Real 4D Lie algebras

J. Patera, P. Winternitz. Subalgebras of real three and four--dimensional Lie algebras.

Journal of Mathematical Physics, 18, 1449--1455, 1977.

In[1]:=
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SetDirectory[NotebookDirectory[]];
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In[2]:=
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<< "SymboLie.wl"
```

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SymboLie (v. 1.6)- A Package for determining Optimal Systems of Lie Subalgebras.
```

In[3]:=
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CS = Table[0, {k, 1, 4}, {i, 1, 4}, {j, 1, 4}];
AllCS = Table[CS, {r, 1, 30}];
AllCS⟦2, 2, 1, 2⟧ = 1; AllCS⟦2, 2, 2, 1⟧ = -1;
AllCS⟦3, 2, 1, 2⟧ = 1; AllCS⟦3, 2, 2, 1⟧ = -1;
AllCS⟦3, 4, 3, 4⟧ = 1; AllCS⟦3, 4, 4, 3⟧ = -1;
AllCS⟦4, 1, 2, 3⟧ = 1; AllCS⟦4, 1, 3, 2⟧ = -1;
AllCS⟦5, 1, 1, 3⟧ = 1; AllCS⟦5, 1, 3, 1⟧ = -1;
AllCS⟦5, 1, 2, 3⟧ = 1; AllCS⟦5, 1, 3, 2⟧ = -1;
AllCS⟦5, 2, 2, 3⟧ = 1; AllCS⟦5, 2, 3, 2⟧ = -1;
AllCS⟦6, 1, 1, 3⟧ = 1; AllCS⟦6, 1, 3, 1⟧ = -1;
AllCS⟦6, 2, 2, 3⟧ = 1; AllCS⟦6, 2, 3, 2⟧ = -1;
AllCS⟦7, 1, 1, 3⟧ = 1; AllCS⟦7, 1, 3, 1⟧ = -1;
AllCS⟦7, 2, 2, 3⟧ = -1; AllCS⟦7, 2, 3, 2⟧ = 1;
AllCS⟦8, 1, 1, 3⟧ = 1; AllCS⟦8, 1, 3, 1⟧ = -1;
AllCS⟦8, 2, 2, 3⟧ = a;
AllCS⟦8, 2, 3, 2⟧ = -a;
(*con abs(a) tra 0 e 1*)AllCS⟦9, 2, 1, 3⟧ = -1;
AllCS⟦9, 2, 3, 1⟧ = 1;
AllCS⟦9, 1, 2, 3⟧ = 1; AllCS⟦9, 1, 3, 2⟧ = -1;
AllCS⟦10, 1, 1, 3⟧ = a;
AllCS⟦10, 1, 3, 1⟧ = -a;
(*a>0*)AllCS⟦10, 1, 2, 3⟧ = 1;
AllCS⟦10, 1, 3, 2⟧ = -1;
AllCS⟦10, 2, 1, 3⟧ = -1; AllCS⟦10, 2, 3, 1⟧ = 1;
AllCS⟦10, 2, 2, 3⟧ = a;
AllCS⟦10, 2, 3, 2⟧ = -a;
(*a>0*)AllCS⟦11, 2, 3, 1⟧ = 2;
AllCS⟦11, 2, 1, 3⟧ = -2;
AllCS⟦11, 1, 1, 2⟧ = 1; AllCS⟦11, 1, 2, 1⟧ = -1;
AllCS⟦11, 3, 2, 3⟧ = 1; AllCS⟦11, 3, 3, 2⟧ = -1;
AllCS⟦12, 3, 1, 2⟧ = 1; AllCS⟦12, 3, 2, 1⟧ = -1;
AllCS⟦12, 1, 2, 3⟧ = 1; AllCS⟦12, 1, 3, 2⟧ = -1;
AllCS⟦12, 2, 3, 1⟧ = 1; AllCS⟦12, 2, 1, 3⟧ = -1;
AllCS⟦13, 1, 2, 4⟧ = 1; AllCS⟦13, 1, 4, 2⟧ = -1;
AllCS⟦13, 2, 3, 4⟧ = 1; AllCS⟦13, 2, 4, 3⟧ = -1;
AllCS⟦14, 1, 1, 4⟧ = a;
AllCS⟦14, 1, 4, 1⟧ = -a;
(*a diverso da 0,1*)AllCS⟦14, 2, 2, 4⟧ = 1;
AllCS⟦14, 2, 4, 2⟧ = -1;
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AllCS⟦14, 2, 3, 4⟧ = 1; AllCS⟦14, 2, 4, 3⟧ = -1;
AllCS⟦14, 3, 3, 4⟧ = 1; AllCS⟦14, 3, 4, 3⟧ = -1;
AllCS⟦15, 1, 1, 4⟧ = 1; AllCS⟦15, 1, 4, 1⟧ = -1;
AllCS⟦15, 2, 2, 4⟧ = 1; AllCS⟦15, 2, 4, 2⟧ = -1;
AllCS⟦15, 2, 3, 4⟧ = 1; AllCS⟦15, 2, 4, 3⟧ = -1;
AllCS⟦15, 3, 3, 4⟧ = 1; AllCS⟦15, 3, 4, 3⟧ = -1;
AllCS⟦16, 1, 1, 4⟧ = 1; AllCS⟦16, 1, 4, 1⟧ = -1;
AllCS⟦16, 2, 3, 4⟧ = 1; AllCS⟦16, 2, 4, 3⟧ = -1;
AllCS⟦17, 1, 1, 4⟧ = 1; AllCS⟦17, 1, 4, 1⟧ = -1;
AllCS⟦17, 1, 2, 4⟧ = 1; AllCS⟦17, 1, 4, 2⟧ = -1;
AllCS⟦17, 2, 2, 4⟧ = 1; AllCS⟦17, 2, 4, 2⟧ = -1;
AllCS⟦17, 2, 3, 4⟧ = 1; AllCS⟦17, 2, 4, 3⟧ = -1;
AllCS⟦17, 3, 3, 4⟧ = 1; AllCS⟦17, 3, 4, 3⟧ = -1;
AllCS⟦18, 1, 1, 4⟧ = 1; AllCS⟦18, 1, 4, 1⟧ = -1;
AllCS⟦18, 2, 2, 4⟧ = a; AllCS⟦18, 2, 4, 2⟧ = -a;
AllCS⟦18, 3, 3, 4⟧ = b;
AllCS⟦18, 3, 4, 3⟧ = -b;
(*-1≤a,b<1,ab≠0*)AllCS⟦19, 1, 1, 4⟧ = 1;
AllCS⟦19, 1, 4, 1⟧ = -1;
AllCS⟦19, 2, 2, 4⟧ = a; AllCS⟦19, 2, 4, 2⟧ = -a;
AllCS⟦19, 3, 3, 4⟧ = a;
AllCS⟦19, 3, 4, 3⟧ = -a;
(*-1≤a<1,a≠0*)AllCS⟦20, 1, 1, 4⟧ = 1;
AllCS⟦20, 1, 4, 1⟧ = -1;
AllCS⟦20, 2, 2, 4⟧ = a;
AllCS⟦20, 2, 4, 2⟧ = -a;
(*-1≤a<1,a≠0*)AllCS⟦20, 3, 3, 4⟧ = 1;
AllCS⟦20, 3, 4, 3⟧ = -1;
AllCS⟦21, 1, 1, 4⟧ = 1; AllCS⟦21, 1, 4, 1⟧ = -1;
AllCS⟦21, 2, 2, 4⟧ = 1; AllCS⟦21, 2, 4, 2⟧ = -1;
AllCS⟦21, 3, 3, 4⟧ = 1; AllCS⟦21, 3, 4, 3⟧ = -1;
AllCS⟦22, 1, 1, 4⟧ = a;
AllCS⟦22, 1, 4, 1⟧ = -a;
(*a≠0,b≥0*)AllCS⟦22, 2, 2, 4⟧ = b;
AllCS⟦22, 2, 4, 2⟧ = -b;
AllCS⟦22, 2, 3, 4⟧ = 1; AllCS⟦22, 2, 4, 3⟧ = -1;
AllCS⟦22, 3, 2, 4⟧ = -1; AllCS⟦22, 3, 4, 2⟧ = 1;
AllCS⟦22, 3, 3, 4⟧ = b; AllCS⟦22, 3, 4, 3⟧ = -b;
AllCS⟦23, 1, 1, 4⟧ = 2; AllCS⟦23, 1, 4, 1⟧ = -2;
AllCS⟦23, 2, 2, 4⟧ = 1; AllCS⟦23, 2, 4, 2⟧ = -1;
AllCS⟦23, 2, 3, 4⟧ = 1; AllCS⟦23, 2, 4, 3⟧ = -1;
AllCS⟦23, 3, 3, 4⟧ = 1; AllCS⟦23, 3, 4, 3⟧ = -1;
AllCS⟦23, 1, 2, 3⟧ = 1; AllCS⟦23, 1, 3, 2⟧ = -1;
AllCS⟦24, 1, 2, 3⟧ = 1; AllCS⟦24, 1, 3, 2⟧ = -1;
AllCS⟦24, 2, 2, 4⟧ = 1; AllCS⟦24, 2, 4, 2⟧ = -1;
AllCS⟦24, 3, 3, 4⟧ = -1; AllCS⟦24, 3, 4, 3⟧ = 1;
AllCS⟦25, 1, 2, 3⟧ = 1;
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AllCS⟦25, 1, 3, 2⟧ = -1;
(*0<abs(b)<1*)AllCS⟦25, 1, 1, 4⟧ = 1 + b;
AllCS⟦25, 1, 4, 1⟧ = -1 - b;
AllCS⟦25, 2, 2, 4⟧ = 1; AllCS⟦25, 2, 4, 2⟧ = -1;
AllCS⟦25, 3, 3, 4⟧ = b; AllCS⟦25, 3, 4, 3⟧ = -b;
AllCS⟦26, 1, 2, 3⟧ = 1; AllCS⟦26, 1, 3, 2⟧ = -1;
AllCS⟦26, 1, 1, 4⟧ = 2; AllCS⟦26, 1, 4, 1⟧ = -2;
AllCS⟦26, 2, 2, 4⟧ = 1; AllCS⟦26, 2, 4, 2⟧ = -1;
AllCS⟦26, 3, 3, 4⟧ = 1; AllCS⟦26, 3, 4, 3⟧ = -1;
AllCS⟦27, 1, 2, 3⟧ = 1; AllCS⟦27, 1, 3, 2⟧ = -1;
AllCS⟦27, 1, 1, 4⟧ = 1; AllCS⟦27, 1, 4, 1⟧ = -1;
AllCS⟦27, 2, 2, 4⟧ = 1; AllCS⟦27, 2, 4, 2⟧ = -1;
AllCS⟦28, 1, 2, 3⟧ = 1; AllCS⟦28, 1, 3, 2⟧ = -1;
AllCS⟦28, 3, 2, 4⟧ = -1; AllCS⟦28, 3, 4, 2⟧ = 1;
AllCS⟦28, 2, 3, 4⟧ = 1; AllCS⟦28, 2, 4, 3⟧ = -1;
AllCS⟦29, 1, 2, 3⟧ = 1;
AllCS⟦29, 1, 3, 2⟧ = -1;
(*a>0*)AllCS⟦29, 1, 1, 4⟧ = 2 a;
AllCS⟦29, 1, 4, 1⟧ = -2 a;
AllCS⟦29, 2, 2, 4⟧ = a; AllCS⟦29, 2, 4, 2⟧ = -a;
AllCS⟦29, 3, 2, 4⟧ = -1; AllCS⟦29, 3, 4, 2⟧ = 1;
AllCS⟦29, 2, 3, 4⟧ = 1; AllCS⟦29, 2, 4, 3⟧ = -1;
AllCS⟦29, 3, 3, 4⟧ = a; AllCS⟦29, 3, 4, 3⟧ = -a;
AllCS⟦30, 1, 1, 3⟧ = 1; AllCS⟦30, 1, 3, 1⟧ = -1;
AllCS⟦30, 2, 2, 3⟧ = 1; AllCS⟦30, 2, 3, 2⟧ = -1;
AllCS⟦30, 2, 1, 4⟧ = -1; AllCS⟦30, 2, 4, 1⟧ = 1;
AllCS⟦30, 1, 2, 4⟧ = 1;
AllCS⟦30, 1, 4, 2⟧ = -1;
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In[91]:=
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pars = Table[{{}, {}}, {k1, 1, 30}];
pars⟦8⟧ = {{a}, {-1 < a, a < 1, a ≠ 0}};(*pars⟦8⟧={a==1/2};*)
pars⟦10⟧ = {{a}, {a > 0}};
pars⟦14⟧ = {{a}, {a ≠ 0, a ≠ 1}};
pars⟦18⟧ = {{a, b}, {-1 ≤ a, a < b, b < 1, a b ≠ 0}};
pars⟦19⟧ = {{a}, {-1 ≤ a, a < 1, a ≠ 0}};
pars⟦20⟧ = {{a}, {-1 ≤ a, a < 1, a ≠ 0}};
pars⟦22⟧ = {{a, b}, {a ≠ 0, b ≥ 0}};
pars⟦25⟧ = {{b}, {-1 < b, b < 1, b ≠ 0}};
pars⟦29⟧ = {{a}, {a > 0}};
```

In[93]:=
```
allalg1 = {}; allalg2 = {}; allalg3 = {};
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In[94]:=
```
For[k1 = 1, k1 ≤ 30, k1++,
  Print["=========================================="];
  Print["Algebra n. ", k1];
  t1 = SessionTime[];
  Print[CommutatorTable[AllCS⟦k1⟧] // MatrixForm];
  alg1 = SubAlgebra[AllCS⟦k1⟧, pars⟦k1⟧, 1];
  AppendTo[allalg1, alg1];
  optalg1 = PrintOptimal[alg1];
  Print[optalg1];
  G = PrintGraph[alg1];
  Print[G];
  alg2 = SubAlgebra[AllCS⟦k1⟧, pars⟦k1⟧, 2];
  AppendTo[allalg2, alg2];
  optalg2 = PrintOptimal[alg2];
  Print[optalg2];
  G = PrintGraph[alg2];
  Print[G];
  alg3 = SubAlgebra[AllCS⟦k1⟧, pars⟦k1⟧, 3];
  AppendTo[allalg3, alg3];
  optalg3 = PrintOptimal[alg3];
  Print[optalg3];
  G = PrintGraph[alg3];
  Print[G];
  t1 = SessionTime[] - t1;
  Print["Time of computation: ", t1]
 ];
Print["=========================================="];
```

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Algebra n. 1

$$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

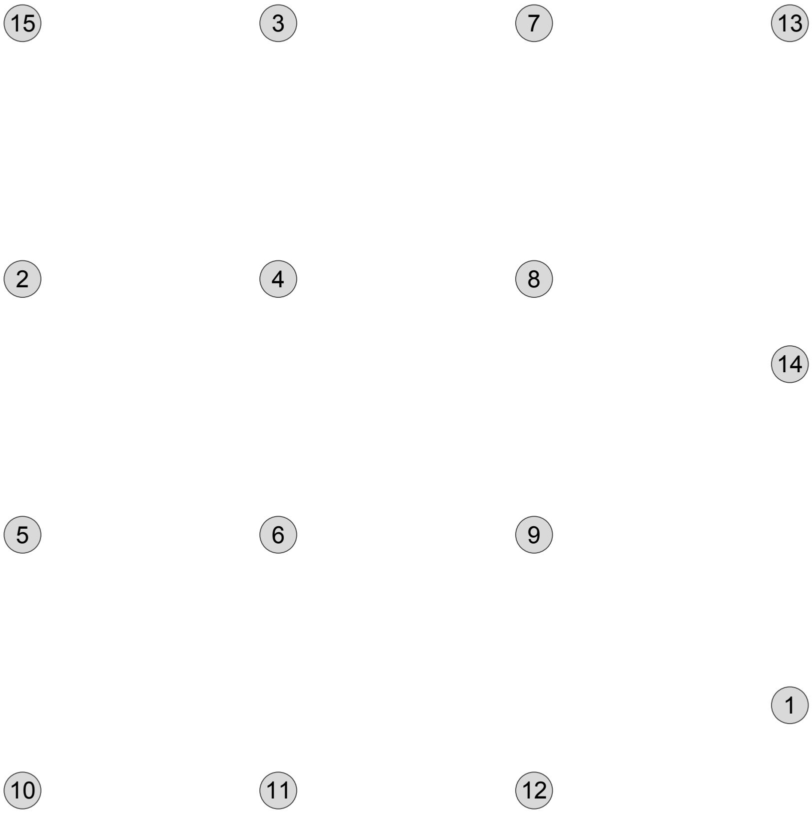
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 15 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_2\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_3\}, \{\Xi_2 + \underset{.}{a}_1 \Xi_3\},$
$\{\Xi_1 + \underset{.}{a}_1 \Xi_4\}, \{\Xi_2 + \underset{.}{a}_1 \Xi_4\}, \{\Xi_3 + \underset{.}{a}_1 \Xi_4\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_3\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_4\},$
$\{\Xi_1 + \underset{.}{a}_1 \Xi_3 + \underset{.}{a}_2 \Xi_4\}, \{\Xi_2 + \underset{.}{a}_1 \Xi_3 + \underset{.}{a}_2 \Xi_4\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_3 + \underset{.}{a}_3 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2\},$
$6 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_3\}, 7 \to \{\Xi_2 + \underset{.}{a}_1 \Xi_3\}, 8 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4\}, 9 \to \{\Xi_2 + \underset{.}{a}_1 \Xi_4\},$
$10 \to \{\Xi_3 + \underset{.}{a}_1 \Xi_4\}, 11 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_3\}, 12 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_4\},$
$13 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_3 + \underset{.}{a}_2 \Xi_4\}, 14 \to \{\Xi_2 + \underset{.}{a}_1 \Xi_3 + \underset{.}{a}_2 \Xi_4\}, 15 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_3 + \underset{.}{a}_3 \Xi_4\}\}$



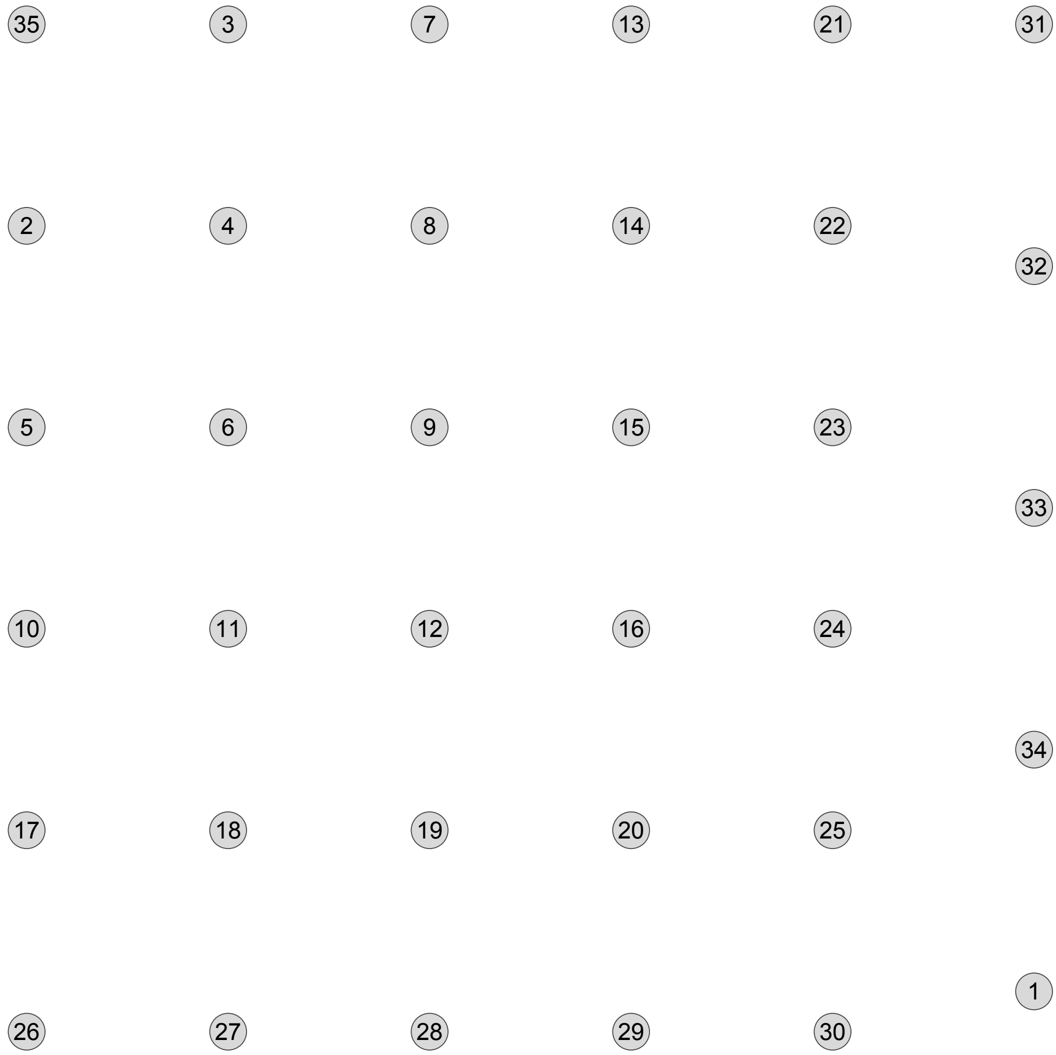
There are 35 2-D families of subalgebras to be analyzed.

Done.

There are 35 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1 \Xi_3\},$
$\{\Xi_1, \Xi_2 + a_1 \Xi_4\}, \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, \{\Xi_2, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3\}, \{\Xi_1 + a_1 \Xi_2, \Xi_4\},$
$\{\Xi_1 + a_1 \Xi_3, \Xi_2\}, \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, \{\Xi_2 + a_1 \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2\}, \{\Xi_1 + a_1 \Xi_4, \Xi_3\},$
$\{\Xi_2 + a_1 \Xi_4, \Xi_3\}, \{\Xi_1, \Xi_2 + a_1 \Xi_3 + a_2 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3 + a_2 \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3\},$
$\{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_3\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_4\},$
$\{\Xi_1 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\}, \{\Xi_2 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_4, \Xi_3\}, \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2\},$
$\{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3 + a_3 \Xi_4\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_3 + a_3 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_4, \Xi_3 + a_3 \Xi_4\},$
$\{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2 + a_3 \Xi_3\}, \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2 + a_3 \Xi_4\}, \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2 + a_3 \Xi_3 + a_4 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 5 \to \{\Xi_2, \Xi_4\},$
$6 \to \{\Xi_3, \Xi_4\}, 7 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3\}, 8 \to \{\Xi_1, \Xi_2 + a_1 \Xi_4\}, 9 \to \{\Xi_1, \Xi_3 + a_1 \Xi_4\},$
$10 \to \{\Xi_2, \Xi_3 + a_1 \Xi_4\}, 11 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3\}, 12 \to \{\Xi_1 + a_1 \Xi_2, \Xi_4\}, 13 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2\},$
$14 \to \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, 15 \to \{\Xi_2 + a_1 \Xi_3, \Xi_4\}, 16 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2\}, 17 \to \{\Xi_1 + a_1 \Xi_4, \Xi_3\},$
$18 \to \{\Xi_2 + a_1 \Xi_4, \Xi_3\}, 19 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3 + a_2 \Xi_4\}, 20 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3 + a_2 \Xi_4\},$
$21 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3\}, 22 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_4\}, 23 \to \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_3, \Xi_4\},$
$24 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_3\}, 25 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_4\}, 26 \to \{\Xi_1 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\},$
$27 \to \{\Xi_2 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\}, 28 \to \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_4, \Xi_3\}, 29 \to \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2\},$
$30 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3 + a_3 \Xi_4\}, 31 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_3 + a_3 \Xi_4\},$
$32 \to \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_4, \Xi_3 + a_3 \Xi_4\}, 33 \to \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2 + a_3 \Xi_3\},$
$34 \to \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2 + a_3 \Xi_4\}, 35 \to \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2 + a_3 \Xi_3 + a_4 \Xi_4\}\}$



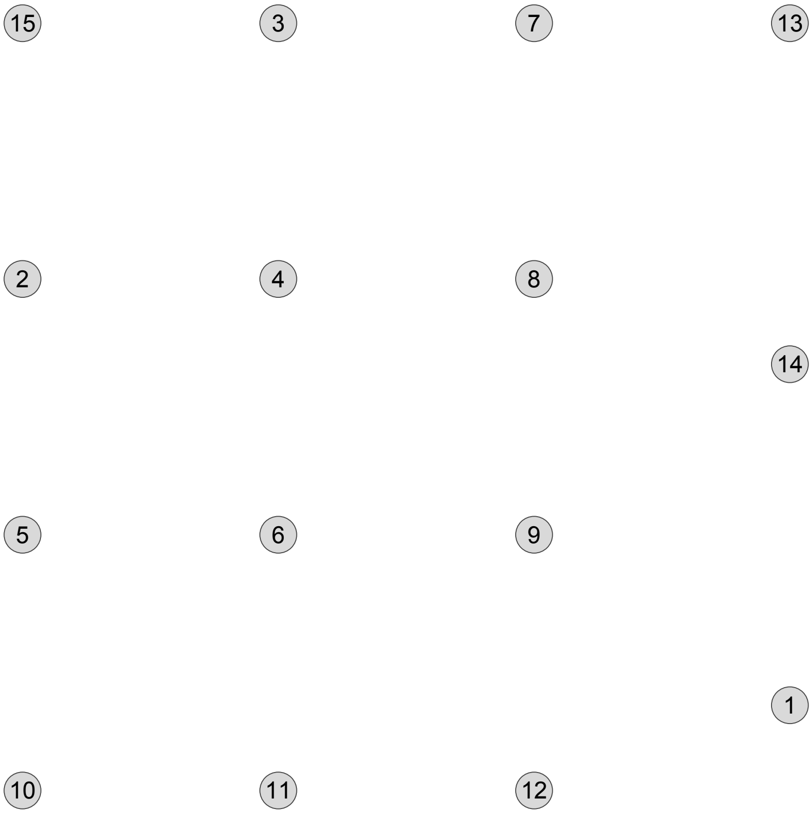
There are 15 3-D families of subalgebras to be analyzed.

