1. Assume the acceleration of gravity is 10 m/sec^2 downwards. A cannonball is fired at ground level. If the cannon ball rises to a height of 80 meters and travels a distance of 240 meters before it hits the ground, what is the magnitude of the initial velocity in meters per second?

(A) 36
(B) 48
(C) 50
(D) 54
(E) 60
(F) 64
(G) 72
(H) 80
(I) None of the above

2. Find the equation of the plane that passes through $(1,3,2)$ and contains the line

$$\begin{aligned} x &= 1 + t \\ y &= -1 - 2t \\ z &= 3 + 2t \end{aligned}$$

The y-coordinate of the point where this plane intersects the $y-$axis is

(A) -1
(B) 0
(C) 1
(D) 2
(E) 3
(F) 4
(G) 5
(H) 6
(I) None of the above

3. Find the curvature for $\mathbf{r}(t) = \langle -t, -\ln(\cos t), 0 \rangle$ at $t = \frac{\pi}{4}$.

(A) 1
(B) $\sqrt{2}$
(C) 2
(D) $2\sqrt{2}$
(E) $\frac{\sqrt{2}}{2}$
(F) $\frac{\sqrt{3}}{2}$
(G) $3\sqrt{2}$
(H) $\frac{\sqrt{2}}{3}$
(I) None of the above

4. Find the arclength of the vector function

$$\mathbf{r}(t) = 3\cos t \ \mathbf{i} + 3\sin t \ \mathbf{j} + 2t^{3/2} \ \mathbf{k}$$

for $0 \le t \le 3$.

(A) 12
(B) 14
(C) 16
(D) 18
(E) 20
(F) 24
(G) 28
(H) 32
(I) None of the above

5. Let

$$\mathbf{r}(t) = \sqrt{2}\cos t\ \mathbf{i} + \sqrt{2}\sin t\ \mathbf{j} + t\ \mathbf{k}$$

Using the parametric equations for the line tangent to the function at $t = \frac{\pi}{4}$, find the coordinates of the point where the tangent line intersects the $xy-\text{plane}$.

(A) $(1,1,0)$
(B) $(1,-1,0)$
(C) $\left(1-\frac{\pi}{4}, 1+\frac{\pi}{4}, 0\right)$
(D) $\left(1+\frac{\pi}{4}, 1-\frac{\pi}{4}, 0\right)$
(E) $\left(\frac{\pi}{2}-1, \frac{\pi}{2}+1, 0\right)$
(F) $\left(1,1,\frac{\pi}{4}\right)$
(G) $(0,0,0)$
(H) The line does not intersect the $xy-\text{plane}$.
(I) None of the above

6. Let $z = x\sqrt{y} + \sqrt{x}$ and $x = 2s+t,\ y = s^2 - 7t$. Find $\frac{\partial z}{\partial t}$ when $s = 4$ and $t = 1$.

(A) $\frac{-22}{3}$
(B) -7
(C) -8
(D) $\frac{-20}{3}$
(E) $\frac{-23}{3}$
(F) $\frac{-25}{3}$
(G) -9
(H) $\frac{-31}{3}$
(I) None of the above

7. Let

$$f(x,y,z)=\ln\left(x^2+y^2\right)-z^3.$$

Using the linearization of f at $(-1,1,1)$, estimate the value of $f(-0.9,1.2,1.1)$.

(A) 0
(B) $\ln(2)+0.7$
(C) $\ln(2)-1.2$
(D) $\ln(2)+1.3$
(E) $\ln(2)+0.5$
(F) $\ln(2)-1.6$
(G) 0.3
(H) 0.7
(I) None of the above

8. Let $f(x,y)=x^3-3xy+y^2$. Find the local minimum of f.

(A) $\frac{3}{2}$
(B) $\frac{5}{2}$
(C) $\frac{7}{2}$
(D) $\frac{9}{2}$
(E) $\frac{25}{16}$
(F) -2
(G) $\frac{-27}{16}$
(H) $\frac{-3}{2}$
(I) None of the above

9. Find the product of the maximum and minimum values of
$f(x, y, z) = (x-2)^2 + (y-1)^2 + (z+2)^2$ on the sphere $x^2 + y^2 + z^2 = 1$.

(A) 0
(B) $\sqrt{21}$
(C) 8
(D) 16
(E) 21
(F) 64
(G) 80
(H) 85
(I) None of the above

10. Compute the integral

$$\int_0^1 \int_0^{2-2x} \frac{(2x-y)^2}{2x+y}\, dy dx$$

HINT: A change of variable might help
(A) 0
(B) $\frac{1}{3}$
(C) $\frac{4}{9}$
(D) $\frac{2}{3}$
(E) $\frac{3}{4}$
(F) 1
(G) $\frac{5}{4}$
(H) $\frac{3}{2}$
(I) None of the above

11. Find the work done by the force field

$$\mathbf{F} = -\frac{1}{2}x\,\mathbf{i} - \frac{1}{2}y\,\mathbf{j} + \frac{1}{4}\mathbf{k}$$

on a particle as it moves along the helix given by

$$\mathbf{r}(t) = \cos t\,\mathbf{i} + \sin t\,\mathbf{j} + t\,\mathbf{k}$$

from the point $(1,0,0)$ to $(-1,0,3\pi)$.

