1. (12 points) Find the equation of the plane passing through $A(1,1,0)$, $B(0,2,3)$, and $C(1,0,3)$. What is the area of $\triangle ABC$? (ANS: $6(x-1)+3(y-1)+z=0, \quad Area = \frac{1}{2}\sqrt{46}$.)

2. (12 points) Find the angle between the planes $x+y-z=1$ and $2x-3y+4z=5$. (ANS. $\theta = \cos^{-1}\frac{-5}{\sqrt{87}}$.)

3. (12 points) Find the equation of the plane which passes through $(-1,2,1)$ and contains the line of intersection of $x+y-z=2$ and $2x-y+3z=1$. (ANS. (x+1)-2(y-2)+4(z-1)=0).)

4. (14 points) If $e^{xy} - e^{zx^2} = 1$, find $\frac{\partial z}{\partial x}$. (ANS. $\frac{\partial z}{\partial x} = \frac{ye^{xy} - 2xze^{zx^2}}{x^2 e^{zx^2}}$.)

5. (12 points) A particle starts at the origin with initial velocity $\mathbf{i} + 2\mathbf{j} + \mathbf{k}$. Its acceleration is $\mathbf{a}(t) = t\mathbf{i} + \mathbf{j} + t^2\mathbf{k}$. Find the position of the particle as a function of t. (ANS. $\mathbf{r}(t) = \langle \frac{t^3}{6} + t, \frac{t^2}{2} + 2t, \frac{t^4}{12} + t \rangle$.

6. (12 points) If $f(x,y) = e^{xy^2}$, find f_{xxy}. (ANS. $4y^3 e^{xy^2} + 2xy^5 e^{xy^2}$.)

7. (14 points) Find the tangential and normal components of the acceleration vector if $\mathbf{r}(t) = (3t - t^3)\mathbf{i} + 3t^2\mathbf{j}$. Your answers should be *vectors*. (ANS. $\mathbf{a}_T = \langle \frac{6t - 6t^3}{1+t^2}, \frac{12t^2}{1+t^2}, 0 \rangle$, $\mathbf{a}_N = \langle \frac{-12t}{1+t^2}, \frac{-6+6t^2}{1+t^2}, 0 \rangle$.)

8. (12 points) Find the extreme values of $f(x,y) = e^{-xy}$ on the region $x^2 + 4y^2 \leq 1$. (ANS. max=$e^{1/4}$, min = $e^{-1/4}$.)

9. (14points) Change the order of integration in the integral $\int_0^1 \int_{y^2}^{2-y} f(x,y)\, dx\, dy$. (ANS. $\int_0^1 \int_0^{\sqrt{x}} f(x,y)\, dy\, dx + \int_1^2 \int_0^{2-x} f(x,y)\, dy\, dx$.)

10. (12 points) Find the volume of the region bounded by $z = 3x^2 + 3y^2$ and $z = 4 - x^2 - y^2$. (Ans. 2π.)

11. (12 points) Evaluate the integral $\int_0^1 \int_0^{\sqrt{1-y^2}} \int_{x^2+y^2}^{\sqrt{x^2+y^2}} xyz\, dz\, dx\, dy$ by changing to cylindrical coordinates. (Ans. 1/96.)

12. (12 points) Find $\int_C \mathbf{F} \cdot d\mathbf{r}$ where $\mathbf{F} = (y^2 e^y)\mathbf{i} + (2xye^y + xy^2 e^y)\mathbf{j}$ and C is any curve from $(0, 0)$ to $(3, 4)$. (Ans. $48e^4$.)

13. (12 points) If $\mathbf{F} = y^2\mathbf{i} + (2xy + e^{3z})\mathbf{j} + 3ye^{3z}\mathbf{k}$ find f so that $\nabla f = \mathbf{F}$. (Ans. $f(x, y) = xy^2 + ye^{3z}$.)

14. (12 points) Evaluate $\int_C xy\, dx + 2x^2 dy$ where C consists of the line segment from $(-2, 0)$ to $(2, 0)$ and the top half of $x^2 + y^2 = 4$. (Ans. 0.)

15. (12 points) Evaluate $\int\int_S \mathbf{F} \cdot d\mathbf{S}$ where $\mathbf{F} = xze^y\mathbf{i} - xze^y\mathbf{j} + z\mathbf{k}$ and S is the part of the plane $x + y + z = 1$ in the first octant with the downward orientation. (Ans. -1/6.)

16. (14 points) Evaluate $\int\int_S \mathbf{F} \cdot d\mathbf{S}$ where $\mathbf{F} = xy\,\mathbf{i} + (y^2 + e^{xz^2})\mathbf{j} + \sin(xy)\mathbf{k}$ and S is the surface bounded by $z = 1 - x^2$, $z = 0$, $y = 0$, and $y + z = 2$. (Ans. 184/35.)

Bonus Problem (5 points): Evaluate the integral $\int_0^\infty \frac{\arctan(\pi x) - \arctan(x)}{x}\, dx$ by first writing it as an iterated integral and then reversing the order of integration. (Ans. $\pi \ln(\pi)/2$.)