Done.

There are 15 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\},$
$\{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1 \Xi_4, \Xi_3\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2, \Xi_4\},$
$\{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3, \Xi_4\},$
$\{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3 + a_2 \Xi_4\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_4, \Xi_3\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_4, \Xi_3 + a_3 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\},$
$5 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4\}, 7 \to \{\Xi_1, \Xi_2 + a_1 \Xi_4, \Xi_3\},$
$8 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3, \Xi_4\}, 9 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2, \Xi_4\}, 10 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3\},$
$11 \to \{\Xi_1, \Xi_2 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\}, 12 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3, \Xi_4\}, 13 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3 + a_2 \Xi_4\},$
$14 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_4, \Xi_3\}, 15 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_4, \Xi_3 + a_3 \Xi_4\}\}$



Time of computation: 1.382925

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Algebra n. 2

$$\begin{pmatrix} 0 & \Xi_2 & 0 & 0 \\ -\Xi_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 11 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + a_1\,\Xi_3\}, \{\Xi_2 + \alpha_1\,\Xi_3\}, \{\Xi_1 + a_1\,\Xi_4\}, \{\Xi_2 + \alpha_1\,\Xi_4\}, \{\Xi_3 + a_1\,\Xi_4\}, \{\Xi_1 + a_1\,\Xi_3 + a_2\,\Xi_4\}, \{\Xi_2 + \alpha_1\,\Xi_3 + a_1\,\Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 6 \to \{\Xi_1 + a_1\,\Xi_3\}, 7 \to \{\Xi_2 + \alpha_1\,\Xi_3\}, 8 \to \{\Xi_1 + a_1\,\Xi_4\}, 9 \to \{\Xi_2 + \alpha_1\,\Xi_4\}, 10 \to \{\Xi_3 + a_1\,\Xi_4\}, 13 \to \{\Xi_1 + a_1\,\Xi_3 + a_2\,\Xi_4\}, 14 \to \{\Xi_2 + \alpha_1\,\Xi_3 + a_1\,\Xi_4\}\}$

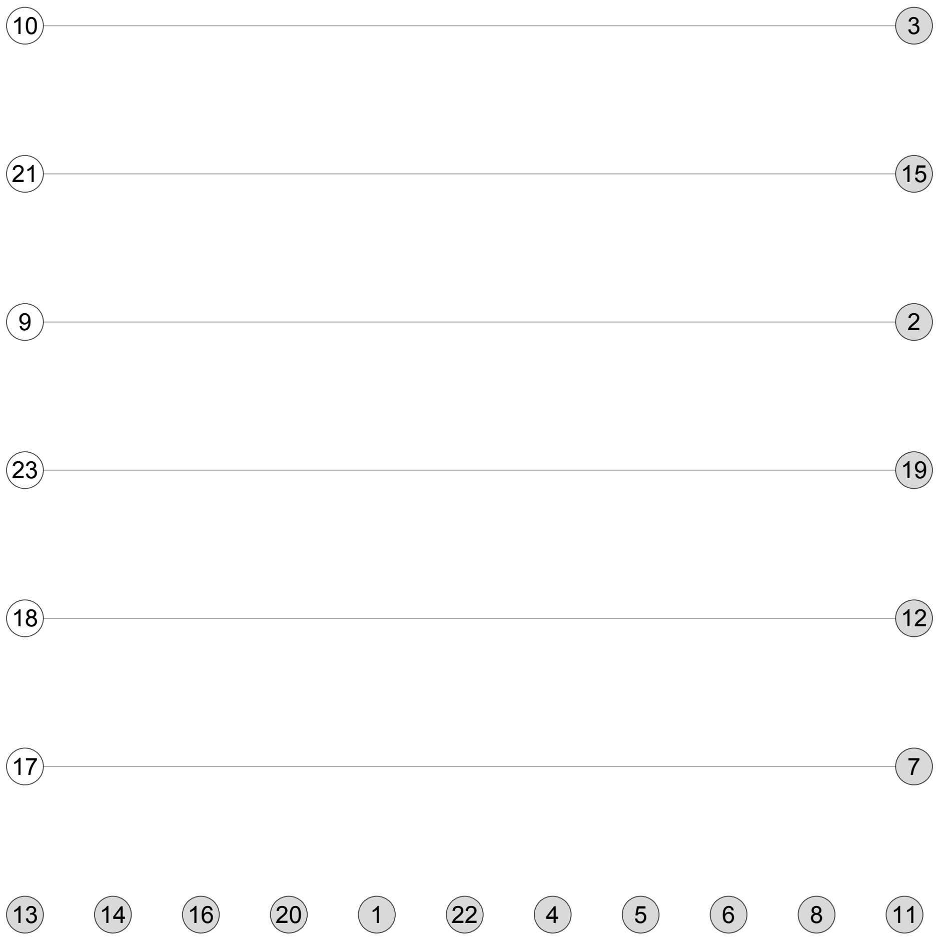
There are 23 2-D families of subalgebras to be analyzed.

Done.

There are 17 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, \{\Xi_2, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2\}, \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, \{\Xi_2 + \alpha_1 \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2\}, \{\Xi_1 + a_1 \Xi_4, \Xi_3\}, \{\Xi_2 + \alpha_1 \Xi_4, \Xi_3\}, \{\Xi_1 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\}, \{\Xi_2 + \alpha_1 \Xi_4, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 5 \to \{\Xi_2, \Xi_4\}, 6 \to \{\Xi_3, \Xi_4\}, 7 \to \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, 8 \to \{\Xi_2, \Xi_3 + a_1 \Xi_4\}, 11 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2\}, 12 \to \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, 13 \to \{\Xi_2 + \alpha_1 \Xi_3, \Xi_4\}, 14 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2\}, 15 \to \{\Xi_1 + a_1 \Xi_4, \Xi_3\}, 16 \to \{\Xi_2 + \alpha_1 \Xi_4, \Xi_3\}, 19 \to \{\Xi_1 + a_1 \Xi_4, \Xi_3 + a_2 \Xi_4\}, 20 \to \{\Xi_2 + \alpha_1 \Xi_4, \Xi_3 + a_1 \Xi_4\}, 22 \to \{\Xi_1 + a_1 \Xi_3 + a_2 \Xi_4, \Xi_2\}\}$

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There are 9 3-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 3-dimensional Lie subalgebras.
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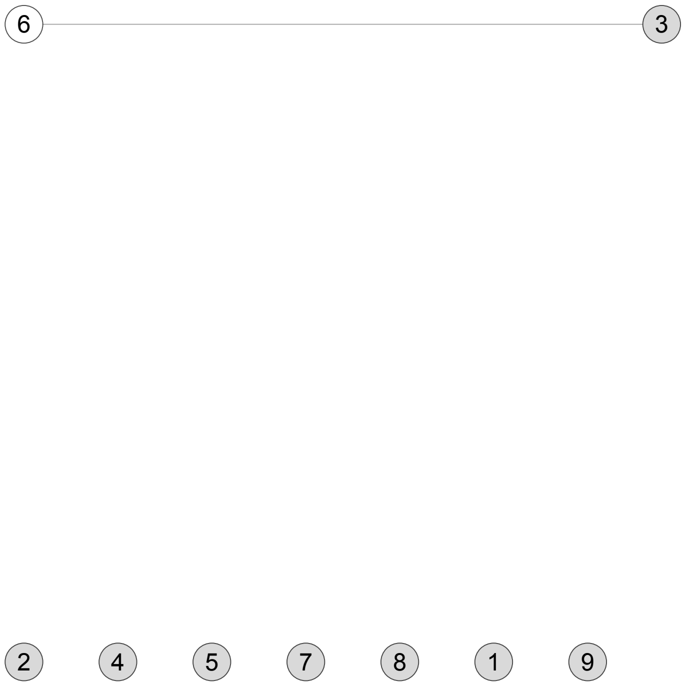
$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_3, \Xi_2, \Xi_4\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4, \Xi_2, \Xi_3\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4, \Xi_2, \Xi_3 + \underset{\cdot}{a}_2 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 5 \to \{\Xi_1, \Xi_2, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, 7 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_3, \Xi_2, \Xi_4\}, 8 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4, \Xi_2, \Xi_3\}, 9 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4, \Xi_2, \Xi_3 + \underset{\cdot}{a}_2 \Xi_4\}\}$



Time of computation: 3.430642

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Algebra n. 3

$$\begin{pmatrix} 0 & \Xi_2 & 0 & 0 \\ -\Xi_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & \Xi_4 \\ 0 & 0 & -\Xi_4 & 0 \end{pmatrix}$$

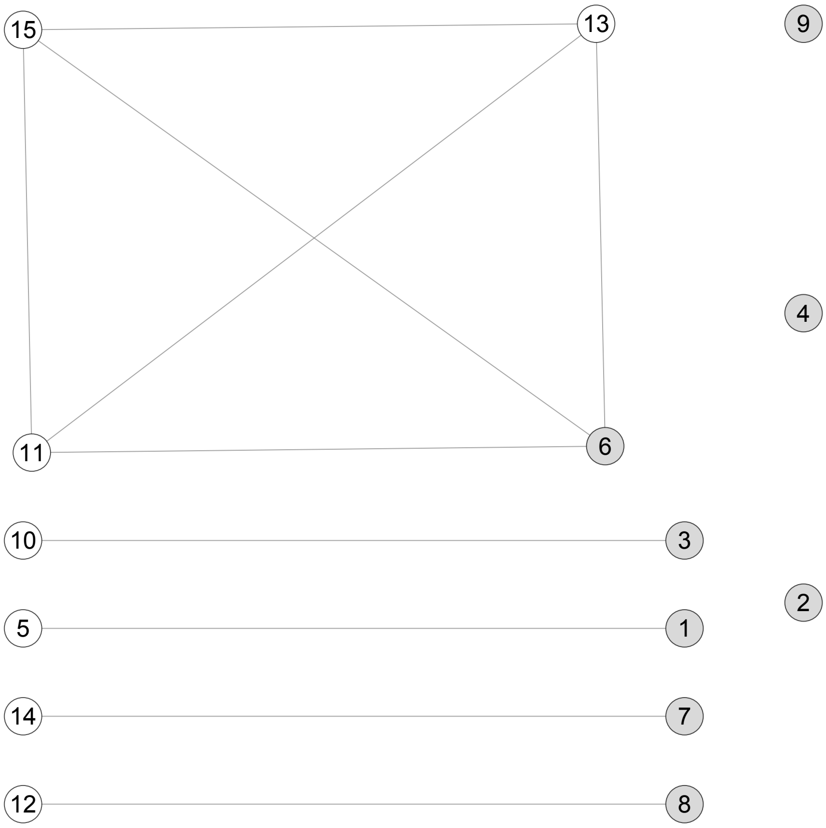
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \underset{\cdot}{a}_1\, \Xi_3\}, \{\Xi_2 + \underset{\cdot}{\alpha}_1\, \Xi_3\}, \{\Xi_1 + \underset{\cdot}{\alpha}_1\, \Xi_4\}, \{\Xi_2 + \underset{\cdot}{\alpha}_1\, \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\},$
$6 \to \{\Xi_1 + \underset{\cdot}{a}_1\, \Xi_3\}, 7 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\, \Xi_3\}, 8 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\, \Xi_4\}, 9 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\, \Xi_4\}\}$



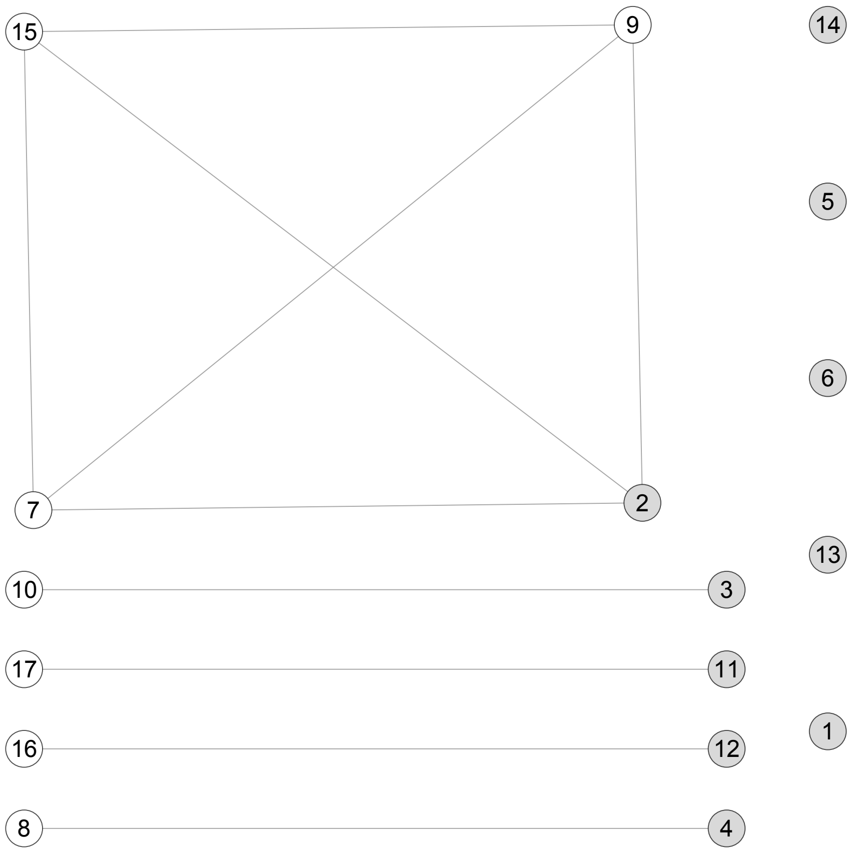
There are 17 2-D families of subalgebras to be analyzed.

Done.

There are 10 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1 + \underset{\circ}{a}_1 \Xi_3, \Xi_2\}, \{\Xi_1 + \underset{\circ}{a}_1 \Xi_3, \Xi_4\}, \{\Xi_2 + \underset{\circ}{\alpha}_1 \Xi_3, \Xi_4\}, \{\Xi_1 + \underset{\circ}{\alpha}_1 \Xi_4, \Xi_2\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 5 \to \{\Xi_2, \Xi_4\}, 6 \to \{\Xi_3, \Xi_4\}, 11 \to \{\Xi_1 + \underset{\circ}{a}_1 \Xi_3, \Xi_2\}, 12 \to \{\Xi_1 + \underset{\circ}{a}_1 \Xi_3, \Xi_4\}, 13 \to \{\Xi_2 + \underset{\circ}{\alpha}_1 \Xi_3, \Xi_4\}, 14 \to \{\Xi_1 + \underset{\circ}{\alpha}_1 \Xi_4, \Xi_2\}\}$



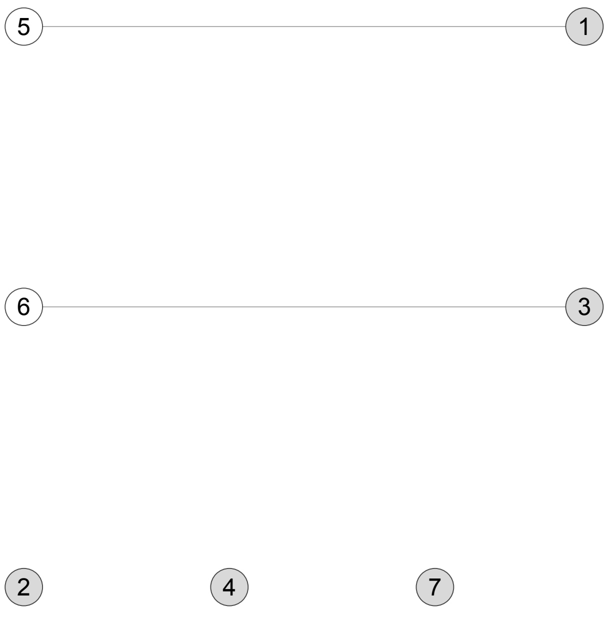
There are 7 3-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 7 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2, \Xi_4\}\}$



Time of computation: 2.441480

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Algebra n. 4

$$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & \Xi_1 & 0 \\ 0 & -\Xi_1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

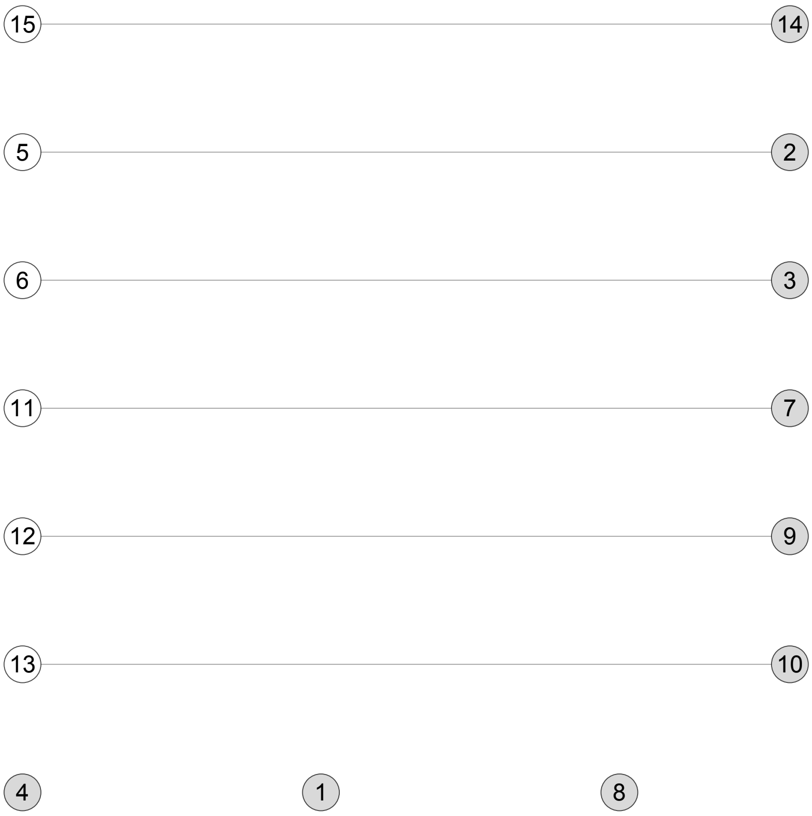
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 9 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_2 + a_1\,\Xi_3\}, \{\Xi_1 + a_1\,\Xi_4\}, \{\Xi_2 + a_1\,\Xi_4\}, \{\Xi_3 + a_1\,\Xi_4\}, \{\Xi_2 + a_1\,\Xi_3 + a_2\,\Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 7 \to \{\Xi_2 + a_1\,\Xi_3\},$
$8 \to \{\Xi_1 + a_1\,\Xi_4\}, 9 \to \{\Xi_2 + a_1\,\Xi_4\}, 10 \to \{\Xi_3 + a_1\,\Xi_4\}, 14 \to \{\Xi_2 + a_1\,\Xi_3 + a_2\,\Xi_4\}\}$



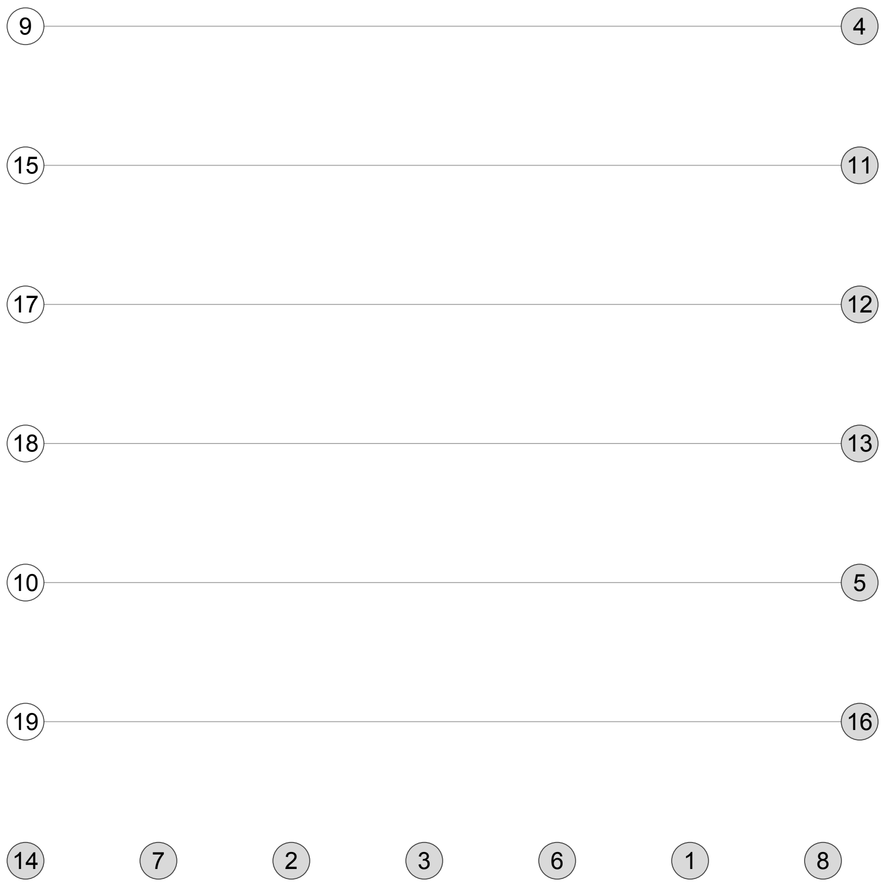
There are 19 2-D families of subalgebras to be analyzed.

Done.

There are 13 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1\,\Xi_3\},$
$\{\Xi_1, \Xi_2 + a_1\,\Xi_4\}, \{\Xi_1, \Xi_3 + a_1\,\Xi_4\}, \{\Xi_2 + a_1\,\Xi_3, \Xi_4\}, \{\Xi_1 + a_1\,\Xi_4, \Xi_2\},$
$\{\Xi_1 + a_1\,\Xi_4, \Xi_3\}, \{\Xi_1, \Xi_2 + a_1\,\Xi_3 + a_2\,\Xi_4\}, \{\Xi_1 + a_1\,\Xi_4, \Xi_2 + a_2\,\Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_4\}, 5 \to \{\Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + a_1\,\Xi_3\},$
$7 \to \{\Xi_1, \Xi_2 + a_1\,\Xi_4\}, 8 \to \{\Xi_1, \Xi_3 + a_1\,\Xi_4\}, 11 \to \{\Xi_2 + a_1\,\Xi_3, \Xi_4\}, 12 \to \{\Xi_1 + a_1\,\Xi_4, \Xi_2\},$
$13 \to \{\Xi_1 + a_1\,\Xi_4, \Xi_3\}, 14 \to \{\Xi_1, \Xi_2 + a_1\,\Xi_3 + a_2\,\Xi_4\}, 16 \to \{\Xi_1 + a_1\,\Xi_4, \Xi_2 + a_2\,\Xi_3\}\}$



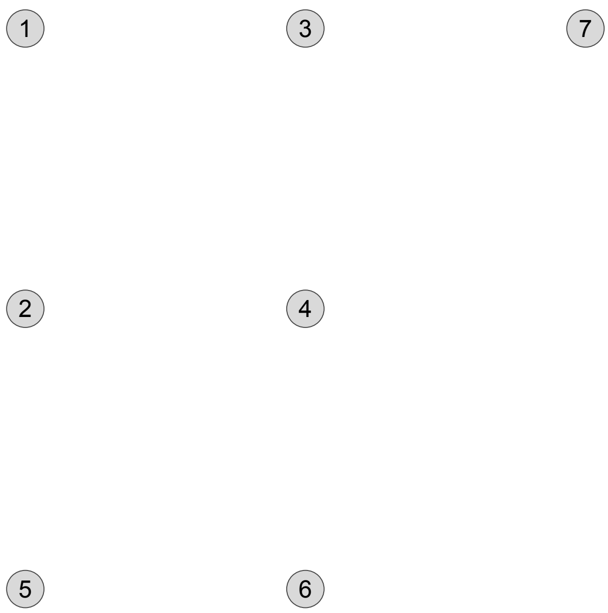
There are 7 3-D families of subalgebras to be analyzed.

Done.

