

$$\text{dSdteqn}[t\_] = -\beta c \text{II}[t, 0] - \mu S c - (D[S[t, a], a] /. a \rightarrow 0)$$

$$\text{dEEdteqn}[t\_] = (1 - \epsilon) \beta c \text{II}[t, 0] - \delta \text{EE}[t, 0] -$$

$$\mu E \text{EE}[t, 0] - D[\text{EE}[t, 0], t] - (D[\text{EE}[t, a], a] /. a \rightarrow 0)$$

$$\text{dIIdteqn}[t\_] = \epsilon \beta c \text{II}[t, 0] + \delta \text{EE}[t, 0] - \mu I \text{II}[t, 0] -$$

$$D[\text{II}[t, 0], t] - (D[\text{II}[t, a], a] /. a \rightarrow 0)$$

$$-c \mu S - c \beta \text{II}[t, 0] - S^{(0,1)}[t, 0]$$

$$-\delta \text{EE}[t, 0] - \mu E \text{EE}[t, 0] + c \beta (1 - \epsilon) \text{II}[t, 0] - \text{EE}^{(0,1)}[t, 0] - \text{EE}^{(1,0)}[t, 0]$$

$$\delta \text{EE}[t, 0] + c \beta \epsilon \text{II}[t, 0] - \mu I \text{II}[t, 0] - \text{II}^{(0,1)}[t, 0] - \text{II}^{(1,0)}[t, 0]$$

$$\text{yEeqn}[t_, a_] = \text{kE} \text{EE}[t, a] - \text{yE}[t, a]$$

$$\text{yIeqn}[t_, a_] = \text{kI} \text{II}[t, a] - \text{yI}[t, a]$$

$$\text{kE} \text{EE}[t, a] - \text{yE}[t, a]$$

$$\text{kI} \text{II}[t, a] - \text{yI}[t, a]$$

$$\text{yEmap}[t_, a_] = \text{Solve}[\text{yEeqn}[t, a] == 0, \text{EE}[t, a]][[1]]$$

$$\text{yImap}[t_, a_] = \text{Solve}[\text{yIeqn}[t, a] == 0, \text{II}[t, a]][[1]]$$

$$\left\{ \text{EE}[t, a] \rightarrow \frac{\text{yE}[t, a]}{\text{kE}} \right\}$$

$$\left\{ \text{II}[t, a] \rightarrow \frac{\text{yI}[t, a]}{\text{kI}} \right\}$$

$$\text{dSdteqn2}[t\_] = \text{dSdteqn}[t] /. (\text{yEmap}[t, a] /. a \rightarrow 0) /. (D[\text{yEmap}[t, a], t] /. a \rightarrow 0) /.$$

$$(D[\text{yEmap}[t, a], a] /. a \rightarrow 0) /. (\text{yImap}[t, a] /. a \rightarrow 0) /.$$

$$(D[\text{yImap}[t, a], t] /. a \rightarrow 0) /. (D[\text{yImap}[t, a], a] /. a \rightarrow 0)$$

$$\text{dEEdteqn2}[t\_] = \text{dEEdteqn}[t] /. (\text{yEmap}[t, a] /. a \rightarrow 0) /. (D[\text{yEmap}[t, a], t] /. a \rightarrow 0) /.$$

$$(D[\text{yEmap}[t, a], a] /. a \rightarrow 0) /. (\text{yImap}[t, a] /. a \rightarrow 0) /.$$

$$(D[\text{yImap}[t, a], t] /. a \rightarrow 0) /. (D[\text{yImap}[t, a], a] /. a \rightarrow 0)$$

$$\text{dIIdteqn2}[t\_] = \text{dIIdteqn}[t] /. (\text{yEmap}[t, a] /. a \rightarrow 0) /. (D[\text{yEmap}[t, a], t] /. a \rightarrow 0) /.$$

$$(D[\text{yEmap}[t, a], a] /. a \rightarrow 0) /. (\text{yImap}[t, a] /. a \rightarrow 0) /.$$

$$(D[\text{yImap}[t, a], t] /. a \rightarrow 0) /. (D[\text{yImap}[t, a], a] /. a \rightarrow 0)$$

$$-c \mu S - \frac{c \beta \text{yI}[t, 0]}{\text{kI}} - S^{(0,1)}[t, 0]$$

$$-\frac{\delta \text{yE}[t, 0]}{\text{kE}} - \frac{\mu E \text{yE}[t, 0]}{\text{kE}} + \frac{c \beta (1 - \epsilon) \text{yI}[t, 0]}{\text{kI}} - \frac{\text{yE}^{(0,1)}[t, 0]}{\text{kE}} - \frac{\text{yE}^{(1,0)}[t, 0]}{\text{kE}}$$

$$\frac{\delta \text{yE}[t, 0]}{\text{kE}} + \frac{c \beta \epsilon \text{yI}[t, 0]}{\text{kI}} - \frac{\mu I \text{yI}[t, 0]}{\text{kI}} - \frac{\text{yI}^{(0,1)}[t, 0]}{\text{kI}} - \frac{\text{yI}^{(1,0)}[t, 0]}{\text{kI}}$$

$$\text{Smap}[t\_] = \text{Solve}[\text{dSdteqn2}[t] == 0, S^{(0,1)}[t, 0]][[1]]$$

$$\left\{ S^{(0,1)}[t, 0] \rightarrow \frac{-c \text{kI} \mu S - c \beta \text{yI}[t, 0]}{\text{kI}} \right\}$$

