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Lampiran 1. Sintaks program untuk memperoleh solusi kestabilan yang mungkin.

```

> restart :
> with(linalg) :
> f1 := (1 - c)·π - β1·x1·x4 - q·β2·x1·x5 - β3·x1·x6 - μ·x1 :
> f2 := c·π - (1 - σ)·βv·x2·x4 - μ·x2 :
> f3 := q·β1·x1·x4 + (1 - σ)·βv·x2·x4 - (φ + ε + μ)·x3 :
> f4 := (1 - q)·β1·x1·x4 + ε·x3 - (α2 + ω1 + μ1)·x4 :
> f5 := q·β2·x1·x5 - (α1 + μ2)·x5 :
> f6 := α1·x5 + α2·x4 + (β3·x1 - ω2 - μ3)·x6 :
> f7 := ω1·x4 + ω2·x6 - (τ + μ)·x7 :
> f8 := φ·x3 + τ·x7 - μ·x8 :
> T := solve( {f1 = 0, f2 = 0, f3 = 0, f4 = 0, f5 = 0, f6 = 0, f7 = 0, f8
    = 0}, [x1, x2, x3, x4, x5, x6, x7, x8])
    [Length of output exceeds limit of 1000000]
> jacob := jacobian(vector([f1, f2, f3, f4, f5, f6, f7, f8]), [x1, x2, x3, x4,
    x5, x6, x7, x8]) :
> fix := T[1] :
> job1 := subs(fix, evalm(jacob)) :
> eigenvalues(job1) :

```

## Lampiran 2. Sintaks program untuk simulasi solusi kestabilan

```

> #Hasil Simulasi Kesetimbangan Bebas Penyakit
> restart :
> with(linalg) : with(plots) : with(DEtools) :
>  $\beta 1 := 0.002 : \beta 2 := 0.003 : \beta 3 := 0.02 : \beta v := 0.35 : c := 0.01 : \sigma$ 
   := 0.01 :  $\omega 1 := 0.01 : \omega 2 := 0.01 :$ 
>  $\pi := 0.027 : \mu := 0.7 : \mu 1 := 0.3 : \mu 2 := 0.5 : \mu 3 := 0.9 : q := 0.5 :$ 
    $\alpha 1 := 0.01 : \alpha 2 := 0.01 : \epsilon := 0.0003 : \varphi := 0.058 : \tau := 0.03 :$ 
>  $R1 := \frac{1}{\mu \cdot (\varphi + \epsilon + \mu 1) \cdot (\alpha 2 + \omega 1 + \mu 1)} (\pi \cdot ((\varphi + \epsilon + \mu 1) \cdot (1$ 
    $- q) \cdot \beta 1 \cdot (1 - c) - (q \cdot \beta 1 \cdot (1 - c) + (1 - \sigma) \cdot \beta v \cdot c) \cdot \epsilon)); R2$ 
   :=  $\frac{q \cdot \beta 2 \cdot (1 - c) \cdot \pi}{\mu \cdot (\alpha 1 + \mu 2)}$ ;  $R3 := \frac{\beta 3 \cdot (1 - c) \cdot \pi}{\mu \cdot (\omega 2 + \mu 3)}$ ;  $R0 := \max([R1,$ 
    $R2, R3]);$ 

```

$R1 := 0.0001188807451$

$R2 := 0.0001123109244$

$R3 := 0.0008392464678$

$R0 := 0.0008392464678$

```

>
>  $f1 := (1 - c) \cdot \pi - \beta 1 \cdot x1 \cdot x4 - q \cdot \beta 2 \cdot x1 \cdot x5 - \beta 3 \cdot x1 \cdot x6 - \mu \cdot x1 :$ 
>  $f2 := c \cdot \pi - (1 - \sigma) \cdot \beta v \cdot x2 \cdot x4 - \mu \cdot x2 :$ 
>  $f3 := q \cdot \beta 1 \cdot x1 \cdot x4 + (1 - \sigma) \cdot \beta v \cdot x2 \cdot x4 - (\varphi + \epsilon + \mu) \cdot x3 :$ 
>  $f4 := (1 - q) \cdot \beta 1 \cdot x1 \cdot x4 + \epsilon \cdot x3 - (\alpha 2 + \omega 1 + \mu 1) \cdot x4 :$ 
>  $f5 := q \cdot \beta 2 \cdot x1 \cdot x5 - (\alpha 1 + \mu 2) \cdot x5 :$ 
>  $f6 := \alpha 1 \cdot x5 + \alpha 2 \cdot x4 + (\beta 3 \cdot x1 - \omega 2 - \mu 3) \cdot x6 :$ 
>  $f7 := \omega 1 \cdot x4 + \omega 2 \cdot x6 - (\tau + \mu) \cdot x7 :$ 
>  $f8 := \varphi \cdot x3 + \tau \cdot x7 - \mu \cdot x8 :$ 
>  $T := solve(\{f1 = 0, f2 = 0, f3 = 0, f4 = 0, f5 = 0, f6 = 0, f7 = 0, f8$ 
   = 0\}, [x1, x2, x3, x4, x5, x6, x7, x8])

```

```

T := [[x1 = 4.443109610, x2 = 0.04487989505, x3 = 0., x4 = 0., x5
      = 0., x6 = 0., x7 = 0., x8 = 0.], [x1 = 45.50000000, x2
      = 0.04487989505, x3 = 0., x4 = 0., x5 = 0., x6 = -31.58222338, x7
      = -0.4326331969, x8 = -0.01854142273], [x1 = 340., x2
      = 0.04487989505, x3 = 0., x4 = 0., x5 = -471.2357570, x6
      = 0.8000607080, x7 = 0.01095973573, x8 = 0.0004697029597],
[x1 = 340., x2 = -146.8783069, x3 = 134.7212873, x4 =
-2.020819310, x5 = -468.5257295, x6 = 0.7988905753, x7 =
-0.01673874979, x8 = 11.16190357], [x1 = 319.8734866, x2 =
-0.0002593993944, x3 = -148.2503569, x4 = -351.5447445, x5
= 0., x6 = 0.6406317695, x7 = -4.806905654, x8 =
-12.48961124], [x1 = 4.472067605, x2 = 2301.717071, x3 =
-2124.725792, x4 = -2.020162629, x5 = 0., x6 =
-0.02461935700, x7 = -0.02801071214, x8 = -176.0499089], [x1
= 45.46780913, x2 = 2002.540837, x3 = -1848.660190, x4 =
-2.020156744, x5 = 0., x6 = -31.37778794, x7 = -0.4575060916,
x8 = -153.1943089]]

```

> *jacob* := *jacobian*(*vector*([*f1*, *f2*, *f3*, *f4*, *f5*, *f6*, *f7*, *f8*]), [x1, x2, x3, x4, x5, x6, x7, x8])

```

jacob := [[ -0.002 x4 - 0.0015 x5 - 0.02 x6 - 0.7, 0, 0, -0.002 x1,
            -0.0015 x1, -0.02 x1, 0, 0],
[ 0, -0.3465 x4 - 0.7, 0, -0.3465 x2, 0, 0, 0, 0],
[ 0.0010 x4, 0.3465 x4, -0.7583, 0.0010 x1 + 0.3465 x2, 0, 0, 0, 0],
[ 0.0010 x4, 0, 0.0003, 0.0010 x1 - 0.32, 0, 0, 0, 0],
[ 0.0015 x5, 0, 0, 0, 0.0015 x1 - 0.51, 0, 0, 0],
[ 0.02 x6, 0, 0, 0.01, 0.01, 0.02 x1 - 0.91, 0, 0],
[ 0, 0, 0, 0.01, 0, 0.01, -0.73, 0],
[ 0, 0, 0.058, 0, 0, 0, 0.03, -0.7]]

```

> *fix* := *T*[1]

```

fix := [x1 = 4.443109610, x2 = 0.04487989505, x3 = 0., x4 = 0., x5
        = 0., x6 = 0., x7 = 0., x8 = 0.]

