6 D Lie algebra studied by Ovsiannikov.

L . V . Ovsiannikov . The group analysis algorithms . In “Modern Group Analysis : advanced analytical and computational methods in mathematical physics”, Proceedings of the International Workshop, Acireale, October 27-- 31, 1992, Edited by N . H . Ibragimov, M . Torrisi and A . Valenti, Kluwer Academic Publishers, 277-- 289, 1993.

In[1]:=
```
SetDirectory[NotebookDirectory[]];
```

In[2]:=
```
<< "SymboLie.wl"
```

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

In[3]:=
```
gens = {{1, 0, 0}, {0, 1, 0}, {t, 0, 0}, {0, t, 0}, {y, -x, 0}, {0, 0, 1}};
vars = {x, y, t};
pars = {{}, {}};
```

In[4]:=
```
cs = StructureConstants[gens, vars];
```

In[5]:=
```
ct = CommutatorTable[cs]; ct // MatrixForm
```

Out[5]//MatrixForm=

$$\begin{pmatrix} 0 & 0 & 0 & 0 & -\Xi_2 & 0 \\ 0 & 0 & 0 & 0 & \Xi_1 & 0 \\ 0 & 0 & 0 & 0 & -\Xi_4 & -\Xi_1 \\ 0 & 0 & 0 & 0 & \Xi_3 & -\Xi_2 \\ \Xi_2 & -\Xi_1 & \Xi_4 & -\Xi_3 & 0 & 0 \\ 0 & 0 & \Xi_1 & \Xi_2 & 0 & 0 \end{pmatrix}$$

In[6]:=
```
FastRun = 1;
```

In[7]:=
```
Timing[alg1 = SubAlgebra[cs, pars, 1];]
```

```
There are 63 1-D families of subalgebras to be analyzed.
Done.
```

Out[7]= {942.654, Null}

In[8]:=
```
PrintOptimal[alg1]
```

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

Out[8]= $\{\{\Xi_1\}, \{\Xi_3\}, \{\Xi_5\}, \{\Xi_6\}, \{\Xi_2 + \underset{\cdot}{a}_1 \Xi_3\}, \{\Xi_3 + \underset{\cdot}{a}_1 \Xi_6\}, \{\Xi_5 + \underset{\cdot}{a}_1 \Xi_6\}\}$

In[9]:=
```
PrintGraph[alg1, 1]
```

$\{1 \to \{\Xi_1\},\ 2 \to \{\Xi_2\},\ 3 \to \{\Xi_3\},\ 4 \to \{\Xi_4\},\ 5 \to \{\Xi_5\},\ 6 \to \{\Xi_6\},\ 7 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2\},\ 8 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_3\},$

$9 \to \{\Xi_2 + \underset{\cdot}{a}_1\,\Xi_3\},\ 10 \to \{\Xi_1 + \underset{\cdot}{a}_1\,\Xi_4\},\ 11 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_4\},\ 12 \to \{\Xi_3 + \underset{\cdot}{\alpha}_1\,\Xi_4\},\ 13 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_5\},$

$14 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_5\},\ 15 \to \{\Xi_3 + \underset{\cdot}{\alpha}_1\,\Xi_5\},\ 16 \to \{\Xi_4 + \underset{\cdot}{\alpha}_1\,\Xi_5\},\ 17 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_6\},\ 18 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_6\},$

$19 \to \{\Xi_3 + \underset{\cdot}{a}_1\,\Xi_6\},\ 20 \to \{\Xi_4 + \underset{\cdot}{a}_1\,\Xi_6\},\ 21 \to \{\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},\ 22 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{a}_1\,\Xi_3\},$

$23 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{a}_1\,\Xi_4\},\ 24 \to \{\Xi_1 + \underset{\cdot}{a}_1\,\Xi_3 + \underset{\cdot}{a}_2\,\Xi_4\},\ 25 \to \{\Xi_2 + \underset{\cdot}{a}_1\,\Xi_3 + \underset{\cdot}{a}_2\,\Xi_4\},\ 26 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_5\},$

$27 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_5\},\ 28 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{a}_1\,\Xi_5\},\ 29 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5\},\ 30 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{\alpha}_2\,\Xi_5\},$

$31 \to \{\Xi_3 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{\alpha}_2\,\Xi_5\},\ 32 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_6\},\ 33 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_6\},\ 34 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{a}_1\,\Xi_6\},$

$35 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_6\},\ 36 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{\alpha}_2\,\Xi_6\},\ 37 \to \{\Xi_3 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_6\},$

