3-10 Determine whether or not $\mathbf{F}$ is a conservative vector field. If it is, find a function f such that $\mathbf{F} = \nabla f$.

5. $\mathbf{F}(x, y) = y^2 e^{xy}\mathbf{i} + (1 + xy)e^{xy}\mathbf{j}$
7. $\mathbf{F}(x, y) = (ye^x + \sin(y))\mathbf{i} + (e^x + x\cos(y))\mathbf{j}$
9. $\mathbf{F}(x, y) = (y^2\cos(x) + \cos(y))\mathbf{i} + (2xy\sin(x) - x\sin(y))\mathbf{j}$

12-18 Find a function f such that $\mathbf{F} = \nabla f$ and use it to evaluate $\int_C \mathbf{F} \cdot d\mathbf{r}$ along the given curve C.

13. $\mathbf{F}(x, y) = x^2y^3\mathbf{i} + x^3y^2\mathbf{j},\ C : \mathbf{r}(t) = \langle t^3 - 2t, t^3 + 2t\rangle,\ 0 \le t \le 1$
15. $\mathbf{F}(x, y, z) = yz\mathbf{i} + xz\mathbf{j} + (xy + 2z)\mathbf{k}$, C is the line segment from $(1, 0, -2)$ and to $(4, 6, 3)$
17. $\mathbf{F}(x, y, z) = yze^{xz}\mathbf{i} + e^{xz}\mathbf{j} + xye^{xz}\mathbf{k},\ C : \mathbf{r}(t) = \langle t^2 + 1, t^2 - 1, t^2 - 2t\rangle,\ 0 \le t \le 2$

19. Show that $\int_C 2xe^{-y}\ dx + (2y - x^2e^{-y})\ dy$ where C is any path from (1,0) to (2,1) is independent of path and evaluate the integral.

23. Find the work done by the force field $\mathbf{F}(x, y) = x^3\mathbf{i} + y^3\mathbf{j}$ in moving an object from $P(1, 0)$ to $Q(2, 2)$.

31-34 Determine whether or not the given set is (a) open, (b) connected and (c) simply-connected.

31. $\{(x, y) : 0 < y < 3\}$
33. $\{(x, y) : 1 \le x^2 + y^2 \le 4,\ y \le 0\}$