```

> *job1* := *subs*(*fix*, *evalm*(*jacob*))

```

job1 := [[ -0.7, 0, 0, -0.008886219220, -0.006664664415,
           -0.08886219220, 0, 0],
          [0, -0.7, 0, -0.01555088363, 0, 0, 0, 0],
          [0, 0, -0.7583, 0.01999399324, 0, 0, 0, 0],
          [0, 0, 0, 0.0003, -0.3155568904, 0, 0, 0, 0],
          [0, 0, 0, 0, -0.5033353356, 0, 0, 0],
          [0, 0, 0, 0.01, 0.01, -0.8211378078, 0, 0],
          [0, 0, 0, 0.01, 0, 0.01, -0.73, 0],
          [0, 0, 0, 0.058, 0, 0, 0, 0.03, -0.7]]

```

```

> eigenvalues(job1)
-0.7000000000000000, -0.7000000000000000, -0.7000000000000000,
-0.7300000000000000, -0.8211378078000000,
-0.758313547391953, -0.315543343008047,
-0.5033353356000000

```

```

> Jadi, untuk bebas penyakit, T1 yang stabil atau [T0 stabil]
    Jadi, untuk bebas penyakit, T1 yang stabil atau [T0 stabil]

```

```

> #Hasil Simulasi Kesetimbangan Endemik

```

```

> restart :

```

```

> with(linalg) : with(plots) : with(DEtools) :

```

```

> beta1 := 0.6 : beta2 := 0.9 : beta3 := 0.85 : beta_v := 0.35 : c := 0.01 : sigma
    := 0.01 : omega1 := 0.01 : omega2 := 0.01 :

```

```

> pi := 1.33 : mu := 0.7 : mu1 := 0.3 : mu2 := 0.5 : mu3 := 0.9 : q := 0.5 :
    alpha1 := 0.01 : alpha2 := 0.01 : epsilon := 0.0003 : phi := 0.058 : tau := 0.03 :

```

```

> R1 := 1 / (mu * (phi + epsilon + mu1) * (alpha2 + omega1 + mu1) * (pi * ((phi + epsilon + mu1) * (1
    - q) * beta1 * (1 - c) - (q * beta1 * (1 - c) + (1 - sigma) * beta_v * c) * epsilon))); R2
    := q * beta2 * (1 - c) * pi / (mu * (alpha1 + mu2)); R3 := beta3 * (1 - c) * pi / (mu * (omega2 + mu3)); R0 := max([R1,
    R2, R3]);

```

```

R1 := 1.761943771

```

```

R2 := 1.659705882

```

```

R3 := 1.756978022

```

```

R0 := 1.761943771

```

```

> f1 := (1 - c) * pi - beta1 * x1 * x4 - q * beta2 * x1 * x5 - beta3 * x1 * x6 - mu * x1 :

```

```

> f2 := c * pi - (1 - sigma) * beta_v * x2 * x4 - mu * x2 :

```

```

> f3 := q * beta1 * x1 * x4 + (1 - sigma) * beta_v * x2 * x4 - (phi + epsilon + mu) * x3 :

```

```

> f4 := (1 - q) * beta1 * x1 * x4 + epsilon * x3 - (alpha2 + omega1 + mu1) * x4 :

```

```

> f5 := q * beta2 * x1 * x5 - (alpha1 + mu2) * x5 :

```

```

> f6 := alpha1 * x5 + alpha2 * x4 + (beta3 * x1 - omega2 - mu3) * x6 :

```

- >  $f7 := \omega1 \cdot x4 + \omega2 \cdot x6 - (\tau + \mu) \cdot x7$ ;  
 >  $f8 := \varphi \cdot x3 + \tau \cdot x7 - \mu \cdot x8$ ;  
 >  $T := solve(\{f1 = 0, f2 = 0, f3 = 0, f4 = 0, f5 = 0, f6 = 0, f7 = 0, f8 = 0\}, [x1, x2, x3, x4, x5, x6, x7, x8])$
- $T := [[x1 = 4.443109610, x2 = 0.04487989505, x3 = 0., x4 = 0., x5 = 0., x6 = 0., x7 = 0., x8 = 0.], [x1 = 1.133333333, x2 = 0.04487989505, x3 = 0., x4 = 0., x5 = 7.034059639, x6 = -1.318886182, x7 = -0.01806693401, x8 = -0.0007742971717], [x1 = 1.070588235, x2 = 0.04487989505, x3 = 0., x4 = 0., x5 = 0., x6 = 2.594247211, x7 = 0.03553763303, x8 = 0.001523041416], [x1 = 1.133333333, x2 = -146.8783069, x3 = 134.7212873, x4 = -2.020819310, x5 = 10.09788246, x6 = -1.514449341, x7 = -0.04842833769, x8 = 11.16054545], [x1 = 1.066229973, x2 = 0.03254202722, x3 = 0.3344777244, x4 = 0.7659321696, x5 = 0., x6 = 2.067559523, x7 = 0.03881495469, x8 = 0.02937736665], [x1 = 1.076535551, x2 = -22.52968407, x3 = 19.97685519, x4 = -2.024226331, x5 = 0., x6 = 4.004231366, x7 = 0.02712335664, x8 = 1.656387574], [x1 = -6.039659393, x2 = 15557.11096, x3 = -14356.17285, x4 = -2.020196192, x5 = 0., x6 = -0.003342642236, x7 = -0.02771971006, x8 = -1189.512652]]$
- >  $jcob := jacobian(vector([f1, f2, f3, f4, f5, f6, f7, f8]), [x1, x2, x3, x4, x5, x6, x7, x8])$
- $jcob := [[-0.6 x4 - 0.45 x5 - 0.85 x6 - 0.7, 0, 0, -0.6 x1, -0.45 x1, -0.85 x1, 0, 0], [0, -0.3465 x4 - 0.7, 0, -0.3465 x2, 0, 0, 0, 0], [0.30 x4, 0.3465 x4, -0.7583, 0.30 x1 + 0.3465 x2, 0, 0, 0, 0], [0.30 x4, 0, 0.0003, 0.30 x1 - 0.32, 0, 0, 0, 0], [0.45 x5, 0, 0, 0, 0.45 x1 - 0.51, 0, 0, 0], [0.85 x6, 0, 0, 0.01, 0.01, 0.85 x1 - 0.91, 0, 0], [0, 0, 0, 0.01, 0, 0.01, -0.73, 0], [0, 0, 0.058, 0, 0, 0.03, -0.7]]$
- >  $fix := T[1]$   
 $fix := [x1 = 4.443109610, x2 = 0.04487989505, x3 = 0., x4 = 0., x5 = 0., x6 = 0., x7 = 0., x8 = 0.]$
- >  $job1 := subs(fix, evalm(jcob))$



```

job1 := [[ -0.7, 0, 0, -2.665865766, -1.999399324, -3.776643168, 0, 0],
          [ 0, -0.7, 0, -0.01555088363, 0, 0, 0, 0],
          [ 0, 0, -0.7583, 1.348483767, 0, 0, 0, 0],
          [ 0, 0, 0.0003, 1.012932883, 0, 0, 0, 0],
          [ 0, 0, 0, 0, 1.489399324, 0, 0, 0],
          [ 0, 0, 0, 0.01, 0.01, 2.866643168, 0, 0],
          [ 0, 0, 0, 0.01, 0, 0.01, -0.73, 0],
          [ 0, 0, 0.058, 0, 0, 0, 0.03, -0.7]]

```

> *eigenvalues(job1)*

```

-0.7000000000000000, -0.7000000000000000, -0.7000000000000000,
-0.7300000000000000, 2.866643168000000,
-0.758528368037891, 1.01316125103789, 1.489399324000000

