```
dSdteqn[t_] = c - β S[t] II[t] / (S[t] + EE[t] + II[t]) - μS S[t] - D[S[t], t]
dEEdteqn[t_] =
 (1 - ϵ) β S[t] II[t] / (S[t] + EE[t] + II[t]) - δ EE[t] - μE EE[t] - D[EE[t], t]
dIIdteqn[t_] = ϵ β S[t] II[t] / (S[t] + EE[t] + II[t]) + δ EE[t] - μI II[t] - D[II[t], t]
```

$$c - \mu S\, S[t] - \frac{\beta\, II[t]\, S[t]}{EE[t] + II[t] + S[t]} - S'[t]$$

$$-\delta\, EE[t] - \mu E\, EE[t] + \frac{\beta\,(1-\epsilon)\, II[t]\, S[t]}{EE[t] + II[t] + S[t]} - EE'[t]$$

$$\delta\, EE[t] - \mu I\, II[t] + \frac{\beta\,\epsilon\, II[t]\, S[t]}{EE[t] + II[t] + S[t]} - II'[t]$$

```
yEeqn[t_] = kE EE[t] - yE[t]
yIeqn[t_] =  kI II[t] - yI[t]
```

$$kE\, EE[t] - yE[t]$$

$$kI\, II[t] - yI[t]$$

```
yEmap[t_] = Solve[yEeqn[t] == 0, EE[t]][[1]]
yImap[t_] = Solve[yIeqn[t] == 0, II[t]][[1]]
```

$$\left\{EE[t] \to \frac{yE[t]}{kE}\right\}$$

$$\left\{II[t] \to \frac{yI[t]}{kI}\right\}$$

```
dSdteqn2[t_] = dSdteqn[t] /. yEmap[t] /. D[yEmap[t], t] /. yImap[t] /. D[yImap[t], t]
dEEdteqn2[t_] =
 dEEdteqn[t] /. yEmap[t] /. D[yEmap[t], t] /. yImap[t] /. D[yImap[t], t]
dIIdteqn2[t_] = dIIdteqn[t] /. yEmap[t] /. D[yEmap[t], t] /. yImap[t] /. D[yImap[t], t]
```

$$c - \mu S\, S[t] - \frac{\beta\, S[t]\, yI[t]}{kI\left(S[t] + \frac{yE[t]}{kE} + \frac{yI[t]}{kI}\right)} - S'[t]$$

$$-\frac{\delta\, yE[t]}{kE} - \frac{\mu E\, yE[t]}{kE} + \frac{\beta\,(1-\epsilon)\, S[t]\, yI[t]}{kI\left(S[t] + \frac{yE[t]}{kE} + \frac{yI[t]}{kI}\right)} - \frac{yE'[t]}{kE}$$

$$\frac{\delta\, yE[t]}{kE} - \frac{\mu I\, yI[t]}{kI} + \frac{\beta\,\epsilon\, S[t]\, yI[t]}{kI\left(S[t] + \frac{yE[t]}{kE} + \frac{yI[t]}{kI}\right)} - \frac{yI'[t]}{kI}$$

```
Smap[t_] = Solve[dIIdteqn2[t] == 0, S[t]][[1]]
```

$$\left\{S[t] \to -\frac{(kI\, yE[t] + kE\, yI[t])\,(kI\,\delta\, yE[t] - kE\,\mu I\, yI[t] - kE\, yI'[t])}{kE\, kI\,(kI\,\delta\, yE[t] + kE\,\beta\,\epsilon\, yI[t] - kE\,\mu I\, yI[t] - kE\, yI'[t])}\right\}$$

```
dSdteqn3[t_] = dSdteqn2[t] /. Smap[t] /. D[Smap[t], t]
dEEdteqn3[t_] = dEEdteqn2[t] /. Smap[t] /. D[Smap[t], t]
```

