Part I Multiple Choice NO CALCULATOR ALLOWED

Name: ________________ **Alpha:** __________ **Instructor:** ____________

Instructions: No calculator is allowed for Part I of this exam. Fill in the top part of your Scantron sheet, including the bubbles for your alpha code and version number. There is room for your work on this exam. Fill in your answers on the bubble sheet. When you are done with Part I, hand in your **bubble sheet** and this **exam** to your instructor, who will give you Part II. You can use your calculator for Part II. But you cannot return to Part I.

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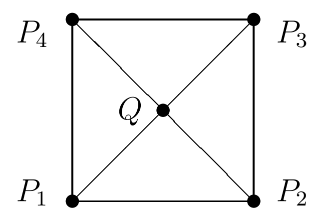
1. The figure shows a unit square with vertices P_1, P_2, P_3, P_4. The diagonals intersect at Q. Which one of the listed equations is true?



(a) $\overrightarrow{P_1P_2} + \overrightarrow{P_2P_3} + \overrightarrow{P_3P_4} = \overrightarrow{P_4P_1}$
(b) $\overrightarrow{QP_2} + \overrightarrow{QP_4} = \overrightarrow{P_2P_4}$
(c) $\overrightarrow{P_1Q} + \overrightarrow{QP_3} = \overrightarrow{P_1P_4}$
(d) $|\overrightarrow{P_1P_2} + \overrightarrow{P_2P_3}| = 2$
(e) $\overrightarrow{P_1P_2} + \overrightarrow{P_2P_3} = 2\,\overrightarrow{P_1Q}$

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2. For the configuration of points in Problem 1, what is the vector projection of $\overrightarrow{P_1Q}$ onto $\overrightarrow{P_1P_2}$?

(a) $\overrightarrow{P_1P_2}$
(b) $2\,\overrightarrow{P_1P_2}$
(c) $\frac{1}{2}\,\overrightarrow{P_1P_2}$
(d) $\sqrt{2}\ \overrightarrow{P_1P_2}$
(e) $\frac{1}{\sqrt{2}}\,\overrightarrow{P_1P_2}$

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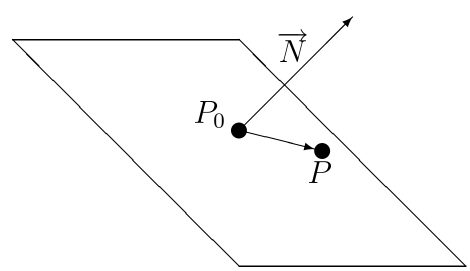
3. A plane has normal vector $\overrightarrow{N} = \langle a, b, c\rangle$ and contains the point $P_0 = (x_0, y_0, z_0)$. Suppose the point $P = (x, y, z)$ is also on the plane. Construct the vector $\overrightarrow{P_0P} = \langle x - x_0, y - y_0, z - z_0\rangle$ from P_0 to P. Which one of the following statements must be true?



(a) $\overrightarrow{N} \times \overrightarrow{P_0P} = 0$
(b) $\overrightarrow{N} \times \overrightarrow{P_0P} = \overrightarrow{0}$
(c) $\overrightarrow{N} \cdot \overrightarrow{P_0P} = \overrightarrow{0}$
(d) $\overrightarrow{N} \cdot \overrightarrow{P_0P} = 0$
(e) $|\overrightarrow{N} + \overrightarrow{P_0P}| = 0$

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4. What is the distance between the origin and the point where the xy-plane intersects the line with parametric equations $x = 3t$, $y = 4t$, $z = 6t - 12$?

(a) 15
(b) 5
(c) 7
(d) 10
(e) 6

5. The two lines

$$\vec{r}_1(t) = \langle 1+4t,\ 2+5t,\ 3+6t\rangle \qquad \text{and} \qquad \vec{r}_2(t) = \langle -6+7t,\ -6+8t,\ -6+9t\rangle$$

intersect at the point $(1,2,3)$. Which one of the listed vectors is perpendicular to the plane that contains both lines?

(a) $\langle 1,2,3\rangle \times \langle -6,-6,-6\rangle$
(b) $\langle 1,2,3\rangle \times \langle 7,8,9\rangle$
(c) $\langle 4,5,6\rangle \times \langle -6,-6,-6\rangle$
(d) $\langle 1,2,3\rangle \times \langle 4,5,6\rangle$
(e) $\langle 4,5,6\rangle \times \langle 7,8,9\rangle$

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6. Which one of the listed vector-valued function defines a circle?

(a) $\mathbf{r}(t) = \langle 3\cos(2t),\ 3\sin(2t),\ 4\rangle$
(b) $\mathbf{r}(t) = \langle 3\cos(2t),\ 4\sin(2t),\ 0\rangle$
(c) $\mathbf{r}(t) = \langle 3\cos(t),\ 3\sin(t),\ 4t\rangle$
(d) $\mathbf{r}(t) = \langle 3\cos(t),\ 4\sin(t),\ 0\rangle$
(e) $\mathbf{r}(t) = \langle 3\cos^2(t),\ 3\sin^2(t),\ 4t\rangle$

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7. The position of a particle is $\mathbf{r}(t) = 2e^{2t}\,\mathbf{i} + 3t^2\,\mathbf{j}$. What is the acceleration at $t=0$?