```

> *fix2 := T[3]*

```

fix2 := [x1 = 1.070588235, x2 = 0.04487989505, x3 = 0., x4 = 0., x5
         = 0., x6 = 2.594247211, x7 = 0.03553763303, x8
         = 0.001523041416]

```

> *job3 := subs(fix2, evalm(jcob))*

```

job3 := [[ -2.905110129, 0, 0, -0.6423529410, -0.4817647058,
           -0.9099999998, 0, 0],
          [ 0, -0.7, 0, -0.01555088363, 0, 0, 0, 0],
          [ 0, 0, -0.7583, 0.3367273541, 0, 0, 0, 0],
          [ 0, 0, 0.0003, 0.0011764705, 0, 0, 0, 0],
          [ 0, 0, 0, 0, -0.0282352942, 0, 0, 0],
          [ 2.205110129, 0, 0, 0.01, 0.01, -2. 10-10, 0, 0],
          [ 0, 0, 0, 0.01, 0, 0.01, -0.73, 0],
          [ 0, 0, 0.058, 0, 0, 0, 0.03, -0.7]]

```

> *eigenvalues(job3)*

```

-0.7000000000000000, -0.7000000000000000, -0.7300000000000000,
-1.77390533792354, 0.00130945753067514,
-1.13120479127647, -0.758432987030675,
-0.0282352942000000

```

> *fix4 := T[5]*

```

fix4 := [x1 = 1.066229973, x2 = 0.03254202722, x3 = 0.3344777244,
         x4 = 0.7659321696, x5 = 0., x6 = 2.067559523, x7
         = 0.03881495469, x8 = 0.02937736665]

```

- >  $job5 := subs(fix4, evalm(jcob))$   
 $job5 := [[ -2.916984897, 0, 0, -0.6397379838, -0.4798034878,$   
 $-0.9062954770, 0, 0],$   
 $[0, -0.9653954968, 0, -0.01127581243, 0, 0, 0, 0],$   
 $[0.2297796509, 0.2653954968, -0.7583, 0.3311448043, 0, 0, 0, 0],$   
 $[0.2297796509, 0, 0.0003, -0.0001310081, 0, 0, 0, 0],$   
 $[0, 0, 0, 0, -0.0301965122, 0, 0, 0],$   
 $[1.757425595, 0, 0, 0.01, 0.01, -0.0037045230, 0, 0],$   
 $[0, 0, 0, 0.01, 0, 0.01, -0.73, 0],$   
 $[0, 0, 0.058, 0, 0, 0, 0.03, -0.7]]$
  
- >  $eigenvalues(job5)$   
 $-0.7000000000000000, -0.7300000000000000, -2.07948678496962,$   
 $-0.00150590685337147, -0.758660001059819,$   
 $-0.839458613307186, -0.965404618710008,$   
 $-0.0301965122000000$
  
- > *Jadi, untuk endemik, titik T5 yang stabil*  
*Jadi, untuk endemik, titik T5 yang stabil*

## Lampiran 3. Sintaks program untuk plot kestabilan

```

> #Hasil Plot Kesetimbangan Bebas Penyakit
> restart :
> with(linalg) : with(plots) : with(DEtools) :
>  $\beta_1 := 0.002 : \beta_2 := 0.003 : \beta_3 := 0.02 : \beta_v := 0.35 : c := 0.01 : \sigma$ 
   := 0.01 :  $\omega_1 := 0.01 : \omega_2 := 0.01 :$ 
>  $\pi := 0.027 : \mu := 0.7 : \mu_1 := 0.3 : \mu_2 := 0.5 : \mu_3 := 0.9 : q := 0.5 :$ 
    $\alpha_1 := 0.01 : \alpha_2 := 0.01 : \varepsilon := 0.0003 : \varphi := 0.058 : \tau := 0.03 :$ 
>
>  $R1 := \frac{1}{\mu \cdot (\varphi + \varepsilon + \mu_1) \cdot (\alpha_2 + \omega_1 + \mu_1)} (\pi \cdot ((\varphi + \varepsilon + \mu_1) \cdot (1$ 
   -  $q) \cdot \beta_1 \cdot (1 - c) - (q \cdot \beta_1 \cdot (1 - c) + (1 - \sigma) \cdot \beta_v \cdot c) \cdot \varepsilon)); R2$ 
   :=  $\frac{q \cdot \beta_2 \cdot (1 - c) \cdot \pi}{\mu \cdot (\alpha_1 + \mu_2)}$ ;  $R3 := \frac{\beta_3 \cdot (1 - c) \cdot \pi}{\mu \cdot (\omega_2 + \mu_3)}$ ;  $R0 := \max([R1,$ 
    $R2, R3]);$ 

```

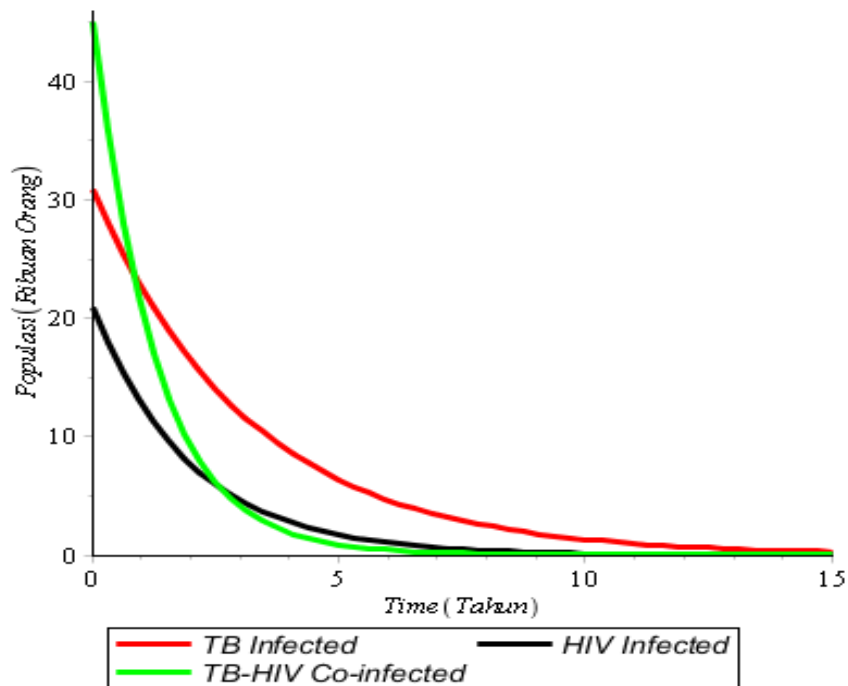
$R1 := 0.0001188807451$   
 $R2 := 0.0001123109244$   
 $R3 := 0.0008392464678$   
 $R0 := 0.0008392464678$

```

>  $B1 := \frac{d}{dt}x1(t) = (1 - c) \cdot \pi - \beta_1 \cdot x1(t) \cdot x4(t) - q \cdot \beta_2 \cdot x1(t) \cdot x5(t)$ 
   -  $\beta_3 \cdot x1(t) \cdot x6(t) - \mu \cdot x1(t) :$ 
>  $B2 := \frac{d}{dt}x2(t) = c \cdot \pi - (1 - \sigma) \cdot \beta_v \cdot x2(t) \cdot x4(t) - \mu \cdot x2(t) :$ 
>  $B3 := \frac{d}{dt}x3(t) = q \cdot \beta_1 \cdot x1(t) \cdot x4(t) + (1 - \sigma) \cdot \beta_v \cdot x2(t) \cdot x4(t) - (\varphi$ 
   +  $\varepsilon + \mu_1) \cdot x3(t) :$ 
>  $B4 := \frac{d}{dt}x4(t) = (1 - q) \cdot \beta_1 \cdot x1(t) \cdot x4(t) + \varepsilon \cdot x3(t) - (\alpha_2 + \omega_1$ 
   +  $\mu_1) \cdot x4(t) :$ 
>  $B5 := \frac{d}{dt}x5(t) = q \cdot \beta_2 \cdot x1(t) \cdot x5(t) - (\alpha_1 + \mu_2) \cdot x5(t) :$ 
>  $B6 := \frac{d}{dt}x6(t) = \alpha_1 \cdot x5(t) + \alpha_2 \cdot x4(t) + (\beta_3 \cdot x1(t) - \omega_2 - \mu_3)$ 
    $\cdot x6(t) :$ 
>  $B7 := \frac{d}{dt}x7(t) = \omega_1 \cdot x4(t) + \omega_2 \cdot x6(t) - (\tau + \mu) \cdot x7(t) :$ 
>  $B8 := \frac{d}{dt}x8(t) = \varphi \cdot x3(t) + \tau \cdot x7(t) - \mu \cdot x8(t) :$ 
>