There are 7 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + \underset{.}{a}_1 \Xi_4\},$
$\{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_4, \Xi_3\}, \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_4, \Xi_3 + \underset{.}{a}_2 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_1, \Xi_2, \Xi_3 + \underset{.}{a}_1 \Xi_4\},$
$5 \to \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_4, \Xi_3\}, 7 \to \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_4, \Xi_3 + \underset{.}{a}_2 \Xi_4\}\}$



Time of computation: 2.306443

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Algebra n. 5

$$\begin{pmatrix} 0 & 0 & \Xi_1 & 0 \\ 0 & 0 & \Xi_1 + \Xi_2 & 0 \\ -\Xi_1 & -\Xi_1 - \Xi_2 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

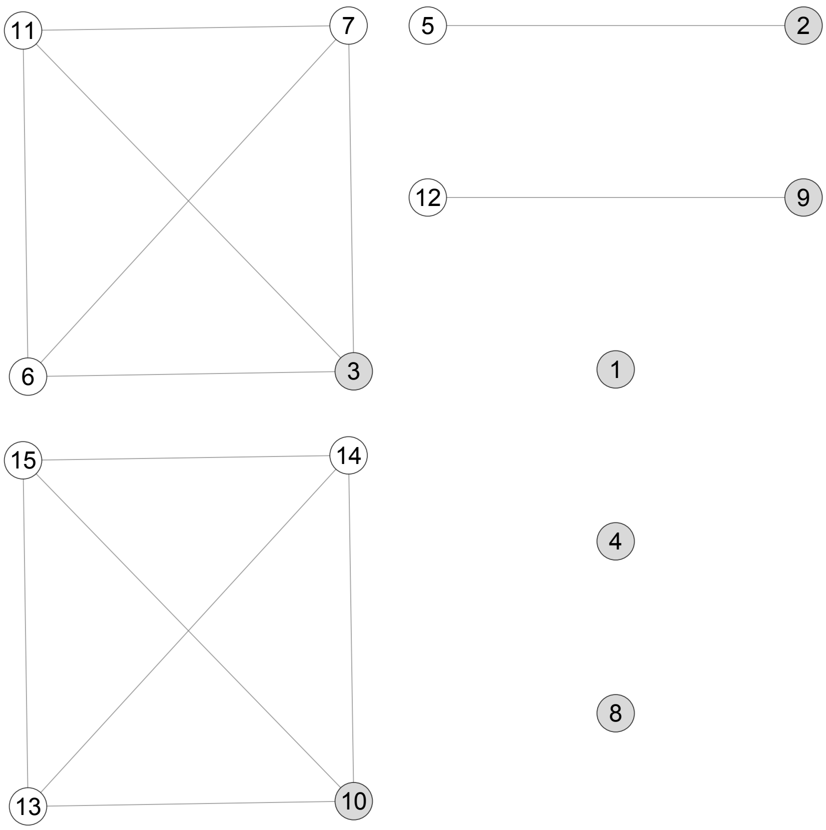
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 7 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_4\}, \{\Xi_2 + a_1 \Xi_4\}, \{\Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 8 \to \{\Xi_1 + \alpha_1 \Xi_4\}, 9 \to \{\Xi_2 + a_1 \Xi_4\}, 10 \to \{\Xi_3 + a_1 \Xi_4\}\}$



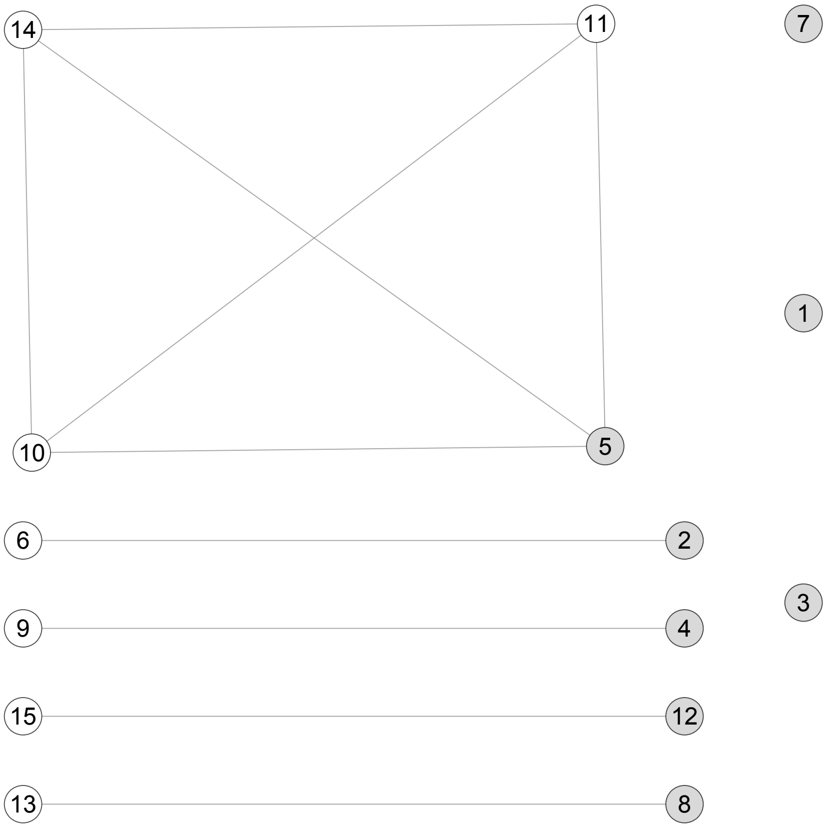
There are 15 2-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4\}, \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_4, \Xi_2\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_4\}, 5 \to \{\Xi_3, \Xi_4\}, 7 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4\}, 8 \to \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, 12 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2\}\}$



There are 5 3-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1\, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1\, \Xi_4\}\}$

Time of computation: 8.263238

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Algebra n. 6

$$\begin{pmatrix} 0 & 0 & \Xi_1 & 0 \\ 0 & 0 & \Xi_2 & 0 \\ -\Xi_1 & -\Xi_2 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

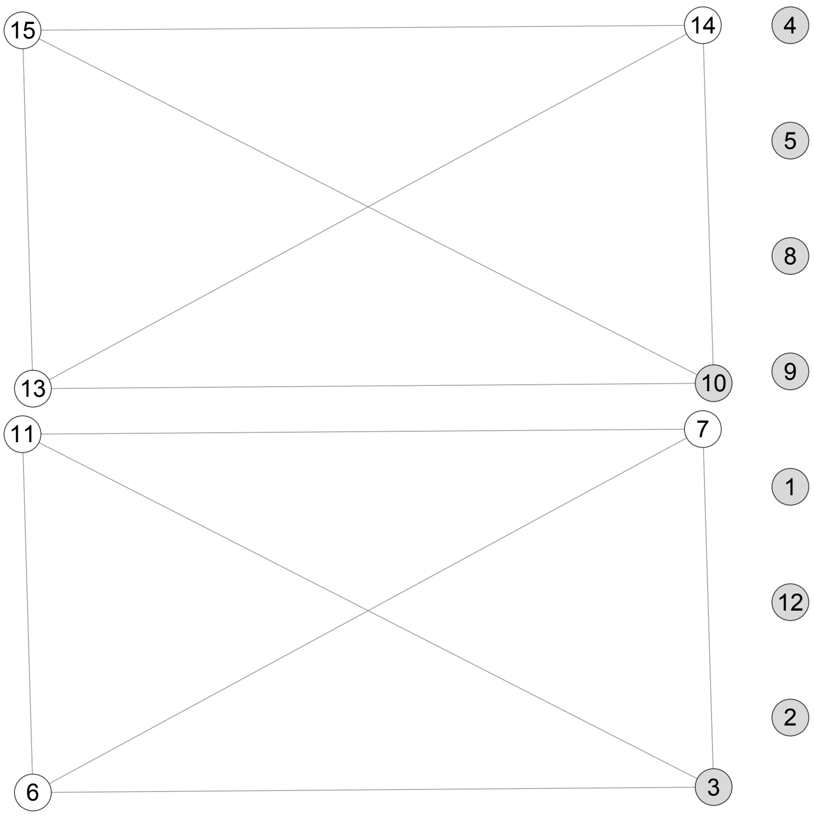
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 9 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + a_1 \Xi_2\}, \{\Xi_1 + \alpha_1 \Xi_4\}, \{\Xi_2 + \alpha_1 \Xi_4\}, \{\Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2 + \alpha_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + a_1 \Xi_2\},$
$8 \to \{\Xi_1 + \alpha_1 \Xi_4\}, 9 \to \{\Xi_2 + \alpha_1 \Xi_4\}, 10 \to \{\Xi_3 + a_1 \Xi_4\}, 12 \to \{\Xi_1 + a_1 \Xi_2 + \alpha_1 \Xi_4\}\}$



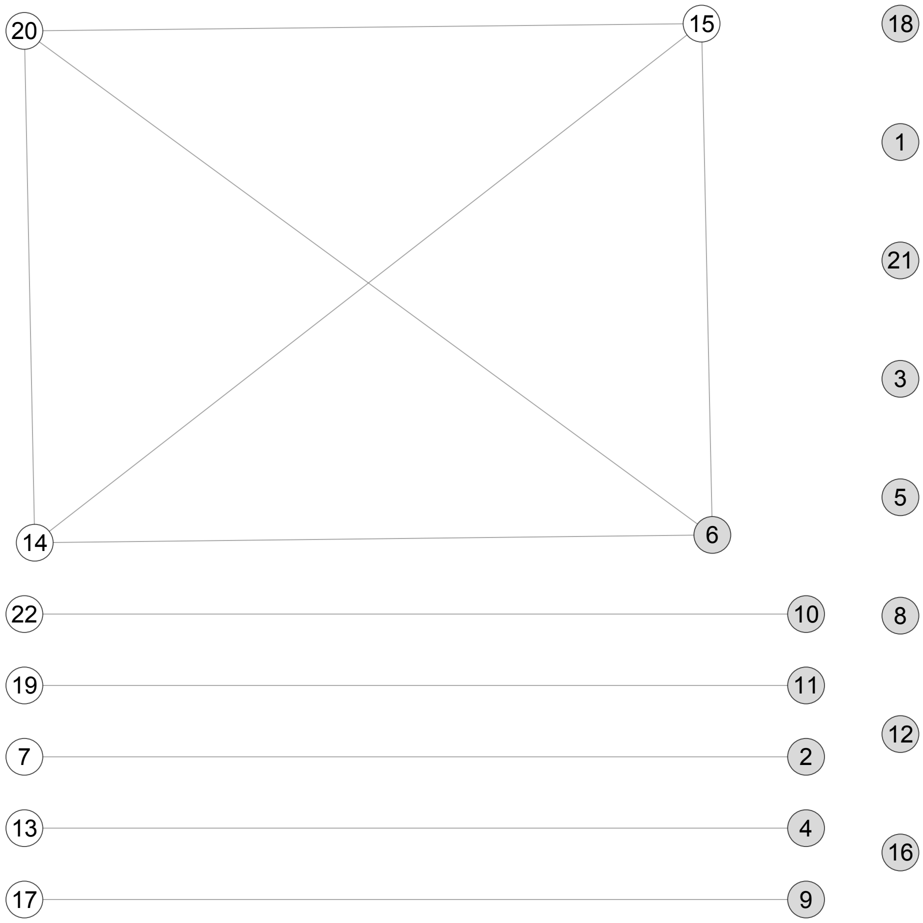
There are 22 2-D families of subalgebras to be analyzed.

Done.

There are 14 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\},$
$\{\Xi_1, \Xi_2 + \alpha_1 \Xi_4\}, \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, \{\Xi_2, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3\},$
$\{\Xi_1 + a_1 \Xi_2, \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3 + a_2 \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\},$
$5 \to \{\Xi_2, \Xi_4\}, 6 \to \{\Xi_3, \Xi_4\}, 8 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4\}, 9 \to \{\Xi_1, \Xi_3 + a_1 \Xi_4\},$
$10 \to \{\Xi_2, \Xi_3 + a_1 \Xi_4\}, 11 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3\}, 12 \to \{\Xi_1 + a_1 \Xi_2, \Xi_4\},$
$16 \to \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2\}, 18 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3 + a_2 \Xi_4\}, 21 \to \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2 + a_1 \Xi_4\}\}$



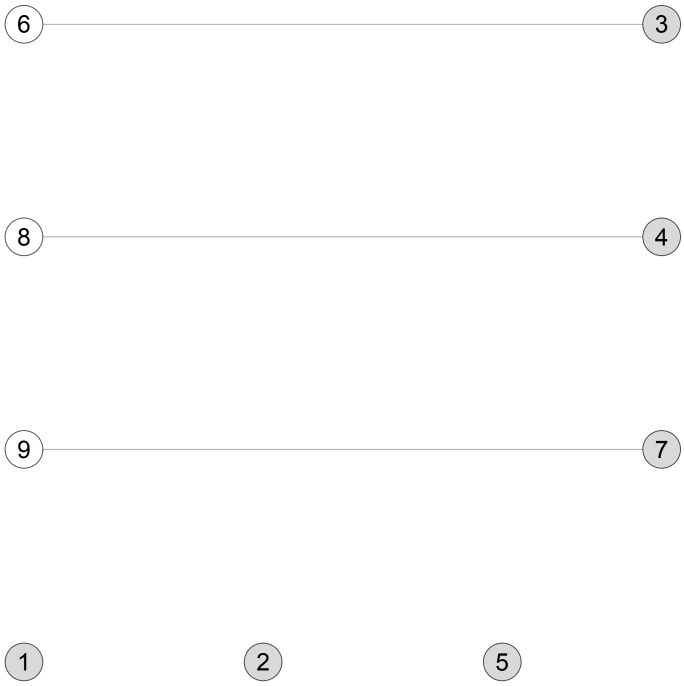
There are 9 3-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\},$
$4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 5 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}, 7 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3, \Xi_4\}\}$



Time of computation: 3.010770

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Algebra n. 7

$$\begin{pmatrix} 0 & 0 & \Xi_1 & 0 \\ 0 & 0 & -\Xi_2 & 0 \\ -\Xi_1 & \Xi_2 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

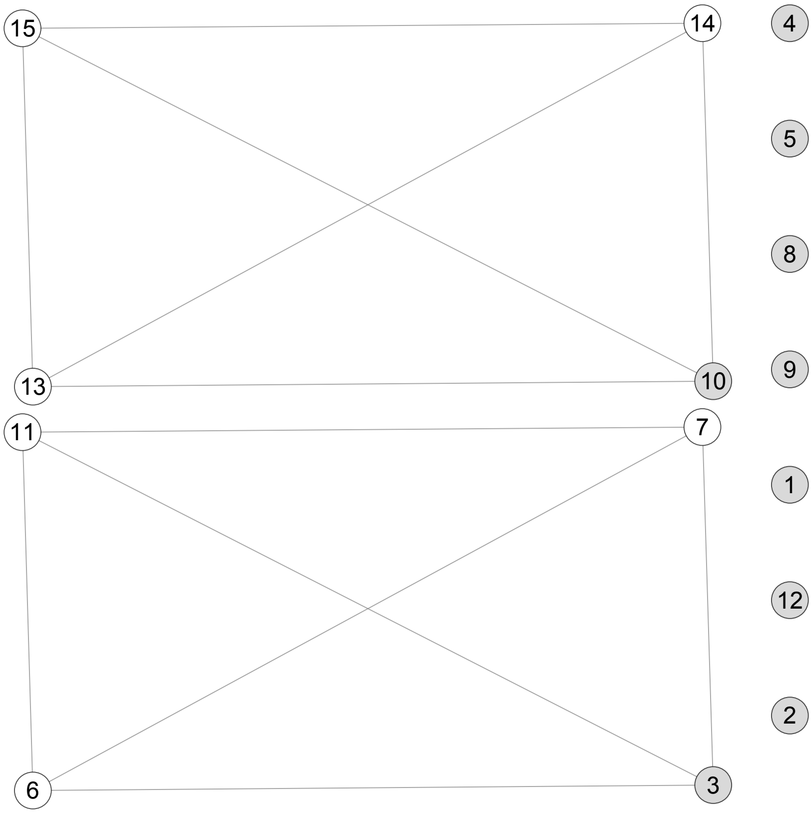
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 9 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2\}, \{\Xi_1 + \alpha_1 \Xi_4\}, \{\Xi_2 + \alpha_1 \Xi_4\}, \{\Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + \alpha_1 \Xi_2\},$
$8 \to \{\Xi_1 + \alpha_1 \Xi_4\}, 9 \to \{\Xi_2 + \alpha_1 \Xi_4\}, 10 \to \{\Xi_3 + a_1 \Xi_4\}, 12 \to \{\Xi_1 + \alpha_1 \Xi_2 + a_1 \Xi_4\}\}$

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There are 19 2-D families of subalgebras to be analyzed.
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Done.
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There are 12 optimal families of 2-dimensional Lie subalgebras.
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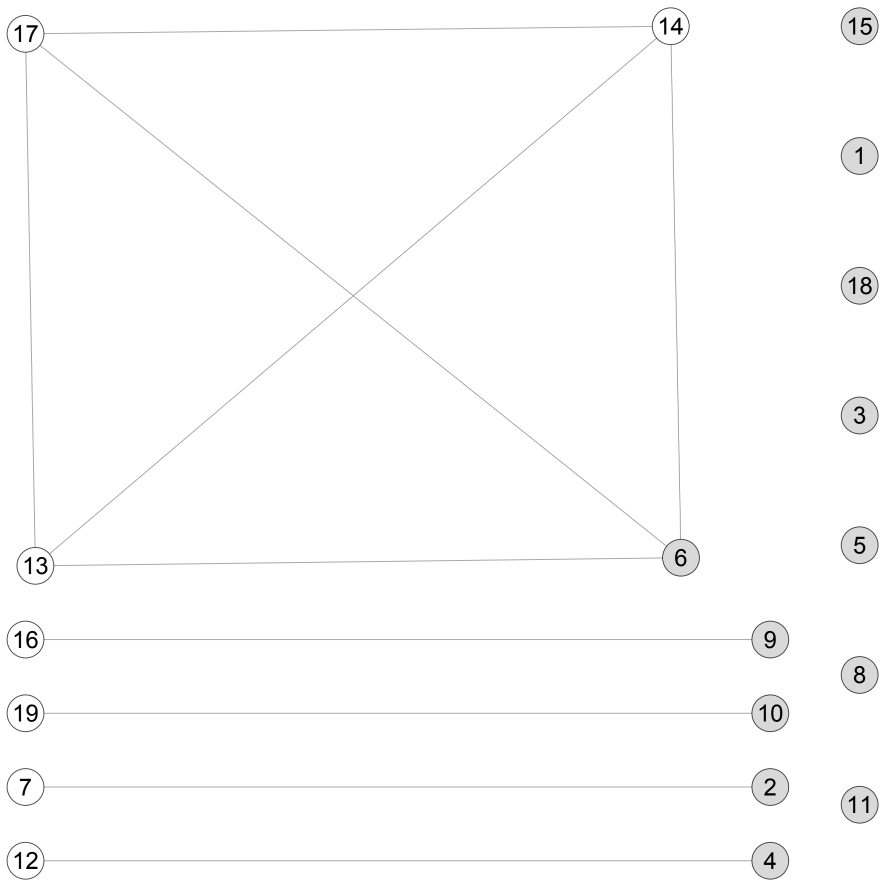
$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \underset{\cdot}{\alpha}_1 \Xi_4\},$
$\{\Xi_1, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, \{\Xi_2, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_2, \Xi_4\}, \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_4, \Xi_2\}, \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_4, \Xi_2 + \underset{\cdot}{a}_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 5 \to \{\Xi_2, \Xi_4\},$
$6 \to \{\Xi_3, \Xi_4\}, 8 \to \{\Xi_1, \Xi_2 + \underset{\cdot}{\alpha}_1 \Xi_4\}, 9 \to \{\Xi_1, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, 10 \to \{\Xi_2, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\},$
$11 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_2, \Xi_4\}, 15 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_4, \Xi_2\}, 18 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_4, \Xi_2 + \underset{\cdot}{a}_1 \Xi_4\}\}$



There are 7 3-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 5 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

Time of computation: 2.438456

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Algebra n. 8

$$\begin{pmatrix} 0 & 0 & \Xi_1 & 0 \\ 0 & 0 & a\,\Xi_2 & 0 \\ -\Xi_1 & -a\,\Xi_2 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

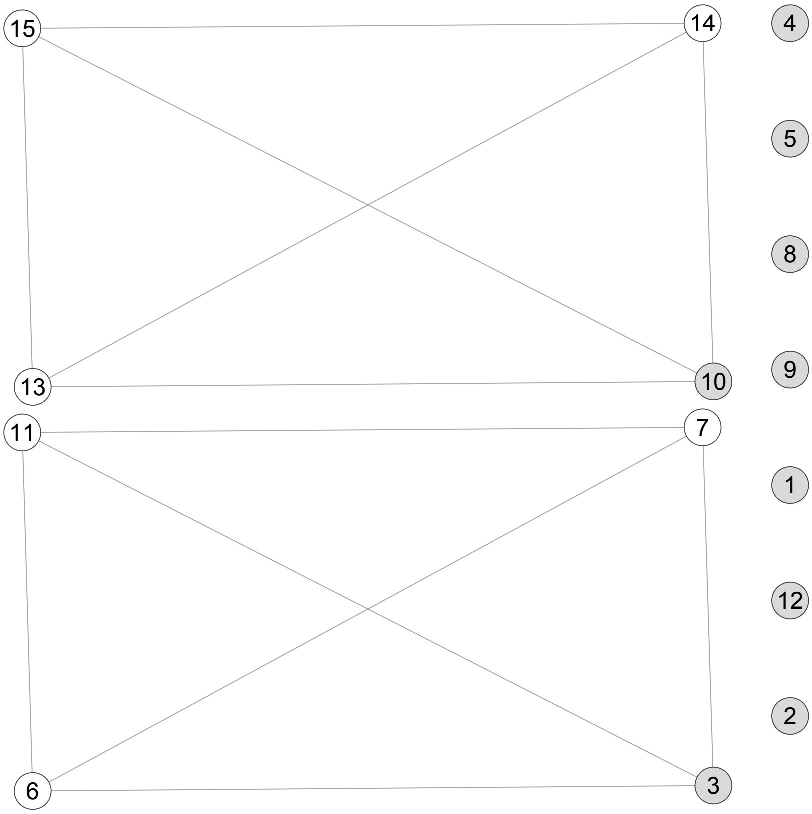
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 9 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2\}, \{\Xi_1 + \alpha_1 \Xi_4\}, \{\Xi_2 + \alpha_1 \Xi_4\}, \{\Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + \alpha_1 \Xi_2\},$
$8 \to \{\Xi_1 + \alpha_1 \Xi_4\}, 9 \to \{\Xi_2 + \alpha_1 \Xi_4\}, 10 \to \{\Xi_3 + a_1 \Xi_4\}, 12 \to \{\Xi_1 + \alpha_1 \Xi_2 + a_1 \Xi_4\}\}$



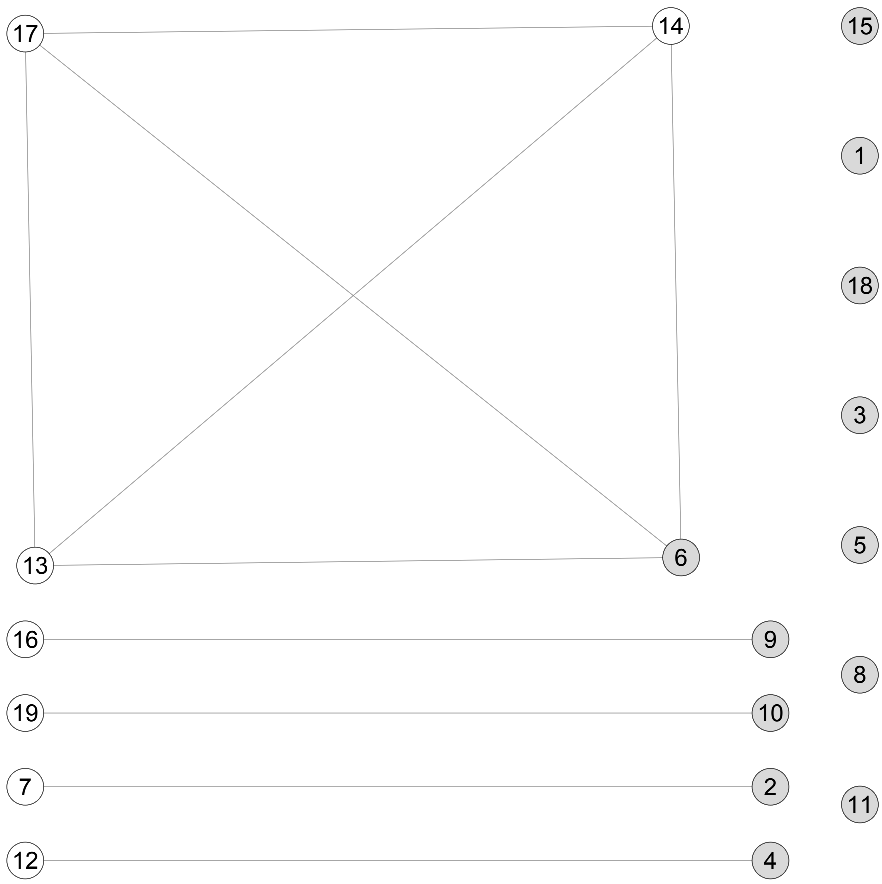
There are 19 2-D families of subalgebras to be analyzed.

Done.