$38 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},\ 39 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},\ 40 \to \{\Xi_3 + \underset{\cdot}{a}_1\,\Xi_5 + \underset{\cdot}{a}_2\,\Xi_6\},$

$41 \to \{\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5 + \underset{\cdot}{a}_2\,\Xi_6\},\ 42 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_3 + \underset{\cdot}{a}_1\,\Xi_4\},\ 43 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_3 + \underset{\cdot}{\alpha}_3\,\Xi_5\},$

$44 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5\},\ 45 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5\},\ 46 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5\},$

$47 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_3 + \underset{\cdot}{a}_1\,\Xi_6\},\ 48 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{a}_1\,\Xi_4 + \underset{\cdot}{a}_2\,\Xi_6\},\ 49 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{a}_1\,\Xi_4 + \underset{\cdot}{a}_2\,\Xi_6\},$

$50 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{a}_1\,\Xi_4 + \underset{\cdot}{a}_2\,\Xi_6\},\ 51 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_5 + \underset{\cdot}{\alpha}_3\,\Xi_6\},\ 52 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},$

$53 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},\ 54 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{\alpha}_2\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},\ 55 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{\alpha}_2\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},$

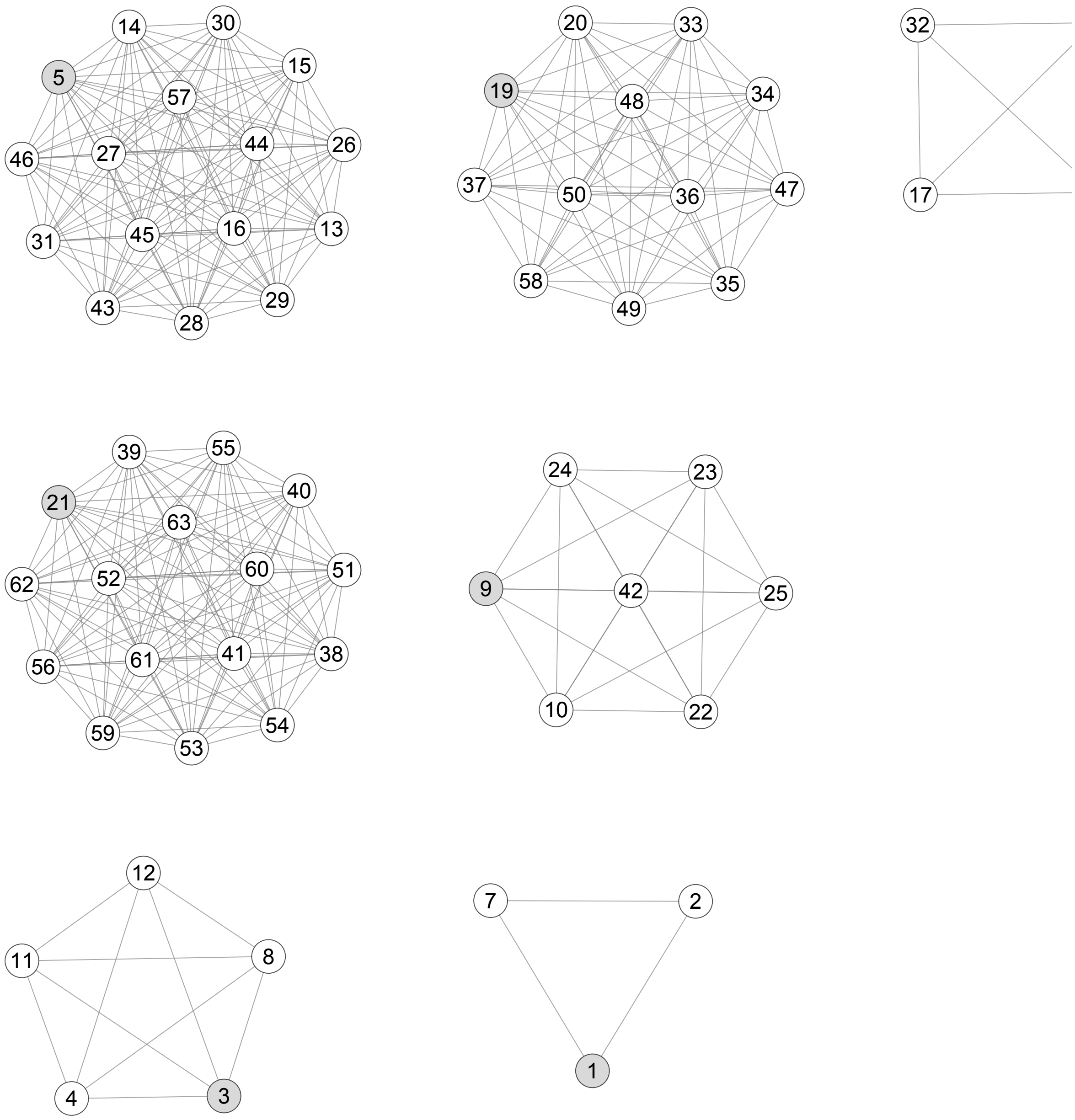
$56 \to \{\Xi_3 + \underset{\cdot}{\alpha}_1\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5 + \underset{\cdot}{a}_2\,\Xi_6\},\ 57 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_3 + \underset{\cdot}{\alpha}_3\,\Xi_4 + \underset{\cdot}{\alpha}_4\,\Xi_5\},$

