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3. (10 points)

(a) **Answer:**Samantha's public modulus is $N = pq = 541 \cdot 1223 = \boxed{661643}$.Samantha's private signing key, d , can be obtained by solving for d such that

$$\begin{aligned}de &\equiv 1 \pmod{(p-1)(q-1)} \\159853d &\equiv 1 \pmod{659880} \\ \Rightarrow d &= \boxed{561517}.\end{aligned}$$

(b) **Answer:**The signature, S , is

$$\begin{aligned}S &\equiv D^d \pmod{N} \\S &\equiv 630579^{561517} \pmod{661643} \\S &\equiv 206484 \pmod{661643} \\ \Rightarrow S &= \boxed{206484}.\end{aligned}$$