1) $P_t \sim P(\lambda t)$ ... passengers having arrived until time t

$X \sim U(0, T)$ ... time at which first train arrives

What are the expectation and variance of number of passengers who enter the first train?

$$E(P_x \mid X = t) = E(P_t) = \lambda t \qquad \Rightarrow E(P_x \mid X) = \lambda X$$

We know that

$$E(P_x) = E(E(P_x \mid X)) = E(\lambda X) = \lambda E(X) = \lambda \frac{T-0}{2} = \frac{\lambda}{2} T$$

$$V(P_x) = E(V(P_x \mid X)) + V(E(P_x \mid X))$$

$$V(P_x \mid X = t) = V(P_t) = \lambda t \qquad \Rightarrow V(P_x \mid X) = \lambda X$$

$$E(V(P_x \mid X)) = E(\lambda X) = \frac{\lambda}{2} T$$

$$V(E(P_x \mid X)) = V(\lambda X) = \lambda^2 V(X) = \lambda^2 \frac{(T-0)^2}{12} = \frac{\lambda^2}{12} T^2$$

$$V(P_x) = E(V(P_x \mid X)) + V(E(P_x \mid X))$$
$$= \frac{\lambda}{2} T \qquad + \frac{\lambda^2}{12} T^2$$