1. (*10 points*) Let P be the point in the plane given in rectangular coordinates by $(-6, -6\sqrt{3})$. Find the polar coordinates (r, θ) of P (express θ in radians).

2. (*15 points*) Determine whether the following vectors are parallel, perpendicular or neither. Explain why.

a. (*4 pts*) $< 2, -3, 1 >$ and $< 2, 1, -1 >$

b. (*4 pts*) $2\mathbf{i} + \mathbf{j} - 4\mathbf{k}$ and $-7\mathbf{i} - \frac{7}{2}\mathbf{j} + 14\mathbf{k}$

c. (*4 pts*) $\mathbf{a}$ and $\mathbf{a} \times \mathbf{b} + \mathbf{a} \times \mathbf{c}$, where $\mathbf{a}, \mathbf{b}$ and $\mathbf{c}$ are arbitrary vectors.

d. (*3 pts*) $< 1, 2, -1 >$ and $\mathbf{n}$, where $\mathbf{n}$ is any vector perpendicular to the plane defined by $2x - y - z = 1$

3. (*15 points*)

a. (*8 pts*) Determine whether the three points $(1, -5, 2)$, $(-1, -3, 3)$ and $(-3, -1, 5)$ lie on the same line.

b. (*7 pts*) Determine whether the four points $(1, 1, 0)$, $(1, 1, -2)$, $(0, 2, -1)$ and $(5, -3, 0)$ lie on the same plane.

4. (*15 points*) Let $\mathbf{a} =< -1, 0, 1 >$ and $\mathbf{b} =< 2, 2, 0 >$ be vectors.

a. (*8 pts*) Find the angle between $\mathbf{a}$ and $\mathbf{b}$.

b. (*7 pts*) Find two unit vectors orthogonal to $\mathbf{a}$ and $\mathbf{b}$.

5. (*15 points*) Let P be the plane perpendicular to $< 1, 2, 3 >$ passing through the point $< 1, 0, 1 >$.

a. (*5 pts*) Find the scalar equation for the plane P.

b. (*5 pts*) Is the plane P parallel to the plane defined by $2x + 3y - 4z = 2$? Is it perpendicular?

c. (*5 pts*) Does the line given by the parameterization $x(t) = 3t + 1, y(t) = 3$ and $z(t) = -t + 3$ intersect the plane P?

6. (*15 points*)

a. (*10 pts*) Find parametric equations for the line of interesection of the planes $x + y = 1$ and $y + z = 1$.

b. (*5 pts*) Find symmetric equations in x, y and z for the same line.

7. (*15 points*) The curve in space is given by the vector function $\vec{r}(t) = \langle 2\sin(t), \sin(t), \sqrt{5}\cos(t)\rangle$.

a. (*5 pts*) Find the unit tangent and the unit normal vectors.

b. (*5 pts*) Compute the curvature of the curve.

c. (*5 pts*) Find the equation of the osculating plane to the curve at the point $(2, 1, 0)$.

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