```

- >  $s11 := DEplot([B1, B2, B3, B4, B5, B6, B7, B8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..31, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x4(t)]) :$
- >  $s21 := DEplot([B1, B2, B3, B4, B5, B6, B7, B8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..21, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[black], arrows=medium, scene=[t, x5(t)]) :$
- >  $s31 := DEplot([B1, B2, B3, B4, B5, B6, B7, B8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..46, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x6(t)]) :$
- >  $display([s11, s21, s31], labels=[Time(Tahun), Populasi(Ribuan Orang)], labeldirections=[horizontal, vertical])$



```

> #Hasil Plot Kesetimbangan Endemik
> restart :
> with(linalg) : with(plots) : with(DEtools) :
>  $\beta_1 := 0.6 : \beta_2 := 0.9 : \beta_3 := 0.85 : \beta_v := 0.35 : c := 0.01 : \sigma$ 
   := 0.01 :  $\omega_1 := 0.01 : \omega_2 := 0.01 :$ 
>  $\pi := 1.33 : \mu := 0.7 : \mu_1 := 0.3 : \mu_2 := 0.5 : \mu_3 := 0.9 : q := 0.5 :$ 
    $\alpha_1 := 0.01 : \alpha_2 := 0.01 : \varepsilon := 0.0003 : \varphi := 0.058 : \tau := 0.03 :$ 
>  $R1 := \frac{1}{\mu \cdot (\varphi + \varepsilon + \mu_1) \cdot (\alpha_2 + \omega_1 + \mu_1)}$  ( $\pi \cdot ((\varphi + \varepsilon + \mu_1) \cdot (1$ 
    $- q) \cdot \beta_1 \cdot (1 - c) - (q \cdot \beta_1 \cdot (1 - c) + (1 - \sigma) \cdot \beta_v \cdot c) \cdot \varepsilon)$ );  $R2$ 
   :=  $\frac{q \cdot \beta_2 \cdot (1 - c) \cdot \pi}{\mu \cdot (\alpha_1 + \mu_2)}$ ;  $R3 := \frac{\beta_3 \cdot (1 - c) \cdot \pi}{\mu \cdot (\omega_2 + \mu_3)}$ ;  $R0 := \max([R1,$ 
    $R2, R3])$ ;

```

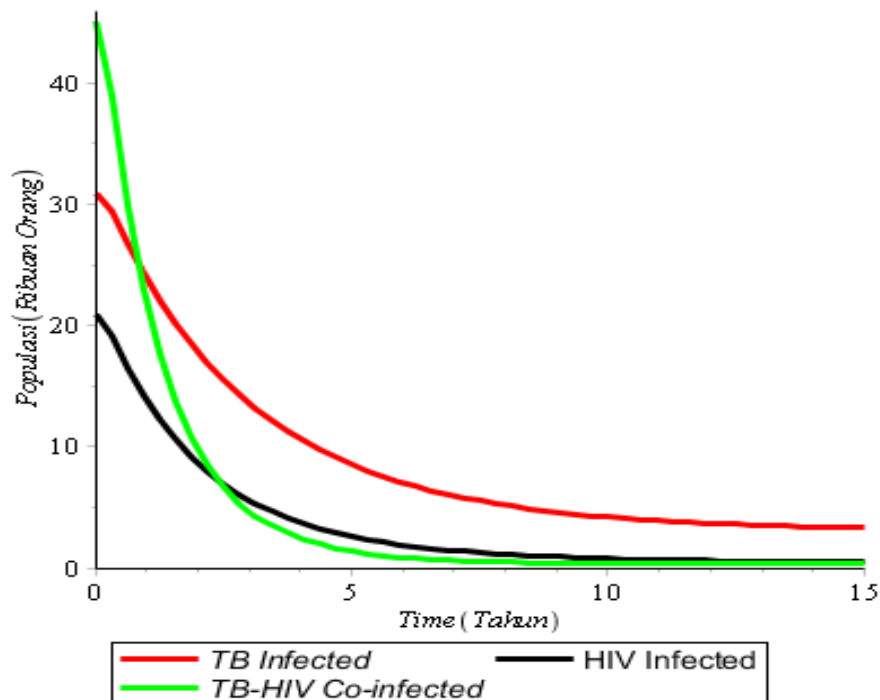
$R1 := 1.761943771$   
 $R2 := 1.659705882$   
 $R3 := 1.756978022$   
 $R0 := 1.761943771$

```

>  $B1 := \frac{d}{dt}x1(t) = (1 - c) \cdot \pi - \beta_1 \cdot x1(t) \cdot x4(t) - q \cdot \beta_2 \cdot x1(t) \cdot x5(t)$ 
    $- \beta_3 \cdot x1(t) \cdot x6(t) - \mu \cdot x1(t) :$ 
>  $B2 := \frac{d}{dt}x2(t) = c \cdot \pi - (1 - \sigma) \cdot \beta_v \cdot x2(t) \cdot x4(t) - \mu \cdot x2(t) :$ 
>  $B3 := \frac{d}{dt}x3(t) = q \cdot \beta_1 \cdot x1(t) \cdot x4(t) + (1 - \sigma) \cdot \beta_v \cdot x2(t) \cdot x4(t) - (\varphi$ 
    $+ \varepsilon + \mu_1) \cdot x3(t) :$ 
>  $B4 := \frac{d}{dt}x4(t) = (1 - q) \cdot \beta_1 \cdot x1(t) \cdot x4(t) + \varepsilon \cdot x3(t) - (\alpha_2 + \omega_1$ 
    $+ \mu_1) \cdot x4(t) :$ 
>  $B5 := \frac{d}{dt}x5(t) = q \cdot \beta_2 \cdot x1(t) \cdot x5(t) - (\alpha_1 + \mu_2) \cdot x5(t) :$ 
>  $B6 := \frac{d}{dt}x6(t) = \alpha_1 \cdot x5(t) + \alpha_2 \cdot x4(t) + (\beta_3 \cdot x1(t) - \omega_2 - \mu_3)$ 
    $\cdot x6(t) :$ 
>  $B7 := \frac{d}{dt}x7(t) = \omega_1 \cdot x4(t) + \omega_2 \cdot x6(t) - (\tau + \mu) \cdot x7(t) :$ 
>  $B8 := \frac{d}{dt}x8(t) = \varphi \cdot x3(t) + \tau \cdot x7(t) - \mu \cdot x8(t) :$ 
>

```

- >  $p12 := DEplot([B1, B2, B3, B4, B5, B6, B7, B8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..31, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x4(t)]) :$
- >  $p22 := DEplot([B1, B2, B3, B4, B5, B6, B7, B8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..21, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[black], arrows=medium, scene=[t, x5(t)]) :$
- >  $p32 := DEplot([B1, B2, B3, B4, B5, B6, B7, B8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..46, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x6(t)]) :$
- >  $display([p12, p22, p32], labels=[Time(Tahun), Populasi(Ribuan Orang)], labeldirections=[horizontal, vertical])$



