Q3) $G_t = R_{t+1} + \gamma R_{t+2} + \gamma^2 R_{t+3} + \dots + \gamma^{T-t-1} R_T + \gamma^{T-t} V(S_T)$ .... $(*)$

$$RHS = \sum_{u=t}^{T-1} \gamma^{u-t}(R_{u+1} + \gamma V(S_{u+1}) - V(S_u)) = \sum_{u=t}^{T-1} \gamma^{u-t} R_{u+1} + \sum_{u=t}^{T-1} \gamma^{u-t+1} V(S_{u+1}) - \underbrace{\sum_{u=t}^{T-1} \gamma^{u-t} V(S_u)}_{\text{change of variable } u \to u+1}$$

$$-\sum_{u=t-1}^{T-2} \gamma^{u-t+1} V(S_{u+1})$$

almost cancels each other.

$$\Rightarrow \boxed{\gamma^{T-t} V(S_T) - V(S_t)}$$

$$RHS = \sum_{u=t}^{T-1} \gamma^{u-t} R_{u+1} + \gamma^{T-t} V(S_T) - V(S_t)$$

$$= \underbrace{R_{t+1} + \gamma R_{t+2} + \gamma^2 R_{t+3} + \dots + \gamma^{T-t-1} R_T + \gamma^{T-t}}_{\text{by } (*) \ = G_t} V(S_T) - V(S_t)$$

$$= G_t - V(S_t) = LHS.,$$ we are done $\square$.