$$
\begin{aligned}
&\mathbf{c} + \frac{\mu \mathbf{S}\,(\mathbf{kI}\,\mathbf{yE}[t] + \mathbf{kE}\,\mathbf{yI}[t])\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])}{\mathbf{kE}\,\mathbf{kI}\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])} + \\
&\frac{(\mathbf{kI}\,\delta\,\mathbf{yE}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])\,(\mathbf{kI}\,\mathbf{yE}'[t] + \mathbf{kE}\,\mathbf{yI}'[t])}{\mathbf{kE}\,\mathbf{kI}\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])} + \\
&(\beta\,\mathbf{yI}[t]\,(\mathbf{kI}\,\mathbf{yE}[t] + \mathbf{kE}\,\mathbf{yI}[t])\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t]))\Big/ \\
&\Big(\mathbf{kE}\,\mathbf{kI}^2\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t]) \\
&\quad\Big(\frac{\mathbf{yE}[t]}{\mathbf{kE}} + \frac{\mathbf{yI}[t]}{\mathbf{kI}} - \frac{(\mathbf{kI}\,\mathbf{yE}[t] + \mathbf{kE}\,\mathbf{yI}[t])\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])}{\mathbf{kE}\,\mathbf{kI}\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])}\Big)\Big) + \\
&\frac{(\mathbf{kI}\,\mathbf{yE}[t] + \mathbf{kE}\,\mathbf{yI}[t])\,(\mathbf{kI}\,\delta\,\mathbf{yE}'[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}'[t] - \mathbf{kE}\,\mathbf{yI}''[t])}{\mathbf{kE}\,\mathbf{kI}\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])} - \\
&((\mathbf{kI}\,\mathbf{yE}[t] + \mathbf{kE}\,\mathbf{yI}[t])\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t]) \\
&\quad(\mathbf{kI}\,\delta\,\mathbf{yE}'[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}'[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}'[t] - \mathbf{kE}\,\mathbf{yI}''[t]))\Big/ \\
&\Big(\mathbf{kE}\,\mathbf{kI}\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t])^2\Big) \\
&- \frac{\delta\,\mathbf{yE}[t]}{\mathbf{kE}} - \frac{\mu\mathbf{E}\,\mathbf{yE}[t]}{\mathbf{kE}} - \frac{\mathbf{yE}'[t]}{\mathbf{kE}} - \\
&(\beta\,(1-\epsilon)\,\mathbf{yI}[t]\,(\mathbf{kI}\,\mathbf{yE}[t] + \mathbf{kE}\,\mathbf{yI}[t])\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t]))\Big/ \\
&\Big(\mathbf{kE}\,\mathbf{kI}^2\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t]) \\
&\quad\Big(\frac{\mathbf{yE}[t]}{\mathbf{kE}} + \frac{\mathbf{yI}[t]}{\mathbf{kI}} - ((\mathbf{kI}\,\mathbf{yE}[t] + \mathbf{kE}\,\mathbf{yI}[t])\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t]))\,/ \\
&\qquad(\mathbf{kE}\,\mathbf{kI}\,(\mathbf{kI}\,\delta\,\mathbf{yE}[t] + \mathbf{kE}\,\beta\,\epsilon\,\mathbf{yI}[t] - \mathbf{kE}\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kE}\,\mathbf{yI}'[t]))\Big)\Big)
\end{aligned}
$$

```
IPOPish1[t_] = Simplify[Denominator[Together[dSdteqn3[t]]] Together[dSdteqn3[t]]]
IPOPish2[t_] = Simplify[Denominator[Together[dEEdteqn3[t]]] Together[dEEdteqn3[t]]]
```

$$
\begin{aligned}
&\mathbf{kI}^3\,\delta^2\,(\delta + \epsilon\,\mu\mathbf{S})\,\mathbf{yE}[t]^3 + \\
&\mathbf{kI}^2\,\delta\,\mathbf{yE}[t]^2\,(\mathbf{c}\,\mathbf{kE}\,\mathbf{kI}\,\delta\,\epsilon + \mathbf{kE}\,(-3\,\delta\,\mu\mathbf{I} + \delta\,\epsilon\,\mu\mathbf{S} - 2\,\epsilon\,\mu\mathbf{I}\,\mu\mathbf{S} + \beta\,\epsilon\,(2\,\delta + \epsilon\,\mu\mathbf{S}))\,\mathbf{yI}[t] + \\
&\quad\mathbf{kI}\,\delta\,\epsilon\,\mathbf{yE}'[t] + \mathbf{kE}\,(\delta\,(-3+\epsilon) - \epsilon\,(\beta\,\epsilon + 2\,\mu\mathbf{S}))\,\mathbf{yI}'[t]) + \mathbf{kE}\,\mathbf{kI}\,\mathbf{yE}[t] \\
&\quad\Big(\mathbf{kE}\,\Big(\beta^2\,\delta\,\epsilon^2 + \beta\,\epsilon\,(-4\,\delta\,\mu\mathbf{I} + \delta\,\epsilon\,\mu\mathbf{S} - \epsilon\,\mu\mathbf{I}\,\mu\mathbf{S}) + \mu\mathbf{I}\,(3\,\delta\,\mu\mathbf{I} - 2\,\delta\,\epsilon\,\mu\mathbf{S} + \epsilon\,\mu\mathbf{I}\,\mu\mathbf{S})\Big)\,\mathbf{yI}[t]^2 + \\
&\quad\mathbf{yI}'[t]\,(-2\,\mathbf{c}\,\mathbf{kE}\,\mathbf{kI}\,\delta\,\epsilon - 2\,\mathbf{kI}\,\delta\,\epsilon\,\mathbf{yE}'[t] + \mathbf{kE}\,(\delta\,(3-2\,\epsilon) + \epsilon\,(\beta\,\epsilon + \mu\mathbf{S}))\,\mathbf{yI}'[t]) + \\
&\quad\mathbf{yI}[t]\,(2\,\mathbf{kI}\,\delta\,\epsilon\,(\beta\,\epsilon - \mu\mathbf{I})\,\mathbf{yE}'[t] - \mathbf{kE}\,(-2\,\epsilon\,\mu\mathbf{I}\,\mu\mathbf{S} + \beta\,\epsilon\,(4\,\delta + \epsilon\,\mu\mathbf{S}) + 2\,\delta\,((-3+\epsilon)\,\mu\mathbf{I} + \epsilon\,\mu\mathbf{S})) \\
&\qquad\mathbf{yI}'[t] + \mathbf{kE}\,\epsilon\,(2\,\mathbf{c}\,\mathbf{kI}\,\delta\,(\beta\,\epsilon - \mu\mathbf{I}) - \beta\,\epsilon\,\mathbf{yI}''[t]))\Big) + \\
&\mathbf{kE}^2\,\Big(-\mathbf{kE}\,(\beta\,\epsilon - \mu\mathbf{I})\,\mu\mathbf{I}\,(\beta\,\epsilon - \mu\mathbf{I} + \epsilon\,\mu\mathbf{S})\,\mathbf{yI}[t]^3 + \mathbf{yI}'[t]^2 \\
&\quad(\mathbf{c}\,\mathbf{kE}\,\mathbf{kI}\,\epsilon + \mathbf{kI}\,\epsilon\,\mathbf{yE}'[t] + \mathbf{kE}\,(-1+\epsilon)\,\mathbf{yI}'[t]) + \mathbf{yI}[t]\,\mathbf{yI}'[t]\,(2\,\mathbf{c}\,\mathbf{kE}\,\mathbf{kI}\,\epsilon\,(-\beta\,\epsilon + \mu\mathbf{I}) + \\
&\quad\mathbf{kI}\,\epsilon\,(-\beta\,\epsilon + 2\,\mu\mathbf{I})\,\mathbf{yE}'[t] + \mathbf{kE}\,(2\,\beta\,\epsilon + (-3+2\,\epsilon)\,\mu\mathbf{I} + \epsilon\,\mu\mathbf{S})\,\mathbf{yI}'[t]) + \\
&\quad\mathbf{yI}[t]^2\,\Big(\mathbf{kI}\,\epsilon\,\Big(\beta\,\epsilon\,(\delta - \mu\mathbf{I}) + \mu\mathbf{I}^2\Big)\,\mathbf{yE}'[t] + \mathbf{kE}\,\Big(-\Big(\beta^2\,\epsilon^2 + \beta\,\epsilon\,((-4+\epsilon)\,\mu\mathbf{I} + \epsilon\,\mu\mathbf{S}) - \\
&\qquad\mu\mathbf{I}\,((-3+\epsilon)\,\mu\mathbf{I} + 2\,\epsilon\,\mu\mathbf{S})\Big)\,\mathbf{yI}'[t] + \epsilon\,\Big(\mathbf{c}\,\mathbf{kI}\,(-\beta\,\epsilon + \mu\mathbf{I})^2 - \beta\,\epsilon\,\mathbf{yI}''[t]\Big)\Big)\Big)\Big) \\
&- \mathbf{kI}\,(\delta + \epsilon\,\mu\mathbf{E})\,\mathbf{yE}[t] - \mathbf{kE}\,(-1+\epsilon)\,\mu\mathbf{I}\,\mathbf{yI}[t] - \mathbf{kI}\,\epsilon\,\mathbf{yE}'[t] + \mathbf{kE}\,\mathbf{yI}'[t] - \mathbf{kE}\,\epsilon\,\mathbf{yI}'[t]
\end{aligned}
$$

```
Monos1 = Sort[
  MonomialList[IPOPish1[t], {yI[t], yI'[t], yI''[t], yE[t], yE'[t], yE''[t]}]]
Monos2 = Sort[MonomialList[IPOPish2[t],
   {yI[t], yI'[t], yI''[t], yE[t], yE'[t], yE''[t]}]]
```

