1. Find the domain of the following functions.
   (a) $f(x, y) = \sqrt{4 - x^2 - y^2}$
   (b) $f(x, y) = \sqrt{4 + x^2 + y^2}$
   (c) $f(x, y) = \sqrt{y - x^2}$

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2. Consider the following three functions.

$$\gamma_1(t) = \begin{pmatrix} 1 + t^2 \\ t \end{pmatrix}, \quad \gamma_2(t) = \begin{pmatrix} 1 + t^3 \\ t^3 \end{pmatrix}, \quad \gamma_3(t) = \begin{pmatrix} 2\cos t \\ 2\sin t \end{pmatrix}.$$

   (a) Which of the above functions traces out a curve that passes through $(0, -1)$? There may be more than one. Justify your answer in each case.
   (b) Which one traces out a line? Which one traces out a circle? Which one traces out a parabola?
   (c) For each function, write a Cartesian equation (in the variables x, y) which describes the curve that is traced out by that function.

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3. Consider the points $A(1, 3, 1)$, $B(2, 2, -1)$, and $C(2, 0, 3)$.
   (a) Find an equation for the plane containing the points A, B, C.
   (b) Find the area of the triangle with vertices A, B, C.

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4. For each of the following, compute the path derivative $(f \circ \gamma)'(t)$ at the given value of t.
   (a) $f(x, y) = x^2 y, \quad \gamma(t) = \begin{pmatrix} t^2 \\ t \end{pmatrix}, \quad t = 1.$
   (b) $f(x, y, z) = x + yz, \quad \gamma(t) = \begin{pmatrix} t \\ 2t \\ 3t \end{pmatrix}, \quad t = 2.$

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5. Consider the parametric curve

$$\gamma(t) = \begin{pmatrix} \cos(2t) \\ \sin(2t) \\ (4\sqrt{2})t \end{pmatrix}.$$

(a) Find the equation for the tangent line at the point $(0,1,\pi\sqrt{2})$.

(b) Does the line from (a) intersect the xy-plane? If so, where?

(c) Find the speed and the acceleration vector at $(0,1,\pi\sqrt{2})$.

(d) Find the linear acceleration and the angular acceleration at time t.

(e) Find the unit tangent vector and the unit normal vector at time t.

(f) Find the curvature at time t.

(g) Find the length of the part of the curve from $(0,1,\pi\sqrt{2})$ to $(1,0,4\pi\sqrt{2})$.

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6. *Mark each of the following statements as true or false:*

   (a) For motion in space, if the speed is constant, then the acceleration is always zero.

   (b) For motion in space, if the velocity is constant, then the acceleration is always zero.

   (c) For motion in space, the velocity is always perpendicular to the acceleration.

   (d) If the velocity of a particle is always perpendicular to acceleration, then the speed of the particle must be constant.

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7. Consider the following parametric curves:

$$\mathbf{u}(t) = \begin{pmatrix} t\cos t \\ t\sin t \\ t^2 \end{pmatrix}, \qquad \mathbf{v}(t) = \begin{pmatrix} \cos t \\ 2\sin t \\ -1-3\sin^2 t \end{pmatrix}, \qquad \mathbf{w}(t) = \begin{pmatrix} e^t\cos(5t) \\ e^t\sin(5t) \\ e^t \end{pmatrix}.$$

   (a) Which of these curves lie on the surface $z^2 = x^2 + y^2$?

   (b) Which of these curves lie on the surface $z = -x^2 - y^2$?

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8. Let $f(x,y) = 2x^3 - \frac{1}{4}xy^2$.

   (a) Find an equation for the tangent plane to the graph of $f(x,y)$ at $(1,2,f(1,2))$.

   (b) Estimate the value of $f(0.95, 2.1)$.

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9. Suppose that $\mathbf{u}$, $\mathbf{v}$, $\mathbf{w}$ are vectors in 3D space such that $\|\mathbf{u}\| = 5$, $\|\mathbf{w}\| = 2$, $\mathbf{u}\cdot\mathbf{v} = 7$, and $\mathbf{u}\cdot\mathbf{w} = -3$. Find each of the following quantities:

   (a) $\mathbf{u}\cdot\mathbf{u}$

(b) $\mathbf{w} \cdot 2\mathbf{u}$

(c) $\mathbf{u} \cdot (\mathbf{v} - \mathbf{w})$

(d) $(\mathbf{u} + \mathbf{w}) \cdot (\mathbf{u} - \mathbf{w})$