1. Find the area of the triangle whose vertices are
   \( P = (2, 4, -3), \quad Q = (3, 4, -2) \quad \text{and} \quad R = (0, 6, -3). \)
   
   a. 1  
   b. \( \sqrt{3} \)  
   c. \( 2\sqrt{3} \)  
   d. 6  
   e. 12

2. Which of the following is the plane which passes through the point \( (4, 2, 1) \) and is perpendicular to the line \( (x, y, z) = (1 + 2t, 2 + t, 3 + 3t) \)?
   
   a. \( 2x - y + 3z = 13 \)  
   b. \( 2x - y + 3z = 9 \)  
   c. \( 2x + y + 3z = 13 \)  
   d. \( 2x + y + 3z = 9 \)  
   e. \( -2x + y - 3z = -9 \)
3. The quadratic surface \( x^2 + y^2 - z^2 + 4x + 4y - 6z = 0 \) is

a. an elliptic hyperboloid  
b. a hyperbolic paraboloid  
c. a hyperboloid of 1 sheet  
d. a hyperboloid of 2 sheets  
e. a cone.

4. The plot at the right is the graph of which equation?

a. \( z = -x^2 + y^2 \)  
b. \( z = x^2 - y^2 \)  
c. \( z^2 = x^2 - y^2 \)  
d. \( z^2 = -x^2 + y^2 \)  
e. \( z^2 - x^2 - y^2 = 1 \)

5. An airplane is travelling due South with constant speed and constant altitude as it flies over College Station. Since its path is part of a circle around the earth, its acceleration points directly toward the center of the earth. In which direction does it binormal \( \vec{B} \) point?

a. Up  
b. North  
c. East  
d. South  
e. West
6. For the curve \( \vec{r}(t) = (4 \cos t, \ 3t, \ 4 \sin t) \) which of the following is FALSE?

a. \( \vec{v} = (-4 \sin t, \ 3, \ 4 \cos t) \)
b. \( \vec{a} = (-4 \cos t, \ 0, \ -4 \sin t) \)
c. \( |\vec{v}| = 25 \)
d. Arc length between \( t = 0 \) and \( t = 2\pi \) is \( 10\pi \)
e. \( a_T = 0 \)

7. A wire in the shape of the curve \( \vec{r}(t) = (4 \cos t, \ 3t, \ 4 \sin t) \) has linear mass density \( \rho = y + z \). Find its total mass between \( t = 0 \) and \( t = 2\pi \).

a. \( 6\pi \)
b. \( 12\pi \)
c. \( 30\pi \)
d. \( 6\pi^2 \)
e. \( 30\pi^2 \)

8. Find the work done to move an object along the curve \( \vec{r}(t) = (4 \cos t, \ 3t, \ 4 \sin t) \) between \( t = 0 \) and \( t = 2\pi \) by the force \( \vec{F} = (z, 0, -x) \)?

a. \( -32\pi \)
b. \( -25\pi \)
c. \( -25\pi^2 \)
d. \( 25\pi \)
e. \( 32\pi \)
9. Find the plane tangent to the graph of $z = xe^y$ at the point $(2, 0)$. Its $z$-intercept is

a. $e$

b. 2

c. 0

d. $-2$

e. $-e$

10. Find the plane tangent to the graph of $xz^3 + zy^2 + 4x^4 = 42$ at the point $(1, 2, 0)$. Its $z$-intercept is

a. 10

b. $\frac{5}{4}$

c. $\frac{5}{2}$

d. $\frac{2}{5}$

e. $\frac{4}{5}$
11. Hans Duo is currently at \((x, y, z) = (3, 2, 1)\) and flying the Milenium Eagle through a deadly polaron field whose density is \(\rho = x^2z + yz^2\). In what unit vector direction should he travel to reduce the density as fast as possible?

a. \((6, 1, 13)\)

b. \(\frac{1}{\sqrt{206}} (-6, 1, -13)\)

c. \((-6, -1, -13)\)

d. \(\frac{1}{\sqrt{206}} (-6, -1, -13)\)

e. \(\frac{1}{\sqrt{206}} (6, -1, 13)\)

12. The point \((x, y) = (9, 3)\) is a critical point of the function \(f(x, y) = x^2 - 2xy + 4y^3\). Use the Second Derivative Test to classify this critical point.

a. local minimum

b. local maximum

c. saddle point

d. TEST FAILS
13. Find the scalar and vector projections of the vector \( \vec{a} = \langle 1, 2, -2 \rangle \) along the vector \( \vec{b} = \langle 2, -1, 2 \rangle \).

14. The pressure, \( P \), volume, \( V \), and temperature, \( T \), of an ideal gas are related by

\[ P = \frac{kT}{V} \]

for some constant \( k \). For a certain sample \( k = 10 \text{ cm}^3\text{-atm}\text{°K}^{-1} \).

At a certain instant, the volume and temperature are \( V = 2000 \text{ cm}^3 \), and \( T = 300 \text{°K} \), and are increasing at \( \frac{dV}{dt} = 40 \text{ cm}^3\text{sec}^{-1} \), and \( \frac{dT}{dt} = 5 \text{°K}\text{sec}^{-1} \).

At that instant, what is the pressure, is it increasing or decreasing and at what rate?
15. If two resistors, with resistances $R_1$ and $R_2$, are arranged in parallel, the total resistance $R$ is given by

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{or} \quad R = \frac{R_1R_2}{R_1 + R_2}$$

If $R_1 = 4\,\Omega$ and $R_2 = 6\,\Omega$ and the uncertainty in the measurement of $R_1$ is $\Delta R_1 = 0.03\,\Omega$ and for $R_2$ is $\Delta R_2 = 0.02\,\Omega$. Find $R$ and use differentials to estimate the uncertainty in the measurement of $R$.

16. Find the point(s) on the surface $z^2 = 46 - 2x - 4y$ which are closest to the origin.

HINT: Explain why you can minimize the square of the distance instead of the distance. Use the Second Derivative Test to check it is a local minimum.