   Using the data given here, we get the following parameters for the model of Example 4.10: \( \lambda = 60 \), \( \mu_{10} \), \( M = 8 \), \( H = 4 \). Using these and \( \epsilon = 10^{-5} \) in the uniformization algorithm we compute \( M(8) \). The system starts in state 0, and all the servers are busy in states 8,9,10,11, and 12. Hence the desired answer is
   \[
   \sum_{j=8}^{12} m_{0,j}(8) = 0.7629 + 0.5697 + 0.4257 + 0.3184 + 0.2384 = 2.315 \text{ hours}.
   \]

2. Computational Problem 4.22.
   Using the \( R \) matrix from Computational Problem 4.2, we get the limiting distribution
   \[
   p = [0.1667, 0.1667, 0.1667, 0.1667, 0.1667, 0.1667].
   \]

   The limiting distribution \( p \) is given by the solution to Equations 4.43 and 4.44. Using the \( R \) matrix from Example 4.10, and the data from Computational Problem 4.9, we get
   \[
   p = [0.0023, 0.0140, 0.0421, 0.0843, 0.1264, 0.1517, 0.1517, 0.1300, 0.0975, 0.0731, 0.0548, 0.0411, 0.0309].
   \]
   i. All clerks are busy in states 8, 9, 10, 11, 12. Hence the desired answer is \( p_8 + p_9 + p_{10} + p_{11} + p_{12} = 0.2975 \).
   ii. The system has to turn away calls when it is in state 12. Hence the desired answer is \( p_{12} = 0.0309 \).
   iii. The expected number of busy clerks in steady state is given by:
   \[
   \sum_{i=0}^{12} \min(i, 8)p_i = 5.8149.
   \]

   Let \( X(t) \) be the number of operating processors at time \( t \). Then \( \{X(t), t \geq 0\} \) is a CTMC with rate matrix given by (assuming 365 days in year, and
using years as the unit of time)

\[
R = \begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 73 \\
0.50 & 0 & 0 & 0 & 0 & 0 \\
0.06 & 0.94 & 0 & 0 & 0 & 0 \\
0.09 & 0 & 1.41 & 0 & 0 & 0 \\
0.12 & 0 & 0 & 1.88 & 0 & 0 \\
0.15 & 0 & 0 & 0 & 2.35 & 0
\end{bmatrix}
\]

and The limiting distribution \( p \) is given by the solution to Equations 4.43 and 4.44. Using the above \( R \) matrix, we get

\[
p = [0.0035, 0.4040, 0.2149, 0.1524, 0.1216, 0.1035].
\]

The revenue rate at each state is given as

\[
c(i) = i (100 \text{ dollars/hour}) \times (8760 \text{ hours/year}) = i \times 876,000 \text{ dollars/year}
\]

for \( 1 \leq i \leq 5 \), and

\[
c(0) = -(200 \text{ dollars/hour}) \times (8760 \text{ hours/year}) = -1,752,000 \text{ dollars/year}.
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\]

Computing \( M(1) \), we get:

\[
g(1) = M(1)c = [3453894.8, 1460871.1, 1643824.3, 2210428.3, 2858204.2, 3516772.1]'.
\]

The desired answer is \( g(5,1) = $3,516,772. \)

5. Computational Problem 4.44.

Consider the system using server 1. We have \( l = 5 \) per hour \( \mu = 7.5 \) per hour, and capacity = 10. Let \( X(t) \) be the number of customers in the system at time \( t \). Then \( \{X(t), t \geq 0\} \) is a CTMC with state space \( \{0,1, \cdots, 10\} \) as described in Example ??.. Each customer spends 8 minutes in service on the average, and pays $10 for it. This means that the system earns money at rate of $75 per hour that the server is busy. It has to pay the server at a rate of $20 per hour whether it is busy or not. This revenue structure can be accounted for by the following revenue vector:

\[
e(i) = \begin{cases} 
-20 & \text{if } i = 0, \\
75 - 20 & \text{otherwise.}
\end{cases}
\]
Let $p$ be the limiting distribution of $\{X(t), t \geq 0\}$. The long run revenue rate per hour is then given by

$$\sum_{i=0}^{10} c(i)p_i = 75(1 - p(0)) - 20.$$ 

Using the results of Example 4.25, we get

$$p(0) = 0.3372.$$ 

Hence the long run revenue rate is

$$75(1 - 0.3372) - 20 = 29.71 \text{ dollars/hour.}$$

Similar analysis with server 2 yields the long run revenue rate to be 33.44 dollars/hour. Hence it is more profitable to use the slower but cheaper server 2.