There are 12 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4\},$
$\{\Xi_1, \Xi_3 + a_1 \Xi_4\}, \{\Xi_2, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2, \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2\}, \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 5 \to \{\Xi_2, \Xi_4\},$
$6 \to \{\Xi_3, \Xi_4\}, 8 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4\}, 9 \to \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, 10 \to \{\Xi_2, \Xi_3 + a_1 \Xi_4\},$
$11 \to \{\Xi_1 + \alpha_1 \Xi_2, \Xi_4\}, 15 \to \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2\}, 18 \to \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2 + a_1 \Xi_4\}\}$



There are 7 3-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 5 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

Time of computation: 2.544504

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Algebra n. 9

$$\begin{pmatrix} 0 & 0 & -\Xi_2 & 0 \\ 0 & 0 & \Xi_1 & 0 \\ \Xi_2 & -\Xi_1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

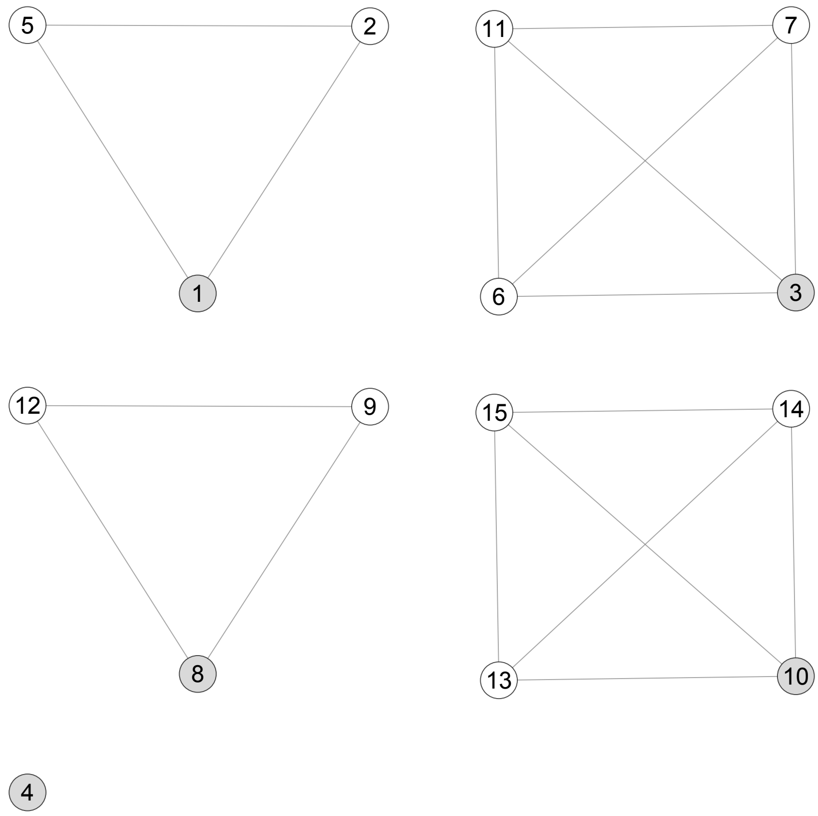
There are 15 1–D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 1–dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4\}, \{\Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 8 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4\}, 10 \to \{\Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}\}$



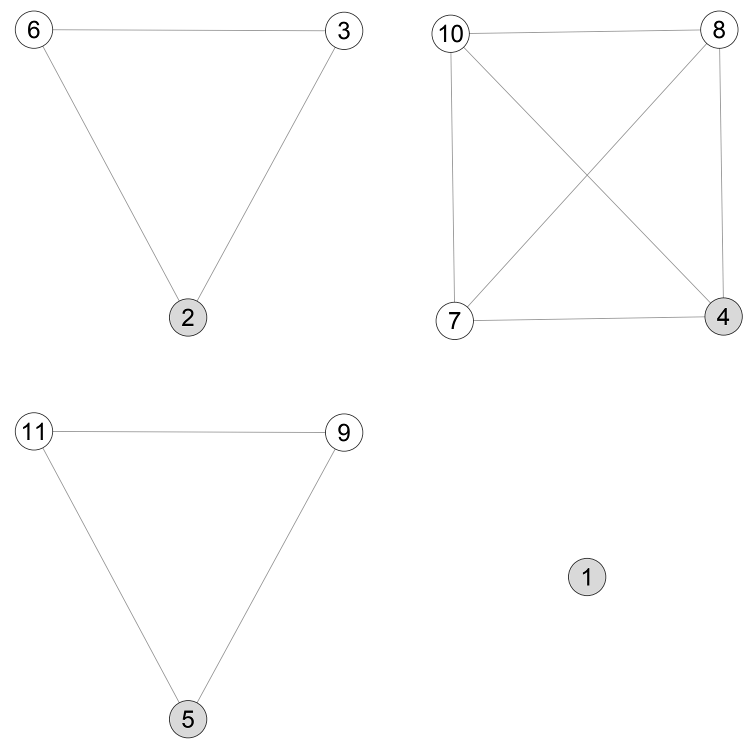
There are 11 2–D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 2–dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \underset{\cdot}{a}_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_3, \Xi_4\}, 5 \to \{\Xi_1, \Xi_2 + \underset{\cdot}{a}_1 \Xi_4\}\}$



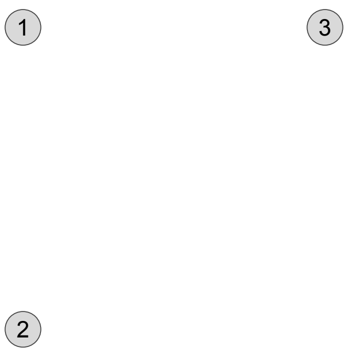
There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1\,\Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1\,\Xi_4\}\}$



Time of computation: 9.738252

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Algebra n. 10

$$\begin{pmatrix} 0 & 0 & a\,\Xi_1 - \Xi_2 & 0 \\ 0 & 0 & \Xi_1 + a\,\Xi_2 & 0 \\ -a\,\Xi_1 + \Xi_2 & -\Xi_1 - a\,\Xi_2 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

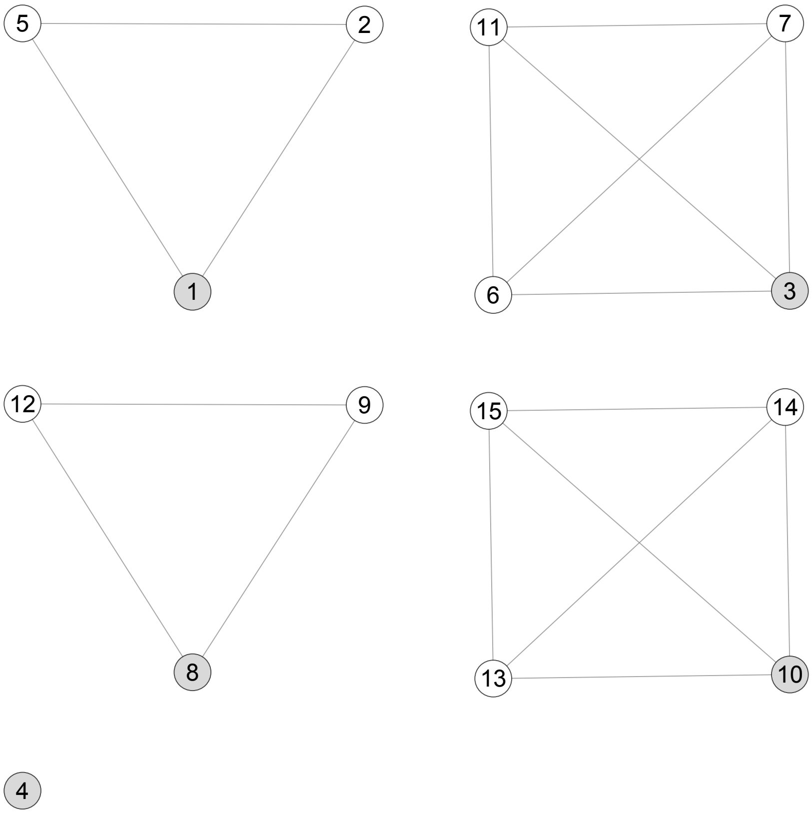
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + a_1\,\Xi_4\}, \{\Xi_3 + a_1\,\Xi_4\}\}$

$\{1 \to \{\Xi_1\},\ 3 \to \{\Xi_3\},\ 4 \to \{\Xi_4\},\ 8 \to \{\Xi_1 + a_1\,\Xi_4\},\ 10 \to \{\Xi_3 + a_1\,\Xi_4\}\}$



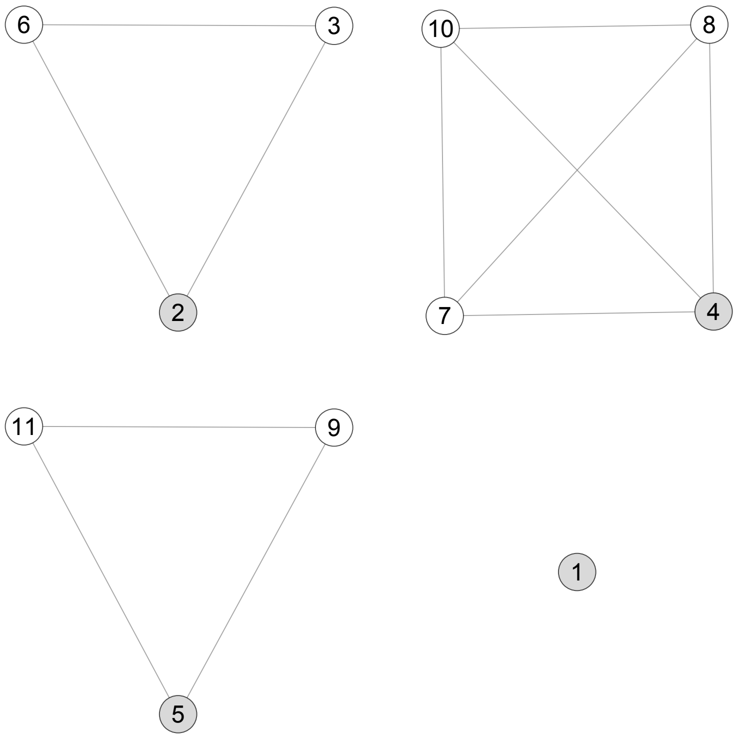
There are 11 2-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1,\ \Xi_2\},\ \{\Xi_1,\ \Xi_4\},\ \{\Xi_3,\ \Xi_4\},\ \{\Xi_1,\ \Xi_2 + a_1\,\Xi_4\}\}$

$\{1 \to \{\Xi_1,\ \Xi_2\},\ 2 \to \{\Xi_1,\ \Xi_4\},\ 4 \to \{\Xi_3,\ \Xi_4\},\ 5 \to \{\Xi_1,\ \Xi_2 + a_1\,\Xi_4\}\}$



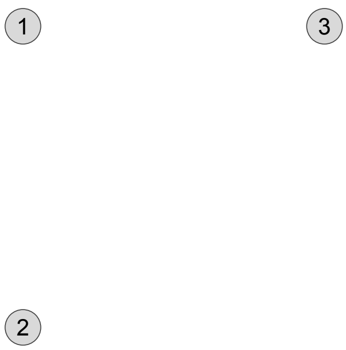
There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$



Time of computation: 57.876057

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Algebra n. 11

$$\begin{pmatrix} 0 & \Xi_1 & -2\,\Xi_2 & 0 \\ -\Xi_1 & 0 & \Xi_3 & 0 \\ 2\,\Xi_2 & -\Xi_3 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

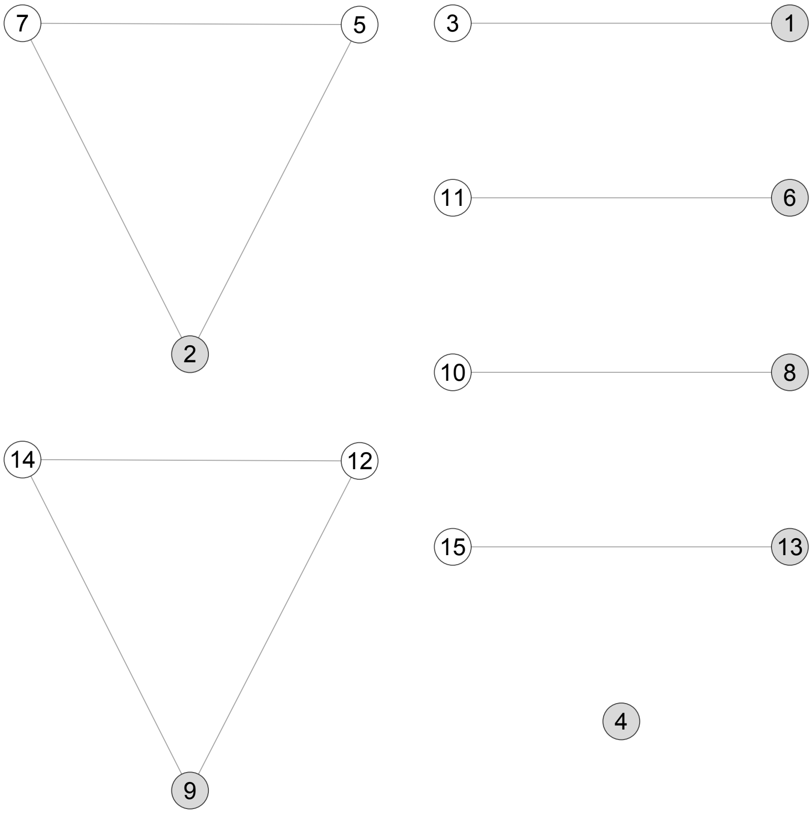
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 7 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_3\}, \{\Xi_1 + \alpha_1 \Xi_4\}, \{\Xi_2 + a_1 \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\},\ 2 \to \{\Xi_2\},\ 4 \to \{\Xi_4\},\ 6 \to \{\Xi_1 + \alpha_1\, \Xi_3\},$
$8 \to \{\Xi_1 + \alpha_1\, \Xi_4\},\ 9 \to \{\Xi_2 + a_1\, \Xi_4\},\ 13 \to \{\Xi_1 + \alpha_1\, \Xi_3 + a_1\, \Xi_4\}\}$



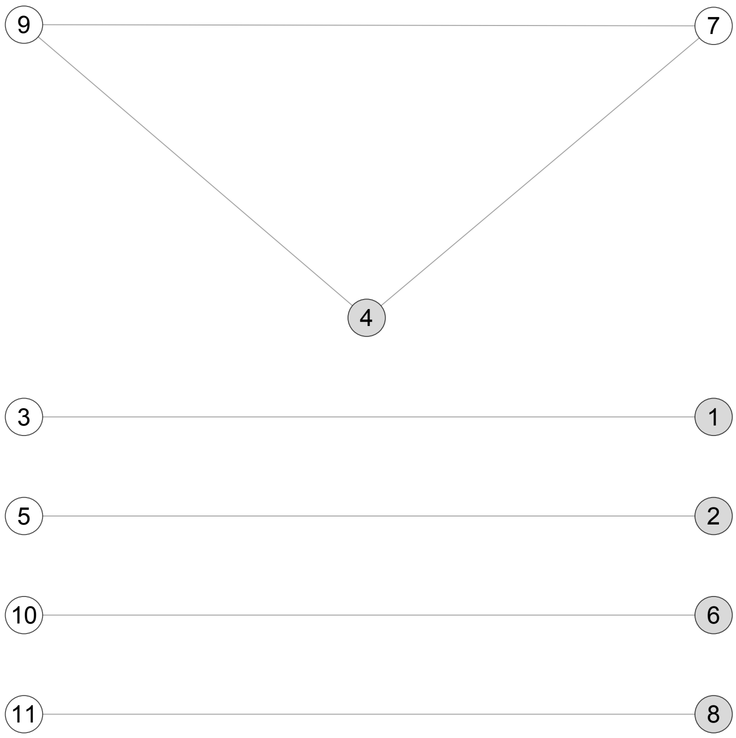
There are 11 2-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1\, \Xi_4\}, \{\Xi_1 + \alpha_1\, \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\},\ 2 \to \{\Xi_1, \Xi_4\},\ 4 \to \{\Xi_2, \Xi_4\},\ 6 \to \{\Xi_1, \Xi_2 + a_1\, \Xi_4\},\ 8 \to \{\Xi_1 + \alpha_1\, \Xi_3, \Xi_4\}\}$



There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 2 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}\}$

Time of computation: 5.277123

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Algebra n. 12

$$\begin{pmatrix} 0 & \Xi_3 & -\Xi_2 & 0 \\ -\Xi_3 & 0 & \Xi_1 & 0 \\ \Xi_2 & -\Xi_1 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

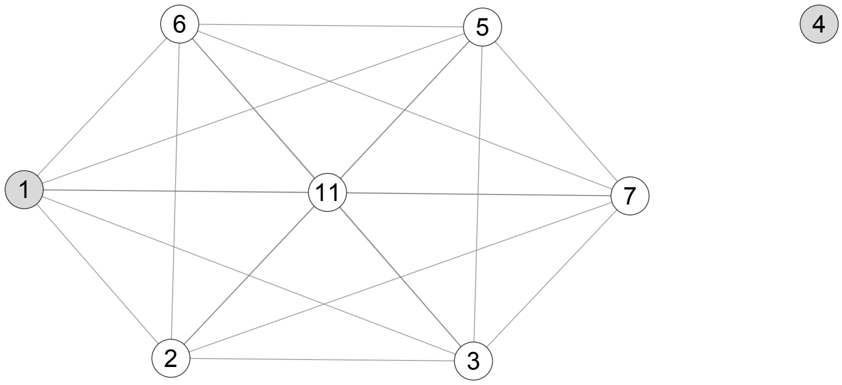
There are 15 1-D families of subalgebras to be analyzed.

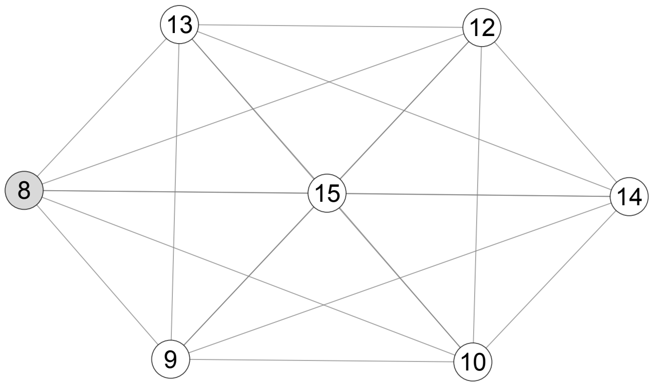
Done.

There are 3 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_4\}, \{\Xi_1 + a_1 \Xi_4\}\}$

{1 → {Ξ_1}, 4 → {Ξ_4}, 8 → {$\Xi_1 + a_1 \Xi_4$}}





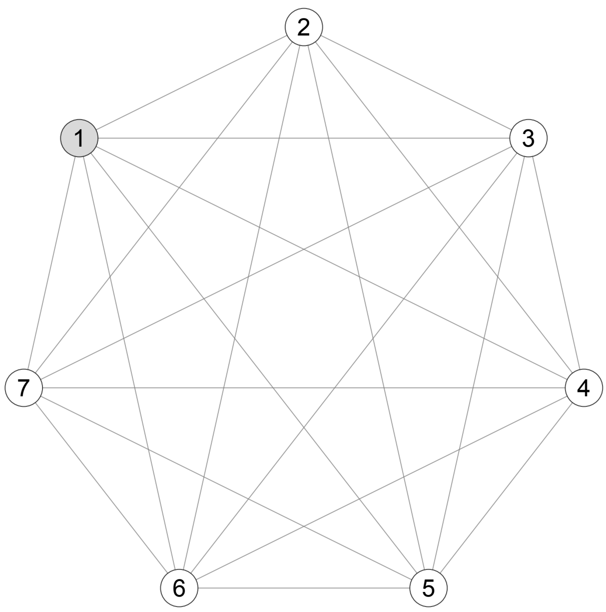
There are 7 2-D families of subalgebras to be analyzed.

Done.

There are 1 optimal families of 2-dimensional Lie subalgebras.

{{Ξ_1, Ξ_4}}

{1 → {Ξ_1, Ξ_4}}



There are 1 3-D families of subalgebras to be analyzed.

Done.

There are 1 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}\}$

Time of computation: 59.427010

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Algebra n. 13

$$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & \Xi_2 \\ 0 & -\Xi_1 & -\Xi_2 & 0 \end{pmatrix}$$

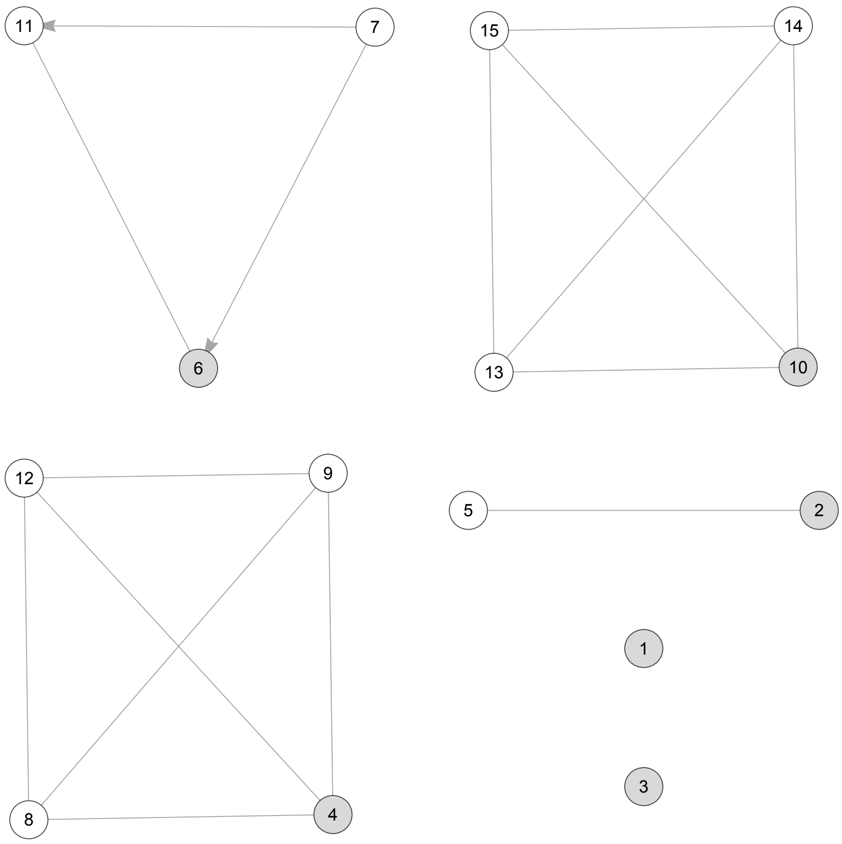
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + a_1 \Xi_3\}, \{\Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 6 \to \{\Xi_1 + a_1 \Xi_3\}, 10 \to \{\Xi_3 + a_1 \Xi_4\}\}$



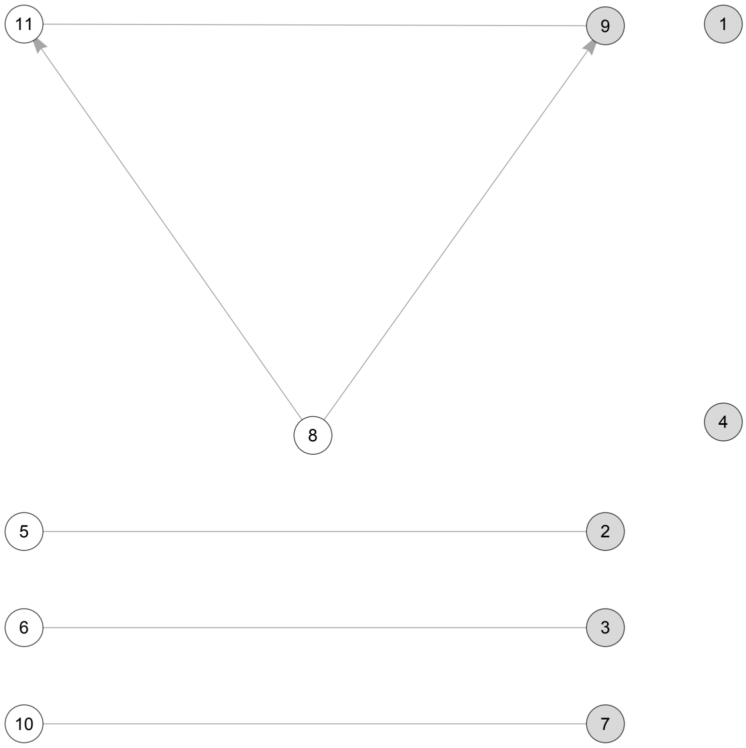
There are 11 2-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 7 \to \{\Xi_1, \Xi_3 + a_1 \Xi_4\}, 9 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2\}\}$



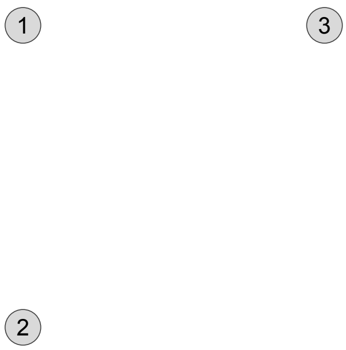
There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$



Time of computation: 5.455947

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Algebra n. 14

$$\begin{pmatrix} 0 & 0 & 0 & a\,\Xi_1 \\ 0 & 0 & 0 & \Xi_2 \\ 0 & 0 & 0 & \Xi_2 + \Xi_3 \\ -a\,\Xi_1 & -\Xi_2 & -\Xi_2 - \Xi_3 & 0 \end{pmatrix}$$

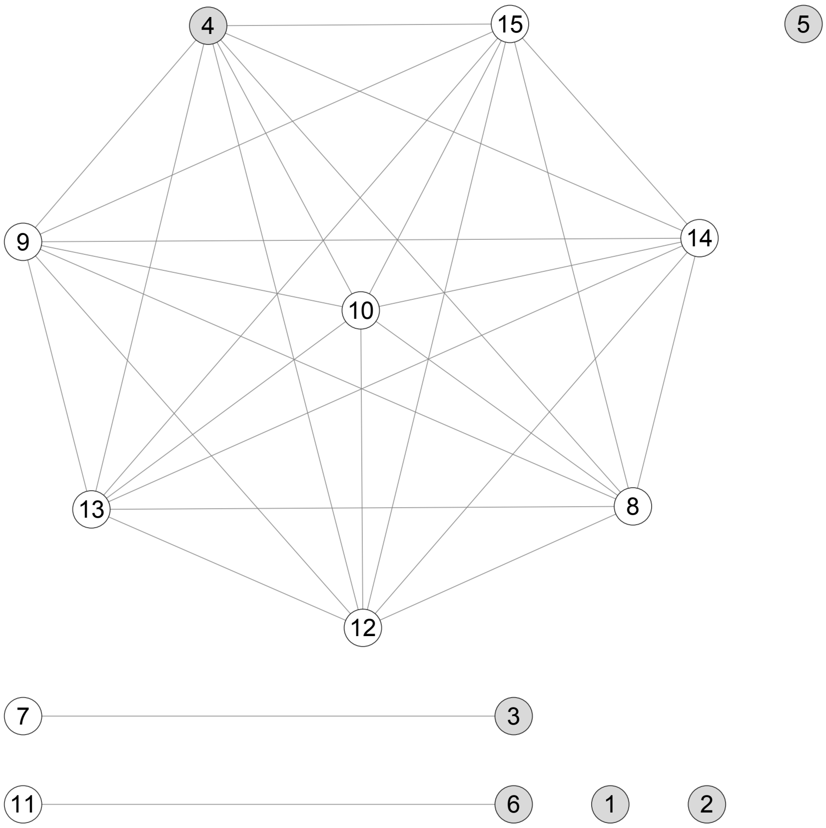
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2\}, \{\Xi_1 + a_1 \Xi_3\}\}$

{1 → {Ξ_1}, 2 → {Ξ_2}, 3 → {Ξ_3}, 4 → {Ξ_4}, 5 → {$\Xi_1 + \alpha_1 \Xi_2$}, 6 → {$\Xi_1 + a_1 \Xi_3$}}



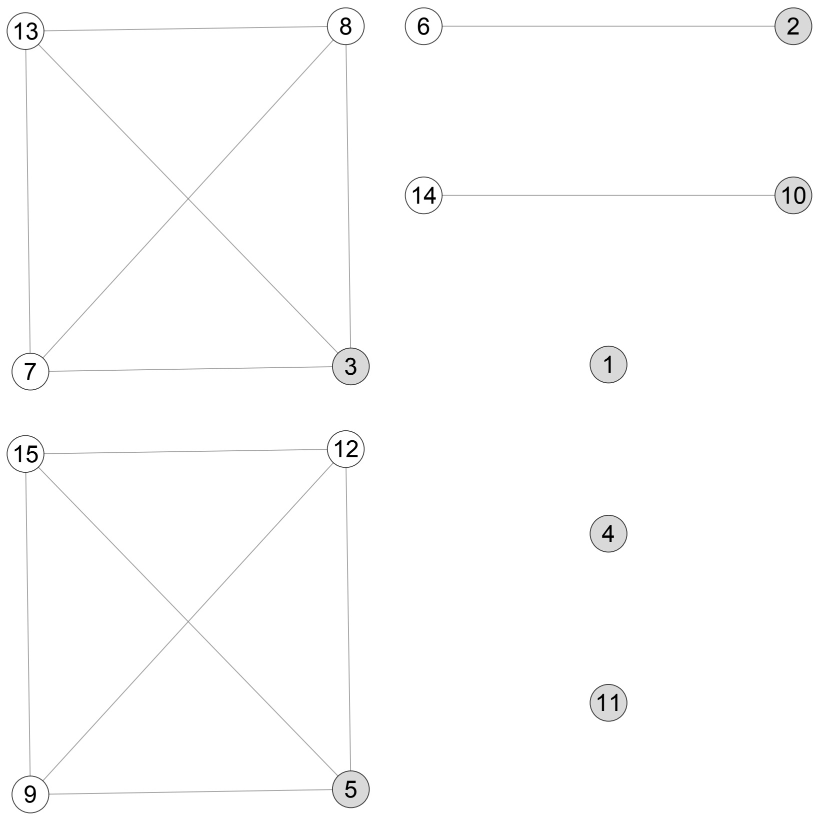
There are 15 2-D families of subalgebras to be analyzed.