$58 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_3 + \underset{\cdot}{\alpha}_3\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_6\},\ 59 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_3 + \underset{\cdot}{\alpha}_3\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},$

$60 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_4 + \underset{\cdot}{\alpha}_3\,\Xi_5 + \underset{\cdot}{a}_1\,\Xi_6\},\ 61 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5 + \underset{\cdot}{a}_2\,\Xi_6\},$

$62 \to \{\Xi_2 + \underset{\cdot}{\alpha}_1\,\Xi_3 + \underset{\cdot}{\alpha}_2\,\Xi_4 + \underset{\cdot}{a}_1\,\Xi_5 + \underset{\cdot}{a}_2\,\Xi_6\},\ 63 \to \{\Xi_1 + \underset{\cdot}{\alpha}_1\,\Xi_2 + \underset{\cdot}{\alpha}_2\,\Xi_3 + \underset{\cdot}{\alpha}_3\,\Xi_4 + \underset{\cdot}{\alpha}_4\,\Xi_5 + \underset{\cdot}{\alpha}_5\,\Xi_6\}\}$

Out[9]=



In[10]:= **Timing[alg2 = SubAlgebra[cs, pars, 2];]**

```
There are 60 2-D families of subalgebras to be analyzed.
Done.
```

Out[10]=

{8405.31, Null}

In[11]:= **PrintOptimal[alg2]**

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

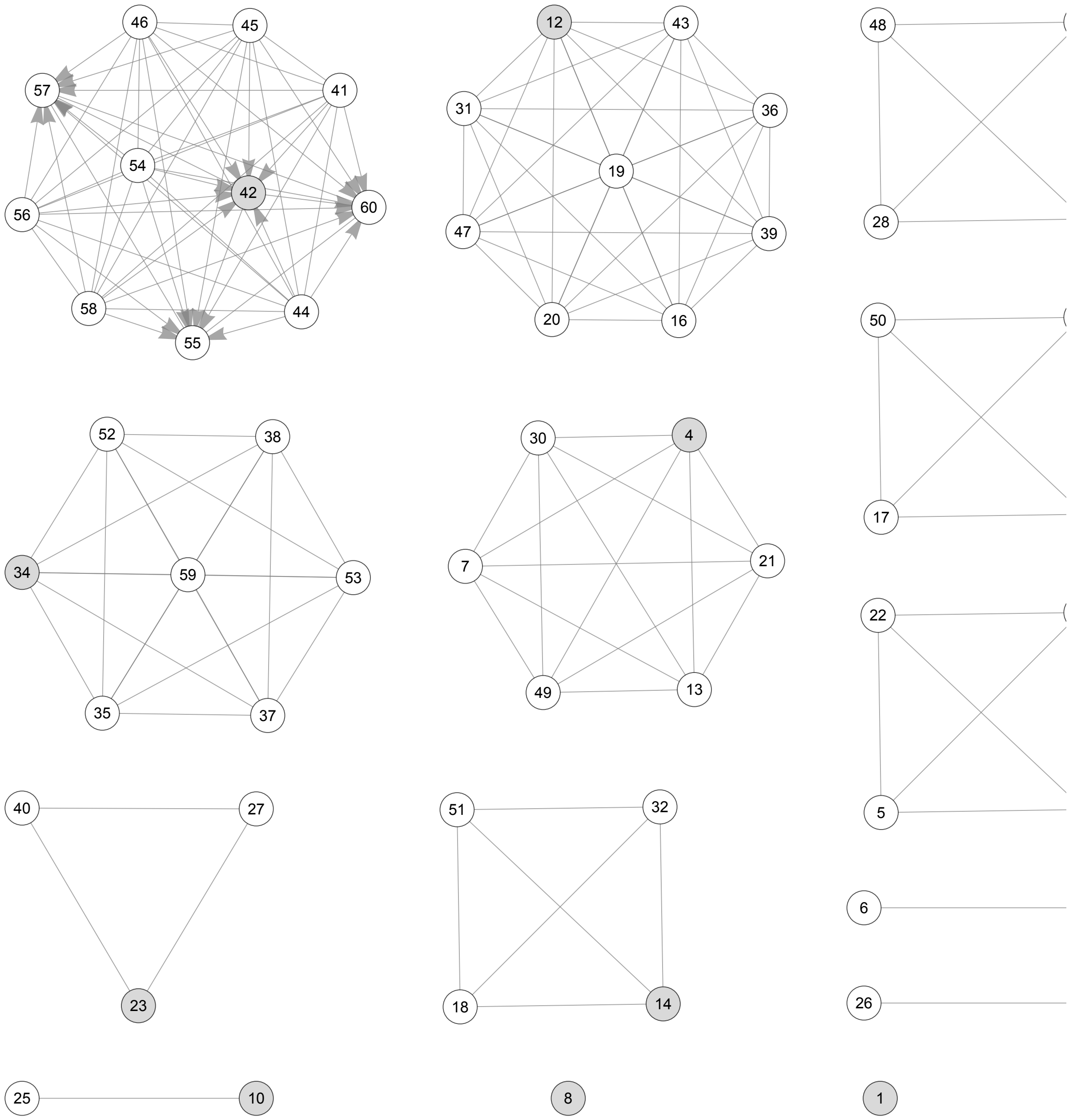
Out[11]=

$\{\{\Xi_1, \Xi_2\}, \{\Xi_1, \Xi_3\}, \{\Xi_1, \Xi_4\}, \{\Xi_1, \Xi_6\}, \{\Xi_3, \Xi_4\}, \{\Xi_5, \Xi_6\},$
$\{\Xi_1, \Xi_2 + \underset{\cdot}{a}_1 \Xi_3\}, \{\Xi_1, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4\}, \{\Xi_1, \Xi_3 + \underset{\cdot}{a}_1 \Xi_6\}, \{\Xi_1, \Xi_4 + \underset{\cdot}{a}_1 \Xi_6\},$
$\{\Xi_1 + \underset{\cdot}{a}_1 \Xi_3, \Xi_4\}, \{\Xi_2 + \underset{\cdot}{a}_1 \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_3 + \underset{\cdot}{a}_1 \Xi_4 + \underset{\cdot}{a}_2 \Xi_6\}, \{\Xi_1 + \underset{\cdot}{a}_1 \Xi_4, \Xi_2 + \underset{\cdot}{a}_2 \Xi_3\}\}$

