$$\left(-\frac{\hbar^2}{2}\frac{\partial}{\partial z}\frac{1}{m_e^*(z)}\frac{\partial}{\partial z}+U(z)\right)\varphi_n(z)=E_n\varphi_n(z)$$

$$m_e^*=m_0 m_r$$

The discretization of the given Schrödinger equation is

$$-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_{i+1}^*}+\frac{1}{m_i^*}\right)\varphi_{i+1}+\left(\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_{i+1}^*}+\frac{2}{m_i^*}+\frac{1}{m_{i-1}^*}\right)+U_i\right)\varphi_i-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_i^*}+\frac{1}{m_{i-1}^*}\right)\varphi_{i-1}=E_i\varphi_i$$

with boundary condition : $\varphi_0=\varphi_{N+1}=0$

when i=1 :

$$-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_2^*}+\frac{1}{m_1^*}\right)\varphi_2+\left(\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_2^*}+\frac{2}{m_1^*}+\frac{1}{m_0^*}\right)+U_1\right)\varphi_1=E_1\varphi_1$$

when i=2 :

$$-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_3^*}+\frac{1}{m_2^*}\right)\varphi_3+\left(\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_3^*}+\frac{2}{m_2^*}+\frac{1}{m_1^*}\right)+U_2\right)\varphi_2-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_2^*}+\frac{1}{m_1^*}\right)\varphi_1=E_2\varphi_2$$

when i=3 :

$$-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_4^*}+\frac{1}{m_3^*}\right)\varphi_4+\left(\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_4^*}+\frac{2}{m_3^*}+\frac{1}{m_2^*}\right)+U_3\right)\varphi_3-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_3^*}+\frac{1}{m_2^*}\right)\varphi_2=E_3\varphi_3$$

when i= N-1 :

$$-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_N^*}+\frac{1}{m_{N-1}^*}\right)\varphi_N+\left(\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_N^*}+\frac{2}{m_{N-1}^*}+\frac{1}{m_{N-2}^*}\right)+U_{N-1}\right)\varphi_{N-1}-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_{N-1}^*}+\frac{1}{m_{N-2}^*}\right)\varphi_{N-2}=E_{N-1}\varphi_{N-1}$$

when i= N :

$$\left(\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_{N+1}^*}+\frac{2}{m_N^*}+\frac{1}{m_{N-1}^*}\right)+U_N\right)\varphi_N-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_N^*}+\frac{1}{m_{N-1}^*}\right)\varphi_{N-1}=E_N\varphi_N$$

$$
\begin{pmatrix}
\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_2^*}+\frac{2}{m_1^*}+\frac{1}{m_0^*}\right)+U_1 & -\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_2^*}+\frac{1}{m_1^*}\right) & & & & \\
-\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_2^*}+\frac{1}{m_1^*}\right) & \frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_3^*}+\frac{2}{m_2^*}+\frac{1}{m_1^*}\right)+U_2 & -\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_3^*}+\frac{1}{m_2^*}\right) & & & \\
 & -\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_3^*}+\frac{1}{m_2^*}\right) & \frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_4^*}+\frac{2}{m_3^*}+\frac{1}{m_2^*}\right)+U_3 & -\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_4^*}+\frac{1}{m_3^*}\right) & & \\
 & & & & & \\
 & & -\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_{N-1}^*}+\frac{1}{m_{N-2}^*}\right) & \frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_N^*}+\frac{2}{m_{N-1}^*}+\frac{1}{m_{N-2}^*}\right)+U_{N-1} & -\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_N^*}+\frac{1}{m_{N-1}^*}\right) \\
 & & & -\frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_N^*}+\frac{1}{m_{N-1}^*}\right) & \frac{\hbar^2}{4}\frac{1}{\Delta z^2}\left(\frac{1}{m_{N+1}^*}+\frac{2}{m_N^*}+\frac{1}{m_{N-1}^*}\right)+U_N
\end{pmatrix}
\begin{pmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\\ \dots\\ \varphi_{N-2}\\ \varphi_{N-1}\\ \varphi_N\end{pmatrix}
= E\begin{pmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\\ \dots\\ \varphi_{N-2}\\ \varphi_{N-1}\\ \varphi_N\end{pmatrix}
$$

a) Write an algorithm or pseudocode to solve the matrix above.

b) Convert the algorithm into a MATLAB code.


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