Done.

There are 7 optimal families of 2-dimensional Lie subalgebras.

{{Ξ_1, Ξ_2}, {Ξ_1, Ξ_3}, {Ξ_1, Ξ_4}, {Ξ_2, Ξ_3}, {Ξ_2, Ξ_4}, {$\Xi_1 + a_1 \Xi_2$, Ξ_3}, {$\Xi_1 + \alpha_1 \Xi_3$, Ξ_2}}

{1 → {Ξ_1, Ξ_2}, 2 → {Ξ_1, Ξ_3}, 3 → {Ξ_1, Ξ_4}, 4 → {Ξ_2, Ξ_3},
5 → {Ξ_2, Ξ_4}, 10 → {$\Xi_1 + a_1 \Xi_2$, Ξ_3}, 11 → {$\Xi_1 + \alpha_1 \Xi_3$, Ξ_2}}



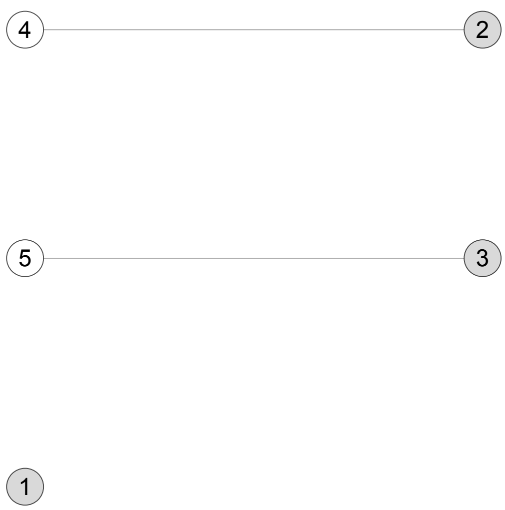
There are 5 3-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_2, \Xi_3, \Xi_4\}\}$



Time of computation: 37.129170

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Algebra n. 15

$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & \Xi_2 \\ 0 & 0 & 0 & \Xi_2+\Xi_3 \\ -\Xi_1 & -\Xi_2 & -\Xi_2-\Xi_3 & 0 \end{pmatrix}$$

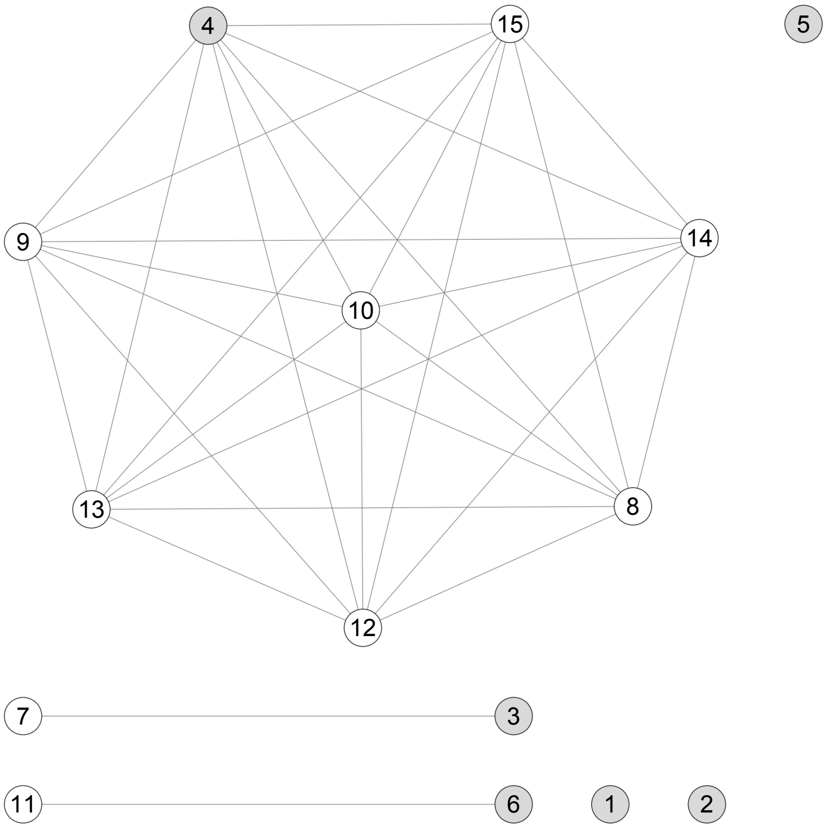
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + a_1 \Xi_2\}, \{\Xi_1 + a_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + a_1 \Xi_2\}, 6 \to \{\Xi_1 + a_1 \Xi_3\}\}$



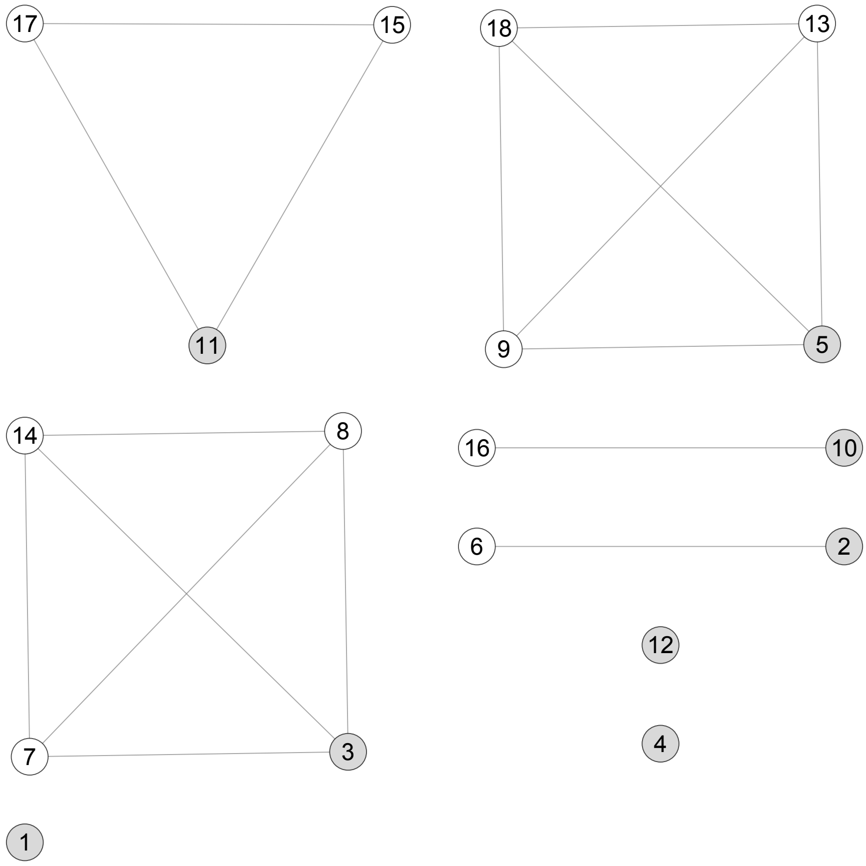
There are 18 2-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\},$
$\{\Xi_2, \Xi_4\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3\}, \{\Xi_1 + a_1 \Xi_2, \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\},$
$5 \to \{\Xi_2, \Xi_4\}, 10 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3\}, 11 \to \{\Xi_1 + a_1 \Xi_2, \Xi_4\}, 12 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2\}\}$



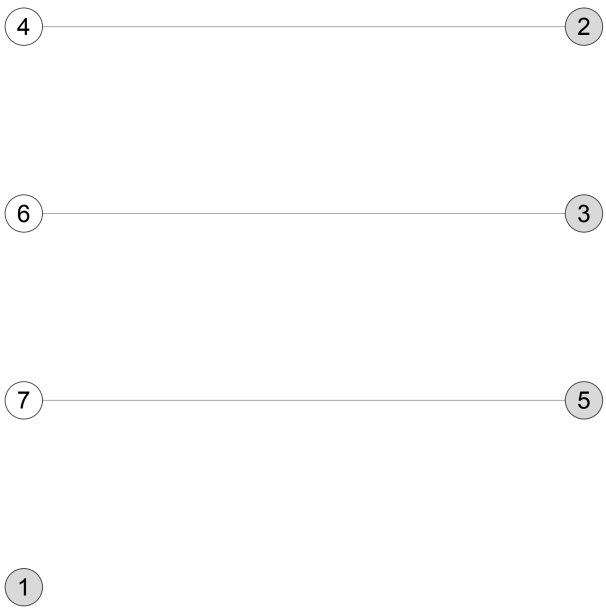
There are 7 3-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_3, \Xi_2, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_2, \Xi_3, \Xi_4\}, 5 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_3, \Xi_2, \Xi_4\}\}$



Time of computation: 82.038207

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Algebra n. 16

$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \Xi_2 \\ -\Xi_1 & 0 & -\Xi_2 & 0 \end{pmatrix}$$

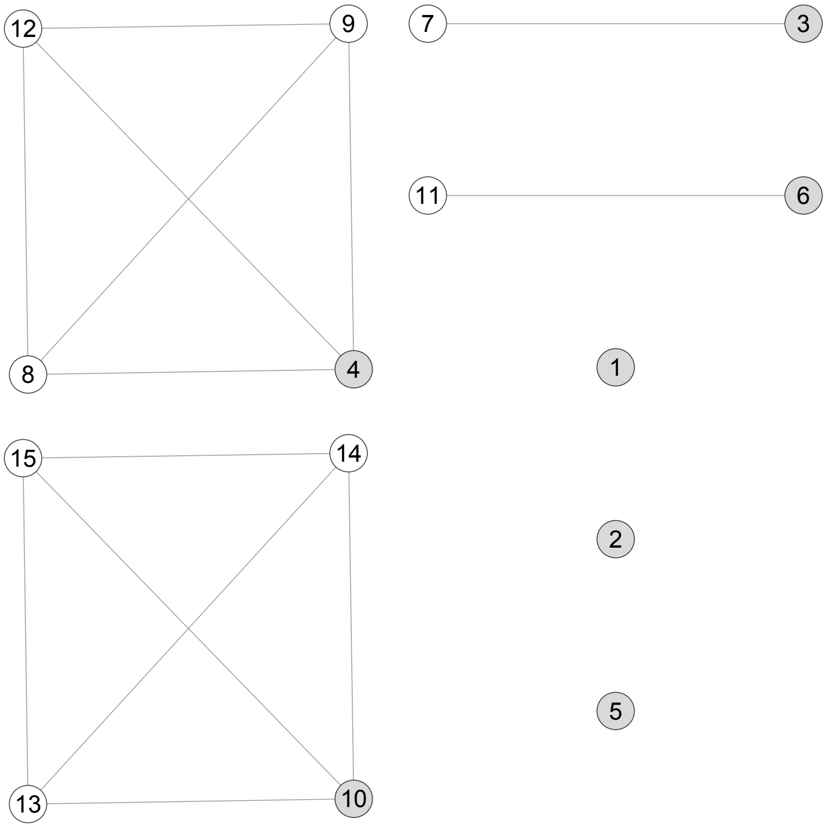
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 7 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_2\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_3\}, \{\Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_2\}, 6 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_3\}, 10 \to \{\Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}\}$



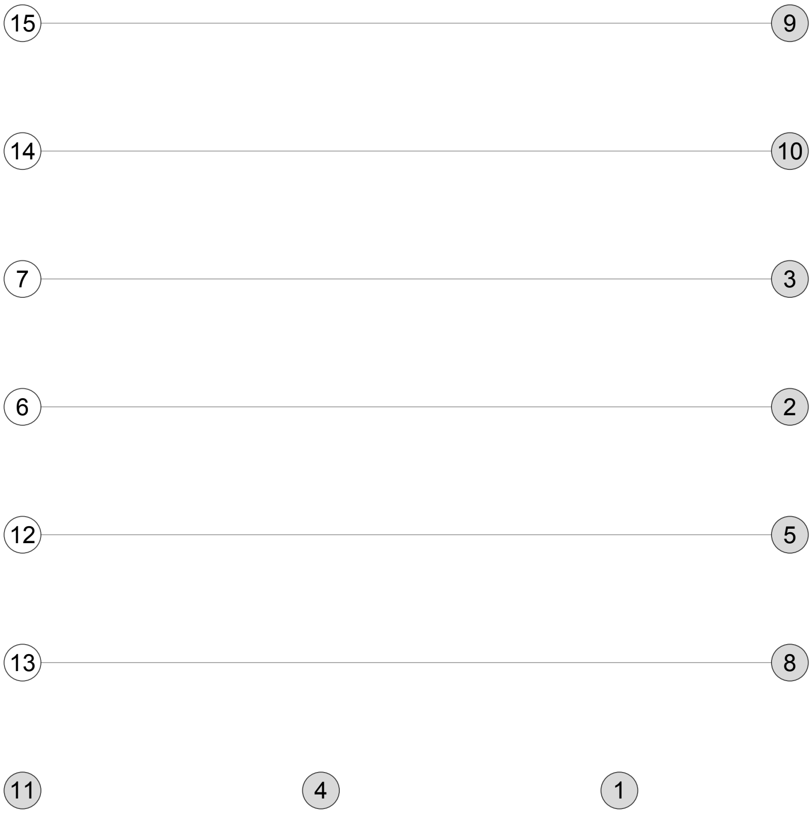
There are 15 2-D families of subalgebras to be analyzed.

Done.

There are 9 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\},$
$\{\Xi_1, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, \{\Xi_2, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_2, \Xi_3\}, \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_3, \Xi_2\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 5 \to \{\Xi_2, \Xi_4\},$
$8 \to \{\Xi_1, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, 9 \to \{\Xi_2, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, 10 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_2, \Xi_3\}, 11 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1 \Xi_3, \Xi_2\}\}$



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There are 5 3-D families of subalgebras to be analyzed.
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Done.
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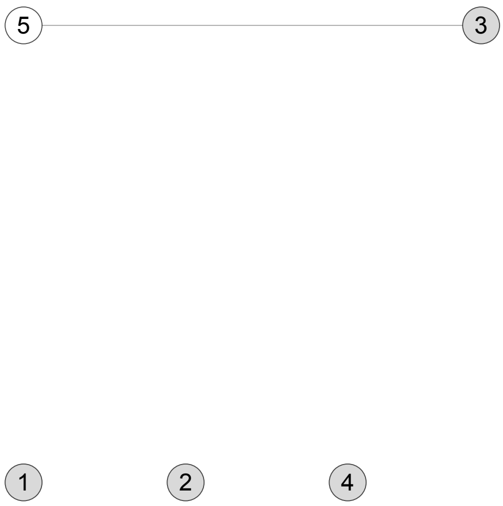
```
There are 4 optimal families of 3-dimensional Lie subalgebras.
```

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_2, \Xi_3, \Xi_4\}, 4 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$



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Time of computation: 9.039540
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Algebra n. 17
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$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & \Xi_1 + \Xi_2 \\ 0 & 0 & 0 & \Xi_2 + \Xi_3 \\ -\Xi_1 & -\Xi_1 - \Xi_2 & -\Xi_2 - \Xi_3 & 0 \end{pmatrix}$$

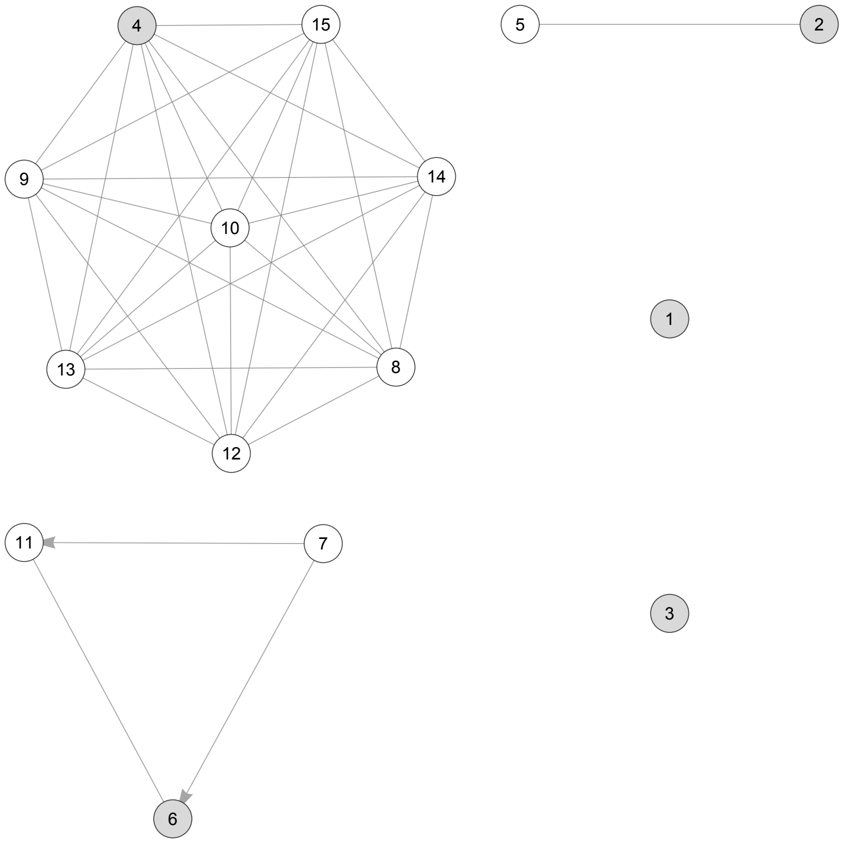
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + a_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 6 \to \{\Xi_1 + a_1 \Xi_3\}\}$



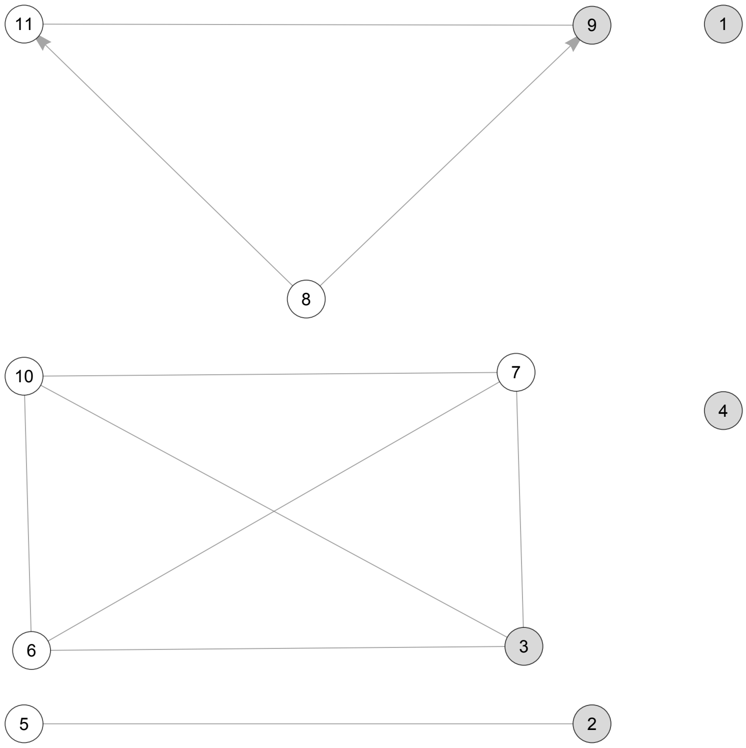
There are 11 2-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 9 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2\}\}$



There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 2 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}\}$

Time of computation: 46.033450

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Algebra n. 18

$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & a\,\Xi_2 \\ 0 & 0 & 0 & b\,\Xi_3 \\ -\Xi_1 & -a\,\Xi_2 & -b\,\Xi_3 & 0 \end{pmatrix}$$

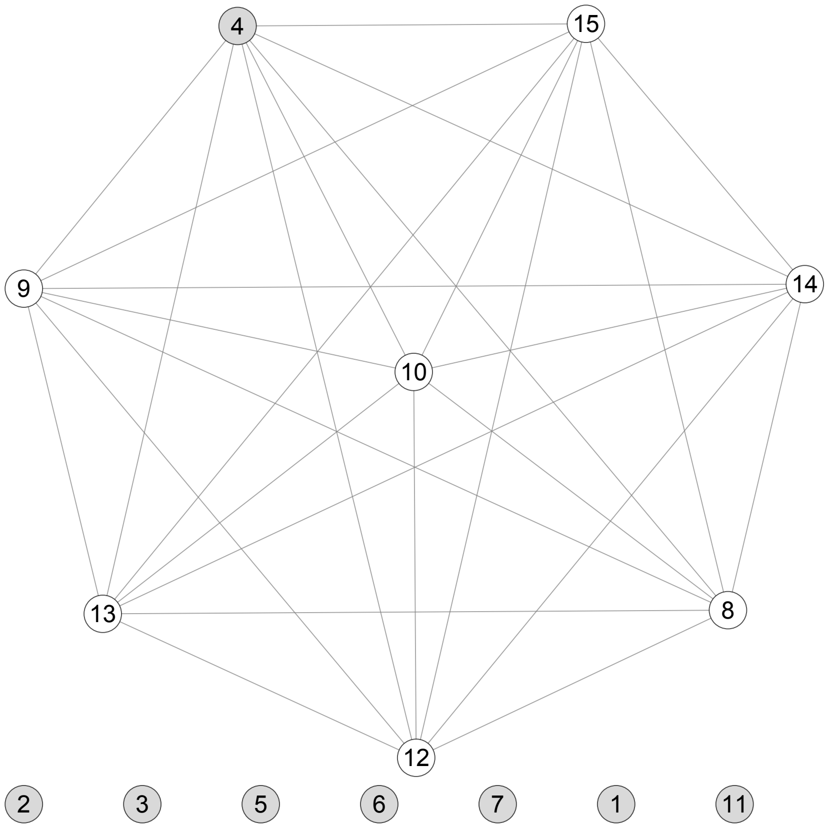
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2\}, \{\Xi_1 + \alpha_1 \Xi_3\}, \{\Xi_2 + \alpha_1 \Xi_3\}, \{\Xi_1 + \alpha_1 \Xi_2 + a_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1\},\ 2 \to \{\Xi_2\},\ 3 \to \{\Xi_3\},\ 4 \to \{\Xi_4\},\ 5 \to \{\Xi_1 + \alpha_1\,\Xi_2\},$
$6 \to \{\Xi_1 + \alpha_1\,\Xi_3\},\ 7 \to \{\Xi_2 + \alpha_1\,\Xi_3\},\ 11 \to \{\Xi_1 + \alpha_1\,\Xi_2 + a_1\,\Xi_3\}\}$



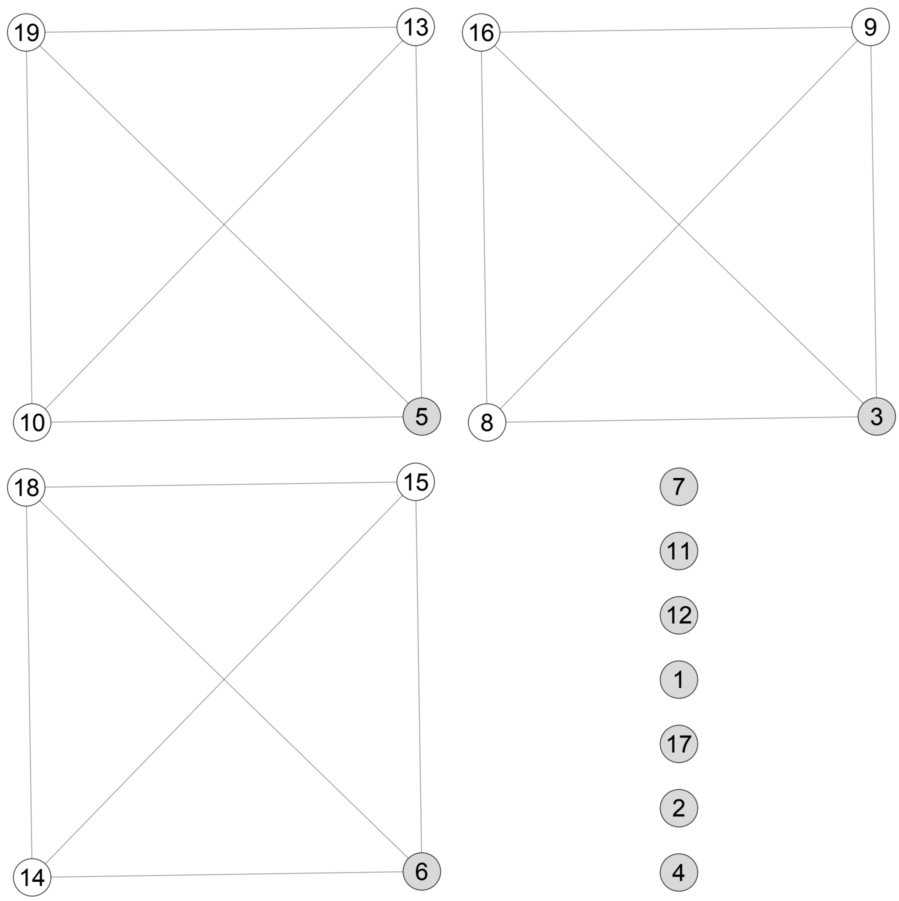
There are 19 2-D families of subalgebras to be analyzed.