$$\{c\, kE\, kI^3\, \delta^2\, \epsilon\, yE[t]^2,\ (kI^3\, \delta^3 + kI^3\, \delta^2\, \epsilon\, \mu S)\, yE[t]^3,$$
$$(2\, c\, kE^2\, kI^2\, \beta\, \delta\, \epsilon^2 - 2\, c\, kE^2\, kI^2\, \delta\, \epsilon\, \mu I)\, yE[t]\, yI[t],$$
$$(2\, kE\, kI^2\, \beta\, \delta^2\, \epsilon - 3\, kE\, kI^2\, \delta^2\, \mu I + kE\, kI^2\, \delta^2\, \epsilon\, \mu S + kE\, kI^2\, \beta\, \delta\, \epsilon^2\, \mu S - 2\, kE\, kI^2\, \delta\, \epsilon\, \mu I\, \mu S)$$
$$yE[t]^2\, yI[t],\ (c\, kE^3\, kI\, \beta^2\, \epsilon^3 - 2\, c\, kE^3\, kI\, \beta\, \epsilon^2\, \mu I + c\, kE^3\, kI\, \epsilon\, \mu I^2)\, yI[t]^2,$$
$$(kE^2\, kI\, \beta^2\, \delta\, \epsilon^2 - 4\, kE^2\, kI\, \beta\, \delta\, \epsilon\, \mu I + 3\, kE^2\, kI\, \delta\, \mu I^2 + kE^2\, kI\, \beta\, \delta\, \epsilon^2\, \mu S -$$
$$2\, kE^2\, kI\, \delta\, \epsilon\, \mu I\, \mu S - kE^2\, kI\, \beta\, \epsilon^2\, \mu I\, \mu S + kE^2\, kI\, \epsilon\, \mu I^2\, \mu S)\, yE[t]\, yI[t]^2,$$
$$(-kE^3\, \beta^2\, \epsilon^2\, \mu I + 2\, kE^3\, \beta\, \epsilon\, \mu I^2 - kE^3\, \mu I^3 - kE^3\, \beta\, \epsilon^2\, \mu I\, \mu S + kE^3\, \epsilon\, \mu I^2\, \mu S)\, yI[t]^3,$$
$$kI^3\, \delta^2\, \epsilon\, yE[t]^2\, yE'[t],\ (2\, kE\, kI^2\, \beta\, \delta\, \epsilon^2 - 2\, kE\, kI^2\, \delta\, \epsilon\, \mu I)\, yE[t]\, yI[t]\, yE'[t],$$
$$(kE^2\, kI\, \beta\, \delta\, \epsilon^2 - kE^2\, kI\, \beta\, \epsilon^2\, \mu I + kE^2\, kI\, \epsilon\, \mu I^2)\, yI[t]^2\, yE'[t],\ -2\, c\, kE^2\, kI^2\, \delta\, \epsilon\, yE[t]\, yI'[t],$$
$$(-3\, kE\, kI^2\, \delta^2 + kE\, kI^2\, \delta^2\, \epsilon - kE\, kI^2\, \beta\, \delta\, \epsilon^2 - 2\, kE\, kI^2\, \delta\, \epsilon\, \mu S)\, yE[t]^2\, yI'[t],$$
$$(-2\, c\, kE^3\, kI\, \beta\, \epsilon^2 + 2\, c\, kE^3\, kI\, \epsilon\, \mu I)\, yI[t]\, yI'[t],\ (-4\, kE^2\, kI\, \beta\, \delta\, \epsilon + 6\, kE^2\, kI\, \delta\, \mu I -$$
$$2\, kE^2\, kI\, \delta\, \epsilon\, \mu I - 2\, kE^2\, kI\, \delta\, \epsilon\, \mu S - kE^2\, kI\, \beta\, \epsilon^2\, \mu S + 2\, kE^2\, kI\, \epsilon\, \mu I\, \mu S)\, yE[t]\, yI[t]\, yI'[t],$$
$$(-kE^3\, \beta^2\, \epsilon^2 + 4\, kE^3\, \beta\, \epsilon\, \mu I - kE^3\, \beta\, \epsilon^2\, \mu I - 3\, kE^3\, \mu I^2 + kE^3\, \epsilon\, \mu I^2 - kE^3\, \beta\, \epsilon^2\, \mu S + 2\, kE^3\, \epsilon\, \mu I\, \mu S)$$
$$yI[t]^2\, yI'[t],\ -2\, kE\, kI^2\, \delta\, \epsilon\, yE[t]\, yE'[t]\, yI'[t],$$
$$(-kE^2\, kI\, \beta\, \epsilon^2 + 2\, kE^2\, kI\, \epsilon\, \mu I)\, yI[t]\, yE'[t]\, yI'[t],\ c\, kE^3\, kI\, \epsilon\, yI'[t]^2,$$
$$(3\, kE^2\, kI\, \delta - 2\, kE^2\, kI\, \delta\, \epsilon + kE^2\, kI\, \beta\, \epsilon^2 + kE^2\, kI\, \epsilon\, \mu S)\, yE[t]\, yI'[t]^2,$$
$$(2\, kE^3\, \beta\, \epsilon - 3\, kE^3\, \mu I + 2\, kE^3\, \epsilon\, \mu I + kE^3\, \epsilon\, \mu S)\, yI[t]\, yI'[t]^2,\ kE^2\, kI\, \epsilon\, yE'[t]\, yI'[t]^2,$$
$$(-kE^3 + kE^3\, \epsilon)\, yI'[t]^3,\ -kE^2\, kI\, \beta\, \epsilon^2\, yE[t]\, yI[t]\, yI''[t],\ -kE^3\, \beta\, \epsilon^2\, yI[t]^2\, yI''[t]\}$$

