There are 20 problems. Each problem is worth 10 points. SHOW your work. $\boxed{CIRCLE}$ your answer. **NO CALCULATORS!**

1. Is $\boldsymbol{c}(t) = (\sin 2t, \cos 2t)$ a flow line of the vector field $\overrightarrow{\boldsymbol{F}}(x, y) = (y, -x)$?

2. Find the equations of the line tangent to the curve traced out by $\boldsymbol{c}(t) = (t^3 + 1, 4t^2, 5t)$ at $t = 2$.

3. Find the length of the curve traced out by $\boldsymbol{c}(t) = (2, t - 2\pi, t)$ for $2\pi \le t \le 4\pi$.

4. Find the volume of the region between $z = x^2 + y^2$ and $z = 32 - x^2 - y^2$.

5. Find $\displaystyle\int_0^1 \int_x^1 e^{y^2}\, dy\, dx$.

6. Find the equation of the plane which contains $(3, 0, 5)$, $(1, 1, 1)$, and $(2, 3, 4)$. Be sure to check your answer.

7. Find the equations of the line which contains $(1, 2, 4)$ and $(7, 8, 9)$. Be sure to check your answer.

8. Find the intersection of $\frac{x+2}{3} = \frac{y-3}{4} = z + 1$ and $x - 2y + 3z + 7 = 0$. Be sure to check your answer.

9. Find the equation of the plane which is tangent to $z = x^2 + y^2$ at $x = 1$ and $y = 2$.

10. Suppose that $\overrightarrow{\boldsymbol{c}}(t)$ is a path with constant speed. Prove that this path has the property that velocity is always perpendicular to acceleration.

11. Let $w = f(x, y, z)$. View the rectangular coordinates (x, y, z) in terms of the spherical coordinates (ρ, ϕ, θ) . Express $\frac{\partial w}{\partial \theta}$ in terms of $\frac{\partial w}{\partial x}$, $\frac{\partial w}{\partial y}$, $\frac{\partial w}{\partial z}$, ρ , ϕ , and θ .

12. Consider the function $f(x, y) = x^2 - y^2$.
    (a) Graph the level set of value 9 for this function.
    (b) Calculate $\overrightarrow{\nabla} f|_{(3,0)}$. Graph $-\frac{1}{10}\overrightarrow{\nabla} f|_{(3,0)}$ on your graph of part (a) starting at $(3, 0)$.
    (c) Calculate $\overrightarrow{\nabla} f|_{(5,4)}$. Graph $-\frac{1}{10}\overrightarrow{\nabla} f|_{(5,4)}$ on your graph of part (a) starting at $(5, 4)$.

13. Compute the equation of the plane tangent to the surface parametrized by $\boldsymbol{\Phi}(u, v) = (u^2 \cos v, u^2 \sin v, u)$ at $u = 1$ and $v = 0$.

14. Find the area inside $\frac{x^2}{4} + \frac{y^2}{9} = 1$.

15. Evaluate $\displaystyle\iint_S (\overrightarrow{\nabla} \times \overrightarrow{\boldsymbol{F}}) \cdot d\overrightarrow{\boldsymbol{S}}$ where S is the surface $x^2 + y^2 + 3z^2 = 1$, $z \le 0$,

16. Find $\int_{\boldsymbol{c}} (3y + x)\, dx + (8x - 15y) dy$, where $\boldsymbol{c}$ is the path that starts at $(1, 0)$; travels along the x-axis to $(2, 0)$; travels in the upper half plane along the circle with center $(0, 0)$ and radius 2 to $(-2, 0)$; travels along the x-axis to $(-1, 0)$; and travels in the upper half plane along the circle with center $(0, 0)$ and radius 1 back to $(1, 0)$.

17. Compute $\int_{\boldsymbol{c}} \overrightarrow{\boldsymbol{F}} \cdot d\overrightarrow{\boldsymbol{s}}$, where $\overrightarrow{\boldsymbol{F}} = 2z\,\overrightarrow{\boldsymbol{i}} + x\,\overrightarrow{\boldsymbol{j}} + 3y\,\overrightarrow{\boldsymbol{k}}$ and $\boldsymbol{c}$ is the ellipse that is the intersection of $z = x$ and the cylinder $x^2 + y^2 = 4$.

18. Let D^* be the parallelogram, in the xy-plane, with vertices $(0, 0)$, $(2, -1)$, $(3, 2)$, and $(1, 3)$. Let D be the square

$$\{(u, v) \mid 0 \leq u \leq 1 \text{ and } 0 \leq v \leq 1\}.$$

Find a one-to-one function T from the xy-plane to the uv-plane such that D is the image of D^* under T.

19. Let $T(u, v) = (x(u, v), y(u, v))$ be the mapping defined by $T(u, v) = (u, v(1 + u)))$. Let D^* be the rectangle

$$\{(u, v) \mid 0 \leq u \leq 1 \text{ and } 1 \leq v \leq 2\}.$$

Find $D = T(D^*)$ and evaluate $\iint_D (x - y) dx\, dy$.

20. What is the distance from $(1, 1)$ to $3x + 2y = 1$?