

4. (12 points) Compute the flux $\iint_S \mathbf{F} \cdot d\mathbf{S}$ of $\mathbf{F} = (xy^2, x^2y, z)$ through the closed cylinder S (oriented by outward normals) given by $x^2 + y^2 = 4$, $z = -2$, $z = 3$.

5. (18 points) In each of the following parts determine if \mathbf{F} is conservative or not, and give your reason. Then compute $\int_C \mathbf{F} \cdot d\mathbf{s}$ by whatever method seems easiest and most appropriate.
- a. $\mathbf{F} = (z, 0, -x)$, C is the line segment from $(0, -1, 3)$ to $(1, 1, 4)$.

- b. $\mathbf{F} = (2xy, x^2 + 4y^3/(y^4 + z^4), 4z^3/(y^4 + z^4))$, C is given by $x = t$, $y = 4 \cos \theta$, $z = 3 \sin \theta$, $0 \leq t \leq 1$, $0 \leq \theta \leq \pi/2$.

6. (5 points) We found for a vector field \mathbf{F} at a point P , and an axis given by a unit vector $\hat{\mathbf{n}}$, that $(\text{curl } \mathbf{F})(P) \cdot \hat{\mathbf{n}}$ is equal to the “circulation” of \mathbf{F} about P on a surface with normal vector $\hat{\mathbf{n}}$. How is circulation defined?
7. (6 points) Using “flowboxes”, determine if each of the following vector fields has positive, negative, or zero divergence in general.