In[12]:= **PrintGraph[alg2, 1]**

$\{1 \to \{\Xi_1, \Xi_2\}, 2 \to \{\Xi_1, \Xi_3\}, 3 \to \{\Xi_1, \Xi_4\}, 4 \to \{\Xi_1, \Xi_6\}, 5 \to \{\Xi_2, \Xi_3\}, 6 \to \{\Xi_2, \Xi_4\},$
$7 \to \{\Xi_2, \Xi_6\}, 8 \to \{\Xi_3, \Xi_4\}, 9 \to \{\Xi_5, \Xi_6\}, 10 \to \{\Xi_1, \Xi_2 + \underset{.}{a}_1 \Xi_3\}, 11 \to \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_4\},$
$12 \to \{\Xi_1, \Xi_3 + \underset{.}{a}_1 \Xi_4\}, 13 \to \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_6\}, 14 \to \{\Xi_1, \Xi_3 + \underset{.}{a}_1 \Xi_6\}, 15 \to \{\Xi_1, \Xi_4 + \underset{.}{a}_1 \Xi_6\},$
$16 \to \{\Xi_2, \Xi_3 + \underset{.}{a}_1 \Xi_4\}, 17 \to \{\Xi_2, \Xi_3 + \underset{.}{a}_1 \Xi_6\}, 18 \to \{\Xi_2, \Xi_4 + \underset{.}{a}_1 \Xi_6\}, 19 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2, \Xi_3\},$
$20 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2, \Xi_4\}, 21 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_2, \Xi_6\}, 22 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3, \Xi_2\}, 23 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_3, \Xi_4\},$
$24 \to \{\Xi_2 + \underset{.}{a}_1 \Xi_3, \Xi_4\}, 25 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_2\}, 26 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_3\}, 27 \to \{\Xi_2 + \underset{.}{a}_1 \Xi_4, \Xi_3\},$
$28 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_5, \Xi_6\}, 29 \to \{\Xi_2 + \underset{.}{\alpha}_1 \Xi_5, \Xi_6\}, 30 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_6, \Xi_2\}, 31 \to \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{a}_1 \Xi_4\},$
$32 \to \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{a}_1 \Xi_6\}, 33 \to \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_4 + \underset{.}{\alpha}_2 \Xi_6\}, 34 \to \{\Xi_1, \Xi_3 + \underset{.}{a}_1 \Xi_4 + \underset{.}{a}_2 \Xi_6\},$
$35 \to \{\Xi_2, \Xi_3 + \underset{.}{a}_1 \Xi_4 + \underset{.}{a}_2 \Xi_6\}, 36 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_2, \Xi_3 + \underset{.}{a}_1 \Xi_4\}, 37 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2, \Xi_3 + \underset{.}{a}_2 \Xi_6\},$
$38 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2, \Xi_4 + \underset{.}{a}_2 \Xi_6\}, 39 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3, \Xi_2 + \underset{.}{a}_1 \Xi_3\}, 40 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3, \Xi_2 + \underset{.}{a}_1 \Xi_4\},$
$41 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_3, \Xi_4\}, 42 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_2 + \underset{.}{a}_2 \Xi_3\}, 43 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_4, \Xi_2 + \underset{.}{a}_1 \Xi_4\},$
$44 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_3 + \underset{.}{a}_2 \Xi_4\}, 45 \to \{\Xi_2 + \underset{.}{a}_1 \Xi_4, \Xi_3 + \underset{.}{a}_2 \Xi_4\}, 46 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_2 + \underset{.}{a}_2 \Xi_4, \Xi_3\},$
$47 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{a}_1 \Xi_4, \Xi_2\}, 48 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_2 + \underset{.}{\alpha}_2 \Xi_5, \Xi_6\}, 49 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_6, \Xi_2 + \underset{.}{\alpha}_2 \Xi_6\},$
$50 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{\alpha}_2 \Xi_6, \Xi_2\}, 51 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_4 + \underset{.}{a}_1 \Xi_6, \Xi_2\}, 52 \to \{\Xi_1, \Xi_2 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{\alpha}_2 \Xi_4 + \underset{.}{a}_1 \Xi_6\},$
$53 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_2, \Xi_3 + \underset{.}{a}_1 \Xi_4 + \underset{.}{a}_2 \Xi_6\}, 54 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3, \Xi_2 + \underset{.}{a}_1 \Xi_3 + \underset{.}{a}_2 \Xi_4\},$
$55 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_4, \Xi_2 + \underset{.}{a}_2 \Xi_3 + \underset{.}{a}_3 \Xi_4\}, 56 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_2 + \underset{.}{a}_1 \Xi_4, \Xi_3 + \underset{.}{a}_2 \Xi_4\},$
$57 \to \{\Xi_1 + \underset{.}{a}_1 \Xi_3 + \underset{.}{a}_2 \Xi_4, \Xi_2 + \underset{.}{a}_3 \Xi_3\}, 58 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{a}_1 \Xi_4, \Xi_2 + \underset{.}{a}_2 \Xi_4\},$
$59 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{\alpha}_2 \Xi_4 + \underset{.}{a}_1 \Xi_6, \Xi_2\}, 60 \to \{\Xi_1 + \underset{.}{\alpha}_1 \Xi_3 + \underset{.}{\alpha}_2 \Xi_4, \Xi_2 + \underset{.}{a}_1 \Xi_3 + \underset{.}{a}_2 \Xi_4\}\}$

Out[12]=



In[13]:=
```
Timing[alg3 = SubAlgebra[cs, pars, 3];]
```

There are 46 3-D families of subalgebras to be analyzed.

Done.

Out[13]=
```
{17 579.7, Null}
```

In[14]:=
```
PrintOptimal[alg3]
```

There are 12 optimal families of 3-dimensional Lie subalgebras.

