1. Let P be a point on the plane $3x + y - 2z = 2$ and let Q be a point on the plane $3x + y - 2z = 5$. Let $\mathbf{v}$ be the vector that points from P to Q. Which of the following *cannot* be true?

(A) $|\mathbf{v}| = 10$
(B) $|\mathbf{v}| = 100$
(C) $\mathbf{v} \cdot (3\mathbf{i} + \mathbf{j} - 2\mathbf{k}) = 0$
(D) $|\mathbf{v} \times (3\mathbf{i} + \mathbf{j} - 2\mathbf{k})| = 0$
(E) $|\mathbf{v} \times (3\mathbf{i} + \mathbf{j} - 2\mathbf{k})| = 100$
(F) The x-coordinate of $\mathbf{v}$ is zero.
(G) The y-coordinate of $\mathbf{v}$ is zero.
(H) The z-coordinate of $\mathbf{v}$ is zero.

2. In October 2010, Josh Scobee of the Jacksonville Jaguars kicked a remarkable last-second 60-yard (180 feet) field goal to beat the Indianapolis Colts. The football left the ground with an initial horizontal velocity of 45 feet per second toward the goalpost and an initial upward velocity of 67 feet per second. The crossbar of the goalpost is 10 feet high. By how many feet did the ball clear the crossbar? (Assume the acceleration due to gravity is 32 ft/sec^2 and ignore wind resistance.)

(A) 2 feet	(B) 4 feet	(C) 6 feet	(D) 8 feet
(E) 10 feet	(F) 12 feet	(G) 14 feet	(H) 16 feet

3. Let P be the plane tangent to the graph of $x^2e^{2y-z} = 4$ at the point $(2, 1, 2)$. At what point does P intersect the z-axis?

(A) $(0, 0, 3)$	(B) $(0, 0, 2)$	(C) $(0, 0, 1)$	(D) $(0, 0, 0)$
(E) $(0, 0, -1)$	(F) $(0, 0, -2)$	(G) $(0, 0, -3)$	(H) $(0, 0, -4)$

4. Calculate the arclength of the curve given parametrically by

$$x = 2t^3, \qquad y = 6t, \qquad z = \frac{3}{t}$$

for $1 \le t \le 3$.

(A) 8 (B) $24\sqrt{3}$ (C) 36 (D) 54

(E) $54\sqrt{3}$ (F) $\dfrac{136}{3}$ (G) 81 (H) $144\sqrt{3}$

5. If three resistors, having resistances are R_1 ohms, R_2 ohms and R_3 ohms respectively, are connected in parallel, then the overall resistance R of the circuit satisfies the equation

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}.$$

At a moment when $R_1 = 6$ ohms, $R_2 = 3$ ohms and $R_3 = 2$ ohms, we have that R_1 is increasing at a rate of 2 ohms/sec, R_2 is increasing at a rate of 4 ohms/sec and R_3 is increasing at a rate of 6 ohms/sec. How fast is the overall resistance R changing?

(A) 6 ohms/sec (B) 4 ohms/sec (C) 2 ohms/sec (D) 1 ohm/sec

(E) 1/2 ohm/sec (F) 1/3 ohm/sec (G) 1/4 ohm/sec (H) 1/6 ohm/sec

6. The function $f(x, y) = 3x^2 + 6xy - y^3$ has

(A) one local maximum and one saddle point
(B) one local minimum and one saddle point
(C) one local maximum and one local minimum
(D) two local maxima
(E) two local minima
(F) two saddle points
(G) a local maximum and no other critical points
(H) a saddle point and no other critical points

7. Find the maximum value of the function $f(x, y, z) = x + yz$ on the surface of the sphere $x^2 + y^2 + z^2 = 4$.

(A) 0 (B) $\frac{1}{\sqrt{2}}$ (C) $\frac{1}{2\sqrt{2}}$ (D) $\frac{3}{2}$

(E) 1 (F) $\sqrt{2}$ (G) $\frac{5}{2}$ (H) $2\sqrt{2}$

8. Calculate $\iint_T y\,dA$ where T is the triangular region with vertices $(-2,0)$, $(2,0)$ and $(0,1)$.

(A) 1/3	(B) 1/2	(C) 2/3	(D) 1
(E) 4/3	(F) 3/2	(G) 5/3	(H) 2

9. Calculate $\displaystyle\int_0^{\pi/3}\int_{y^2}^{\pi^2/9}\frac{\sin\sqrt{x}}{x}dx\,dy$

(A) 0 (B) $\dfrac{\sqrt{3}}{2}$ (C) $\dfrac{\sqrt{3}}{6}$ (D) 1

(E) $\sqrt{3}$ (F) 2 (G) $2\sqrt{3}-1$ (H) $2\sqrt{3}$

10. Find the volume of the solid bounded above by the plane $z = 1$ and below by the surface $z = e^{x^2+y^2-4}$.

(A) $\pi(3 + e^4)$	(B) $\pi(5 - e^{-4})$	(C) $\pi(4 + e^4)$	(D) $\pi(2 + e^4)$
(E) $\pi(2 - e^{-4})$	(F) $\pi(5 + e^4)$	(G) $\pi(4 - e^{-4})$	(H) $\pi(3 + e^{-4})$

11. Let R be the region in the plane bounded by the lines $2x + y = 0$, $2x + y = 2$, $x - y = 1$ and $x - y = 3$. Calculate

$$\iint_R (x + 2y)\, dA.$$

(A change of coordinates will help.)

(A) $-\dfrac{5}{3}$ (B) $-\dfrac{4}{3}$ (C) $-\dfrac{2}{3}$ (D) $-\dfrac{1}{3}$

(E) $\dfrac{1}{3}$ (F) $\dfrac{2}{3}$ (G) $\dfrac{4}{3}$ (H) $\dfrac{5}{3}$

12. Compute the volume of the solid bounded by the four surfaces $x = z^2$, $x = 4 + 3z$, $x + y = 0$ and $x + y = 1$

(A) $\frac{8}{3}$ (B) $\frac{13}{2}$ (C) $\frac{22}{3}$ (D) $\frac{25}{2}$

(E) 12 (F) $\frac{35}{3}$ (G) $\frac{27}{2}$ (H) $\frac{50}{3}$

13. Compute the work done by the force field

$$\vec{F} = (8xe^y + \cos x)\,\mathbf{i} + (4x^2e^y + 4y^3)\,\mathbf{j}$$

along the path $\mathbf{c}(t) = (t - t^2\,,\, t)$ for $0 \le t \le 1$.

(A) 0 (B) $\frac{1}{4}$ (C) 1 (D) -1

(E) $-\frac{1}{2}$ (F) $-\frac{1}{4}$ (G) -2 (H) 2

14. Evaluate

$$\int_C (12x^2y^5 + 2x)\, dx + (20x^3y^4 + 3x)\, dy$$

where C is the unit circle $x^2 + y^2 = 1$, traversed counter-clockwise.

(A) 0 (B) π (C) $\dfrac{\pi}{2}$ (D) 2π

(E) $\dfrac{\pi}{3}$ (F) 3π (G) $\dfrac{\pi}{4}$ (H) 4π

15. Let $y(t)$ be the solution to the differential equation

$$t\frac{dy}{dt} = t^{5/2} + 2y$$

satisfying $y(1) = 3$. What is $y(4)$?

(A) 32	(B) 64	(C) 68	(D) 76
(E) 80	(F) 92	(G) 98	(H) 104