Please answer the following questions. **Answers without justifying work will receive no credit.** Partial credit will be given as appropriate, do not leave any problem blank.

1. (5 points) For an arbitrary continuous function $f(x, y)$ write down the equivalent iterated integral in the opposite order of integration to the one shown below.

$$
\int_{0}^{2} \int_{x^2}^{4} f(x, y) \, dy \, dx
$$

2. (10 points) For an arbitrary continuous function $f(x, y, z)$ convert the following triple integral to spherical coordinates.

$$
\int_{-1}^{1} \int_{0}^{\sqrt{1-x^2}} \int_{\frac{\sqrt{2-x^2-y^2}}{x^2+y^2}} f(x, y, z) \, dz \, dy \, dx
$$
3. (10 points) Determine if the following vector field is conservative. If it is, find a potential function.

\[ \mathbf{F}(x, y) = (y \cos x, \sin x - y) \]

4. (12 points) Find the volume of the region above \( z = x^2 + y^2 \) and below \( z = 8 - x^2 - y^2 \).
5. (10 points) Evaluate the line integral

\[ \int_C (x + y) \, dy \]

where \( C \) is the portion of \( x = y^2 \) from \((1, 1)\) to \((1, -1)\).

6. (10 points) Evaluate the triple integral

\[ \iiint_Q \sqrt{x^2 + y^2 + z^2} \, dV \]

where \( Q \) is bounded by \( z = \sqrt{9 - x^2 - y^2} \) and the \( xy \)-plane.
7. (10 points) If \( \mathbf{F}(x, y) = (4xy - 2x)i + (2x^2 - x)j \) find the work done moving along \( y = x^2 \) from \((-2, 4)\) to \((2, 4)\).

8. (10 points) Compute the volume of the solid region bounded by the following surfaces.

\[
z = 1 - x^2, \quad z = 0, \quad y = 2, \quad y = 4
\]
9. (13 points) Use Green’s Theorem to evaluate the following line integral.

\[ \int_C ye^{2x} \, dx + x^2 y^2 \, dy, \]

where \( C \) is the rectangle from \((-2, 0)\) to \((3, 0)\) to \((3, 2)\) to \((-2, 2)\) to \((-2, 0)\).

10. (10 points) The gravitational vector field is

\[ \mathbf{F}(x, y, z) = \frac{-GmM}{(x^2 + y^2 + z^2)^{3/2}} \mathbf{i}, \]

where \( G \) is the universal gravitational constant, and \( M \) and \( m \) are (constant) masses. Find the potential energy of the object of mass \( m \) at position \((a, b, c)\).