**dEEdteqn3[t\_] = dEEdteqn2[t] /. Smap[t]**

**dIIdteqn3[t\_] = dIIdteqn2[t] /. Smap[t]**

$$-\frac{\delta yE[t, 0]}{kE} - \frac{\mu E yE[t, 0]}{kE} + \frac{c \beta (1 - \epsilon) yI[t, 0]}{kI} - \frac{yE^{(0,1)}[t, 0]}{kE} - \frac{yE^{(1,0)}[t, 0]}{kE}$$

$$\frac{\delta yE[t, 0]}{kE} + \frac{c \beta \epsilon yI[t, 0]}{kI} - \frac{\mu I yI[t, 0]}{kI} - \frac{yI^{(0,1)}[t, 0]}{kI} - \frac{yI^{(1,0)}[t, 0]}{kI}$$

**IPOPish1[t\_] = Denominator[Together[dEEdteqn3[t]]] Together[dEEdteqn3[t]]**

**IPOPish2[t\_] = Denominator[Together[dIIdteqn3[t]]] Together[dIIdteqn3[t]]**

$$-kI \delta yE[t, 0] - kI \mu E yE[t, 0] + c kE \beta yI[t, 0] - \\ c kE \beta \epsilon yI[t, 0] - kI yE^{(0,1)}[t, 0] - kI yE^{(1,0)}[t, 0]$$

$$kI \delta yE[t, 0] + c kE \beta \epsilon yI[t, 0] - kE \mu I yI[t, 0] - kE yI^{(0,1)}[t, 0] - kE yI^{(1,0)}[t, 0]$$

**Monos1 = Sort[MonomialList[IPOPish1[t], {yI[t, 0], yE[t, 0], (D[yI[t, a], t] /. a → 0), (D[yI[t, a], a] /. a → 0), (D[yE[t, a], t] /. a → 0), (D[yE[t, a], a] /. a → 0)}]]**

**Monos2 = Sort[MonomialList[IPOPish2[t], {yI[t, 0], yE[t, 0], (D[yI[t, a], t] /. a → 0), (D[yI[t, a], a] /. a → 0), (D[yE[t, a], t] /. a → 0), (D[yE[t, a], a] /. a → 0)}]]**

$$\{(-kI \delta - kI \mu E) yE[t, 0], (c kE \beta - c kE \beta \epsilon) yI[t, 0], -kI yE^{(0,1)}[t, 0], -kI yE^{(1,0)}[t, 0]\}$$

$$\{kI \delta yE[t, 0], (c kE \beta \epsilon - kE \mu I) yI[t, 0], -kE yI^{(0,1)}[t, 0], -kE yI^{(1,0)}[t, 0]\}$$

**MonicMonos1 =**

**Monos1 / (Last[Monos1] /. {yI[t, 0] → 1, yE[t, 0] → 1, (D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1})**

**MonicMonos2 = Monos2 / (Last[Monos2] /. {yI[t, 0] → 1, yE[t, 0] → 1,**

**(D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1})**

$$\left\{ -\frac{(-kI \delta - kI \mu E) yE[t, 0]}{kI}, -\frac{(c kE \beta - c kE \beta \epsilon) yI[t, 0]}{kI}, yE^{(0,1)}[t, 0], yE^{(1,0)}[t, 0] \right\}$$

$$\left\{ -\frac{kI \delta yE[t, 0]}{kE}, -\frac{(c kE \beta \epsilon - kE \mu I) yI[t, 0]}{kE}, yI^{(0,1)}[t, 0], yI^{(1,0)}[t, 0] \right\}$$

**Coeffs1 = MonicMonos1 /.**

**{yI[t, 0] → 1, yE[t, 0] → 1, (D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1}**

**Coeffs2 = MonicMonos2 /. {yI[t, 0] → 1, yE[t, 0] → 1,**

**(D[yI[t, a], t] /. a → 0) → 1, (D[yI[t, a], a] /. a → 0) → 1, (D[yE[t, a], t] /. a → 0) → 1, (D[yE[t, a], a] /. a → 0) → 1}**

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

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

**Coeffs = Union[Coeffs1, Coeffs2]**

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

**TeXForm[Coeffs]**

$\left\{1, -\frac{\delta \text{kI}}{\text{kE}}, -\frac{\beta c \text{kE} - \beta c \text{tE}}{\text{kI}}, -\frac{\beta c \text{kE} \epsilon - \text{kE} \text{tE}}{\epsilon \text{kI}}\right\}$

**xCoeffs = Coeffs /. { $\beta \rightarrow a1$ ,  $\delta \rightarrow a2$ ,  $\epsilon \rightarrow a3$ ,  $\mu E \rightarrow a5$ ,  $c \rightarrow a7$ ,  $kE \rightarrow a8$ ,  $kI \rightarrow a9$ }**

$\left\{1, -\frac{a2 a9}{a8}, -\frac{a1 a7 a8 - a1 a3 a7 a8}{a9}, -\frac{-a2 a9 - a5 a9}{a9}, -\frac{a1 a3 a7 a8 - a8 \mu I}{a8}\right\}$

**Solve[Coeffs == xCoeffs, { $\beta$ ,  $\delta$ ,  $\epsilon$ ,  $\mu E$ ,  $c$ ,  $kE$ ,  $kI$ }]**

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$\left\{\left\{\delta \rightarrow \frac{a1 a2 (-1 + a3) a7}{a1 a3 a7 - c \beta}, \epsilon \rightarrow \frac{a1 a3 a7}{c \beta}, \mu E \rightarrow \frac{a1 a2 a7 + a1 a3 a5 a7 - a2 c \beta - a5 c \beta}{a1 a3 a7 - c \beta}, kI \rightarrow \frac{a9 kE (a1 a3 a7 - c \beta)}{a1 (-1 + a3) a7 a8}\right\}\right\}$