INPUT

```
In[•]:= JacobianMatrix[f_List?VectorQ, x_List] :=
         Outer[D, f, x] /; Equal @@ (Dimensions /@ {f, x})

In[•]:= Subtitute[persamaan_, var_, nil_] :=
         Module[{n = 1, pers = persamaan},
          While[n < Length[var] + 1, pers = pers /. var[[n]] → nil[[n]];
           n++];
          pers]
```

Lampiran 1. Syntax Matriks Jacobian dan Subtitusi

```
In[•]:= NewtonMethod[sistem_, variabel_, nilaiperkiraan_] :=
         Module[{n = 1, f = sistem, j, y, m, x = nilaiperkiraan, d = ConstantArray[c, 100],
           e = ConstantArray[c, 100], h = ConstantArray[c, 100],
           Waktu = ConstantArray[c, 100]},
          While[n < 101,
           Waktu[[n]] =
            AbsoluteTiming[j = Subtitute[JacobianMatrix[f, variabel], variabel, x];
              y = Subtitute[f, variabel, x];
              m = Solve[j.Array[o_## &, {Length[variabel]}] == -y,
                 Array[o_## &, {Length[variabel]}]][[1, All, 2]];
              x = N[Round[x + m, 10^-8]]][[1]];
           d[[n]] = x;
           h[[n]] = Subtitute[f, variabel, x];
           If[n == 1,
            e[[1]] = Sqrt[Sum[(d[[n, i]] - nilaiperkiraan[[i]])^2, {i, Length[variabel]}]],
            e[[n]] = Sqrt[Sum[(d[[n, i]] - d[[n - 1, i]])^2, {i, Length[variabel]}]]];
           If[e[[n]] < 10^-6, Break[]];
           n++];
          d = d[[1 ;; n]];
          e = e[[1 ;; n]];
          h = h[[1 ;; n]];
          Waktu = Waktu[[1 ;; n]];
          TableForm[MapThread[Append, {MapThread[Join, {MapThread[Append, {d, e}], h}],
              Waktu}],
           TableHeadings →
            {Automatic, Append[Join[Append[variabel, "" || "x"^"k" - "x"^"(k-1)" || ""],
                Map["f", variabel]], "Waktu"]}]]
```

Lampiran 2. Syntax Metode Newton

```
In[•]:= BroydenMethod[sistem_, variabel_, nilaiperkiraan_] :=
  Module[{n = 1, f = sistem, A, y, ye, x = nilaiperkiraan, xe = nilaiperkiraan,
    r, t, d = ConstantArray[c, 100], e = ConstantArray[c, 100],
    h = ConstantArray[c, 100], Waktu = ConstantArray[c, 100]},
   While[n < 101,
    Waktu[[n]] =
     AbsoluteTiming[
       If[n == 1, A = Inverse[Subtitute[JacobianMatrix[f, variabel], variabel, x]];
        ye = Subtitute[f, variabel, x];
        y = Subtitute[f, variabel, x];
        x = N[x - A.y], ye = y;
        y = Subtitute[f, variabel, x];
        r = (x - xe).A.(y - ye);
        t = (((x - xe) - A.(y - ye)).(x - xe) * A);
        A = A + (1 / r) * t;
        xe = x;
        x = N[x - A.y]]][[1]];
    d[[n]] = x;
    h[[n]] = Subtitute[f, variabel, x];
    If[n == 1,
     e[[1]] = Sqrt[Sum[(d[[n, i]] - nilaiperkiraan[[i]])^2, {i, Length[variabel]}]],
     e[[n]] = Sqrt[Sum[(d[[n, i]] - d[[n - 1, i]])^2, {i, Length[variabel]}]]];
    If[e[[n]] < 10^-6, Break[]];
    n++];
   d = d[[1 ;; n]];
   e = e[[1 ;; n]];
   h = h[[1 ;; n]];
   Waktu = Waktu[[1 ;; n]];
   TableForm[MapThread[Append, {MapThread[Join, {MapThread[Append, {d, e}], h}],
      Waktu}],
    TableHeadings →
     {Automatic, Append[Join[Append[variabel, "" || "x"^"k" - "x"^"(k-1)" || ""],
        Map["f", variabel]], "Waktu"]}]]
```