Done.

There are 10 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1,\ \Xi_2\},\ \{\Xi_1,\ \Xi_3\},\ \{\Xi_1,\ \Xi_4\},\ \{\Xi_2,\ \Xi_3\},\ \{\Xi_2,\ \Xi_4\},\ \{\Xi_3,\ \Xi_4\},$
$\{\Xi_1,\ \Xi_2 + \alpha_1\,\Xi_3\},\ \{\Xi_1 + \alpha_1\,\Xi_2,\ \Xi_3\},\ \{\Xi_1 + \alpha_1\,\Xi_3,\ \Xi_2\},\ \{\Xi_1 + \alpha_1\,\Xi_3,\ \Xi_2 + a_1\,\Xi_3\}\}$

$\{1 \to \{\Xi_1,\ \Xi_2\},\ 2 \to \{\Xi_1,\ \Xi_3\},\ 3 \to \{\Xi_1,\ \Xi_4\},\ 4 \to \{\Xi_2,\ \Xi_3\},\ 5 \to \{\Xi_2,\ \Xi_4\},\ 6 \to \{\Xi_3,\ \Xi_4\},$
$7 \to \{\Xi_1,\ \Xi_2 + \alpha_1\,\Xi_3\},\ 11 \to \{\Xi_1 + \alpha_1\,\Xi_2,\ \Xi_3\},\ 12 \to \{\Xi_1 + \alpha_1\,\Xi_3,\ \Xi_2\},\ 17 \to \{\Xi_1 + \alpha_1\,\Xi_3,\ \Xi_2 + a_1\,\Xi_3\}\}$



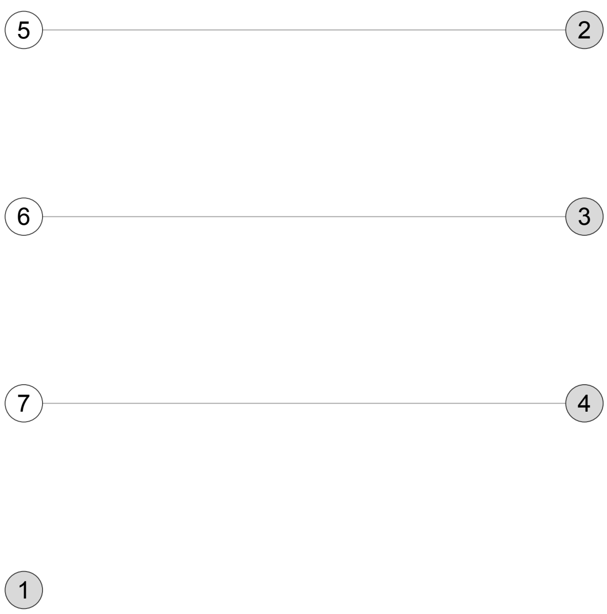
There are 7 3-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}\}$



Time of computation: 5.847802

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Algebra n. 19

$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & a\,\Xi_2 \\ 0 & 0 & 0 & a\,\Xi_3 \\ -\Xi_1 & -a\,\Xi_2 & -a\,\Xi_3 & 0 \end{pmatrix}$$

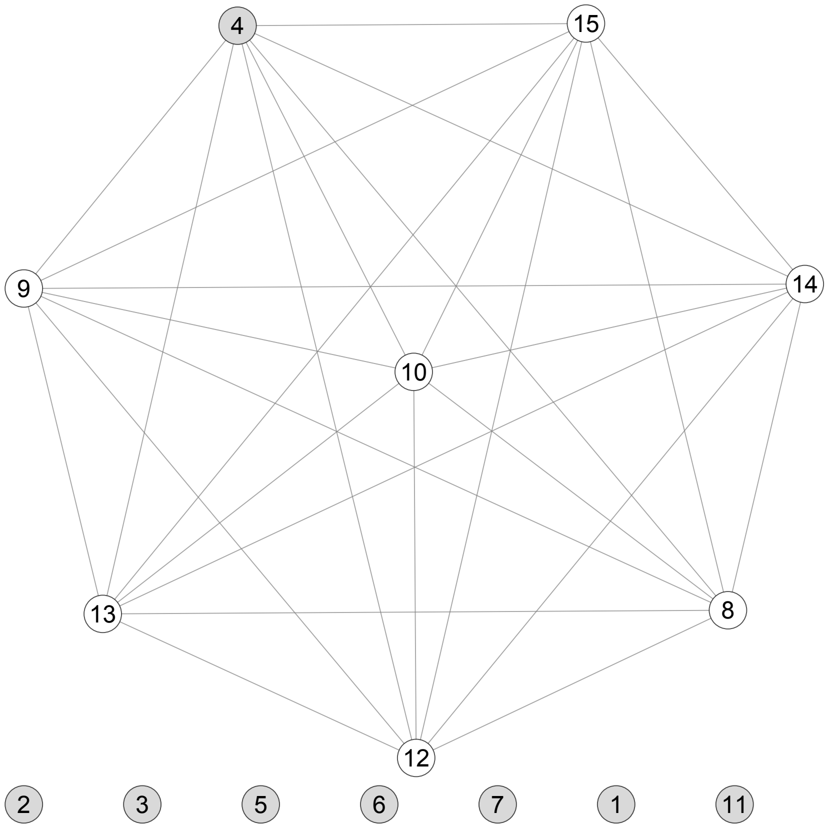
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_2\}, \{\Xi_1 + \alpha_1 \Xi_3\}, \{\Xi_2 + a_1 \Xi_3\}, \{\Xi_1 + \alpha_1 \Xi_2 + a_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + \alpha_1 \Xi_2\},$
$6 \to \{\Xi_1 + \alpha_1 \Xi_3\}, 7 \to \{\Xi_2 + a_1 \Xi_3\}, 11 \to \{\Xi_1 + \alpha_1 \Xi_2 + a_1 \Xi_3\}\}$



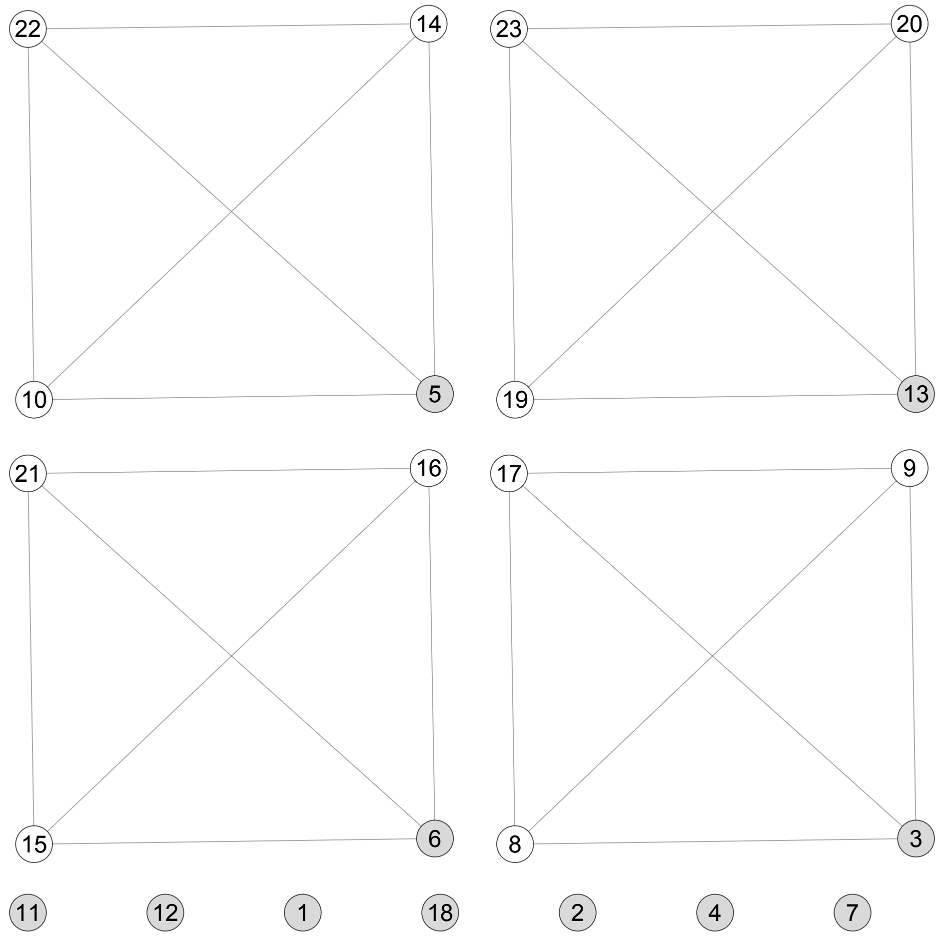
There are 23 2-D families of subalgebras to be analyzed.

Done.

There are 11 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1 \Xi_3\},$
$\{\Xi_1 + \alpha_1 \Xi_2, \Xi_3\}, \{\Xi_1 + \alpha_1 \Xi_3, \Xi_2\}, \{\Xi_2 + a_1 \Xi_3, \Xi_4\}, \{\Xi_1 + \alpha_1 \Xi_3, \Xi_2 + a_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\},$
$5 \to \{\Xi_2, \Xi_4\}, 6 \to \{\Xi_3, \Xi_4\}, 7 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3\}, 11 \to \{\Xi_1 + \alpha_1 \Xi_2, \Xi_3\},$
$12 \to \{\Xi_1 + \alpha_1 \Xi_3, \Xi_2\}, 13 \to \{\Xi_2 + a_1 \Xi_3, \Xi_4\}, 18 \to \{\Xi_1 + \alpha_1 \Xi_3, \Xi_2 + a_1 \Xi_3\}\}$



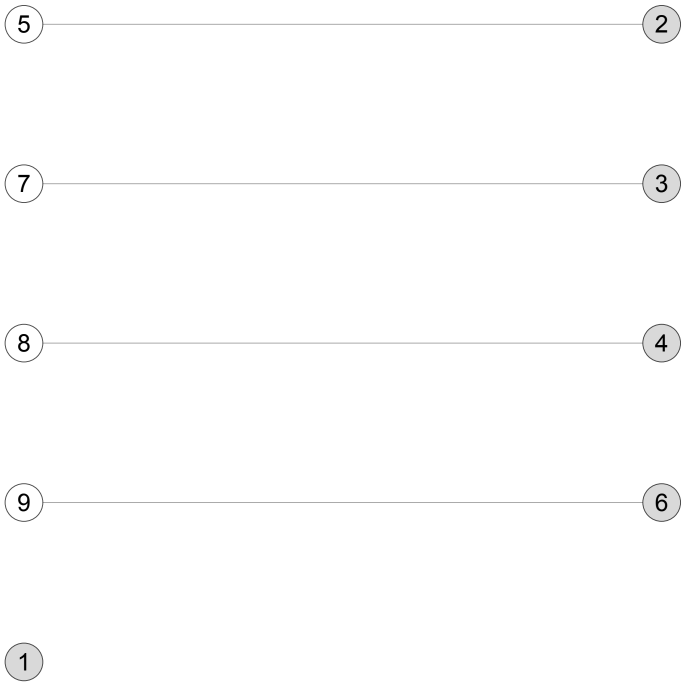
There are 9 3-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4\}\}$



Time of computation: 8.774573

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Algebra n. 20

$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & a\,\Xi_2 \\ 0 & 0 & 0 & \Xi_3 \\ -\Xi_1 & -a\,\Xi_2 & -\Xi_3 & 0 \end{pmatrix}$$

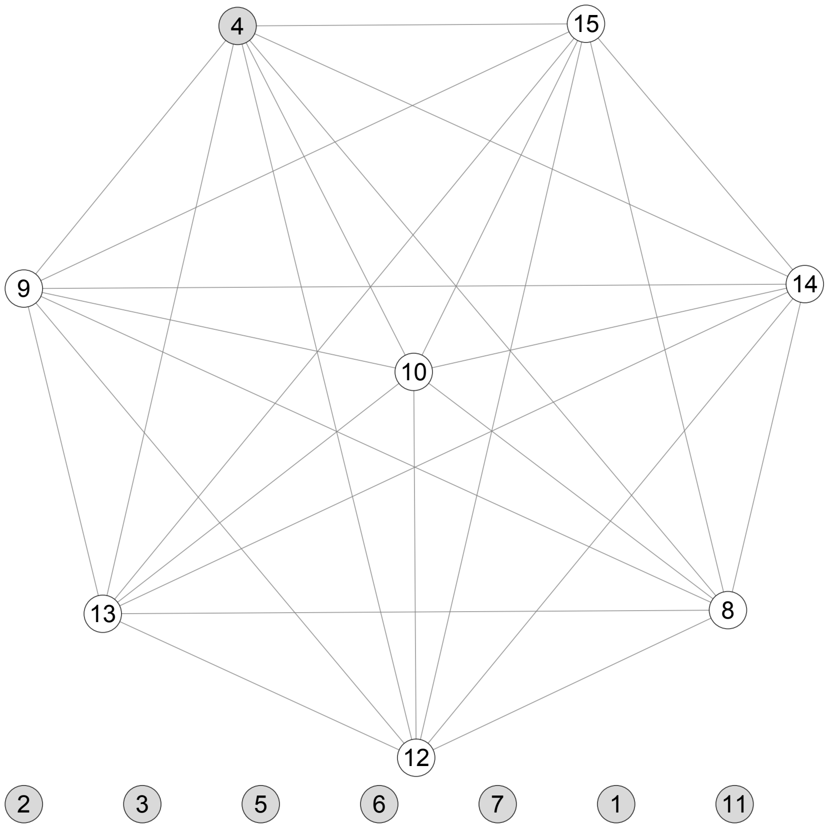
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + \alpha_1\,\Xi_2\}, \{\Xi_1 + a_1\,\Xi_3\}, \{\Xi_2 + \alpha_1\,\Xi_3\}, \{\Xi_1 + \alpha_1\,\Xi_2 + a_1\,\Xi_3\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + \alpha_1\,\Xi_2\},$
$6 \to \{\Xi_1 + a_1\,\Xi_3\}, 7 \to \{\Xi_2 + \alpha_1\,\Xi_3\}, 11 \to \{\Xi_1 + \alpha_1\,\Xi_2 + a_1\,\Xi_3\}\}$



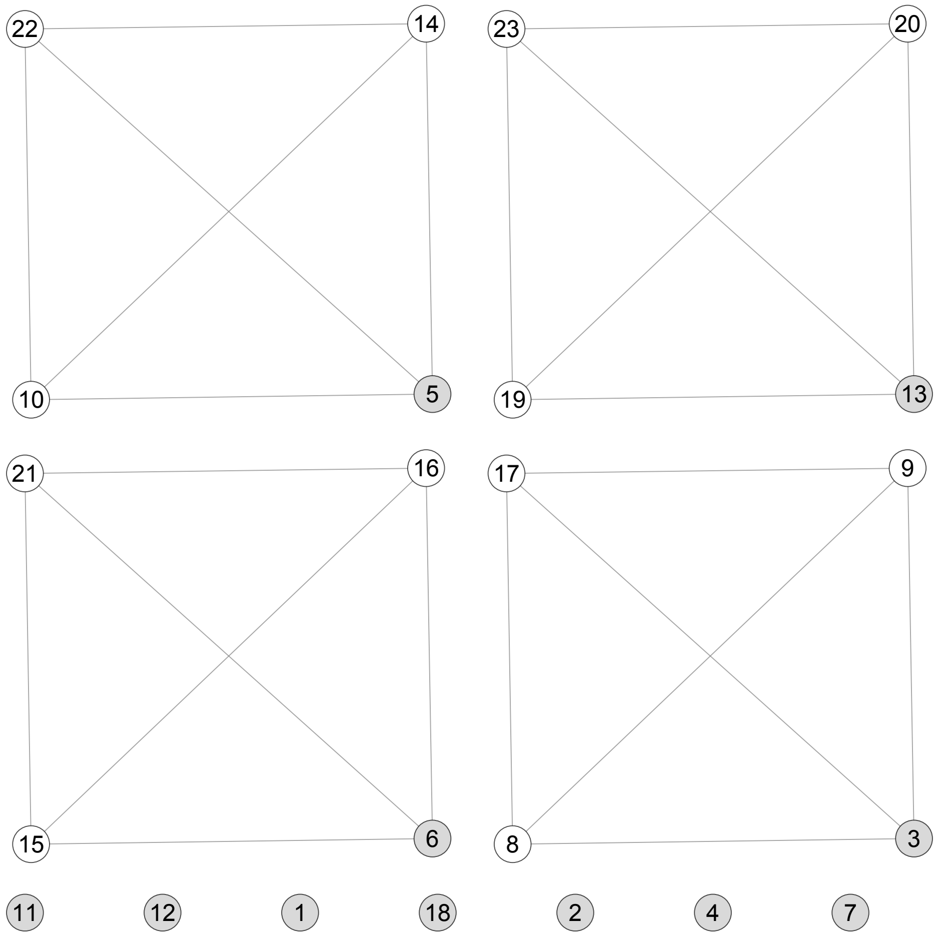
There are 23 2-D families of subalgebras to be analyzed.

Done.

There are 11 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \alpha_1 \Xi_3\},$
$\{\Xi_1 + \alpha_1 \Xi_2, \Xi_3\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2\}, \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2 + \alpha_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\},$
$5 \to \{\Xi_2, \Xi_4\}, 6 \to \{\Xi_3, \Xi_4\}, 7 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_3\}, 11 \to \{\Xi_1 + \alpha_1 \Xi_2, \Xi_3\},$
$12 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2\}, 13 \to \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, 18 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2 + \alpha_1 \Xi_3\}\}$



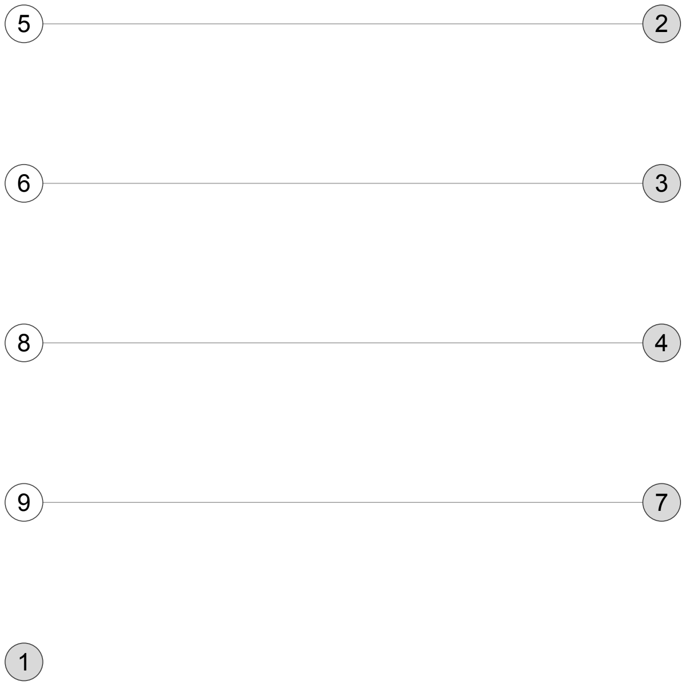
There are 9 3-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 7 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2, \Xi_4\}\}$



Time of computation: 7.689911

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Algebra n. 21

$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & 0 & \Xi_2 \\ 0 & 0 & 0 & \Xi_3 \\ -\Xi_1 & -\Xi_2 & -\Xi_3 & 0 \end{pmatrix}$$

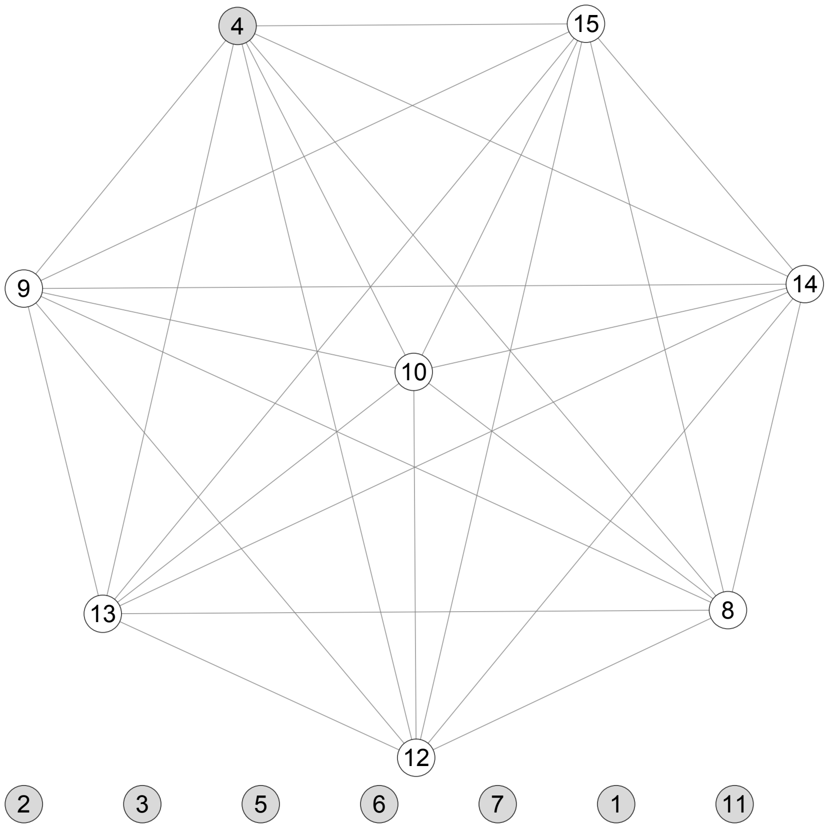
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_1 + a_1 \Xi_2\}, \{\Xi_1 + a_1 \Xi_3\}, \{\Xi_2 + a_1 \Xi_3\}, \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_3\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + a_1 \Xi_2\},$
$6 \to \{\Xi_1 + a_1 \Xi_3\}, 7 \to \{\Xi_2 + a_1 \Xi_3\}, 11 \to \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_3\}\}$



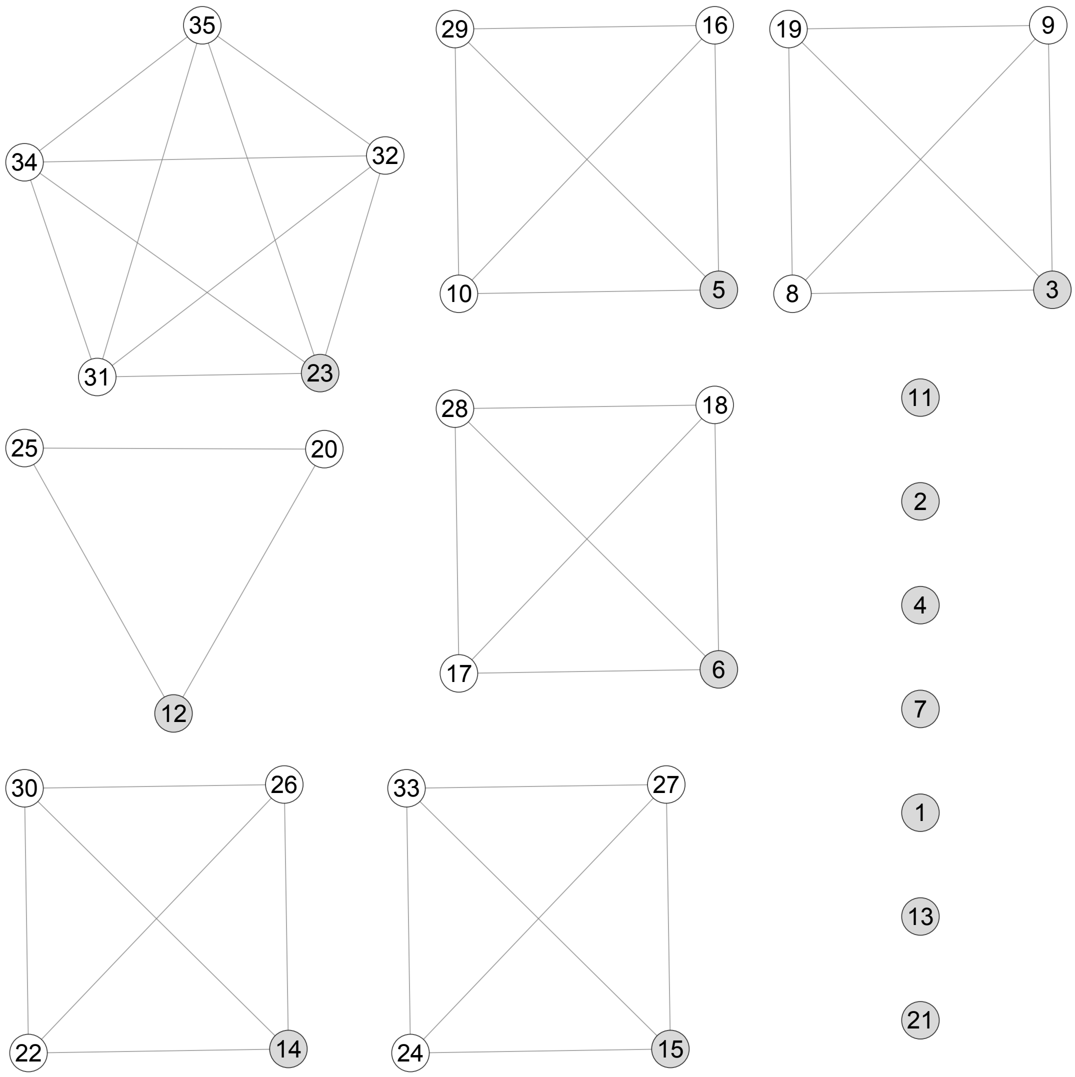
There are 35 2-D families of subalgebras to be analyzed.