#### Lampiran 4. Sintaks program untuk plot laju tingkat efektivitas vaksinasi dan pengobatan

- > #Grafik untuk nilai parameter laju tingkat Efektivitas Vaksinasi dan pengobatan ( $c = 0.09$  dan  $\tau = 0.3$ )
- > restart :
- > with(linalg) : with(plots) : with(DEtools) :
- >  $\beta 1 := 0.6 : \beta 2 := 0.9 : \beta 3 := 0.85 : \beta v := 0.35 : c := 0.09 : \sigma := 0.01 : \omega 1 := 0.01 : \omega 2 := 0.01 :$
- >  $pi := 1.33 : \mu := 0.7 : \mu 1 := 0.3 : \mu 2 := 0.5 : \mu 3 := 0.9 : q := 0.5 : \alpha 1 := 0.01 : \alpha 2 := 0.01 : \varepsilon := 0.0003 : \varphi := 0.058 : \tau := 0.3 :$
- >  $R1 := \frac{1}{\mu \cdot (\varphi + \varepsilon + \mu 1) \cdot (\alpha 2 + \omega 1 + \mu 1)} (pi \cdot ((\varphi + \varepsilon + \mu 1) \cdot (1 - q) \cdot \beta 1 \cdot (1 - c) - (q \cdot \beta 1 \cdot (1 - c) + (1 - \sigma) \cdot \beta v \cdot c) \cdot \varepsilon)) ; R2 := \frac{q \cdot \beta 2 \cdot (1 - c) \cdot pi}{\mu \cdot (\alpha 1 + \mu 2)} ; R3 := \frac{\beta 3 \cdot (1 - c) \cdot pi}{\mu \cdot (\omega 2 + \mu 3)} ; R0 := \max([R1, R2, R3]);$ 
  - $R1 := 1.619425278$
  - $R2 := 1.525588235$
  - $R3 := 1.615000000$
  - $R0 := 1.619425278$
- >  $T1 := \frac{d}{dt} x1(t) = (1 - c) \cdot \pi - \beta 1 \cdot x1(t) \cdot x4(t) - q \cdot \beta 2 \cdot x1(t) \cdot x5(t) - \beta 3 \cdot x1(t) \cdot x6(t) - \mu \cdot x1(t) :$
- >  $T2 := \frac{d}{dt} x2(t) = c \cdot \pi - (1 - \sigma) \cdot \beta v \cdot x2(t) \cdot x4(t) - \mu \cdot x2(t) :$
- >  $T3 := \frac{d}{dt} x3(t) = q \cdot \beta 1 \cdot x1(t) \cdot x4(t) + (1 - \sigma) \cdot \beta v \cdot x2(t) \cdot x4(t) - (\varphi + \varepsilon + \mu 1) \cdot x3(t) :$
- >  $T4 := \frac{d}{dt} x4(t) = (1 - q) \cdot \beta 1 \cdot x1(t) \cdot x4(t) + \varepsilon \cdot x3(t) - (\alpha 2 + \omega 1 + \mu 1) \cdot x4(t) :$
- >  $T5 := \frac{d}{dt} x5(t) = q \cdot \beta 2 \cdot x1(t) \cdot x5(t) - (\alpha 1 + \mu 2) \cdot x5(t) :$
- >  $T6 := \frac{d}{dt} x6(t) = \alpha 1 \cdot x5(t) + \alpha 2 \cdot x4(t) + (\beta 3 \cdot x1(t) - \omega 2 - \mu 3) \cdot x6(t) :$
- >  $T7 := \frac{d}{dt} x7(t) = \omega 1 \cdot x4(t) + \omega 2 \cdot x6(t) - (\tau + \mu) \cdot x7(t) :$
- >  $T8 := \frac{d}{dt} x8(t) = \varphi \cdot x3(t) + \tau \cdot x7(t) - \mu \cdot x8(t) :$
- >

- >  $n11 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t = 0 .. 15, x1 = 0 .. 11, x2 = 0 .. 1, x3 = 0 .. 1, x4 = 0 .. 1, x5 = 0 .. 1, x6 = 0 .. 1, x7 = 0 .. 1, x8 = 0 .. 1, [[x1(0) = 10.107, x2(0) = 15.030, x3(0) = 30.516, x4(0) = 30.908, x5(0) = 20.959, x6(0) = 45.059, x7(0) = 20.109, x8(0) = 40.102]], linecolor = [black], arrows = medium, scene = [t, x1(t)] ) :$
- >  $n21 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t = 0 .. 15, x1 = 0 .. 1, x2 = 0 .. 16, x3 = 0 .. 1, x4 = 0 .. 1, x5 = 0 .. 1, x6 = 0 .. 1, x7 = 0 .. 1, x8 = 0 .. 1, [[x1(0) = 10.107, x2(0) = 15.030, x3(0) = 30.516, x4(0) = 30.908, x5(0) = 20.959, x6(0) = 45.059, x7(0) = 20.109, x8(0) = 40.102]], linecolor = [black], arrows = medium, scene = [t, x2(t)] ) :$
- >  $n31 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t = 0 .. 15, x1 = 0 .. 1, x2 = 0 .. 1, x3 = 0 .. 45, x4 = 0 .. 1, x5 = 0 .. 1, x6 = 0 .. 1, x7 = 0 .. 1, x8 = 0 .. 1, [[x1(0) = 10.107, x2(0) = 15.030, x3(0) = 30.516, x4(0) = 30.908, x5(0) = 20.959, x6(0) = 45.059, x7(0) = 20.109, x8(0) = 40.102]], linecolor = [black], arrows = medium, scene = [t, x3(t)] ) :$
- >  $n41 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t = 0 .. 15, x1 = 0 .. 1, x2 = 0 .. 1, x3 = 0 .. 1, x4 = 0 .. 31, x5 = 0 .. 1, x6 = 0 .. 1, x7 = 0 .. 1, x8 = 0 .. 1, [[x1(0) = 10.107, x2(0) = 15.030, x3(0) = 30.516, x4(0) = 30.908, x5(0) = 20.959, x6(0) = 45.059, x7(0) = 20.109, x8(0) = 40.102]], linecolor = [black], arrows = medium, scene = [t, x4(t)] ) :$
- >  $n51 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t = 0 .. 15, x1 = 0 .. 1, x2 = 0 .. 1, x3 = 0 .. 1, x4 = 0 .. 1, x5 = 0 .. 21, x6 = 0 .. 1, x7 = 0 .. 1, x8 = 0 .. 1, [[x1(0) = 10.107, x2(0) = 15.030, x3(0) = 30.516, x4(0) = 30.908, x5(0) = 20.959, x6(0) = 45.059, x7(0) = 20.109, x8(0) = 40.102]], linecolor = [black], arrows = medium, scene = [t, x5(t)] ) :$
- >  $n61 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t = 0 .. 15, x1 = 0 .. 1, x2 = 0 .. 1, x3 = 0 .. 1, x4 = 0 .. 1, x5 = 0 .. 1, x6 = 0 .. 46, x7 = 0 .. 1, x8 = 0 .. 1, [[x1(0) = 10.107, x2(0) = 15.030, x3(0) = 30.516, x4(0) = 30.908, x5(0) = 20.959, x6(0) = 45.059, x7(0) = 20.109, x8(0) = 40.102]], linecolor = [black], arrows = medium, scene = [t, x6(t)] ) :$