Lampiran 3. Syntax Metode Broyden

```
GaussMethod[sistem_, variabel_, nilaiperkiraan_] :=
 Module[{n = 1, f = sistem, y, z, t, h, j, w, r, x = nilaiperkiraan,
   d = ConstantArray[c, 100], e = ConstantArray[c, 100], he = ConstantArray[c, 100],
   Waktu = ConstantArray[c, 100]},
  While[n < 101,
   Waktu[[n]] =
    AbsoluteTiming[
      z =
       x +
        Solve[Subtitute[JacobianMatrix[f, variabel], variabel, x].
            Array[o## &, {Length[variabel]}] == -Subtitute[f, variabel, x],
          Array[o## &, {Length[variabel]}]][[1, All, 2]];
      t =
       z +
        Solve[Subtitute[JacobianMatrix[f, variabel], variabel, z].
            Array[o## &, {Length[variabel]}] == -Subtitute[f, variabel, z],
          Array[o## &, {Length[variabel]}]][[1, All, 2]];
      h = (t + z) / 2;
      j = (t - z) * Sqrt[3 / 5];
      w = (t - z) * -Sqrt[3 / 5];
      r =
       Inverse[9. (4. Subtitute[JacobianMatrix[f, variabel], variabel, h] +
             5. Subtitute[JacobianMatrix[f, variabel], variabel, (h + w)] / 2 +
             5. Subtitute[JacobianMatrix[f, variabel], variabel, (h + j)] / 2)];
      x = t - r.Subtitute[f, variabel, t]][[1]];
   d[[n]] = x;
   he[[n]] = Subtitute[f, variabel, x];
   If[n == 1,
    e[[1]] = Sqrt[Sum[(d[[n, i]] - nilaiperkiraan[[i]])^2, {i, Length[variabel]}]],
    e[[n]] = Sqrt[Sum[(d[[n, i]] - d[[n - 1, i]])^2, {i, Length[variabel]}]]];
   If[e[[n]] < 10^-6, Break[]];
   n++];
  d = d[[1 ;; n]];
  e = e[[1 ;; n]];
  he = he[[1 ;; n]];
  Waktu = Waktu[[1 ;; n]];
  TableForm[MapThread[Append, {MapThread[Join, {MapThread[Append, {d, e}], he}],
     Waktu}],
   TableHeadings ->
    {Automatic, Append[Join[Append[variabel, "" || "x"^"k" - "x"^"(k-1)" || ""],
       Map["f", variabel]], "Waktu"]}]]
```

Lampiran 4. Syntax Metode Quadrature Gauss

```
In[•]:= NumericMethods[sistem_, variabel_, nilaiperkiraan_] :=
  Module[{a, b, c},
   a = Labeled[NewtonMethod[sistem, variabel, nilaiperkiraan], "Metode Newton", Top];
   b = Labeled[BroydenMethod[sistem, variabel, nilaiperkiraan], "Metode Broyden",
     Top];
   c = Labeled[GaussMethod[sistem, variabel, nilaiperkiraan],
     "Metode Quadrature Gauss", Top];
   CellPrint[{a, b, c}]]
```

Lampiran 5. Syntax Gabungan dari Syntax Ketiga Metode Numerik

OUTPUT

```
In[∘]:= a = {Exp[-Exp[-(x1 + x2)]] - x2 * (1 + x1)^2, x1 * Cos[x2] + x2 * Sin[x1] - 1 / 2}
        v = {x1, x2}
        ap = {0.3532, 0.6061}
```

Out[∘]= $\left\{e^{-e^{-x1-x2}} - (1 + x1)^2\, x2,\ -\frac{1}{2} + x1\, \text{Cos}[x2] + x2\, \text{Sin}[x1]\right\}$

Out[∘]= {x1, x2}

Out[∘]= {0.3532, 0.6061}

```
In[∘]:= NumericMethods[a, v, ap]
```

"Metode Newton"

	x1	x2	$\|\|x^k - x^{(k-1)}\|\|$	f[x1]	f[x2]	Waktu
1	0.384482	0.305899	0.301826	0.0193467	-0.0186303	0.0006638
2	0.397981	0.313346	0.0154162	-0.00036876	0.0000415712	0.0006638
3	0.397996	0.313118	0.000228778	-1.12537×10^{-9}	-5.46146×10^{-9}	0.0004398
4	0.397996	0.313118	0.	-1.12537×10^{-9}	-5.46146×10^{-9}	0.0004327

"Metode Broyden"

	x1	x2	$\|\|x^k - x^{(k-1)}\|\|$	f[x1]	f[x2]	Waktu
1	0.384482	0.305899	0.301826	0.0193467	-0.0186302	0.0004917
2	0.397851	0.30651	0.0133825	0.0110051	-0.00193831	0.0001446
3	0.398645	0.313423	0.00695817	-0.000878666	0.000885719	0.0001345
4	0.397961	0.313423	0.000683714	-0.000484518	0.0000377523	0.0001381
5	0.397967	0.313089	0.000333667	0.0000638682	-0.0000434121	0.0001339
6	0.397997	0.313104	0.0000337104	0.000021893	-1.95503×10^{-6}	0.0001323
7	0.397997	0.313121	0.0000174862	-6.99097×10^{-6}	2.60146×10^{-6}	0.0001324
8	0.397996	0.313118	3.54171×10^{-6}	-8.41795×10^{-7}	-2.04664×10^{-7}	0.0001337
9	0.397996	0.313117	9.33998×10^{-7}	4.79054×10^{-7}	-1.03507×10^{-7}	0.0001338

"Metode Quadrature Gauss"

	x1	x2	$\|\|x^k - x^{(k-1)}\|\|$	f[x1]	f[x2]	Waktu
1	0.397981	0.313343	0.296162	-0.00036415	0.0000410479	0.0060593
2	0.397996	0.313118	0.000225922	0.	0.	0.0016003
3	0.397996	0.313118	0.	0.	0.	0.0015744

Lampiran 6. Hasil Studi Kasus Pertama