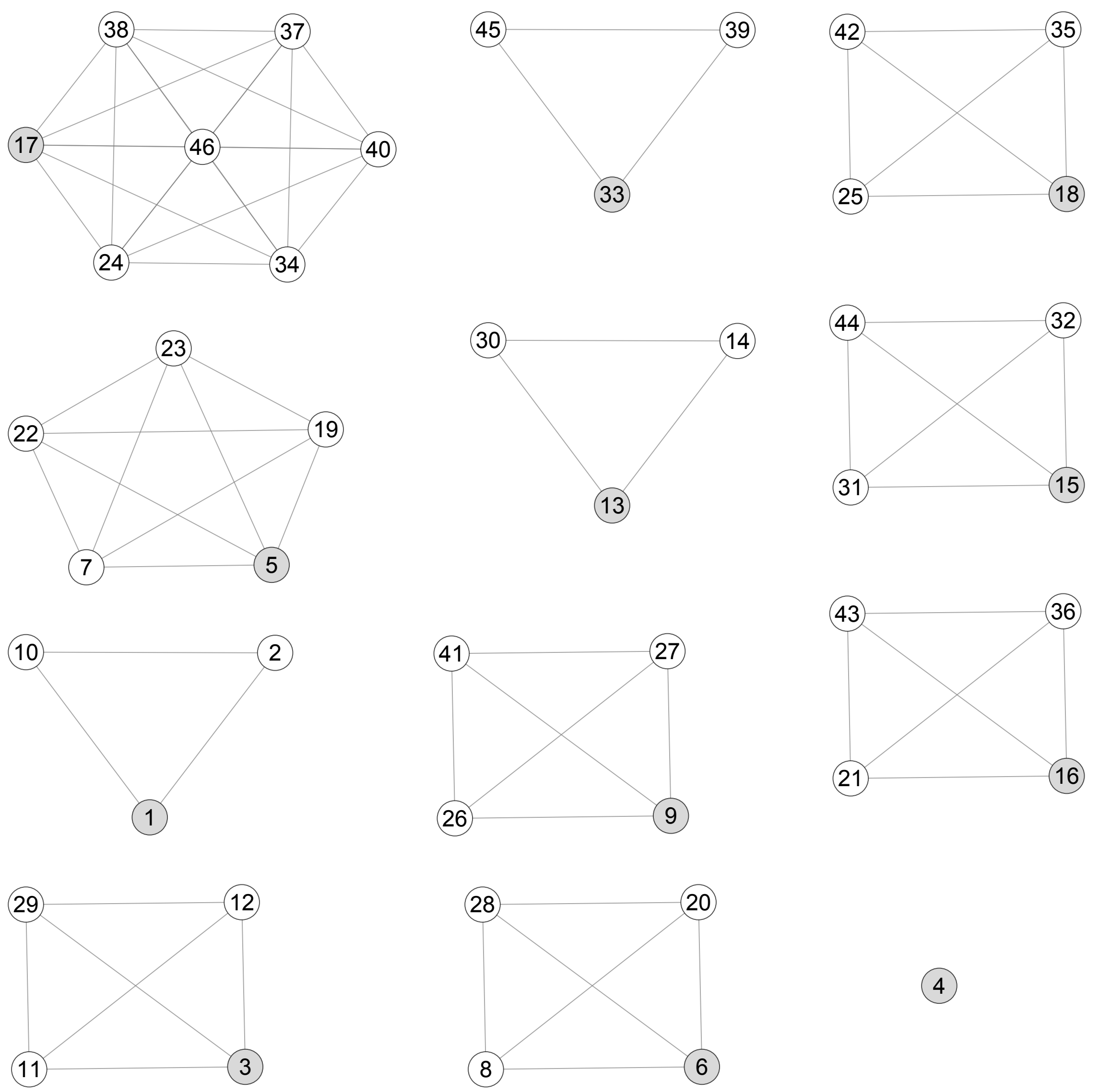
Out[14]=

$$\{\{\Xi_1, \Xi_2, \Xi_3\}, \{\Xi_1, \Xi_2, \Xi_5\}, \{\Xi_1, \Xi_2, \Xi_6\}, \{\Xi_1, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_3, \Xi_6\}, \{\Xi_3, \Xi_4, \Xi_5\}, \{\Xi_1, \Xi_2, \Xi_3 + \underset{\cdot}{a}_1 \Xi_6\}, \{\Xi_1, \Xi_2, \Xi_5 + \underset{\cdot}{a}_1 \Xi_6\}, \{\Xi_1, \Xi_3, \Xi_4 + \underset{\cdot}{a}_1 \Xi_6\}, \{\Xi_1, \Xi_2 + \underset{\cdot}{a}_1 \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2 + \underset{\cdot}{a}_1 \Xi_3, \Xi_6\}, \{\Xi_1, \Xi_2 + \underset{\cdot}{a}_1 \Xi_3, \Xi_4 + \underset{\cdot}{a}_2 \Xi_6\}\}$$