- >  $n71 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..21, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[black], arrows=medium, scene=[t, x7(t)]) :$
- >  $n81 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..41, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[black], arrows=medium, scene=[t, x8(t)]) :$
- > #Grafik untuk nilai parameter laju tingkat Efektivitas Vaksinasi dan pengobatan ( $c=0.15$  dan  $\tau=0.6$ )
- >  $with(linalg) : with(plots) : with(DEtools) :$
- >  $\beta1 := 0.6 : \beta2 := 0.9 : \beta3 := 0.85 : \beta v := 0.35 : c := 0.15 : \sigma := 0.01 : \omega1 := 0.01 : \omega2 := 0.01 :$
- >  $pi := 1.33 : \mu := 0.7 : \mu1 := 0.3 : \mu2 := 0.5 : \mu3 := 0.9 : q := 0.5 : \alpha1 := 0.01 : \alpha2 := 0.01 : \varepsilon := 0.0003 : \varphi := 0.058 : \tau := 0.6 :$
- >  $R1 := \frac{1}{\mu \cdot (\varphi + \varepsilon + \mu1) \cdot (\alpha2 + \omega1 + \mu1)} (pi \cdot ((\varphi + \varepsilon + \mu1) \cdot (1 - q) \cdot \beta1 \cdot (1 - c) - (q \cdot \beta1 \cdot (1 - c) + (1 - \sigma) \cdot \beta v \cdot c) \cdot \varepsilon)) ; R2 := \frac{q \cdot \beta2 \cdot (1 - c) \cdot pi}{\mu \cdot (\alpha1 + \mu2)} ; R3 := \frac{\beta3 \cdot (1 - c) \cdot pi}{\mu \cdot (\omega2 + \mu3)} ; R0 := \max([R1, R2, R3]) ;$
- $R1 := 1.512536407$
- $R2 := 1.425000000$
- $R3 := 1.508516484$
- $R0 := 1.512536407$
- >  $T1 := \frac{d}{dt}x1(t) = (1 - c) \cdot \pi - \beta1 \cdot x1(t) \cdot x4(t) - q \cdot \beta2 \cdot x1(t) \cdot x5(t) - \beta3 \cdot x1(t) \cdot x6(t) - \mu \cdot x1(t) :$
- >  $T2 := \frac{d}{dt}x2(t) = c \cdot \pi - (1 - \sigma) \cdot \beta v \cdot x2(t) \cdot x4(t) - \mu \cdot x2(t) :$
- >  $T3 := \frac{d}{dt}x3(t) = q \cdot \beta1 \cdot x1(t) \cdot x4(t) + (1 - \sigma) \cdot \beta v \cdot x2(t) \cdot x4(t) - (\varphi + \varepsilon + \mu1) \cdot x3(t) :$

- >  $T4 := \frac{d}{dt}x4(t) = (1 - q) \cdot \beta1 \cdot x1(t) \cdot x4(t) + \varepsilon \cdot x3(t) - (\alpha2 + \omega1 + \mu1) \cdot x4(t) :$
- >  $T5 := \frac{d}{dt}x5(t) = q \cdot \beta2 \cdot x1(t) \cdot x5(t) - (\alpha1 + \mu2) \cdot x5(t) :$
- >  $T6 := \frac{d}{dt}x6(t) = \alpha1 \cdot x5(t) + \alpha2 \cdot x4(t) + (\beta3 \cdot x1(t) - \omega2 - \mu3) \cdot x6(t) :$
- >  $T7 := \frac{d}{dt}x7(t) = \omega1 \cdot x4(t) + \omega2 \cdot x6(t) - (\tau + \mu) \cdot x7(t) :$
- >  $T8 := \frac{d}{dt}x8(t) = \varphi \cdot x3(t) + \tau \cdot x7(t) - \mu \cdot x8(t) :$
- >  $b12 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..11, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x1(t)]) :$
- >  $b22 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..16, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x2(t)]) :$
- >  $b32 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..45, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x3(t)]) :$
- >  $b42 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..31, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x4(t)]) :$

- >  $b52 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..21, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x5(t)]) :$
- >  $b62 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..46, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x6(t)]) :$
- >  $b72 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..21, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x7(t)]) :$
- >  $b82 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..41, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[red], arrows=medium, scene=[t, x8(t)]) :$
- > #Grafik untuk nilai parameter laju tingkat Efektivitas Vaksinasi dan pengobatan ( $c = 0.25$  dan  $\tau = 0.9$ )
- >  $with(linalg) : with(plots) : with(DEtools) :$
- >  $\beta1 := 0.6 : \beta2 := 0.9 : \beta3 := 0.85 : \beta v := 0.35 : c := 0.25 : \sigma := 0.01 : \omega1 := 0.01 : \omega2 := 0.01 :$
- >  $pi := 1.33 : \mu := 0.7 : \mu1 := 0.3 : \mu2 := 0.5 : \mu3 := 0.9 : q := 0.5 : \alpha1 := 0.01 : \alpha2 := 0.01 : \varepsilon := 0.0003 : \varphi := 0.058 : \tau := 0.9 :$
- >  $R1 := \frac{1}{\mu \cdot (\varphi + \varepsilon + \mu1) \cdot (\alpha2 + \omega1 + \mu1)} (pi \cdot ((\varphi + \varepsilon + \mu1) \cdot (1 - q) \cdot \beta1 \cdot (1 - c) - (q \cdot \beta1 \cdot (1 - c) + (1 - \sigma) \cdot \beta v \cdot c) \cdot \varepsilon)) ; R2 := \frac{q \cdot \beta2 \cdot (1 - c) \cdot pi}{\mu \cdot (\alpha1 + \mu2)} ; R3 := \frac{\beta3 \cdot (1 - c) \cdot pi}{\mu \cdot (\omega2 + \mu3)} ; R0 := \max([R1, R2, R3]) ;$