$$\{(-kI\, \delta - kI\, \epsilon\, \mu E)\, yE[t],\ (kE\, \mu I - kE\, \epsilon\, \mu I)\, yI[t],\ -kI\, \epsilon\, yE'[t],\ (kE - kE\, \epsilon)\, yI'[t]\}$$

```
Last[Monos2]
```

$$(kE - kE\, \epsilon)\, yI'[t]$$

```
MonicMonos1 = Monos1 / (Last[Monos1] /.
    {yI[t] → 1, yI'[t] → 1, yI''[t] → 1, yE[t] → 1, yE'[t] → 1, yE''[t] → 1})
MonicMonos2 = Monos2 / (Last[Monos2] /. {yI[t] → 1, yI'[t] → 1,
     yI''[t] → 1, yE[t] → 1, yE'[t] → 1, yE''[t] → 1})
```

$$\left\{-\frac{c\, kI^3\, \delta^2\, yE[t]^2}{kE^2\, \beta\, \epsilon},\ -\frac{(kI^3\, \delta^3 + kI^3\, \delta^2\, \epsilon\, \mu S)\, yE[t]^3}{kE^3\, \beta\, \epsilon^2},\right.$$
$$-\frac{(2\, c\, kE^2\, kI^2\, \beta\, \delta\, \epsilon^2 - 2\, c\, kE^2\, kI^2\, \delta\, \epsilon\, \mu I)\, yE[t]\, yI[t]}{kE^3\, \beta\, \epsilon^2},$$
$$-\frac{1}{kE^3\, \beta\, \epsilon^2}(2\, kE\, kI^2\, \beta\, \delta^2\, \epsilon - 3\, kE\, kI^2\, \delta^2\, \mu I + kE\, kI^2\, \delta^2\, \epsilon\, \mu S + kE\, kI^2\, \beta\, \delta\, \epsilon^2\, \mu S - 2\, kE\, kI^2\, \delta\, \epsilon\, \mu I\, \mu S)$$
$$yE[t]^2\, yI[t],\ -\frac{(c\, kE^3\, kI\, \beta^2\, \epsilon^3 - 2\, c\, kE^3\, kI\, \beta\, \epsilon^2\, \mu I + c\, kE^3\, kI\, \epsilon\, \mu I^2)\, yI[t]^2}{kE^3\, \beta\, \epsilon^2},$$
$$-\frac{1}{kE^3\, \beta\, \epsilon^2}(kE^2\, kI\, \beta^2\, \delta\, \epsilon^2 - 4\, kE^2\, kI\, \beta\, \delta\, \epsilon\, \mu I + 3\, kE^2\, kI\, \delta\, \mu I^2 + kE^2\, kI\, \beta\, \delta\, \epsilon^2\, \mu S -$$

