7.33. $\mathrm{P}\{T_n > k\} = \mathrm{P}\{X_1 + \cdots + X_k < n\}$. Now,

$$\mathrm{E}\left[\exp\left(i\frac{\xi}{n}\sum_{j=1}^{k} X_j\right)\right] = \left(\mathrm{E}[\exp(i\xi X_1/n)]\right)^k = \left(\frac{1}{n}\sum_{j=1}^{n} e^{ij\xi/n}\right)^k.$$

Fix $k \geq 1$ and let $n \to \infty$ to find that

$$\mathrm{E}\left[\exp\left(i\frac{\xi}{n}\sum_{j=1}^{k} X_j\right)\right] \to \left(\int_0^1 e^{it\xi}\,dt\right)^k = \mathrm{E}\left[\exp\left(i\xi\sum_{j=1}^{k} U_j\right)\right],$$

where $U_1, U_2, \ldots, U_k$ are i.i.d. $\mathrm{Unif}(0,1)$'s. By the convergence theorem of characteristic functions,

$$\frac{1}{n}\sum_{j=1}^{k} X_j \Rightarrow \sum_{j=1}^{k} U_j.$$

Consequently, $\lim_{n\to\infty} \mathrm{P}\{T_n > k\} = \mathrm{P}\{U_1 + \cdots + U_k < 1\} = 1/k!$, after symmetry considerations. Since $\mathrm{P}\{T_n = k\} = \mathrm{P}\{T_n > k-1\} - \mathrm{P}\{T_n > k\}$ the result follows.