In[15]:= `PrintGraph[alg3, 1]`

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3\}, 2 \to \{\Xi_1, \Xi_2, \Xi_4\}, 3 \to \{\Xi_1, \Xi_2, \Xi_5\}, 4 \to \{\Xi_1, \Xi_2, \Xi_6\},$
$5 \to \{\Xi_1, \Xi_3, \Xi_4\}, 6 \to \{\Xi_1, \Xi_3, \Xi_6\}, 7 \to \{\Xi_2, \Xi_3, \Xi_4\}, 8 \to \{\Xi_2, \Xi_4, \Xi_6\}, 9 \to \{\Xi_3, \Xi_4, \Xi_5\},$
$10 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_4\}, 11 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_5\}, 12 \to \{\Xi_1, \Xi_2, \Xi_4 + \alpha_1 \Xi_5\},$
$13 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_6\}, 14 \to \{\Xi_1, \Xi_2, \Xi_4 + a_1 \Xi_6\}, 15 \to \{\Xi_1, \Xi_2, \Xi_5 + a_1 \Xi_6\},$
$16 \to \{\Xi_1, \Xi_3, \Xi_4 + a_1 \Xi_6\}, 17 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4\}, 18 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_6\},$
$19 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4, \Xi_3\}, 20 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_6, \Xi_3\}, 21 \to \{\Xi_2, \Xi_3 + a_1 \Xi_6, \Xi_4\},$
$22 \to \{\Xi_1 + \alpha_1 \Xi_2, \Xi_3, \Xi_4\}, 23 \to \{\Xi_1 + \alpha_1 \Xi_3, \Xi_2, \Xi_4\}, 24 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3\},$
$25 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_6\}, 26 \to \{\Xi_1 + \alpha_1 \Xi_5, \Xi_3, \Xi_4\}, 27 \to \{\Xi_2 + \alpha_1 \Xi_5, \Xi_3, \Xi_4\},$
$28 \to \{\Xi_1 + \alpha_1 \Xi_6, \Xi_2, \Xi_4\}, 29 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_4 + \alpha_2 \Xi_5\}, 30 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_4 + a_1 \Xi_6\},$
$31 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_5 + a_1 \Xi_6\}, 32 \to \{\Xi_1, \Xi_2, \Xi_4 + \alpha_1 \Xi_5 + a_1 \Xi_6\}, 33 \to \{\Xi_1, \Xi_2 + a_1 \Xi_3, \Xi_4 + a_2 \Xi_6\},$
$34 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4, \Xi_3 + a_1 \Xi_4\}, 35 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_6, \Xi_3 + a_1 \Xi_6\}, 36 \to \{\Xi_1, \Xi_2 + \alpha_1 \Xi_4 + \alpha_2 \Xi_6, \Xi_3\},$
$37 \to \{\Xi_1 + a_1 \Xi_3, \Xi_2 + a_2 \Xi_3, \Xi_4\}, 38 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3 + \alpha_1 \Xi_4\}, 39 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3 + a_2 \Xi_6\},$
$40 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2 + a_2 \Xi_4, \Xi_3\}, 41 \to \{\Xi_1 + \alpha_1 \Xi_2 + \alpha_2 \Xi_5, \Xi_3, \Xi_4\}, 42 \to \{\Xi_1 + \alpha_1 \Xi_6, \Xi_2, \Xi_4 + a_1 \Xi_6\},$
$43 \to \{\Xi_1 + \alpha_1 \Xi_3 + \alpha_2 \Xi_6, \Xi_2, \Xi_4\}, 44 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_4 + \alpha_2 \Xi_5 + \alpha_3 \Xi_6\},$
$45 \to \{\Xi_1 + a_1 \Xi_4, \Xi_2, \Xi_3 + \alpha_1 \Xi_4 + a_2 \Xi_6\}, 46 \to \{\Xi_1 + \alpha_1 \Xi_4, \Xi_2 + \alpha_2 \Xi_4, \Xi_3 + a_1 \Xi_4\}\}$

Out[15]=



In[16]:= `Timing[alg4 = SubAlgebra[cs, pars, 4];]`

There are 11 4-D families of subalgebras to be analyzed.

Done.