$$2\,kE^2\,kI\,\delta\,\epsilon\,\mu I\,\mu S - kE^2\,kI\,\beta\,\epsilon^2\,\mu I\,\mu S + kE^2\,kI\,\epsilon\,\mu I^2\,\mu S\Big)\,yE[t]\,yI[t]^2,$$

$$-\frac{1}{kE^3\,\beta\,\epsilon^2}\Big(-kE^3\,\beta^2\,\epsilon^2\,\mu I + 2\,kE^3\,\beta\,\epsilon\,\mu I^2 - kE^3\,\mu I^3 - kE^3\,\beta\,\epsilon^2\,\mu I\,\mu S + kE^3\,\epsilon\,\mu I^2\,\mu S\Big)\,yI[t]^3,$$

$$-\frac{kI^3\,\delta^2\,yE[t]^2\,yE'[t]}{kE^3\,\beta\,\epsilon},$$

$$-\frac{\Big(2\,kE\,kI^2\,\beta\,\delta\,\epsilon^2 - 2\,kE\,kI^2\,\delta\,\epsilon\,\mu I\Big)\,yE[t]\,yI[t]\,yE'[t]}{kE^3\,\beta\,\epsilon^2},$$

$$-\frac{\Big(kE^2\,kI\,\beta\,\delta\,\epsilon^2 - kE^2\,kI\,\beta\,\epsilon^2\,\mu I + kE^2\,kI\,\epsilon\,\mu I^2\Big)\,yI[t]^2\,yE'[t]}{kE^3\,\beta\,\epsilon^2},\ \frac{2\,c\,kI^2\,\delta\,yE[t]\,yI'[t]}{kE\,\beta\,\epsilon},$$

$$-\frac{1}{kE^3\,\beta\,\epsilon^2}\Big(-3\,kE\,kI^2\,\delta^2 + kE\,kI^2\,\delta^2\,\epsilon - kE\,kI^2\,\beta\,\delta\,\epsilon^2 - 2\,kE\,kI^2\,\delta\,\epsilon\,\mu S\Big)\,yE[t]^2\,yI'[t],$$

$$-\frac{\Big(-2\,c\,kE^3\,kI\,\beta\,\epsilon^2 + 2\,c\,kE^3\,kI\,\epsilon\,\mu I\Big)\,yI[t]\,yI'[t]}{kE^3\,\beta\,\epsilon^2},$$

$$-\frac{1}{kE^3\,\beta\,\epsilon^2}\Big(-4\,kE^2\,kI\,\beta\,\delta\,\epsilon + 6\,kE^2\,kI\,\delta\,\mu I - 2\,kE^2\,kI\,\delta\,\epsilon\,\mu I - 2\,kE^2\,kI\,\delta\,\epsilon\,\mu S -$$

$$kE^2\,kI\,\beta\,\epsilon^2\,\mu S + 2\,kE^2\,kI\,\epsilon\,\mu I\,\mu S\Big)\,yE[t]\,yI[t]\,yI'[t],\ -\frac{1}{kE^3\,\beta\,\epsilon^2}$$

$$\Big(-kE^3\,\beta^2\,\epsilon^2 + 4\,kE^3\,\beta\,\epsilon\,\mu I - kE^3\,\beta\,\epsilon^2\,\mu I - 3\,kE^3\,\mu I^2 + kE^3\,\epsilon\,\mu I^2 - kE^3\,\beta\,\epsilon^2\,\mu S + 2\,kE^3\,\epsilon\,\mu I\,\mu S\Big)$$

$$yI[t]^2\,yI'[t],\ \frac{2\,kI^2\,\delta\,yE[t]\,yE'[t]\,yI'[t]}{kE^2\,\beta\,\epsilon},$$

$$-\frac{\Big(-kE^2\,kI\,\beta\,\epsilon^2 + 2\,kE^2\,kI\,\epsilon\,\mu I\Big)\,yI[t]\,yE'[t]\,yI'[t]}{kE^3\,\beta\,\epsilon^2},\ -\frac{c\,kI\,yI'[t]^2}{\beta\,\epsilon},$$

$$-\frac{1}{kE^3\,\beta\,\epsilon^2}\Big(3\,kE^2\,kI\,\delta - 2\,kE^2\,kI\,\delta\,\epsilon + kE^2\,kI\,\beta\,\epsilon^2 + kE^2\,kI\,\epsilon\,\mu S\Big)\,yE[t]\,yI'[t]^2,$$

$$-\frac{\Big(2\,kE^3\,\beta\,\epsilon - 3\,kE^3\,\mu I + 2\,kE^3\,\epsilon\,\mu I + kE^3\,\epsilon\,\mu S\Big)\,yI[t]\,yI'[t]^2}{kE^3\,\beta\,\epsilon^2},$$

$$-\frac{kI\,yE'[t]\,yI'[t]^2}{kE\,\beta\,\epsilon},\ -\frac{\Big(-kE^3 + kE^3\,\epsilon\Big)\,yI'[t]^3}{kE^3\,\beta\,\epsilon^2},$$

