Problem 1. The planar vector field $\mathbf{F}$ has the form $\mathbf{F}(x, y) = (3x^2y + \mathrm{e}^y)\,\mathbf{i} + Q(x, y)\,\mathbf{j}$.

(a) Find the most general function Q such that the vector field $\mathbf{F}$ be conservative.

(b) Find a function f such that $\mathbf{F} = \nabla f$.

(c) Let the closed curve C consist of the line segments from $(0, 1)$ to $(0, 0)$ and from $(0, 0)$ to $(1, 0)$, and the parabola $y = 1 - x^2$ from $(1, 0)$ to $(0, 1)$. Find the line integral of $\mathbf{F}$ along this curve. Explain briefly how you computed this.