Out[16]=

{3667.72, Null}

In[17]:= `PrintOptimal[alg4]`

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

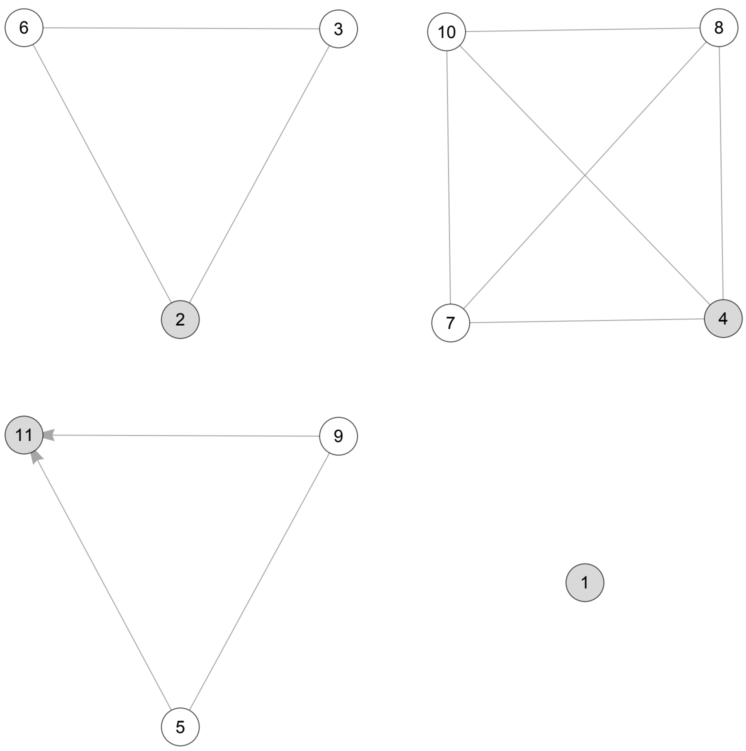
Out[17]=

$\{\{\Xi_1, \Xi_2, \Xi_3, \Xi_4\}, \{\Xi_1, \Xi_2, \Xi_3, \Xi_6\}, \{\Xi_1, \Xi_2, \Xi_5, \Xi_6\}, \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_6, \Xi_4 + a_1 \Xi_6\}\}$

In[18]:= `PrintGraph[alg4, 1]`

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3, \Xi_4\}, 2 \to \{\Xi_1, \Xi_2, \Xi_3, \Xi_6\}, 3 \to \{\Xi_1, \Xi_2, \Xi_4, \Xi_6\},$
$4 \to \{\Xi_1, \Xi_2, \Xi_5, \Xi_6\}, 5 \to \{\Xi_1, \Xi_2, \Xi_3, \Xi_4 + a_1 \Xi_6\}, 6 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_4, \Xi_6\},$
$7 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_5, \Xi_6\}, 8 \to \{\Xi_1, \Xi_2, \Xi_4 + \alpha_1 \Xi_5, \Xi_6\}, 9 \to \{\Xi_1, \Xi_2, \Xi_3 + a_1 \Xi_6, \Xi_4\},$
$10 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_4 + \alpha_2 \Xi_5, \Xi_6\}, 11 \to \{\Xi_1, \Xi_2, \Xi_3 + \alpha_1 \Xi_6, \Xi_4 + a_1 \Xi_6\}\}$

Out[18]=



In[19]:= `Timing[alg5 = SubAlgebra[cs, pars, 5];]`

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

Done.

Out[19]=

{19705., Null}

In[20]:= `PrintOptimal[alg5]`

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

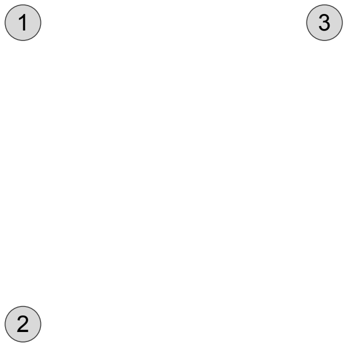
Out[20]=

$\{\{\Xi_1, \Xi_2, \Xi_3, \Xi_4, \Xi_5\}, \{\Xi_1, \Xi_2, \Xi_3, \Xi_4, \Xi_6\}, \{\Xi_1, \Xi_2, \Xi_3, \Xi_4, \Xi_5 + a_1 \Xi_6\}\}$

In[21]:= **PrintGraph[alg5, 1]**

$\{1 \to \{\Xi_1, \Xi_2, \Xi_3, \Xi_4, \Xi_5\}, 2 \to \{\Xi_1, \Xi_2, \Xi_3, \Xi_4, \Xi_6\}, 3 \to \{\Xi_1, \Xi_2, \Xi_3, \Xi_4, \Xi_5 + a_1 \Xi_6\}\}$

Out[21]=



In[22]:= **alg = {alg1, alg2, alg3, alg4, alg5}**

Out[22]=

```
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   {0, 0, 0, 0, 0, 0}, {0, 0, 1, 0, 0, 0}, {0, 0, 0, 0, 0, 0}},
  {{0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0},
   {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}},
  {{0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0},
   {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0}}}}
```

In[23]:=
```
SessionTime[]
```

Out[23]=
```
55 233.206726
```