$$\frac{kI\,yE[t]\,yI[t]\,yI''[t]}{kE},\ yI[t]^2\,yI''[t]\Big\}$$

$$\Big\{\frac{(-kI\,\delta - kI\,\epsilon\,\mu E)\,yE[t]}{kE - kE\,\epsilon},\ \frac{(kE\,\mu I - kE\,\epsilon\,\mu I)\,yI[t]}{kE - kE\,\epsilon},\ -\frac{kI\,\epsilon\,yE'[t]}{kE - kE\,\epsilon},\ yI'[t]\Big\}$$

```
Coeffs1 = MonicMonos1 /.
  {yI[t] → 1, yI'[t] → 1, yI''[t] → 1, yE[t] → 1, yE'[t] → 1, yE''[t] → 1}
Coeffs2 = MonicMonos2 /. {yI[t] → 1, yI'[t] → 1,
    yI''[t] → 1, yE[t] → 1, yE'[t] → 1, yE''[t] → 1}
```

$$\left\{-\frac{c\,kI^3\,\delta^2}{kE^2\,\beta\,\epsilon},\ -\frac{kI^3\,\delta^3+kI^3\,\delta^2\,\epsilon\,\mu S}{kE^3\,\beta\,\epsilon^2},\ -\frac{2\,c\,kE^2\,kI^2\,\beta\,\delta\,\epsilon^2-2\,c\,kE^2\,kI^2\,\delta\,\epsilon\,\mu I}{kE^3\,\beta\,\epsilon^2},\right.$$

$$-\frac{1}{kE^3\,\beta\,\epsilon^2}\left(2\,kE\,kI^2\,\beta\,\delta^2\,\epsilon-3\,kE\,kI^2\,\delta^2\,\mu I+kE\,kI^2\,\delta^2\,\epsilon\,\mu S+kE\,kI^2\,\beta\,\delta\,\epsilon^2\,\mu S-2\,kE\,kI^2\,\delta\,\epsilon\,\mu I\,\mu S\right),$$

$$-\frac{c\,kE^3\,kI\,\beta^2\,\epsilon^3-2\,c\,kE^3\,kI\,\beta\,\epsilon^2\,\mu I+c\,kE^3\,kI\,\epsilon\,\mu I^2}{kE^3\,\beta\,\epsilon^2},$$

$$-\frac{1}{kE^3\,\beta\,\epsilon^2}\left(kE^2\,kI\,\beta^2\,\delta\,\epsilon^2-4\,kE^2\,kI\,\beta\,\delta\,\epsilon\,\mu I+3\,kE^2\,kI\,\delta\,\mu I^2+\right.$$
$$\left.kE^2\,kI\,\beta\,\delta\,\epsilon^2\,\mu S-2\,kE^2\,kI\,\delta\,\epsilon\,\mu I\,\mu S-kE^2\,kI\,\beta\,\epsilon^2\,\mu I\,\mu S+kE^2\,kI\,\epsilon\,\mu I^2\,\mu S\right),$$

$$-\frac{1}{kE^3\,\beta\,\epsilon^2}\left(-kE^3\,\beta^2\,\epsilon^2\,\mu I+2\,kE^3\,\beta\,\epsilon\,\mu I^2-kE^3\,\mu I^3-kE^3\,\beta\,\epsilon^2\,\mu I\,\mu S+kE^3\,\epsilon\,\mu I^2\,\mu S\right),$$

$$-\frac{kI^3\,\delta^2}{kE^3\,\beta\,\epsilon},\ -\frac{2\,kE\,kI^2\,\beta\,\delta\,\epsilon^2-2\,kE\,kI^2\,\delta\,\epsilon\,\mu I}{kE^3\,\beta\,\epsilon^2},\ -\frac{kE^2\,kI\,\beta\,\delta\,\epsilon^2-kE^2\,kI\,\beta\,\epsilon^2\,\mu I+kE^2\,kI\,\epsilon\,\mu I^2}{kE^3\,\beta\,\epsilon^2},$$

$$\frac{2\,c\,kI^2\,\delta}{kE\,\beta\,\epsilon},\ -\frac{-3\,kE\,kI^2\,\delta^2+kE\,kI^2\,\beta\,\delta\,\epsilon^2-kE\,kI^2\,\beta\,\delta\,\epsilon^2-2\,kE\,kI^2\,\delta\,\epsilon\,\mu S}{kE^3\,\beta\,\epsilon^2},$$

$$-\frac{-2\,c\,kE^3\,kI\,\beta\,\epsilon^2+2\,c\,kE^3\,kI\,\epsilon\,\mu I}{kE^3\,\beta\,\epsilon^2},\ -\frac{1}{kE^3\,\beta\,\epsilon^2}\left(-4\,kE^2\,kI\,\beta\,\delta\,\epsilon+6\,kE^2\,kI\,\delta\,\mu I-\right.$$
$$\left.2\,kE^2\,kI\,\delta\,\epsilon\,\mu I-2\,kE^2\,kI\,\delta\,\epsilon\,\mu S-kE^2\,kI\,\beta\,\epsilon^2\,\mu S+2\,kE^2\,kI\,\epsilon\,\mu I\,\mu S\right),\ -\frac{1}{kE^3\,\beta\,\epsilon^2}$$
$$\left(-kE^3\,\beta^2\,\epsilon^2+4\,kE^3\,\beta\,\epsilon\,\mu I-kE^3\,\beta\,\epsilon^2\,\mu I-3\,kE^3\,\mu I^2+kE^3\,\epsilon\,\mu I^2-kE^3\,\beta\,\epsilon^2\,\mu S+2\,kE^3\,\epsilon\,\mu I\,\mu S\right),$$

