1) $(x,y) \in \mathbb{R}^2 \times \{-1;+1\}$

$X = (X_1, X_2)$, $X_1, X_2 \in [0,1]$

$X_1 \sim U(0,1)$, $X_2 \sim g(x_2) = 3x_2^2$ for $0 \leq x_2 \leq 1$

$\eta(x_1, x_2) = \frac{x_1 + x_2}{2}$

a) $\phi^*(X_0) = \arg\max_j \left(P(Y=j \mid X=X_0)\right)$

$= \arg\max_{\{-1,+1\}} \left(P(Y=+1 \mid X=X_0), P(Y=-1 \mid X=X_0)\right)$

$= \boxed{\arg\max_{\{-1,+1\}} \left(\eta(x_1,x_2), 1-\eta(x_1,x_2)\right)}$

The decision boundary is such that $\eta(x_1,x_2) = 1-\eta(x_1,x_2)$

$\iff \frac{x_1+x_2}{2} = 1 - \frac{x_1+x_2}{2}$

$\iff x_1 + x_2 = 2 - x_1 - x_2$

$\iff \boxed{x_2 = 1 - x_1}$

b) We have $f(x_1) = 1$ and $g(x_2) = 3x_2^2$. Also, $X_1 \perp X_2$

Then $P(x) = h(x_1, x_2) = f(x_1)\,g(x_2) = \boxed{3x_2^2}$.