Record your answers to the multiple choice problems by placing an × through one letter for each problem on this page. There are 10 multiple choice questions worth 6 points each and 2 partial credit problems worth 12 points each. You start with 16 points. On the partial credit problems you must show your work and all important steps to receive credit.

You may not use a calculator.

1.  a  b  c  •  e
2.  a  b  c  d  •
3.  a  b  c  d  •
4.  a  b  c  d  •
5.  a  b  c  d  •
6.  a  b  c  •  e
7.  a  b  c  d  •
8.  •  b  c  d  e
9.  a  b  •  d  e
10. a  b  •  d  e
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1. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
2. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
3. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
4. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
5. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
6. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
7. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
8. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
9. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
10. $\boxed{a}$ $\boxed{b}$ $\boxed{c}$ $\boxed{d}$ $\boxed{e}$
1. Find the area of the triangle with vertices (1, 2, 3), (2, 2, 1), (1, 3, 1).

(a) \( \frac{1}{2} \)  
(b) \( \sqrt{3} \)  
(c) 1  
(d) \( \frac{3}{2} \)  
(e) \( 3\sqrt{5} \)

2. Find a unit vector orthogonal to both \( 3\mathbf{i} + 3\mathbf{j} \) and \( 3\mathbf{i} + 3\mathbf{k} \).

(a) \( -\mathbf{i} + \mathbf{j} + \mathbf{k} \)  
(b) \( \frac{1}{3}\mathbf{i} - \frac{1}{3}\mathbf{j} - \frac{1}{3}\mathbf{k} \)  
(c) \( \frac{1}{\sqrt{3}}\mathbf{i} + \frac{1}{\sqrt{3}}\mathbf{j} - \frac{1}{\sqrt{3}}\mathbf{k} \)  
(d) \( -\mathbf{i} + \mathbf{j} - \mathbf{k} \)  
(e) \( \frac{1}{\sqrt{3}}\mathbf{i} - \frac{1}{\sqrt{3}}\mathbf{j} - \frac{1}{\sqrt{3}}\mathbf{k} \)

3. Find the unit normal vector \( \mathbf{N} \) to the curve \( \mathbf{r}(t) = \langle t, t^2, t \rangle \) at the point (1, 1, 1).

(a) \( \langle -1/\sqrt{2}, 0, 1/\sqrt{2} \rangle \)  
(b) \( \langle 2/3, -1/3, 2/3 \rangle \)  
(c) \( \langle 2/\sqrt{5}, -1/\sqrt{5}, 0 \rangle \)  
(d) \( \langle -2/\sqrt{21}, -1/\sqrt{21}, 4/\sqrt{21} \rangle \)  
(e) \( \langle -1/\sqrt{3}, 1/\sqrt{3}, -1/\sqrt{3} \rangle \)

4. Find the equation of the plane containing the point (1, 0, -1) and perpendicular to the line \( x = 2 - t, \ y = -4 + 3t, \ z = 1 + 2t \).

(a) \( x + z = 0 \)  
(b) \( 2x - 4y + z = 1 \)  
(c) \( x + 3y + 2z = -1 \)  
(d) \( -(x - 2) + (y + 4)/3 + (z - 1)/2 = 0 \)  
(e) \( x - 3y - 2z = 3 \)

5. Find the radius of the sphere given by the equation \( x^2 + y^2 + z^2 = 4x + 10y - 10z \).

(a) 5  
(b) \( 4\sqrt{3} \)  
(c) \( 2\sqrt{5} \)  
(d) 8  
(e) \( 3\sqrt{6} \)
6. Find the equation of line tangent to the curve defined by \( \mathbf{r}(t) = (t^4, t^3 + t^2, t + 1/t) \) at the point \((1, 2, 2)\).

(a) \( x = 4t, y = 1 + 5t, z = 1 \)
(b) \( x = 1 + 4t^4, y = 2 + 3t^3 + 2t^2, z = 2 + t - 1/t \)
(c) \( x = 1 + 4t^3, y = 2 + 3t^2 + 2t, z = 3 - 1/t^2 \)
(d) \( x = 1 + 4t, y = 2 + 5t, z = 2 \)
(e) \( x = 1 + 4t, y = 2 + 3t, z = 2 + t \)

7. Suppose a force \( \mathbf{F}(t) = (-\pi \cos(\pi t), -\pi \sin(\pi t), 2t) \) acts on a particle of mass 1. If the particle starts at rest, compute the particle's speed at \( t = 2 \).

(a) \( \pi \)       (b) \( 2 \)       (c) \( \sqrt{4 + \pi^2} \)       (d) \( \sqrt{17} \)       (e) \( 4 \)

8. Let \( f(x, y) = xy^3e^{xy} \). Compute \( f_x \).

(a) \( y^3(1 + xy)e^{xy} \)       (b) \( xy^2(3 + xy)e^{xy} \)       (c) \( y^3e^{xy} \)
(d) \( y^2(y + 3x + xy^2)e^{xy} \)       (e) \( y(y^2 + 1)e^{xy} \)

9. Find the distance from the point \((4, 2, 3)\) to the plane \( 2x - 2y + z = 1 \).

(a) \( 3 \)       (b) \( 5 \)       (c) \( 2 \)       (d) \( 4 \)       (e) \( 1 \)

10. Compute the limit \( \lim_{(x,y)\to(0,0)} \frac{\sqrt{1 + xy} - 1}{xy} \).

(a) \( \sqrt{2} - 1 \)       (b) \( \text{does not exist} \)       (c) \( 1/2 \)
(d) \( 1/(1 + \sqrt{2}) \)       (e) \( 0 \)
11. Find the point where the curves defined by \( \mathbf{r}_1(t) = \langle 3t, t^2, t^3 \rangle \) and \( \mathbf{r}_2(s) = \langle 1 + s, 1 + s, 0 \rangle \) intersect. Then find the angle of intersection.

12. Sketch the domain of the function \( f(x, y) = \sqrt{y - x^2} \). Then sketch several level curves of \( f \) and use them to sketch the graph of \( f \).