Problem 1: Set $I = (0, 1)$ and let $(f_n)_{n=1}^{\infty}$ be a sequence of continuously differentiable functions on $I$. Set $\Omega = \{f_n : 1 \leq n < \infty\}$.

(a) For a given $n$, suppose that $$\sup_{x \in I} |f'_n(x)| < \infty.$$ Prove that then $f_n$ is uniformly continuous.

(b) Suppose that $$\sup_{x \in I} \sup_{1 \leq n < \infty} |f'_n(x)| < \infty.$$ Prove that then $\Omega$ is uniformly equicontinuous.

(c) Suppose that for every $x \in I$, there exists a $\kappa > 0$ such that $$\sup_{1 \leq n < \infty} \sup_{y \in B_\kappa(x)} |f'_n(y)| < \infty.$$ Prove that then $\Omega$ is equicontinuous.

(d) Give an example of a set $\Omega$ of functions satisfying the condition in (c) that is not uniformly equicontinuous.

(e) Suppose that for a given $x \in I$, it is the case that $$\sup_{1 \leq n < \infty} |f'_n(x)| < \infty.$$ Prove that $\Omega$ is not necessarily equicontinuous at $x$.

(f) Which, if any, of the examples listed in (a) – (e) represent a bounded set $\Omega$?