1. The inflow flood hydrograph observed at the entrance of a stream reach is given in the table below. Determine the outflow hydrograph at the exit, 18 km from the entrance, by *Muskingum Method*. The flood wave propagates in the stream with a velocity of 2 m/s.

<table>
<thead>
<tr>
<th>t(hr)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>x(m³/s)</td>
<td>10</td>
<td>12</td>
<td>18</td>
<td>28.5</td>
<td>50</td>
<td>78</td>
<td>107</td>
<td>134.5</td>
<td>147</td>
<td>150</td>
<td>146</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>t(hr)</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>x(m³/s)</td>
<td>129</td>
<td>105</td>
<td>78</td>
<td>59</td>
<td>45</td>
<td>33</td>
<td>24</td>
<td>17</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

**Solution:**

The parameters $a$ and $K$ of the Muskingum method are first estimated. The computation step $\Delta x=6$ km, time step $\Delta t=2$ hr. $K$ is the time it takes the flood wave to pass through the reach:

$$K = \frac{6000}{2} = 3000 \text{s}$$

The value of $a$ is found as 0.25, by trial-and-error, so that a linear relationship is obtained between $ax+(1-a)y$ and $S$. ($S$ is the volume stored in the reach)

$$c_0 = \frac{-aK + 0.5\Delta t}{K - aK + 0.5\Delta t} = \frac{-0.25 \times 3000 + 0.5 \times 7200}{3000 - 0.25 \times 3000 + 0.5 \times 7200} = 0.48$$

$$c_1 = \frac{aK + 0.5\Delta t}{K - aK + 0.5\Delta t} = \frac{0.25 \times 3000 + 0.5 \times 7200}{3000 - 0.25 \times 3000 + 0.5 \times 7200} = 0.75$$

$$c_2 = \frac{K - aK - 0.5\Delta t}{K - aK + 0.5\Delta t} = \frac{3000 - 0.25 \times 3000 - 0.5 \times 7200}{3000 - 0.25 \times 3000 + 0.5 \times 7200} = -0.23$$

with $c_0 + c_1 + c_2 = 1.00$. Results of the computations performed in sections with 6 km intervals, with a time interval of 2 hr, are shown in table below.
As an example, the computation of the discharge at \( x = 6 \text{ km} \) and \( t = 2 \text{ hr} \) is shown below:

\[
y_2 = c_0 \cdot x_2 + c_1 \cdot x_1 + c_2 \cdot y_1 = 0.48 \cdot 18 + 0.75 \cdot 10 - 0.23 \cdot 10 = 13.9 \text{ m}^3/\text{s}
\]

Having obtained the hydrograph at \( x = 6 \text{ km} \), this is taken as the inflow hydrograph, and the outflow hydrograph at the section \( x = 12 \text{ km} \) is derived similarly. For \( t = 2 \text{ hr} \):

\[
y_2 = 0.48 \cdot 13.9 + 0.75 \cdot 10 - 0.23 \cdot 10 = 11.9 \text{ m}^3/\text{s}
\]

The peak discharge of the flood hydrograph at the section \( x = 18 \text{ km} \) is 145.4 m\(^3\)/s, a reduction of 4.6 m\(^3\)/s with respect to the peak of 150 m\(^3\)/s at the entrance section. The base width of the flood wave has increased to 24 hours at \( x = 18 \text{ km} \) from 20 hours at \( x = 0 \).