$$\frac{2\,kI^2\,\delta}{kE^2\,\beta\,\epsilon},\ -\frac{-kE^2\,kI\,\beta\,\epsilon^2+2\,kE^2\,kI\,\epsilon\,\mu I}{kE^3\,\beta\,\epsilon^2},\ -\frac{c\,kI}{\beta\,\epsilon},$$

$$-\frac{3\,kE^2\,kI\,\delta-2\,kE^2\,kI\,\delta\,\epsilon+kE^2\,kI\,\beta\,\epsilon^2+kE^2\,kI\,\epsilon\,\mu S}{kE^3\,\beta\,\epsilon^2},$$

$$\left.-\frac{2\,kE^3\,\beta\,\epsilon-3\,kE^3\,\mu I+2\,kE^3\,\epsilon\,\mu I+kE^3\,\epsilon\,\mu S}{kE^3\,\beta\,\epsilon^2},\ -\frac{kI}{kE\,\beta\,\epsilon},\ -\frac{-kE^3+kE^3\,\epsilon}{kE^3\,\beta\,\epsilon^2},\ \frac{kI}{kE},\ 1\right\}$$

$$\left\{\frac{-kI\,\delta-kI\,\epsilon\,\mu E}{kE-kE\,\epsilon},\ \frac{kE\,\mu I-kE\,\epsilon\,\mu I}{kE-kE\,\epsilon},\ -\frac{kI\,\epsilon}{kE-kE\,\epsilon},\ 1\right\}$$

```
Coeffs = Simplify[Union[Coeffs1, Coeffs2]]
```

$$\left\{1,\ \frac{\mathrm{kI}}{\mathrm{kE}},\ -\frac{\mathrm{c\,kI}}{\beta\epsilon},\ -\frac{\mathrm{kI}}{\mathrm{kE}\,\beta\epsilon},\ \frac{2\,\mathrm{kI}^2\,\delta}{\mathrm{kE}^2\,\beta\epsilon},\ \frac{2\,\mathrm{c\,kI}^2\,\delta}{\mathrm{kE}\,\beta\epsilon},\ -\frac{\mathrm{kI}^3\,\delta^2}{\mathrm{kE}^3\,\beta\epsilon},\ -\frac{\mathrm{c\,kI}^3\,\delta^2}{\mathrm{kE}^2\,\beta\epsilon},\ \frac{\mathrm{kI}\,\epsilon}{\mathrm{kE}\,(-1+\epsilon)},\ \frac{1-\epsilon}{\beta\,\epsilon^2},\right.$$

$$\frac{\mathrm{kI}\,(\delta+\epsilon\,\mu\mathrm{E})}{\mathrm{kE}\,(-1+\epsilon)},\ \mu\mathrm{I},\ \frac{\mathrm{kI}\,(\beta\epsilon-2\,\mu\mathrm{I})}{\mathrm{kE}\,\beta\epsilon},\ 2\,\mathrm{c\,kI}\left(1-\frac{\mu\mathrm{I}}{\beta\epsilon}\right),\ \frac{2\,\mathrm{kI}^2\,\delta\,(-\beta\epsilon+\mu\mathrm{I})}{\mathrm{kE}^2\,\beta\epsilon},\ \frac{2\,\mathrm{c\,kI}^2\,\delta\,(-\beta\epsilon+\mu\mathrm{I})}{\mathrm{kE}\,\beta\epsilon},$$

$$-\frac{\mathrm{kI}\left(\beta\epsilon\,(\delta-\mu\mathrm{I})+\mu\mathrm{I}^2\right)}{\mathrm{kE}\,\beta\epsilon},\ -\frac{\mathrm{c\,kI}\,(-\beta\epsilon+\mu\mathrm{I})^2}{\beta\epsilon},\ -\frac{2\,\beta\epsilon-3\,\mu\mathrm{I}+2\,\epsilon\,\mu\mathrm{I}+\epsilon\,\mu\mathrm{S}}{\beta\,\epsilon^2},$$

$$\frac{\mathrm{kI}\,(\delta\,(-3+2\,\epsilon)-\epsilon\,(\beta\epsilon+\mu\mathrm{S}))}{\mathrm{kE}\,\beta\,\epsilon^2},\ \frac{\mathrm{kI}^2\,\delta\,(-\delta\,(-3+\epsilon)+\epsilon\,(\beta\epsilon+2\,\mu\mathrm{S}))}{\mathrm{kE}^2\,\beta\,\epsilon^2},$$

$$-\frac{\mathrm{kI}^3\,\delta^2\,(\delta+\epsilon\,\mu\mathrm{S})}{\mathrm{kE}^3\,\beta\,\epsilon^2},\ \beta+\mu\mathrm{I}-\frac{4\,\mu\mathrm{I}}{\epsilon}+\mu\mathrm{S}-\frac{\mu\mathrm{I}\,((-3+\epsilon)\,\mu\mathrm{I}+2\,\epsilon\,\mu\mathrm{S})}{\beta\,\epsilon^2},$$

