(15) 1) A mass distribution occupies the region in 3-space enclosed by the surfaces $z = \sqrt{x^2 + y^2}$ and $z = 2$. Its mass density function is $\delta(x, y, z) = x^2 + y^2 + z^2$. Use a triple integral in spherical coordinates to calculate the total mass.
(15) 2) Find the surface area of the parametrized surface $x = t, y = t^2, z = ts^3$, $0 \leq t \leq 2$ and $1 \leq s \leq 3$. 
3) Evaluate the line integral \( \int_C xy \, dx + x \, dy \) where \( C \) consists of the line segment from \((2, -4)\) to \((2, 0)\) followed by the arc of the circle \( x^2 + y^2 = 4 \) from \((2, 0)\) to \((0, 2)\) which is in the first quadrant.
(10) 4) Show that the Force field

$$\vec{F} = \left( 2 + \frac{2x}{1 + y} \right) \vec{i} + \left( 2y - \frac{x^2}{(1 + y)^2} \right) \vec{j}$$

is conservative in the region $y > -1$ by finding a potential function for it. Now calculate the work done by $\vec{F}$ as it acts on an object which moves from $(1, 0)$ to $(9, 3)$ along any piecewise smooth curve in the region $y > -1$. 
Use Green’s theorem to evaluate

\[ \int_C (xy + y^3 \cos x)\,dx + (3y^2 \sin x + x^2)\,dy \]

where \( C \) is the closed curve consisting of the sides of the triangle having vertices \((0,0), (2,0), (0,2)\), directed counterclockwise.
6) Use Green’s theorem in vector form to calculate the outward flux $\int_C \vec{F} \cdot \vec{n} \, ds$

where $\vec{F} = xy^2 \hat{i} + x^2 y \hat{j}$ and $C$ is the circle $x^2 + y^2 = 4$. 
(15) 7) Evaluate the surface integral \( \int \int_S 12xy \, dS \) where \( S \) is that part of \( z = \sqrt{25 - x^2 - y^2} \) which lies above the square \( 0 \leq x \leq 1, \ 0 \leq y \leq 1. \)