3a)

$$\Delta P_t = m_t - m_{t-1} + c(q_t - q_{t-1}) \qquad \text{where} \quad m_t - m_{t-1} = u_t \sim N(0,1)$$

so, $\Delta P_t = u_t + c(q_t - q_{t-1})$

$$u_{t-2} + c\,q_{t-2} - c\,q_{t-3}$$

$$u_t + c\,q_t - c\,q_{t-1}$$

$$
\begin{aligned}
\gamma_2 &= \operatorname{cov}(\Delta P_{t-2}, \Delta P_t) \\
&= E[\Delta P_{t-2}\,\Delta P_t] \\
&= E\big[(u_{t-2} + c(q_{t-2} - q_{t-3}))\cdot(u_t + c(q_t - q_{t-1}))\big] \\
&= E\big[u_t \cdot u_{t-2} + c^2(q_{t-2}\cdot q_t - q_{t-2}q_{t-1} - q_{t-3}\cdot q_t + q_{t-3}q_{t-1}) \\
&\qquad + c(u_{t-2}q_t - u_{t-2}q_{t-1} + u_t q_{t-2} - u_t q_{t-3})\big] \\
&= \cancelto{0}{E[u_t u_{t-2}]} + c\big(\cancelto{0}{E[u_{t-2}q_t]} - \cancelto{0}{E[u_{t-2}q_{t-1}]} + \cancelto{0}{E[u_t q_{t-2}]} - \cancelto{0}{E[u_t q_{t-3}]}\big) \\
&\quad + c^2\big(\cancelto{0}{E[q_{t-2}q_t]} - \cancelto{0}{E[q_{t-2}q_{t-1}]} - \cancelto{0}{E[q_{t-3}q_t]} + \cancelto{0}{E[q_{t-3}q_{t-1}]}\big) \\
&= 0 + c(0) + c^2(0)
\end{aligned}
$$

$$\boxed{\gamma_2 = 0}$$

When $\ell \geq 2$, you will never have a q from the same period again (ex: will never have $q_{t-\ell} \cdot q_{t-\ell}$ when $\ell \geq 2$)

Therefore, the expected values will always evaluate to 0.

$$\boxed{\text{Thus, } \gamma_\ell = 0 \text{ for all } \ell \geq 2}$$