(a) $2\,\mathbf{i}$
(b) $2\,\mathbf{i} + 6\,\mathbf{j}$
(c) $8e\,\mathbf{i}$
(d) $6\,\mathbf{j}$
(e) $8\,\mathbf{i} + 6\,\mathbf{j}$

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8. If $g(x,y) = x^3y^2 - y$, then what is $g_{yx}(2,3)$?

(a) 54
(b) 107
(c) 108
(d) 72
(e) 71

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9. At a certain instant, the base of a rectangle is 4 cm and increasing at a rate of 3 cm/hr, while the height is 6 cm and decreasing at a rate of 2 cm/hr. At what rate is the area of the rectangle changing in units of cm^2/hr?

(a) 26
(b) 10
(c) 0
(d) 24
(e) 14

Problems 10–12 deal with a function $f(x, y, z)$ that satisfies

$$f(2,3,6) = 10 \qquad \text{and} \qquad \nabla f(2,3,6) = \langle 4,\ 3,\ 12 \rangle.$$

10. What is the maximum rate of change of the function f at the point $(2, 3, 6)$?

(a) 7
(b) 19
(c) 13
(d) 17
(e) 10

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11. What is the value of the directional derivative $D_{\mathbf{u}} f(2,3,6)$, where $\mathbf{u} = \frac{1}{\sqrt{2}}\langle 1, -1, 0 \rangle$?

(a) $\frac{1}{\sqrt{2}}$
(b) $-\frac{1}{\sqrt{2}}$
(c) $\frac{3}{\sqrt{2}}$
(d) $\frac{10}{\sqrt{2}}$
(e) $\frac{7}{\sqrt{2}}$

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12. Find an equation of the tangent plane to the surface $f(x, y, z) = 10$ at the point $(2, 3, 6)$.

(a) $2(x-4) + 3(y-3) + 6(z-12) = 0$

(b) $2(x-4) + 3(y-3) + 6(z-12) = 10$

(c) $4(x-2) + 3(y-3) + 12(z-6) = 10$

(d) $4(x-2) + 3(y-3) + 12(z-6) = 0$

(e) $2x + 3y + 6z = 49$

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13. If we want to find the minimum and maximum values of the function $f(x, y, z) = xyz$ subject to the constraint $x^2 + y^2 + z^2 = 2014$ using the method of Lagrange multipliers, then we soon encounter a system of m equations in n unknowns. What is the value of $m + n$?

(a) 4
(b) 6
(c) 8
(d) 10
(e) 12

14. One way to find the point on the plane $2x+3y+z=1$ that is closest to the origin first selects a point (x,y,z) on the plane and then minimizes a certain function $f(x,y)$ of two variables. Which choice for f is suitable?

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

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15. What is the value of the iterated integral

$$\int_0^\pi \int_0^2 (2r+2r\theta)\,dr\,d\theta\,?$$

(a) $4\pi^2/3$
(b) $4\pi+2\pi^2$
(c) $2\pi+\pi^2$
(d) $\pi+4\pi^2$
(e) $8\pi+4\pi^2$

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16. We can approximate the double integral $\int_0^6\int_0^6 f(x,y)\,dy\,dx$ with a Riemann sum by partitioning the region with $0\le x\le 6$ and $0\le y\le 6$ into four equal squares. Which expression could arise as our approximation?

(a) $[f(3,3)+f(3,6)+f(6,3)+f(6,6)]\cdot 4$
(b) $[f(3,3)+f(3,6)+f(6,3)+f(6,6)]\cdot 6$
(c) $[f(3,3)+f(3,6)+f(6,3)+f(6,6)]\cdot 9$
(d) $[f(3,3)+f(3,6)+f(6,3)+f(6,6)]\cdot 16$
(e) $[f(3,3)+f(3,6)+f(6,3)+f(6,6)]\cdot 36$

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17. What do we get when we reverse the order of integration in the double integral

$$\int_0^1\int_0^{2x} f(x,y)\,dy\,dx\,?$$

(a) $\int_0^1\int_{x/2}^2 f(x,y)\,dx\,dy$

(b) $\int_0^2\int_0^{y/2} f(x,y)\,dx\,dy$

(c) $\int_0^2\int_0^{x/2} f(x,y)\,dx\,dy$

(d) $\int_0^1\int_{y/2}^2 f(x,y)\,dx\,dy$

(e) $\int_0^2\int_{y/2}^1 f(x,y)\,dx\,dy$

18. A solid brick occupies the region $0 \le x \le 2$, $0 \le y \le 2$, $0 \le z \le 3$ with length measured in centimeters. The density at point (x, y, z) is $2z$ gm/cm^3. What is the mass (in grams) of the brick?

(a) 9
(b) 18
(c) 24
(d) 27
(e) 36

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19. If E is the solid inside the cylinder $x^2 + y^2 = 5^2$ and between the planes $z = 0$ and $z = 2$, then what is the value of the triple integral

$$\int\int\int_E 1 \, dV \ ?$$

(a) 30π
(b) 40π
(c) 20π
(d) 50π
(e) 10π

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20. What is the cylindrical equation of the surface whose spherical equation is $\rho = 4$?

(a) $r^2 + z^2 = 4$
(b) $r^2 + z^2 = 2$
(c) $r^2 + z^2 = 16$
(d) $r^2 + z^2 = 8$
(e) $r = 4$

End of Part I

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