(15) 1. A mass distribution given by \( f(x, y, z) = z \) units of mass/unit volume is applied to the region of space occupied by the hemisphere

\[
z = \sqrt{4 - x^2 - y^2}.
\]

Use spherical coordinates to find the mass of the hemisphere.
(12) 2. Set up a triple integral for finding the volume of the ellipsoid

\[ \frac{x^2}{4} + \frac{y^2}{9} + z^2 = 1 \]

(Do not attempt to actually find the volume.)

(12) 3. Find the volume of the 3D-region which lies under the plane \( x + y + z = 12 \), and above the region in the \( xy \)-plane which is bounded by the lines \( y = 2x \), \( y = 8 \), \( x = 1 \), and \( x = 3 \).
4. Evaluate the integral
\[ \int_0^4 \int_{y/2}^{y^2} e^{x^2} dx \, dy. \]

(Hint: Since nobody can write down an antiderivative of \(e^{x^2}\), you may want to try changing the order of integration.)

5. Find the surface area of the part of the paraboloid \(z = x^2 + y^2\) which is between the cylinders \(x^2 + y^2 = 9\) and \(x^2 + y^2 = 16\).
(16) 6. Consider the force field

\[ \vec{F}(x, y, z) = \langle y + x \sin z, x + y \sin z, \frac{1}{2}(x^2 + y^2) \cos z \rangle. \]

(a) Find div \( \vec{F} \) and curl \( \vec{F} \).

(b) Find a potential function for \( \vec{F} \).
7. Find the work done by the field 
\[ \vec{F}(x, y) = (xy, 1 - x) \]

in moving an object along the path \( \mathcal{C} \) consisting of

(a) the line segment from \((-2, 0)\) to \((2, 0)\).

(b) the semicircle \( y = \sqrt{4 - x^2} \) from \((2, 0)\) to \((-2, 0)\).