• What is so great about \( G = \left( -\frac{y}{x^2+y^2}, \frac{x}{x^2+y^2} \right) \)?
• How can we extend the idea of integration to \( \mathbb{R}^2 \)?

1. True/False. If false, determine how the question can be made true.
   (a) The work done by a vector field around a loop is zero.
   (b) If \( P, Q \in \mathbb{R}^n \) then the work that vector field \( F \) does from \( P \) to \( Q \) is the negative of the work done from \( Q \) to \( P \).
   (c) Suppose \( F \) is not conservative and \( r(t) \) a path from \( P \) to \( Q \). Then the work that \( F \) does along \( r \) from \( P \) to \( Q \) is equal to the negative of the work done along the reverse path from \( Q \) to \( P \).
   (d) Suppose the curl of the vector field \( F \) is equal to \((0, 0, 0)\). Then the word done around every loop is equal to 0.

2. Find the line integrals using potential functions.
   (a) Let \( r(t) \) be the line from \((1, 5)\) to \((-2, 3)\).
   \[ \int_r y^2 \, dx + (2xy - 1) \, dy = \]
   (b) Let \( r(t) = (1 + \cos t, -2 + 3 \sin t) \) for \( 0 \leq t \leq \pi/2 \).
   \[ \int_r (2xy^3 + y - 1) \, dx + (3x^2y^2 + x) \, dy = \]
   (c) Let \( r(t) \) be the upper hemisphere of the unit circle oriented counter-clockwise.
   \[ \int_r (y - e^y) \, dx + (x - xe^y) \, dy = \]

3. Let \( r(t) \) be the unit circle oriented positively. Compute
   \[ \frac{1}{2\pi} \int_r \frac{y^3 + x^2y - 4x}{2(y^2 + x^2)^2} \, dx - \frac{(xy^2 + 4y + x^3)}{2(y^2 + x^2)^2} \, dy = \]

4. Let
   \[ G = \left( -\frac{y}{x^2+y^2}, \frac{x}{x^2+y^2} \right) \]
   \[ F = \left( \frac{y^3 + x^2y - 4x}{2(y^2 + x^2)^2}, -\frac{(xy^2 + 4y + x^3)}{2(y^2 + x^2)^2} \right) \]
   Find \( k \) and \( \phi \) so that \( F = kG + \nabla \phi \).
   \[ k = \]
   \[ \nabla \phi = \]
   \[ \phi = \]