1. (20) (**Show all work**). Let W be the region inside the sphere of radius 3 given by $x^2+y^2+z^2 = 9$ which is bounded by $x \geq 0$, $y \geq 0$, $z \leq 0$. Let $f(x,y,z) = x + y^2 + z^3$. In Cartesian coordinates, $\displaystyle\int\int\int_W f\,dV = \int_0^3 \int_0^{\sqrt{9-x^2}} \int_{-\sqrt{9-x^2-y^2}}^{0} (x + y^2 + z^3)\,dz\,dy\,dx.$

   Write down, but do **not** evaluate iterated integrals which equal $\displaystyle\int\int\int_W f\,dV$ in:

   (a) Cylindrical coordinates:

   (b) Spherical coordinates:

2. (15) (**Show all work**). Let $f(x,y) = x^3\sin(y^3)$, and let D be the region in the xy-plane bounded by $x = 0$, $x = 2$, $y = x^2$ and $y = 4$.

   (a) Draw (and shade) the region of integration D.

   (b) Write down two iterated integrals (reversing the order of integration to obtain the second) which equal $\displaystyle\int\int_D x^3\sin(y^3)\,dA$.

   (c) Evaluate either integral in part (b).

3. (10)(**Show all work**). Evaluate $\displaystyle\int_{-2}^{2}\int_{-\sqrt{4-y^2}}^{0} e^{x^2+y^2}\,dx\,dy.$

4. (10) (**Show all work**). Let $\mathbf{F} = (-y, x, e^{xyz})$ be a vector field, and $\mathbf{c}(t) = (t^3, t^2, 7)$, $0 \leq t \leq 2$ a path. Evaluate the (line) integral of the vector field $\mathbf{F}$ along the given path.

5. (20) (**Show all work**). The region W is the region in the first octant (i.e., $x, y, z \geq 0$) and between the spheres $x^2 + y^2 + z^2 = 4$ and $x^2 + y^2 + z^2 = 9$.

   Evaluate the integral $\displaystyle\int\int\int_W \frac{z^2}{x^2+y^2+z^2}\,dV$

6. (15) (**Show all work**). Let D be the region in the plane consisting of that part of the unit disk $x^2 + y^2 \leq 1$, which lies on or above the lines $y = 0$ and $y = (\sqrt{3})x$. If the mass density of the region is given by the function $\delta(x,y) = \sin(x^2+y^2)$, find the mass of the region.

7. (10) (**Show all work**). Observe that $\mathbf{F} = (2xy, x^2)$ is a gradient vector field ($\mathbf{F} = \nabla f$ for $f(x,y) = x^2y$).
   Let $\mathbf{c}_1(t) = (t, 2 + \sin t)$ $(0 \leq t \leq 4\pi)$ and $\mathbf{c}_2(t) = (2\pi(1+\cos t), 2(1+\sin t))$ $(0 \leq t \leq \pi)$ be two paths whose images connect the points $(0,2)$ and $(4\pi, 2)$.

   Determine the values of $\displaystyle\int_{\mathbf{c}_1} \nabla f \cdot d\mathbf{s}$ and $\displaystyle\int_{\mathbf{c}_2} \nabla f \cdot d\mathbf{s}$, and explain why they are related.