Exercise 2-6 Solution file from Kelton/Sadowski/Zupick, *Simulation With Arena*, 6th edition, McGraw-Hill, 2015

(a) (Reason 1): The estimates of the expected interarrival and service times are subject to random variation, so they are not exact; thus, the 19.31 from the M/M/1 queueing formula is not exact since it depends on these numbers. (Reason 2): The queueing-theoretic formula assumes interarrival and service times that are both exponentially distributed, and we don't know that this is true for the (given) values in Table 2-1. (Reason 3): The formula is for long-run (infinite-length) performance, but our simulation was for only 20 simulated minutes, which may not be "close enough" to infinity. (Reason 4): The formula is an exact value (no variance), but our simulation output is for the interarrival and service times that happen to have been given in Table 2-1; other input values, even if from the same "source," would, in general, clearly produce different output results.

(b) It's different from the 2.53 from the 20-minute simulation run since it's longer (much longer), yielding different input so different output. It's different from the 19.31 for reasons (1), (2), and (4) given in our solution to part (a); reason (3), while technically still valid, is perhaps not as convincing since a million is closer to infinity than 20 is.

(c) The M/M/1 formula for the expected waiting time in queue with these values is $3.33^2/(5 - 3.33) = 6.67$. This differs from the 19.31 since we're now using exact, not estimated, values for the mean interarrival and service times. It's different from the 2.53 for any of reasons (2), (3), and (4) given in our solution to part (a). It's different from the 3.60 for reasons (2) and (4) given in our solution to part (a).

(d) This is actually quite close to the theoretical result of 6.67 from part (c) since the conditions are similar—long run (if not quite infinite), exponential interarrival and service times—the only probable explanation for the small discrepancy is that the simulation produces results that are subject to uncertainty (though not much in such a long simulation, producing lots of output data). It differs from the 3.60 since we're using a different interarrival-time distribution here (exponential instead of triangular) even though the mean is the same, and also due to the fact that both results are subject to variation. It differs from the 2.53 due to the different service-time distribution, different run length, and the fact that both results are subject to variation. It differs from the 19.31 since the parameters used for the 19.31 were not exact, and since the simulation result here is subject to variation.