A cannon sits atop a cliff that is 176 feet tall. It is aimed at an angle of  $53.1301^\circ$  above the horizontal, and it shoots a projectile at the speed of 25 feet per second.

(a) Find the initial velocity vector of the projectile.

(b) Using part(a), the fact that  $\vec{a}(t) = -32\vec{j}$ , and assuming  $\vec{r}(0) = 176\vec{j}$ , find the velocity,  $\vec{v}(t)$ , and the position,  $\vec{r}(t)$ , of the projectile for any time  $t$ .

(c) At what time does the projectile hit the ground?

(d) With what speed does the projectile come smashing into the basin below the cliff?

7. Let  $\vec{r}(t) = 3t\vec{i} + \sqrt{\frac{3}{2}}t^2\vec{j} + \frac{t^3}{3}\vec{k}$ .

(a) How far does a particle travel along this curve from  $t = 2$  to  $t = 5$ ?

(b) Find  $\vec{T}(\sqrt{6})$ .

(c) Find  $a_T(\sqrt{6})$  and  $a_N(\sqrt{6})$ .

(d) Find the curvature,  $K$ , at  $t = \sqrt{6}$ .

(e) Find  $\vec{N}(\sqrt{6})$ .

(f) Find  $\vec{B}(\sqrt{6})$ .

8. Suppose we have two planes:

$$\text{plane 1: } 4x - 5y + 8z = 21$$

$$\text{plane 2: } 3x - 3y - 4z = -5.$$

In addition, let  $P = (3, 2, 6)$

(a) Find the distance from the point  $P$  to plane 1.

(b) Determine the parametric equations for the line normal to plane 2 that goes through the point  $P$ .

(c) Determine symmetric equations for the line of intersection between plane 1 and plane 2.