$$R1 := 1.334388289$$

$$R2 := 1.257352941$$

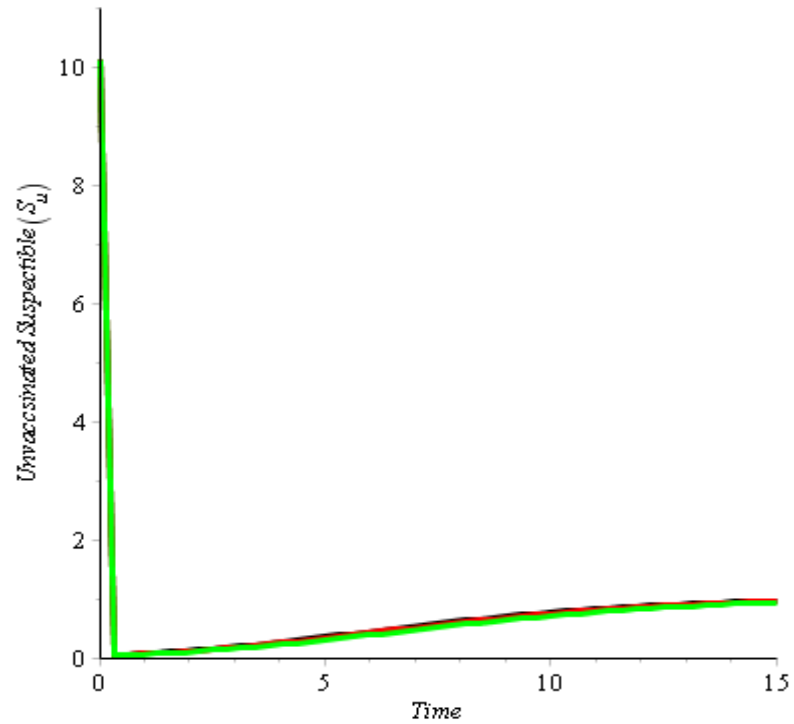
$$R3 := 1.331043956$$

$$R0 := 1.334388289$$

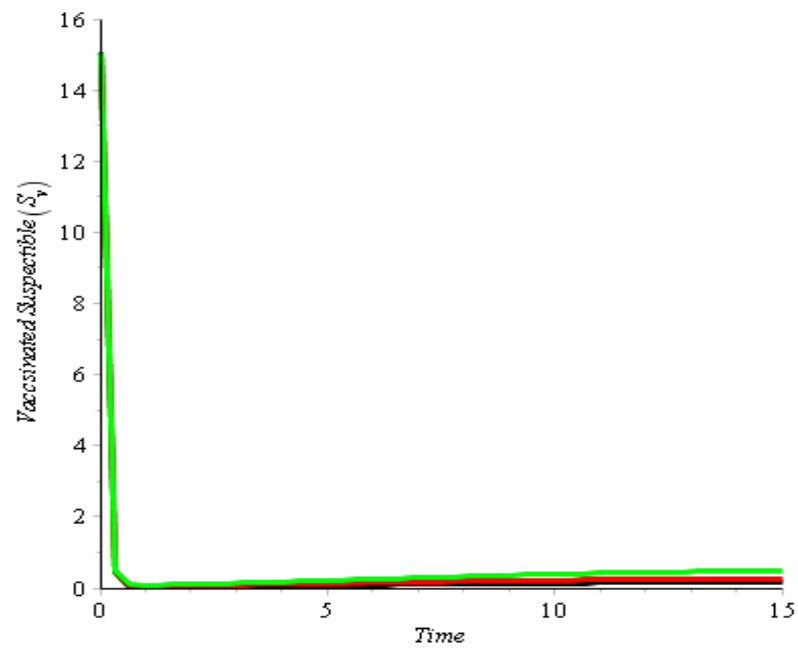
- >  $T1 := \frac{d}{dt}x1(t) = (1 - c) \cdot \pi - \beta1 \cdot x1(t) \cdot x4(t) - q \cdot \beta2 \cdot x1(t) \cdot x5(t) - \beta3 \cdot x1(t) \cdot x6(t) - \mu \cdot x1(t) :$
- >  $T2 := \frac{d}{dt}x2(t) = c \cdot \pi - (1 - \sigma) \cdot \betav \cdot x2(t) \cdot x4(t) - \mu \cdot x2(t) :$
- >  $T3 := \frac{d}{dt}x3(t) = q \cdot \beta1 \cdot x1(t) \cdot x4(t) + (1 - \sigma) \cdot \betav \cdot x2(t) \cdot x4(t) - (\varphi + \varepsilon + \mu1) \cdot x3(t) :$
- >  $T4 := \frac{d}{dt}x4(t) = (1 - q) \cdot \beta1 \cdot x1(t) \cdot x4(t) + \varepsilon \cdot x3(t) - (\alpha2 + \omega1 + \mu1) \cdot x4(t) :$
- >  $T5 := \frac{d}{dt}x5(t) = q \cdot \beta2 \cdot x1(t) \cdot x5(t) - (\alpha1 + \mu2) \cdot x5(t) :$
- >  $T6 := \frac{d}{dt}x6(t) = \alpha1 \cdot x5(t) + \alpha2 \cdot x4(t) + (\beta3 \cdot x1(t) - \omega2 - \mu3) \cdot x6(t) :$
- >  $T7 := \frac{d}{dt}x7(t) = \omega1 \cdot x4(t) + \omega2 \cdot x6(t) - (\tau + \mu) \cdot x7(t) :$
- >  $T8 := \frac{d}{dt}x8(t) = \varphi \cdot x3(t) + \tau \cdot x7(t) - \mu \cdot x8(t) :$
- >  $c13 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..11, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x1(t)]) :$
- >  $c23 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..11, x2=0..16, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x2(t)]) :$

- >  $c33 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..45, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x3(t)]) :$
- >  $c43 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..31, x5=0..1, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x4(t)]) :$
- >  $c53 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..21, x6=0..1, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x5(t)]) :$
- >  $c63 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..46, x7=0..1, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x6(t)]) :$
- >  $c73 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..21, x8=0..1, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x7(t)]) :$
- >  $c83 := DEplot([T1, T2, T3, T4, T5, T6, T7, T8], [x1(t), x2(t), x3(t), x4(t), x5(t), x6(t), x7(t), x8(t)], t=0..15, x1=0..1, x2=0..1, x3=0..1, x4=0..1, x5=0..1, x6=0..1, x7=0..1, x8=0..41, [[x1(0)=10.107, x2(0)=15.030, x3(0)=30.516, x4(0)=30.908, x5(0)=20.959, x6(0)=45.059, x7(0)=20.109, x8(0)=40.102]], linecolor=[green], arrows=medium, scene=[t, x8(t)]) :$

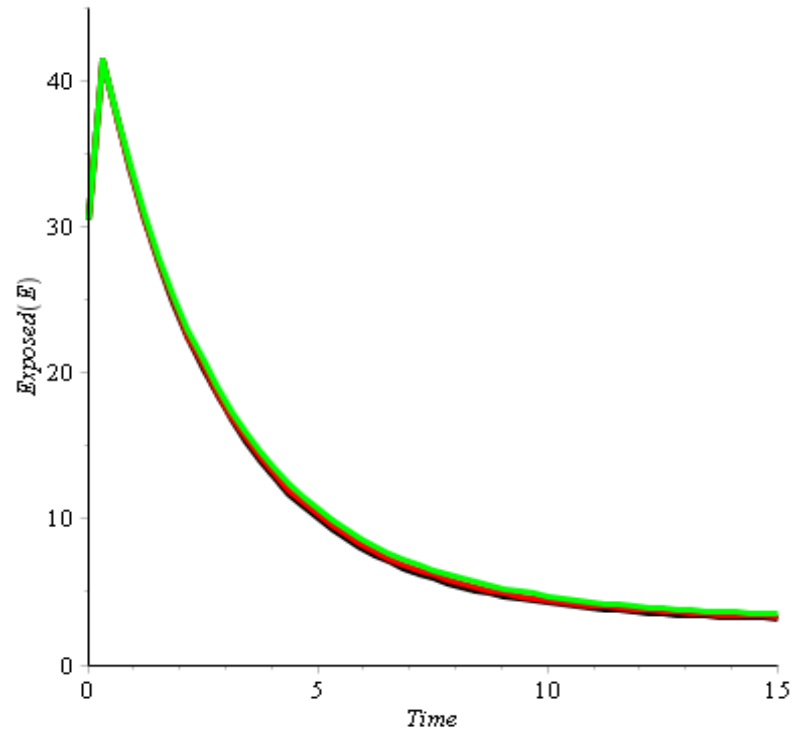
> `display([n11, b12, c13], labels = [Time, Unvaccinated Susceptible( $S_u$ )], labeldirections = [horizontal, vertical])`



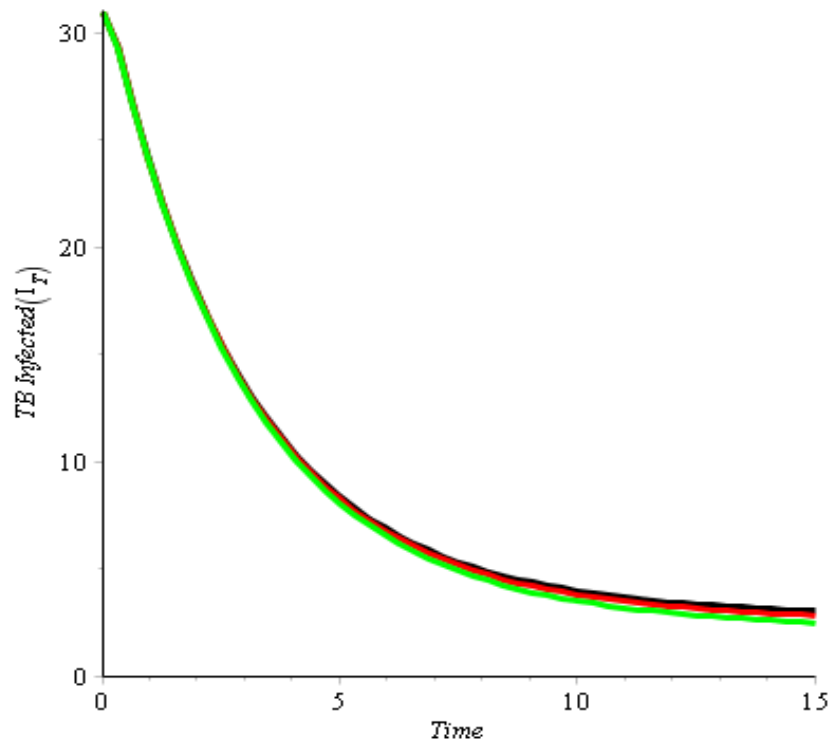
> `display([n21, b22, c23], labels = [Time, Vaccinated Susceptible( $S_v$ )], labeldirections = [horizontal, vertical])`