$$\frac{\mathrm{kI}\,(-2\,\epsilon\,\mu\mathrm{I}\,\mu\mathrm{S}+\beta\epsilon\,(4\,\delta+\epsilon\,\mu\mathrm{S})+2\,\delta\,((-3+\epsilon)\,\mu\mathrm{I}+\epsilon\,\mu\mathrm{S}))}{\mathrm{kE}\,\beta\,\epsilon^2},$$

$$-\frac{\mathrm{kI}^2\,\delta\,(-3\,\delta\,\mu\mathrm{I}+\delta\,\epsilon\,\mu\mathrm{S}-2\,\epsilon\,\mu\mathrm{I}\,\mu\mathrm{S}+\beta\epsilon\,(2\,\delta+\epsilon\,\mu\mathrm{S}))}{\mathrm{kE}^2\,\beta\,\epsilon^2},\ \frac{(\beta\epsilon-\mu\mathrm{I})\,\mu\mathrm{I}\,(\beta\epsilon-\mu\mathrm{I}+\epsilon\,\mu\mathrm{S})}{\beta\,\epsilon^2},$$

$$\left.-\frac{1}{\mathrm{kE}\,\beta\,\epsilon^2}\mathrm{kI}\left(\beta^2\,\delta\,\epsilon^2+\beta\epsilon\,(-4\,\delta\,\mu\mathrm{I}+\delta\,\epsilon\,\mu\mathrm{S}-\epsilon\,\mu\mathrm{I}\,\mu\mathrm{S})+\mu\mathrm{I}\,(3\,\delta\,\mu\mathrm{I}-2\,\delta\,\epsilon\,\mu\mathrm{S}+\epsilon\,\mu\mathrm{I}\,\mu\mathrm{S})\right)\right\}$$

```
xCoeffs =
 Coeffs /. {β → a1, δ → a2, ϵ → a3, μS → a4, μE → a5,  μI → a6, c → a7, kE → a8, kI → a9}
```

$$\left\{1,\ \frac{a9}{a8},\ -\frac{a7\ a9}{a1\ a3},\ -\frac{a9}{a1\ a3\ a8},\ \frac{2\ a2\ a9^2}{a1\ a3\ a8^2},\ \frac{2\ a2\ a7\ a9^2}{a1\ a3\ a8},\ -\frac{a2^2\ a9^3}{a1\ a3\ a8^3},\right.$$
$$-\frac{a2^2\ a7\ a9^3}{a1\ a3\ a8^2},\ \frac{a3\ a9}{(-1+a3)\ a8},\ \frac{1-a3}{a1\ a3^2},\ \frac{(a2+a3\ a5)\ a9}{(-1+a3)\ a8},\ a6,\ \frac{(a1\ a3-2\ a6)\ a9}{a1\ a3\ a8},$$
$$2\left(1-\frac{a6}{a1\ a3}\right)a7\ a9,\ \frac{2\ a2\ (-a1\ a3+a6)\ a9^2}{a1\ a3\ a8^2},\ \frac{2\ a2\ (-a1\ a3+a6)\ a7\ a9^2}{a1\ a3\ a8},$$
$$-\frac{\left(a1\ a3\ (a2-a6)+a6^2\right)a9}{a1\ a3\ a8},\ -\frac{(-a1\ a3+a6)^2\ a7\ a9}{a1\ a3},\ -\frac{2\ a1\ a3+a3\ a4-3\ a6+2\ a3\ a6}{a1\ a3^2},$$
$$\frac{(a2\ (-3+2\ a3)-a3\ (a1\ a3+a4))\ a9}{a1\ a3^2\ a8},\ \frac{a2\ (-a2\ (-3+a3)+a3\ (a1\ a3+2\ a4))\ a9^2}{a1\ a3^2\ a8^2},$$
$$-\frac{a2^2\ (a2+a3\ a4)\ a9^3}{a1\ a3^2\ a8^3},\ a1+a4+a6-\frac{4\ a6}{a3}-\frac{a6\ (2\ a3\ a4+(-3+a3)\ a6)}{a1\ a3^2},$$
$$\frac{(a1\ a3\ (4\ a2+a3\ a4)-2\ a3\ a4\ a6+2\ a2\ (a3\ a4+(-3+a3)\ a6))\ a9}{a1\ a3^2\ a8},$$
$$-\frac{a2\ (a2\ a3\ a4+a1\ a3\ (2\ a2+a3\ a4)-3\ a2\ a6-2\ a3\ a4\ a6)\ a9^2}{a1\ a3^2\ a8^2},$$
$$\frac{(a1\ a3-a6)\ (a1\ a3+a3\ a4-a6)\ a6}{a1\ a3^2},\ -\frac{1}{a1\ a3^2\ a8}$$
$$\left.\left(a1^2\ a2\ a3^2+a1\ a3\ (a2\ a3\ a4-4\ a2\ a6-a3\ a4\ a6)+a6\ (-2\ a2\ a3\ a4+3\ a2\ a6+a3\ a4\ a6)\right)a9\right\}$$

```
Solve[Coeffs == xCoeffs, {β, δ, ϵ, μS, μE, μI, c, kE, kI}]
```

MessageTemplate[Solve, svars, Equations may not give solutions for all "solve" variables., 2, 25, 1, 33627886200554543902, Local]

$$\left\{\left\{\beta \to a1,\ \delta \to a2,\ \epsilon \to a3,\ \mu S \to a4,\ \mu E \to a5,\ \mu I \to a6,\ c \to \frac{a7\ a9}{kI},\ kE \to \frac{a8\ kI}{a9}\right\}\right\}$$