Problem (1)

Define X_i as the value chosen in the ith iteration. It follows that

$$X = \frac{1}{k}\sum_{i=1}^{k} X_i$$

From this, we can compute $\mathbb{E}\left[X\right]$ and $\mathrm{Var}\left[X\right]$.

$$\begin{aligned}
\mathbb{E}\left[X\right] &= \frac{1}{k}\mathbb{E}\left[\sum_{i=1}^{k} X_i\right] \\
&= \frac{1}{k}\sum_{i=1}^{k}\mathbb{E}\left[X_i\right] \\
&= \frac{1}{k}\sum_{i=1}^{k}\mathbb{E}\left[X_i\right] \\
&= \frac{1}{k}\sum_{i=1}^{k}\sum_{j=1}^{n} z_j\frac{1}{n} \\
&= \frac{1}{k}\sum_{i=1}^{k}\sum_{j=1}^{n} z_j\frac{1}{n} \\
&= \frac{1}{k}\sum_{i=1}^{k}\alpha \\
&= \alpha
\end{aligned}$$

$$\begin{aligned}
\mathrm{Var}\left[X\right] &= \mathbb{E}\left[X^2\right] - \mathbb{E}\left[X\right]^2 \\
\mathrm{Var}\left[X\right] &= \sum_{i=1}^{n}\frac{1}{n}z_i^2 - \alpha^2
\end{aligned}$$

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$$Hf = \frac{\partial}{\partial w}\nabla f = \frac{\partial}{\partial w}\frac{-1}{n}\sum_{i\in[n]}\frac{y^i(x^i)}{(1+\exp(y^i w^T x^i))}$$