

- ✓4.2 ✓4.10 ✓4.18
- ✓4.3 ✓4.11
- ✓4.4 ✓4.13
- 4.6 ✓4.14
- ✓4.8 ✓4.15
- ✓4.9 ✓4.16

Michael Vu

[4.34]

1.  $12^{49} \pmod{15}$

$$12^4 \equiv 1 \pmod{15}$$

$$(12^4)^{12} \equiv 1^{12} \pmod{15}$$

$$12^{48} \equiv 1 \pmod{15}$$

$$12^{49} \equiv 12 \pmod{15}$$

$$2685619$$

$$139$$

$$\begin{array}{r} 24170571 \\ 8056857 \\ 2685619 \end{array}$$

$$373301041$$

$$4 \times 4$$

$$\begin{array}{r} 139 \\ 139 \\ \hline 1251 \\ -417 \\ \hline 19321 \end{array}$$

$$\begin{array}{r} 4 \\ 7 \\ \hline 74 \end{array}$$

$$\begin{array}{r} 19321 \\ 139 \\ \hline 173889 \\ 57963 \\ \hline 19321 \\ 2685619 \end{array}$$

$$\begin{array}{r} 7 \\ 1 \\ \hline 174 \end{array}$$

2.  $139^{112} \pmod{27}$

$$\phi(27) = 18$$

$$139^{18} \equiv 1 \pmod{27}$$

$$(139^{18})^6 \equiv 1^6 \pmod{27}$$

$$139^{108} \equiv 1 \pmod{27}$$

$$139^{108} \equiv 139^4 \pmod{27} \equiv 13 \pmod{27}$$

$$139^{112} \equiv 13 \pmod{27}$$

$$\begin{array}{r} 13825964 \\ 27 \overline{) 373301041} \\ \underline{27} \phantom{000000000} \\ 103 \phantom{000000000} \\ \underline{81} \phantom{000000000} \\ 223 \phantom{000000000} \\ \underline{216} \phantom{000000000} \\ 70 \phantom{000000000} \\ \underline{54} \phantom{000000000} \\ 161 \phantom{000000000} \\ \underline{135} \phantom{000000000} \\ 260 \phantom{000000000} \\ \underline{243} \phantom{000000000} \\ 174 \phantom{000000000} \\ \underline{162} \phantom{000000000} \\ 121 \phantom{000000000} \\ \underline{108} \phantom{000000000} \\ 13 \end{array}$$