ENGR 326
Lab Assignment – Romberg Integration Program

An irrigation district is considering adding to the reservoir capacity of their irrigation system. Currently when the annual water yield (runoff) from their watershed sources exceeds 20 inches (this is a volume per area), the reservoir system capacity is exceeded. A larger reservoir capacity would allow more runoff to be captured during the winter and spring and used for irrigation later in the year. An economic analysis has determined that the expansion is not justified at this time unless the probability of the water yield exceeding 20 inches in any year is greater than 18 percent (or the probability of less than 20 inches is less than 82 percent). From an analysis of the runoff data, it has been determined that the probability distribution of the annual water yield can be approximated with the gamma distribution, which has the probability density function (pdf)

$$f_X(x) = \frac{\lambda^\eta x^{\eta-1} e^{-\lambda x}}{\Gamma(\eta)} \qquad x,\ \lambda,\ \eta > 0$$

where x is the annual water yield in inches, λ is a shape parameter (1/inches), and η is a dimensionless shape parameter. Using 32 years of data, the values of the distribution parameters were estimated to be $\eta = 5.922$ and $\lambda = 0.404$. The probability that the annual yield is less than 20 inches can be determined by integrating the pdf

$$\Pr(X \le 20) = \int_0^{20} f_X(x)\mathrm{d}x$$

Write a general program that can integrate a user defined function (given in a user specified function subprogram) using Romberg integration (based on the trapezoid rule). Using the program, investigate the cost efficiency of expanding the irrigation district's reservoirs.