$$\frac{d^2 y_1}{dz^2} - \phi_1 y_1 y_2 = 0$$

$$\frac{d^2 y_2}{dz^2} - \phi_2 y_1 y_2 = 0$$

$$z = 0 \qquad \frac{dy_1}{dz} = \frac{dy_2}{dz} = 0$$

$$z = 1 \qquad y_1 = 1; \quad y_2 = 0.5$$

Unknowns

y_1	U_1
	U_2
	. . .
	U_{N1-1}
	U_{N1}
y_2	U_{N1+1}
	U_{N1+2}
	. . .
	U_{2N1-1}
	U_{2N1}

Residual Equations

BVP1	i = 1	$R(1) = \sum_{j=1}^{N1} D(1, j)\ U(j)$
	i = 2 . . . i = N1-1	$R(i) = \sum_{j=1}^{N1} DD(i, j)\ U(j) - \phi_1 U(i)\ U(N1+i)$
	i = N1	$R(N1) = U(N1) - 1$
BVP2	i = N1+1	$R(N1+1) = \sum_{j=1}^{N1} D(1, j)\ U(N1+j)$
	i = N1+2 . . . i = 2N1-1	$R(N1+i) = \sum_{j=1}^{N1} DD(i, j)\ U(N1+j) - \phi_2 U(i)\ U(N1+i)$
	i = 2N1	$R(2N1) = U(2N1) - 0.5$

Residual Equations

$$R(1) = \sum_{j=1}^{N1} D(1, j)\ U(j) \qquad\qquad i = 0$$

$$R(i) = \sum_{j=1}^{N1} DD(i, j)\ U(j) - \phi_1 U(i)\ U(N1+i) \qquad\qquad 2 \le i \le N1-1$$

$$R(N1) = U(N1) - 1 \qquad\qquad i = \mathrm{N1}$$

$$R(N1+1) = \sum_{j=1}^{N1} D(1, j)\ U(N1+j) \qquad\qquad i = \mathrm{N1+1}$$

$$R(N1+i) = \sum_{j=1}^{N1} DD(i, j)\ U(N1+j) - \phi_2 U(i)\ U(N1+i) \qquad\qquad N1+2 \le i \le 2N1-1$$

$$R(2N1) = U(2N1) - 0.5 \qquad\qquad i = \mathrm{2N1}$$

Jacobian Matrix

$$J(1, j) = D(1, j) \qquad\qquad 1 \le j \le N1$$

$$J(i, j) = DD(i, j) - \phi_1\ U(N1+i)\ \delta_{i,j} \qquad\qquad 2 \le i \le N1-1, 1 \le j \le N1$$

$$J(i, N1+j) = -\ \phi_1\ U(i)\ \delta_{i,j} \qquad\qquad 2 \le i \le N1-1, 1 \le j \le N1$$

$$J(N1, j) = \delta_{N1,\mathrm{j}} \qquad\qquad 1 \le j \le N1$$

$$J(N1+1, N1+j) = D(1, j) \qquad\qquad 1 \le j \le N1$$

$$J(N1+i, N1+j) = DD(i, j) - \phi_2\ U(i)\ \delta_{i,j} \qquad\qquad 2 \le i \le N1-1, 1 \le j \le N1$$

$$J(N1+i, j) = -\ \phi_2\ U(N1+i)\ \delta_{i,j} \qquad\qquad 2 \le i \le N1-1, 1 \le j \le N1$$

$$J(2N1, N1+j) = \delta_{N1,\mathrm{j}} \qquad\qquad 1 \le j \le N1$$