(A) $\frac{\pi}{4}$
(B) $\frac{\pi}{2}$
(C) $\frac{3\pi}{2}$
(D) $\frac{3\pi}{4}$
(E) $\frac{\pi}{3}$
(F) $\frac{\pi}{6}$
(G) $\frac{4\pi}{3}$
(H) π
(I) None of the above

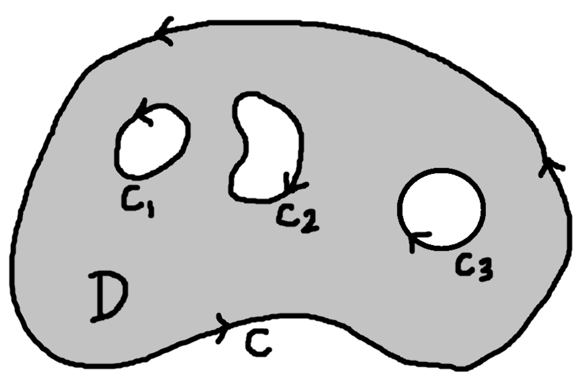
12. Consider the planar region D drawn below whose boundary consists of the curves $C, C_1, C_2,$ and $C_3,$ oriented as shown. Suppose that $\mathbf{F}(x,y)$ is a vector field whose component functions and their partial derivatives are continuous on D, and that

$$\oint_{C_1} \mathbf{F}\cdot d\mathbf{r} = 1, \quad \oint_{C_2} \mathbf{F}\cdot d\mathbf{r} = -5, \quad \oint_{C_3} \mathbf{F}\cdot d\mathbf{r} = 2, \text{ and } \iint_D \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right) dA = -1.$$

Evaluate

$$\oint_C \mathbf{F}\cdot d\mathbf{r}\,?$$

Carefully justify your answer.



(A) -1
(B) 0
(C) 1
(D) 3
(E) 5
(F) -7
(G) -9
(H) -11
(I) None of the above

13. A particle moves along the line segments from
$(0,0,0)$ to $(1,0,0)$ to $(1,5,1)$ to $(0,5,1)$ and back to $(0,0,0)$
under the influence of the vector field
$\mathbf{F}(x,y,z) = z^2\mathbf{i} + 3xy\mathbf{j} + 4y^2\mathbf{k}$.
Find the work done.

(A) 0
(B) 13
(C) 27
(D) 30
(E) $\frac{71}{2}$
(F) $\frac{73}{2}$
(G) $\frac{81}{2}$
(H) $\frac{95}{2}$
(I) None of the above

14. Let S be the portion of the surface $z = xy$ lying inside the cylinder $x^2 + y^2 = 1$. Compute the surface area S.

(A) 0
(B) π
(C) $\frac{\pi}{2}$
(D) $\frac{3\pi}{2}$
(E) $\frac{4\pi}{3}\left(\sqrt{2}-1\right)$
(F) $2\pi\left(2\sqrt{2}-1\right)$
(G) $2\pi\left(\sqrt{2}-1\right)$
(H) $\frac{2\pi}{3}\left(2\sqrt{2}-1\right)$
(I) None of the above

15. A sphere of radius 2 has a hole or radius 1 drilled straight through the center. What is the volume remaining? In terms of inequalities, the region is $R=\{(x,y,z)|x^2+y^2+z^2\leq 4 \text{ and } x^2+y^2\geq 1\}$.

(A) 2π
(B) $4\pi\sqrt{3}$
(C) 6π
(D) $4\pi\left(2-\sqrt{2}\right)$
(E) $\frac{4\pi}{9}\left(12-\sqrt{3}\right)$
(F) $10\pi-2$
(G) $5\pi\sqrt{3}$
(H) $4\pi-\sqrt{2}$
(I) None of the above

16. Let $\mathbf{F}(x,y,z)=z\arctan\left(y^2\right)\mathbf{i}+z\ln\left(x^2+3\right)\mathbf{j}+z\,\mathbf{k}$.

Find the outward flux of $\mathbf{F}$ through S, the part of the paraboloid $x^2+y^2+z=9$ that lies above the plane $z=5$ and is oriented upward.

(A) 0
(B) 4π
(C) 6π
(D) 8π
(E) 16π
(F) 24π
(G) 28π
(H) 32π
(I) None of the above

Problem	Answer		Problem	Answer
1	C		9	F
2	G		10	C
3	E		11	D
4	B		12	D
5	D		13	F
6	A		14	H
7	C		15	E
8	G		16	G