Done.

There are 14 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1 \Xi_3\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3\}, \{\Xi_1 + a_1 \Xi_2, \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2\}, \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, \{\Xi_2 + a_1 \Xi_3, \Xi_4\}, \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3\}, \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 5 \to \{\Xi_2, \Xi_4\}, 6 \to \{\Xi_3, \Xi_4\}, 7 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3\}, 11 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3\}, 12 \to \{\Xi_1 + a_1 \Xi_2, \Xi_4\}, 13 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2\}, 14 \to \{\Xi_1 + a_1 \Xi_3, \Xi_4\}, 15 \to \{\Xi_2 + a_1 \Xi_3, \Xi_4\}, 21 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3\}, 23 \to \{\Xi_1 + a_1 \Xi_2 + a_2 \Xi_3, \Xi_4\}\}$



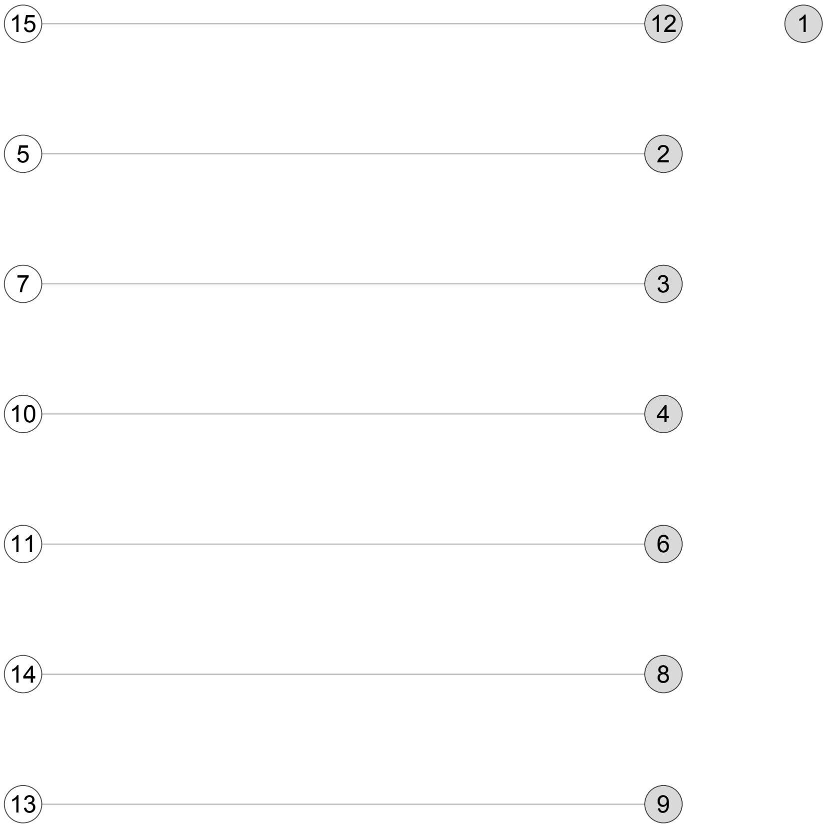
There are 15 3-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_3, \Xi_4\},$
$\{\Xi_1 + \underset{.}{a}_1 \Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_3, \Xi_2, \Xi_4\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_3, \Xi_2 + \underset{.}{a}_2 \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_3, \Xi_4\},$
$8 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2, \Xi_3, \Xi_4\}, 9 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_3, \Xi_2, \Xi_4\}, 12 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_3, \Xi_2 + \underset{.}{a}_2 \Xi_3, \Xi_4\}\}$



Time of computation: 23.635729

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Algebra n. 22

$$\begin{pmatrix} 0 & 0 & 0 & a\,\Xi_1 \\ 0 & 0 & 0 & b\,\Xi_2 - \Xi_3 \\ 0 & 0 & 0 & \Xi_2 + b\,\Xi_3 \\ -a\,\Xi_1 & -b\,\Xi_2 + \Xi_3 & -\Xi_2 - b\,\Xi_3 & 0 \end{pmatrix}$$

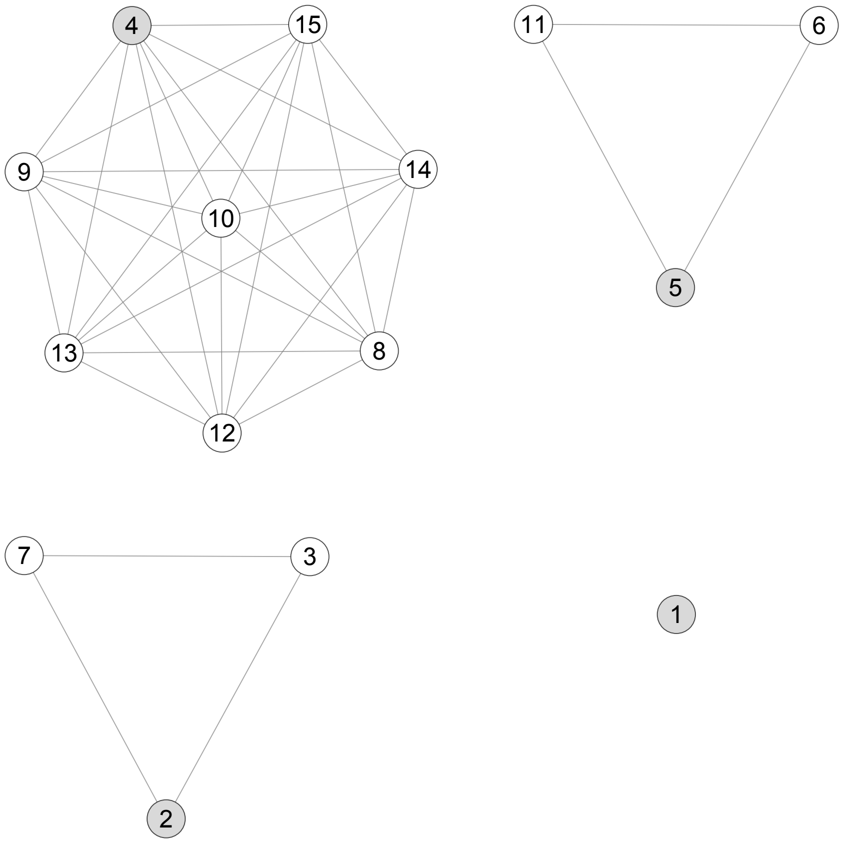
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_4\}, \{\Xi_1 + \underset{.}{a}_1\,\Xi_2\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 4 \to \{\Xi_4\}, 5 \to \{\Xi_1 + \underset{.}{a}_1\,\Xi_2\}\}$