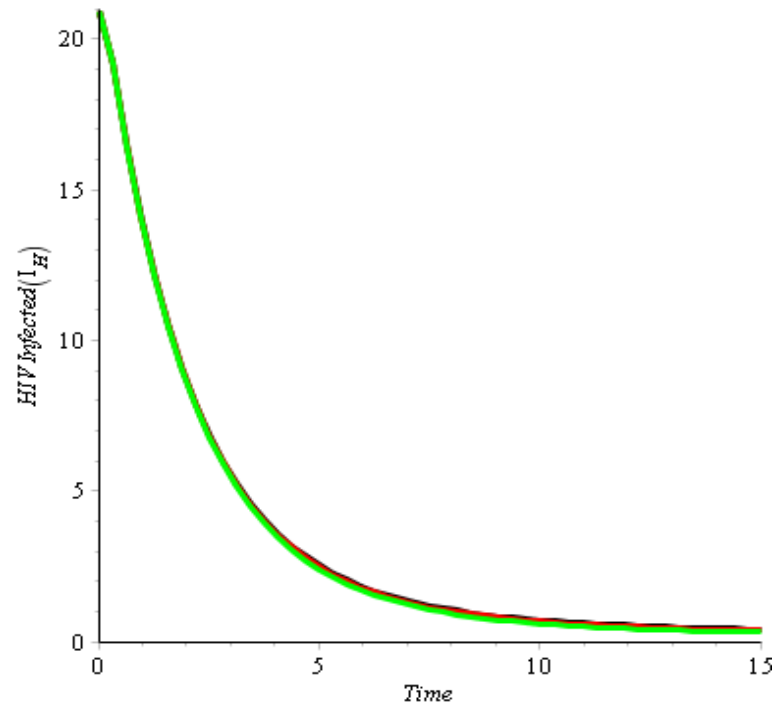
> `display([n31, b32, c33], labels = [Time, Exposed(E)],  
labeldirections = [horizontal, vertical])`



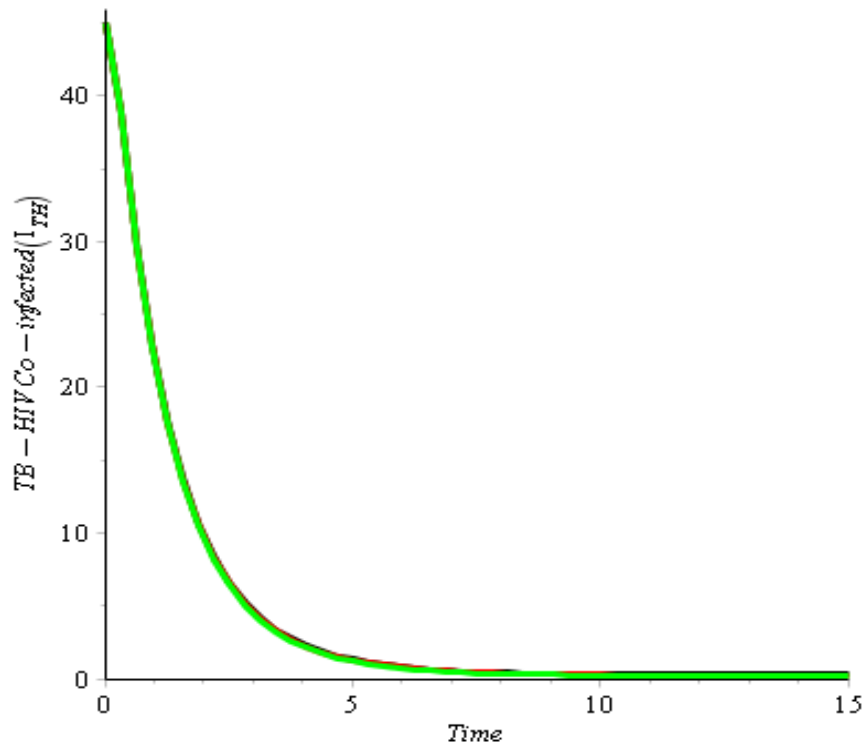
> `display([n41, b42, c43], labels = [Time, TB Infected(IT)],  
labeldirections = [horizontal, vertical])`



> `display([n51, b52, c53], labels = [Time, HIV Infected( $I_H$ )],  
labeldirections = [horizontal, vertical])`



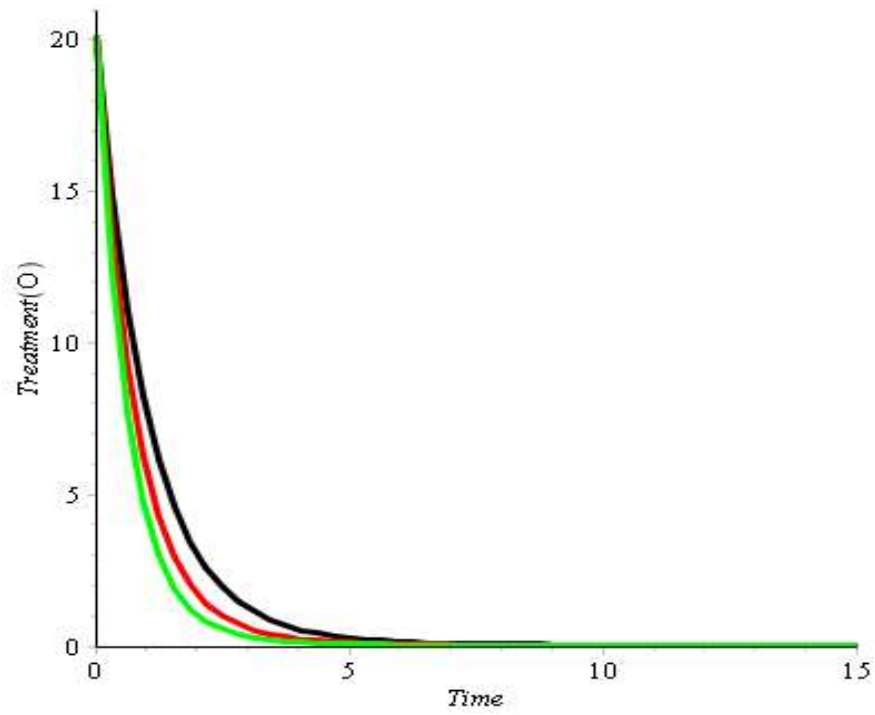
> `display([n61, b62, c63], labels = [Time, TB - HIV Co  
- infected( $I_{TH}$ )], labeldirections = [horizontal, vertical])`





&gt;

```
display([n71, b72, c73], labels = [Time, Treatment(O)], labeldirections = [horizontal, vertical])
```



```
> display([n81, b82, c83], labels = [Time, Recovered(P)], labeldirections = [horizontal, vertical])
```

