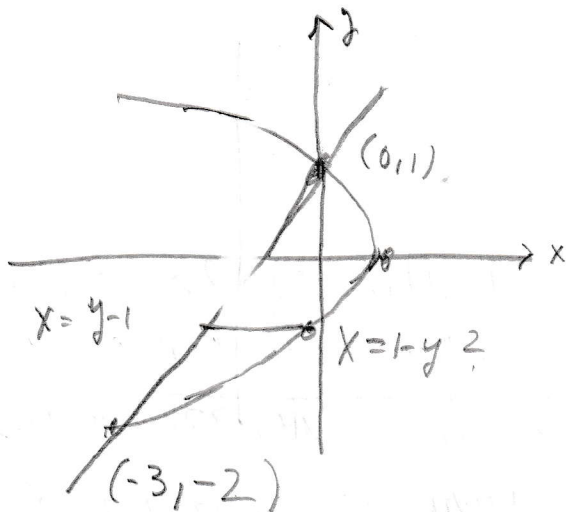
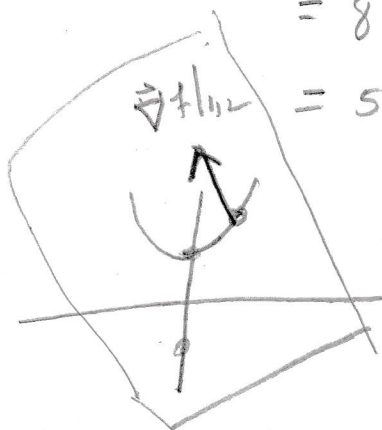


①



$$\begin{aligned}
 \text{area} &= \int_{-2}^1 \int_{y-1}^{1-y^2} dx dy \\
 &= \int_{-2}^1 1 - y^2 - (y - 1) dy \\
 &= \int_{-2}^1 2 - y^2 - y dy \\
 &= \left[2y - \frac{y^3}{3} - \frac{y^2}{2} \right]_{-2}^1 \\
 &= 2 - \frac{1}{3} - \frac{1}{2} - \left(4 + \frac{8}{3} - 2 \right) \\
 &= 8 - \frac{1}{3} - \frac{1}{2} - \frac{8}{3} \\
 &= 5 - \frac{1}{2} = \boxed{\frac{9}{2}}
 \end{aligned}$$

② $\nabla f(1, 2) = \begin{pmatrix} 4 \\ -1 \end{pmatrix}$



$$\begin{aligned}
 \nabla f &= -2x\vec{i} + 2y\vec{j} \\
 \nabla f|_{(1,2)} &= -2\vec{i} + 4\vec{j}
 \end{aligned}$$

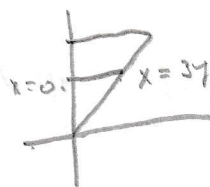
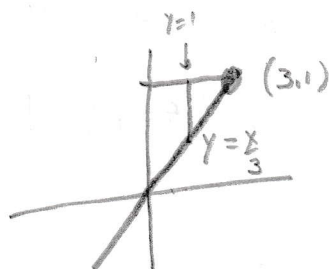
③



$$\begin{aligned}
 \int_0^{2\pi} \int_0^2 r(4-r^2) dr d\theta &= 2\pi \int_0^2 (4r - r^3) dr = 2\pi \left(2r^2 - \frac{r^4}{4} \right) \Big|_0^2 \\
 &= 2\pi (8 - 4) = \boxed{8\pi}
 \end{aligned}$$

④

$$y = \frac{x}{3}$$



$$\begin{aligned}
 &\int_0^1 \int_0^{3y} e^{y^2} dx dy \\
 &= \int_0^1 3y e^{y^2} dy \\
 &= \left[\frac{3}{2} e^{y^2} \right]_0^1 = \boxed{\frac{3}{2} e - \frac{3}{2}}
 \end{aligned}$$