3. [11 points] Sewage flows into the tank described in the previous problem at a rate of \( f(t) \) cubic meters per day. Let \( t \) be the number of days since December 1, when the tank had 1 m\(^3\) of sewage. A graph of \( f(t) \) is given below. Use it to answer the following questions.

![Graph of f(t)](image)

a. [3 points] Suppose that \( V(t) \) gives the volume of sewage in the tank at time \( t \). Find a formula for \( V(t) \) in terms of \( f(t) \).

\[
\text{Solution: } V(t) = 1 + \int_{0}^{t} f(t) dt
\]

b. [2 points] For what times \( t \) in [0, 24] is \( V(t) \) concave up? 

\[
\text{Solution: } 4 < t < 10
\]

c. [2 points] For what times \( t \) in [0, 24] is \( V(t) \) concave down?

\[
\text{Solution: } 14 < t < 24
\]

d. [4 points] Fill out the table below. Using the values in your table, compute Riemann sums with 3 subintervals to find an underestimate and an overestimate for \( V(12) \). Justify why the Riemann sums you selected yield the appropriate under and upper estimates. Do not forget to include the units in your answer.

<table>
<thead>
<tr>
<th>( t )</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(t) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{Solution: } \begin{array}{cccc}
 t & 0 & 4 & 8 \\
 f(t) & 1 & 1 & \approx 1.75 \\
 f(t) & 3 & & & \\
\end{array}
\]

\( f(t) \) is increasing in (0, 12) then

Upper estimate (Right hand sum): \( 4(1 + 1.75 + 3) + 1 = 24 \) m\(^3\)
Lower estimate (Left hand sum): \( 4(1 + 1 + 1.75) + 1 = 16 \) m\(^3\)