MCexample1

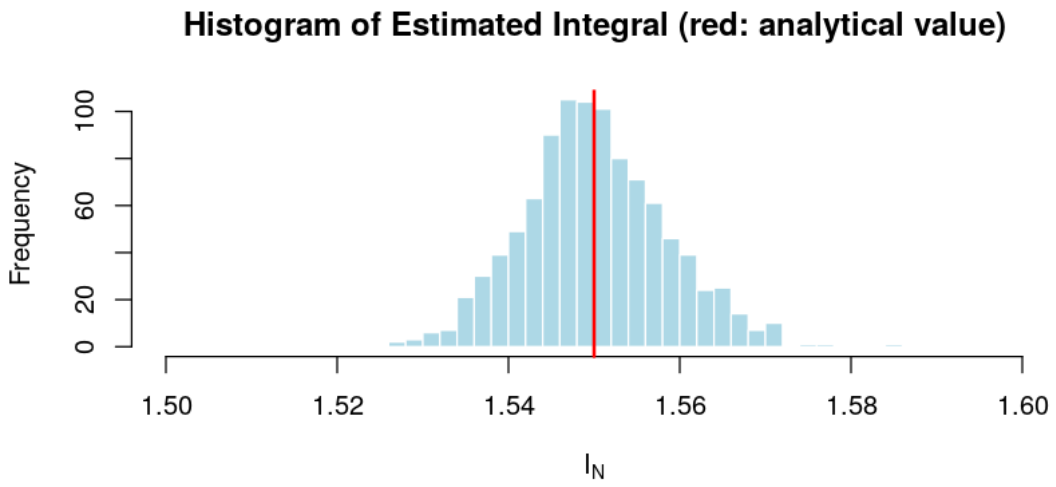
March 13, 2025

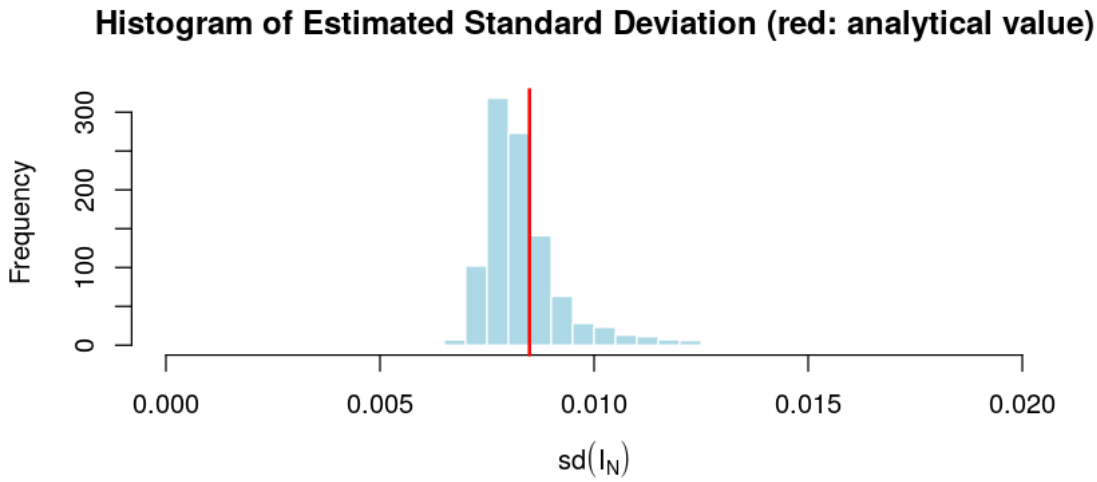
[6]:
```r
#  Standard Monte Carlo Integration

# Parameters
np  <- 10000     # number of samples per Monte Carlo run
nmc <- 1000      # number of Monte Carlo runs
set.seed(12345)  # Uncomment for reproducibility

# Function to integrate
f <- function(x) {
  x^(-1/3) + x / 10
}

# Initialize arrays to store results
integrals <- numeric(nmc)
squared_integrals <- numeric(nmc)
```

[7]:
```r
# Monte Carlo integration loop
for (i in 1:nmc) {
  x <- runif(np, min = 1.0e-20)  # Generate random samples in [1.0e-20, 1]
  y <- f(x)                      # Evaluate the function at each sample point

  integrals[i] <- mean(y)        # Store the mean of the function evaluations
  squared_integrals[i] <- mean(y^2)  # Store the mean of the squared function␣
 ↪evaluations
}
```

[8]:
```r
# Plot the results
par(mfrow = c(2, 1))

# Histogram of the estimated integrals
hist(integrals, breaks = 30, xlim = c(1.5, 1.6), xlab = expression(I[N]),
     main = "Histogram of Estimated Integral (red: analytical value)",
     col = "lightblue", border = "white")
abline(v = 31/20, col = "red", lwd = 2)  # Analytical value of the integral

# Calculate the standard deviation of the integrals
std_dev <- sqrt((squared_integrals - integrals^2) / np)
```

```r
# Histogram of the estimated standard deviations
hist(std_dev, breaks = 30, xlim = c(0, 0.02), xlab = expression(sd(I[N])),
     main = "Histogram of Estimated Standard Deviation (red: analytical value)",
     col = "lightblue", border = "white")
abline(v = 0.849 / sqrt(np), col = "red", lwd = 2)  # Analytical value of the␣
↪standard deviation
```





[9]:
```r
# Print results
cat("Standard deviation of MC integrals: ", sd(integrals), "\n")
cat("MC estimate of dispersion: ", mean(std_dev), "\n")
cat("Analytical estimate of standard deviation of MC integrals: ", 0.849 /␣
↪sqrt(np), "\n")
```

```
Standard deviation of MC integrals:  0.008290599
MC estimate of dispersion:  0.008355459
Analytical estimate of standard deviation of MC integrals:  0.00849
```

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