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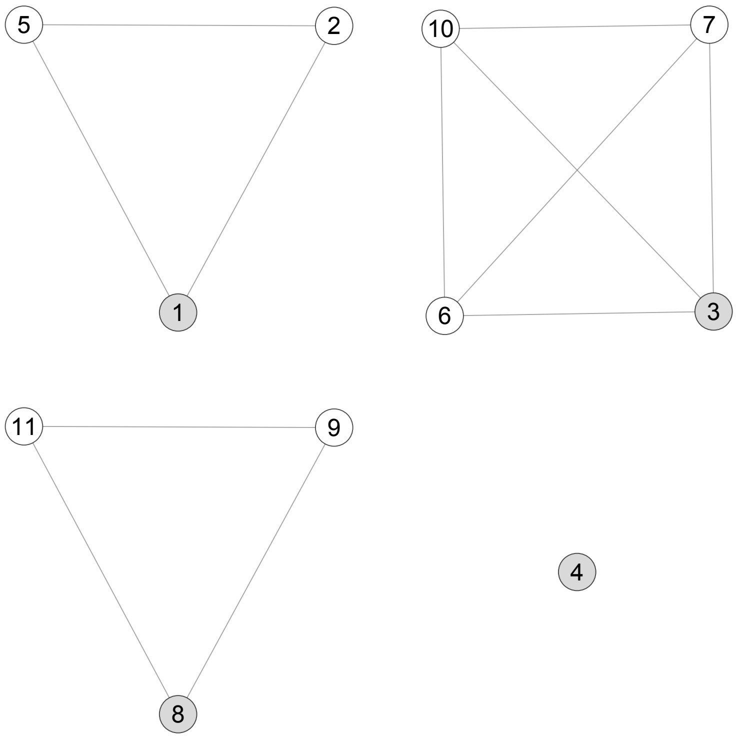
There are 11 2-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 2-dimensional Lie subalgebras.
```

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_3\}, \{\Xi_1 + a_1 \Xi_2, \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_3\}, 8 \to \{\Xi_1 + a_1 \Xi_2, \Xi_3\}\}$



There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 2 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_2, \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_2, \Xi_3, \Xi_4\}\}$

Time of computation: 152.251413

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Algebra n. 23

$$\begin{pmatrix} 0 & 0 & 0 & 2\Xi_1 \\ 0 & 0 & \Xi_1 & \Xi_2 \\ 0 & -\Xi_1 & 0 & \Xi_2 + \Xi_3 \\ -2\Xi_1 & -\Xi_2 & -\Xi_2 - \Xi_3 & 0 \end{pmatrix}$$

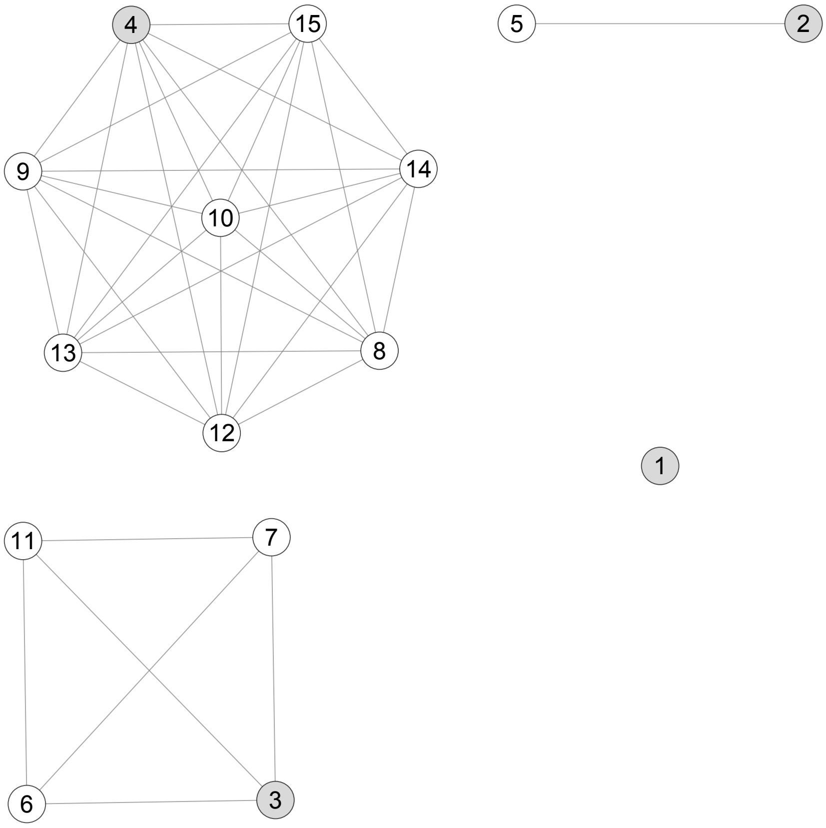
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}\}$

{1 → {Ξ$_1$}, 2 → {Ξ$_2$}, 3 → {Ξ$_3$}, 4 → {Ξ$_4$}}



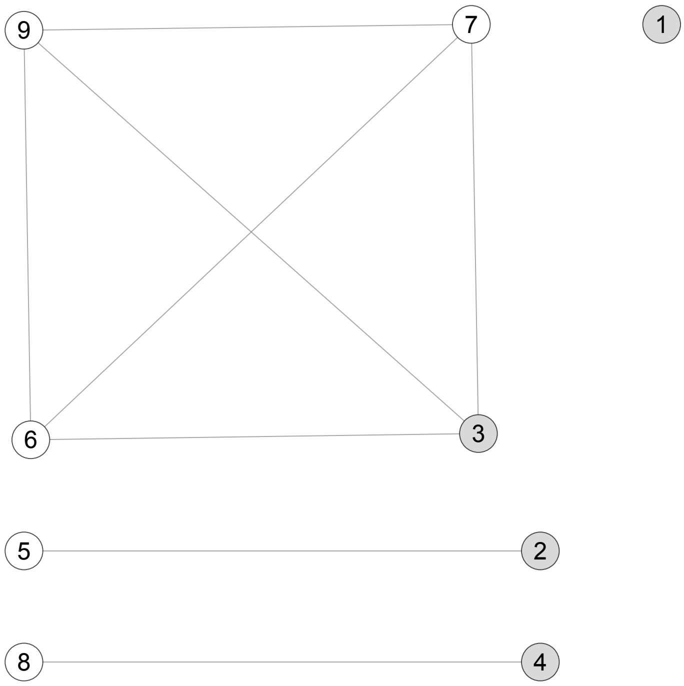
There are 9 2-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 2-dimensional Lie subalgebras.

{{Ξ$_1$, Ξ$_2$}, {Ξ$_1$, Ξ$_3$}, {Ξ$_1$, Ξ$_4$}, {Ξ$_2$, Ξ$_4$}}

{1 → {Ξ$_1$, Ξ$_2$}, 2 → {Ξ$_1$, Ξ$_3$}, 3 → {Ξ$_1$, Ξ$_4$}, 4 → {Ξ$_2$, Ξ$_4$}}



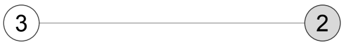
There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 2 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}\}$



Time of computation: 82.807977

==

Algebra n. 24

$$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & \Xi_1 & \Xi_2 \\ 0 & -\Xi_1 & 0 & -\Xi_3 \\ 0 & -\Xi_2 & \Xi_3 & 0 \end{pmatrix}$$

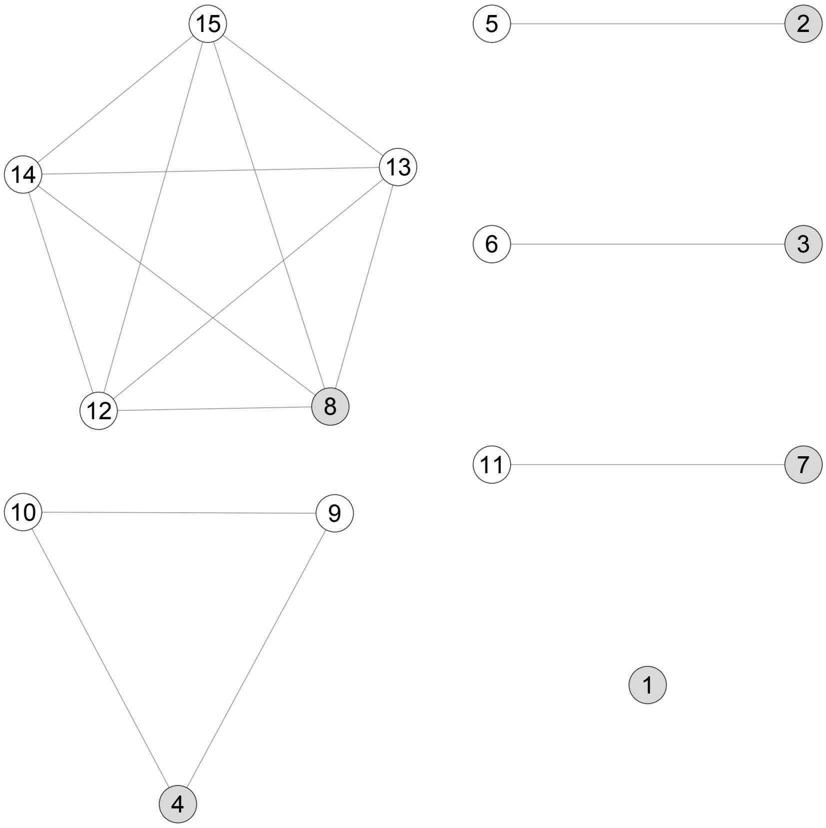
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_2 + \underset{\cdot}{\alpha}_1 \Xi_3\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 7 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1 \Xi_3\}, 8 \to \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4\}\}$



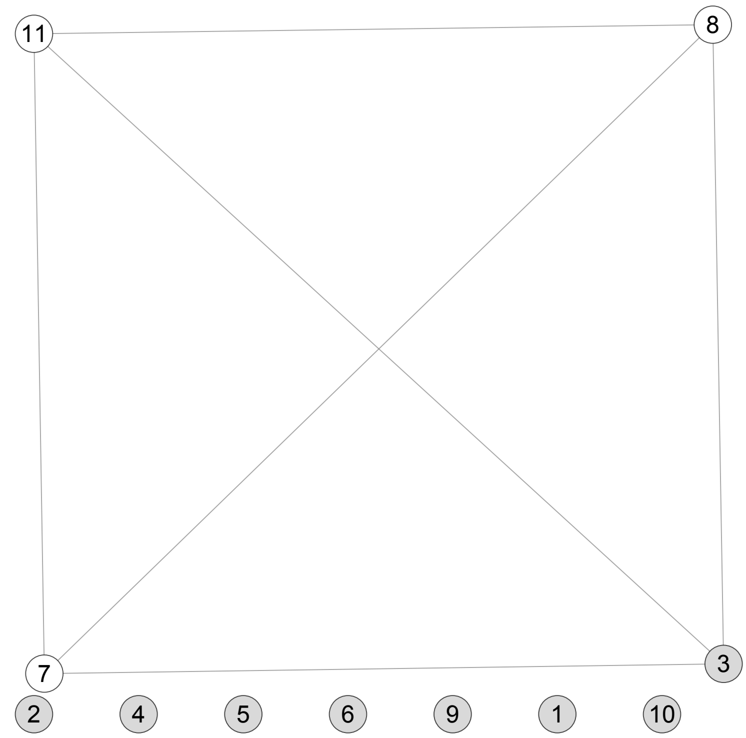
There are 11 2-D families of subalgebras to be analyzed.

Done.

There are 8 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_4\},$
$\{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_3\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_2\}, \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_4\},$
$5 \to \{\Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_3\}, 9 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_2\}, 10 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_3\}\}$



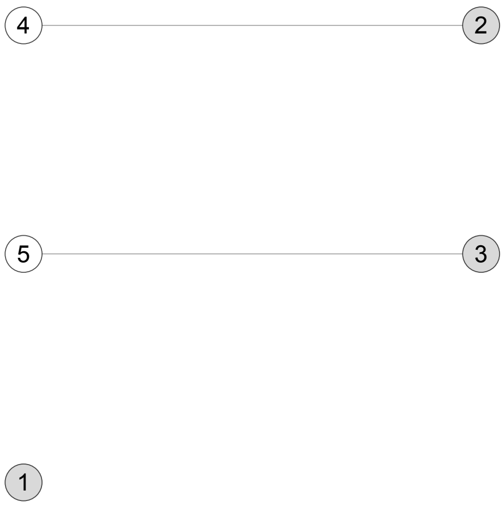
There are 5 3-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}\}$



Time of computation: 3.801006

==

Algebra n. 25

$$\begin{pmatrix} 0 & 0 & 0 & (1+b)\,\Xi_1 \\ 0 & 0 & \Xi_1 & \Xi_2 \\ 0 & -\Xi_1 & 0 & b\,\Xi_3 \\ (-1-b)\,\Xi_1 & -\Xi_2 & -b\,\Xi_3 & 0 \end{pmatrix}$$

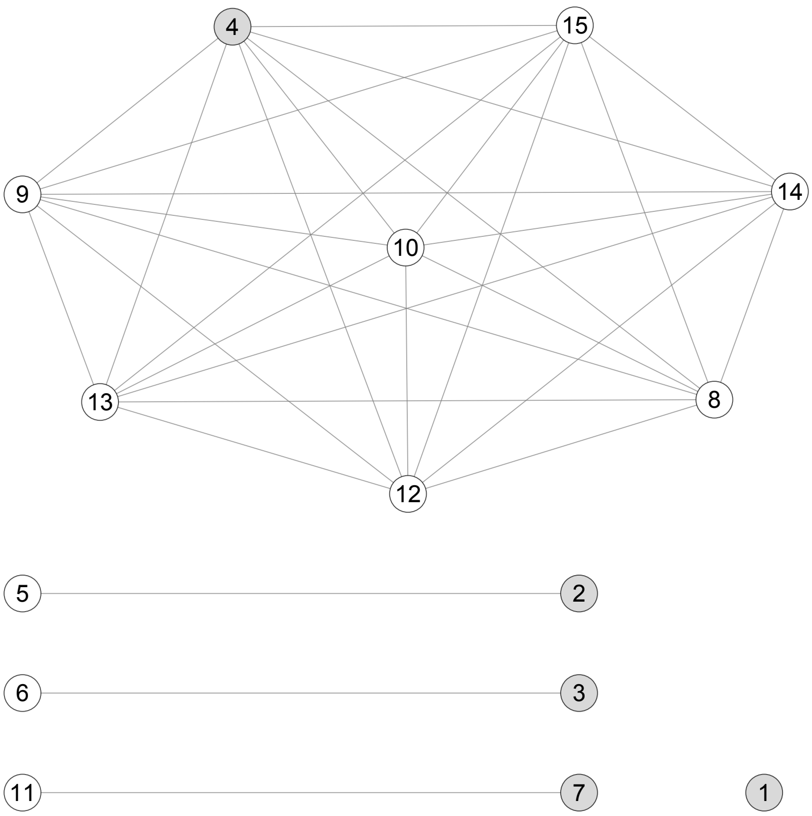
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_2 + \alpha_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 7 \to \{\Xi_2 + \alpha_1 \Xi_3\}\}$



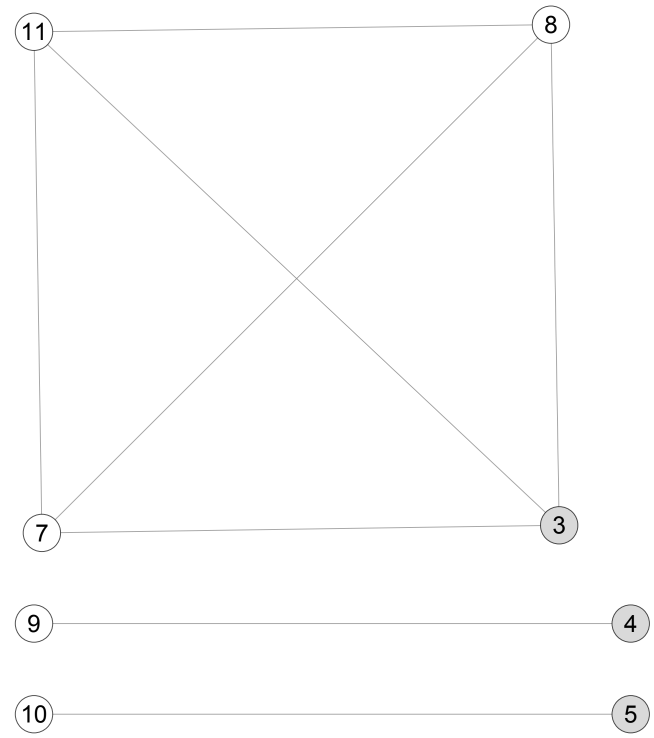
There are 11 2-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \alpha_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_2, \Xi_4\}, 5 \to \{\Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_3\}\}$



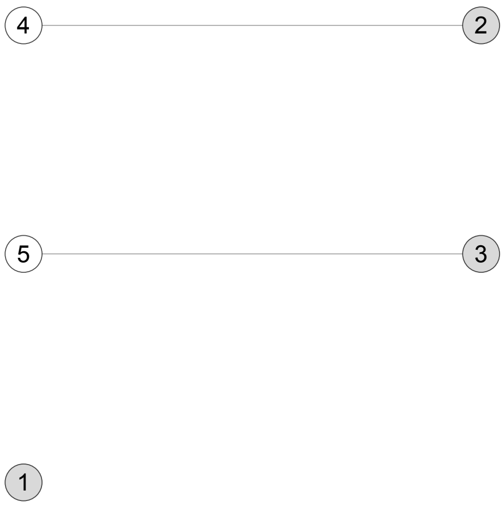
There are 5 3-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}\}$



Time of computation: 8.018379

==

Algebra n. 26

$$\begin{pmatrix} 0 & 0 & 0 & 2\,\Xi_1 \\ 0 & 0 & \Xi_1 & \Xi_2 \\ 0 & -\Xi_1 & 0 & \Xi_3 \\ -2\,\Xi_1 & -\Xi_2 & -\Xi_3 & 0 \end{pmatrix}$$

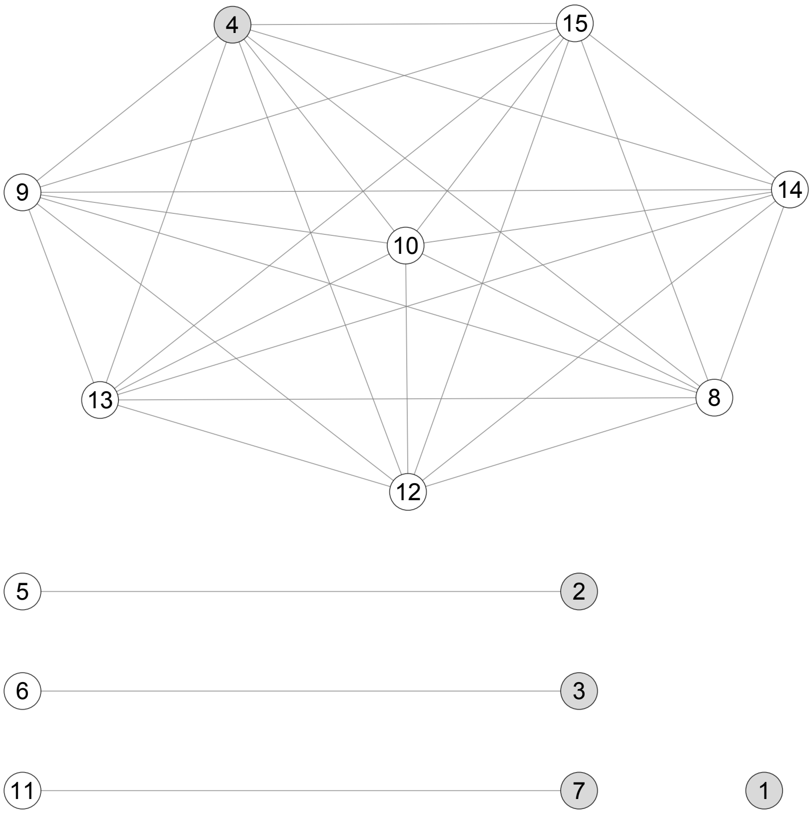
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 5 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_2 + a_1 \Xi_3\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 7 \to \{\Xi_2 + a_1 \Xi_3\}\}$



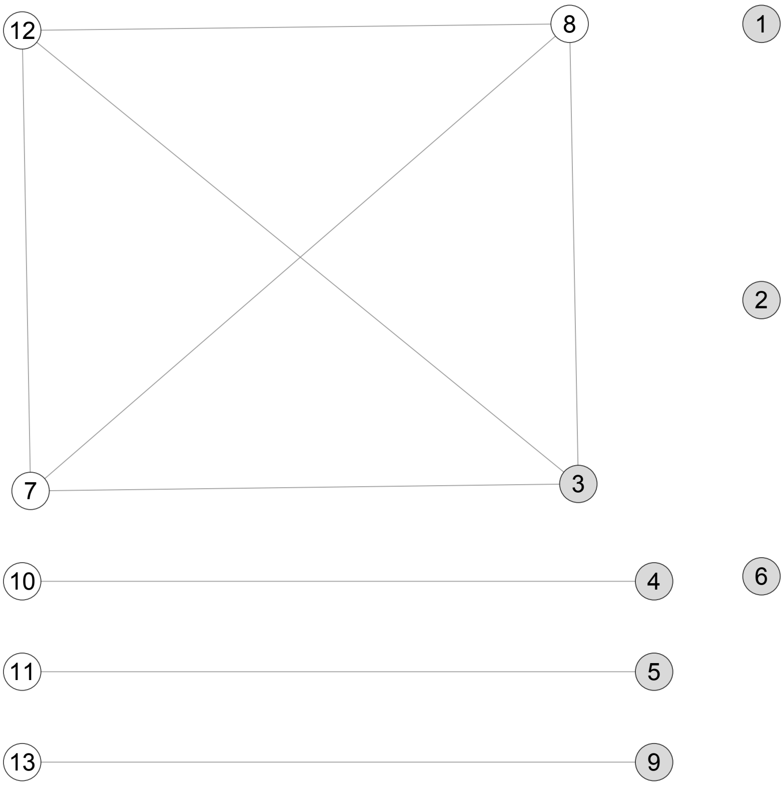
There are 13 2-D families of subalgebras to be analyzed.

Done.

There are 7 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1 \Xi_3\}, \{\Xi_2 + a_1 \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\},$
$4 \to \{\Xi_2, \Xi_4\}, 5 \to \{\Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3\}, 9 \to \{\Xi_2 + a_1 \Xi_3, \Xi_4\}\}$



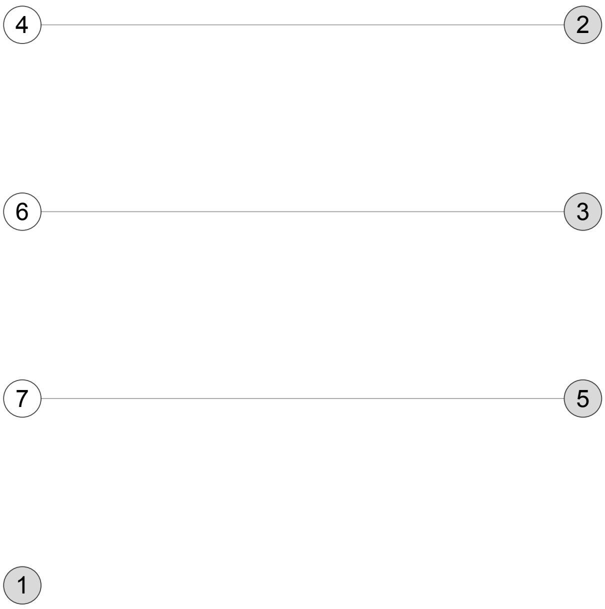
There are 7 3–D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 5 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4\}\}$



Time of computation: 11.168949

==

Algebra n. 27

$$\begin{pmatrix} 0 & 0 & 0 & \Xi_1 \\ 0 & 0 & \Xi_1 & \Xi_2 \\ 0 & -\Xi_1 & 0 & 0 \\ -\Xi_1 & -\Xi_2 & 0 & 0 \end{pmatrix}$$

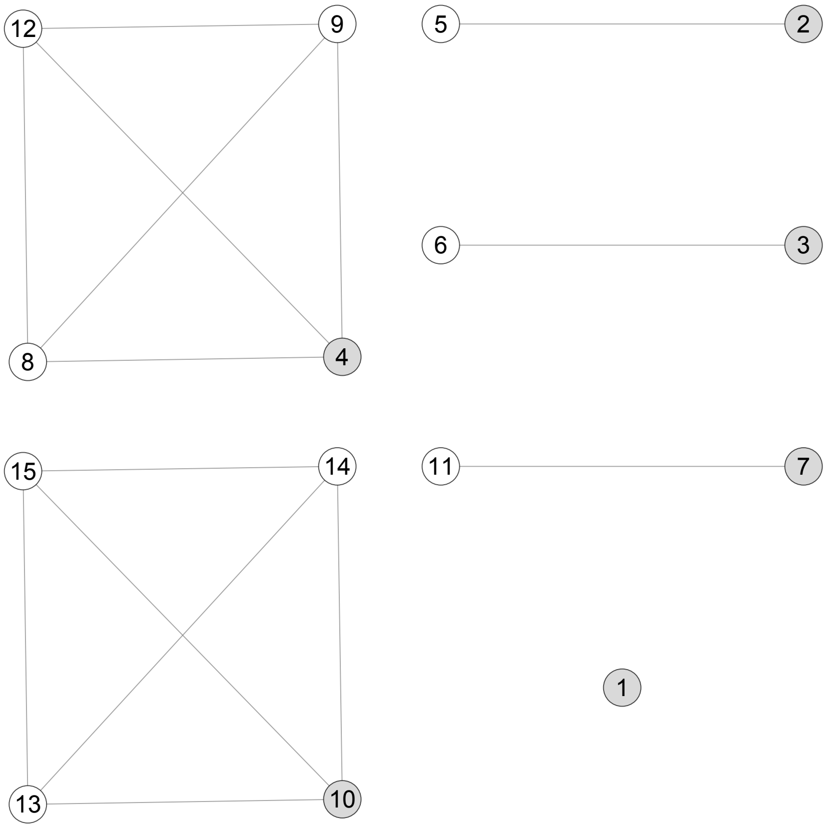
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 6 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_2 + \alpha_1 \Xi_3\}, \{\Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 7 \to \{\Xi_2 + \alpha_1 \Xi_3\}, 10 \to \{\Xi_3 + a_1 \Xi_4\}\}$



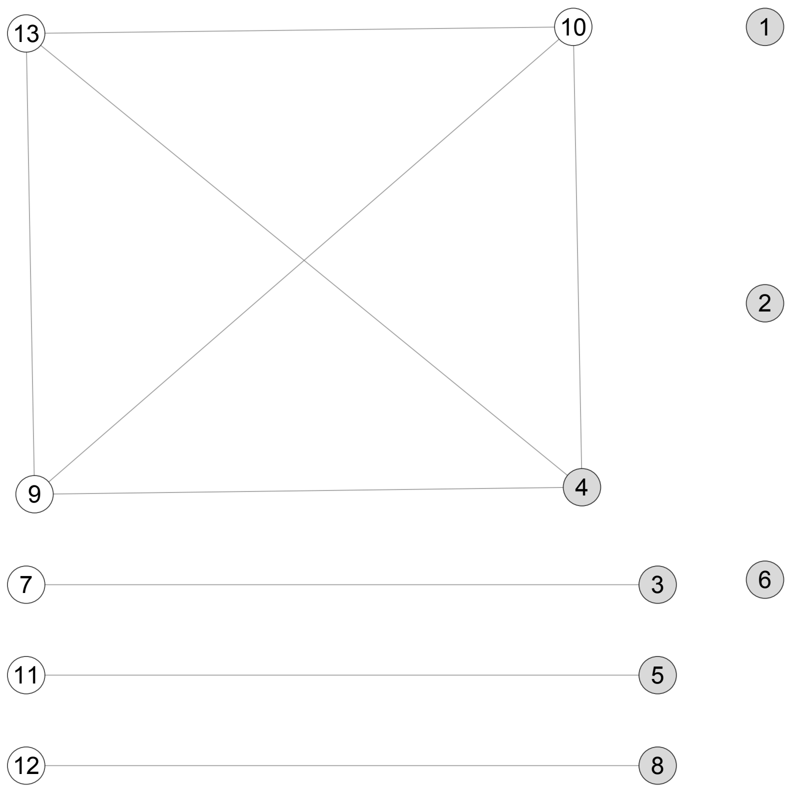
There are 13 2-D families of subalgebras to be analyzed.

Done.

There are 7 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_2, \Xi_4\}, \{\Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \alpha_1 \Xi_3\}, \{\Xi_1, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\},$
$4 \to \{\Xi_2, \Xi_4\}, 5 \to \{\Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_3\}, 8 \to \{\Xi_1, \Xi_3 + a_1 \Xi_4\}\}$



There are 5 3-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_3, \Xi_4\}, 4 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

Time of computation: 7.696302

==

Algebra n. 28

$$\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & \Xi_1 & -\Xi_3 \\ 0 & -\Xi_1 & 0 & \Xi_2 \\ 0 & \Xi_3 & -\Xi_2 & 0 \end{pmatrix}$$

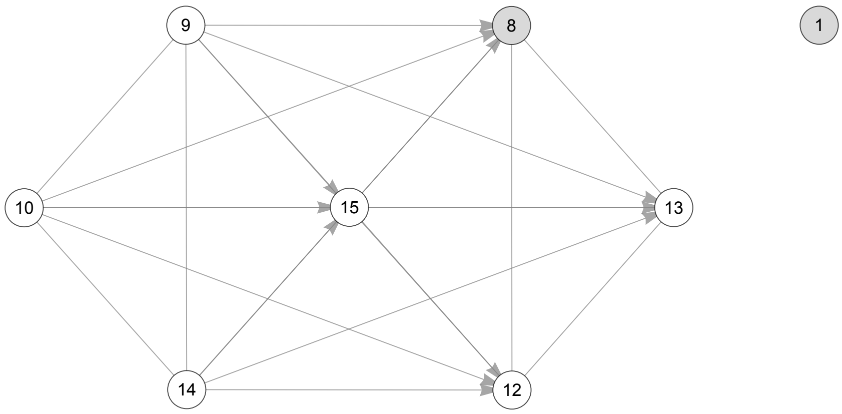
There are 15 1-D families of subalgebras to be analyzed.

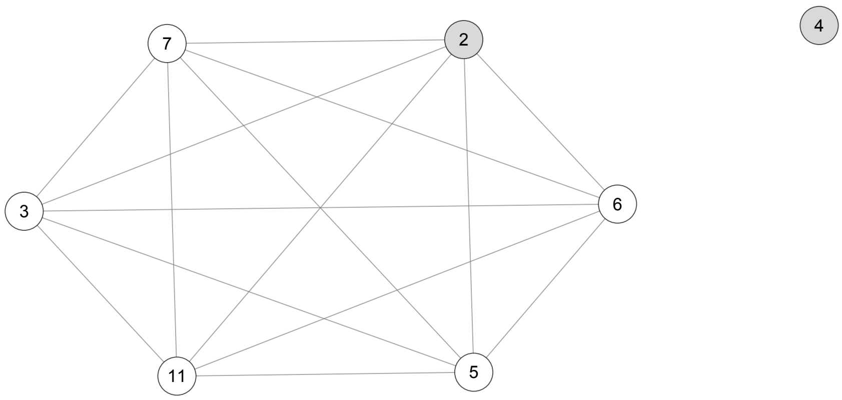
Done.

There are 4 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_4\}, \{\Xi_1 + a_1\, \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 4 \to \{\Xi_4\}, 8 \to \{\Xi_1 + a_1\, \Xi_4\}\}$





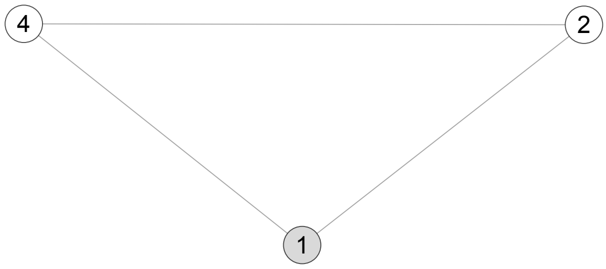
There are 7 2-D families of subalgebras to be analyzed.

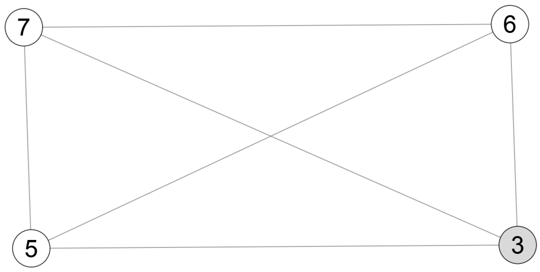
Done.

There are 2 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 3 \to \{\Xi_1, \Xi_4\}\}$





There are 1 3-D families of subalgebras to be analyzed.

Done.

There are 1 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}\}$

Time of computation: 56.414244

==

Algebra n. 29

$$\begin{pmatrix} 0 & 0 & 0 & 2\,a\,\Xi_1 \\ 0 & 0 & \Xi_1 & a\,\Xi_2 - \Xi_3 \\ 0 & -\Xi_1 & 0 & \Xi_2 + a\,\Xi_3 \\ -2\,a\,\Xi_1 & -a\,\Xi_2 + \Xi_3 & -\Xi_2 - a\,\Xi_3 & 0 \end{pmatrix}$$

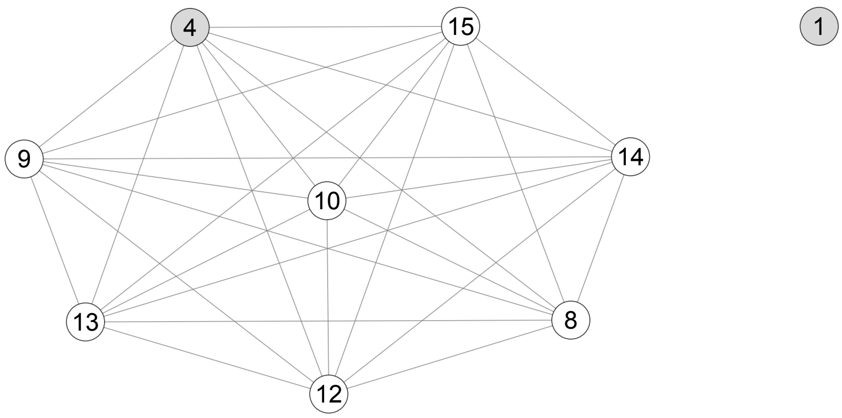
There are 15 1-D families of subalgebras to be analyzed.

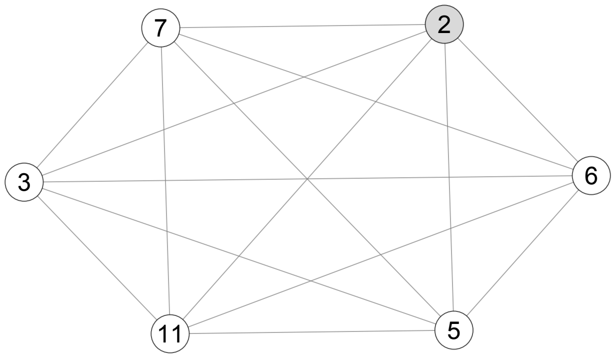
Done.

There are 3 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_2\}, \{\Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 2 \to \{\Xi_2\}, 4 \to \{\Xi_4\}\}$





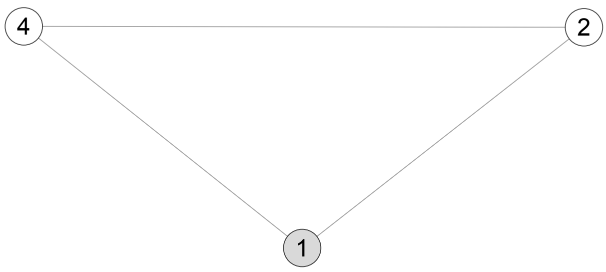
There are 7 2-D families of subalgebras to be analyzed.

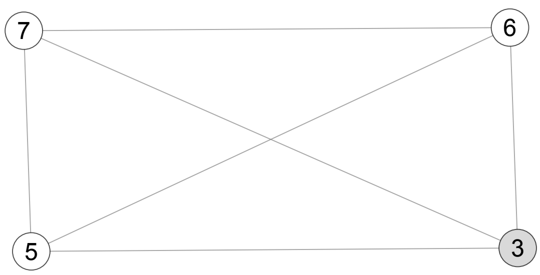
Done.

There are 2 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 3 \to \{\Xi_1, \Xi_4\}\}$





There are 1 3-D families of subalgebras to be analyzed.

Done.

There are 1 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}\}$

Time of computation: 595.903093

===

Algebra n. 30

$$\begin{pmatrix} 0 & 0 & \Xi_1 & -\Xi_2 \\ 0 & 0 & \Xi_2 & \Xi_1 \\ -\Xi_1 & -\Xi_2 & 0 & 0 \\ \Xi_2 & -\Xi_1 & 0 & 0 \end{pmatrix}$$

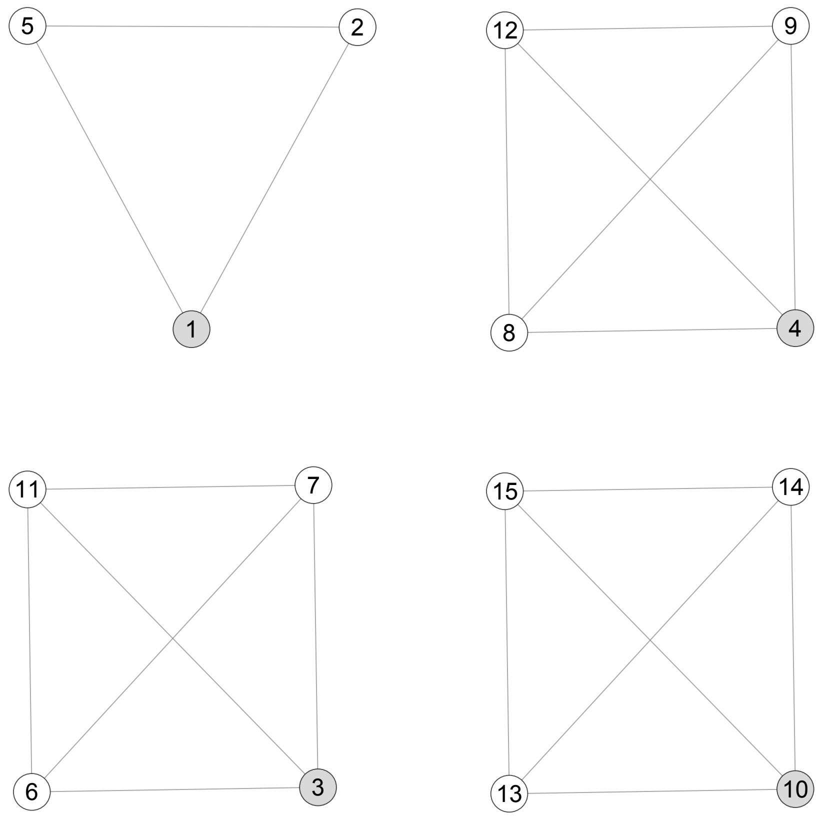
There are 15 1-D families of subalgebras to be analyzed.

Done.

There are 4 optimal families of 1-dimensional Lie subalgebras.

$\{\{\Xi_1\}, \{\Xi_3\}, \{\Xi_4\}, \{\Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1\}, 3 \to \{\Xi_3\}, 4 \to \{\Xi_4\}, 10 \to \{\Xi_3 + a_1 \Xi_4\}\}$



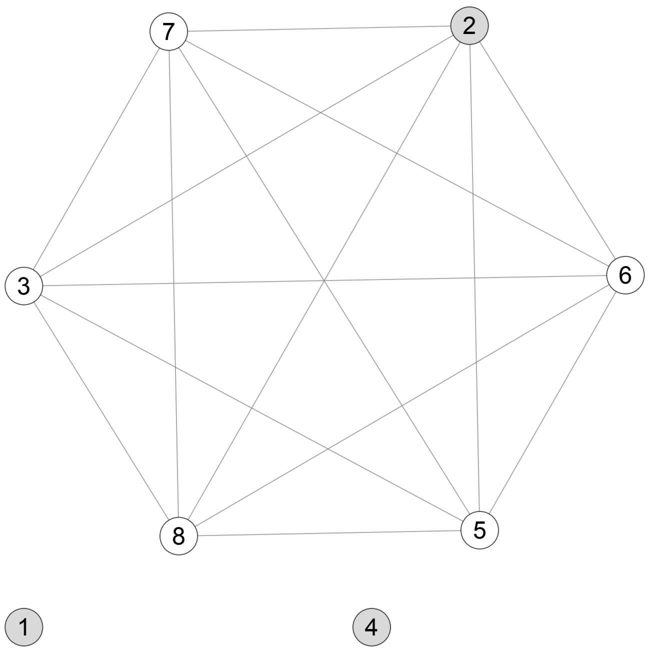
There are 8 2-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 2-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_3, \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 4 \to \{\Xi_3, \Xi_4\}\}$



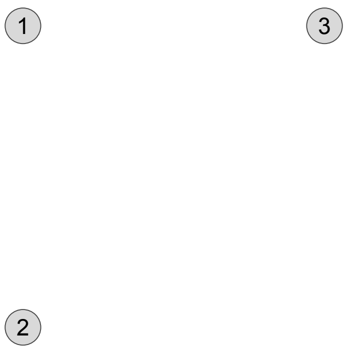
There are 3 3-D families of subalgebras to be analyzed.

Done.

There are 3 optimal families of 3-dimensional Lie subalgebras.

$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_4\}\}$



Time of computation: 36.789230

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In[96]:= **allalg1**

Out[96]=

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```

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In[97]:= **allalg2**

Out[97]=

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Out[98]=

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