Aufgabe 1

$$\langle E^*, f(E)\rangle = \begin{pmatrix} 3 & 1 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ -1 & 0 & 3 & 1 \\ 0 & 1 & 0 & 3 \end{pmatrix}$$

a) ges.: $\chi_f(X)$, EW von f

$$\chi_f(x) = \det(f - X\, id_V) = \begin{vmatrix} 3-X & 1 & 0 & 0 \\ 0 & 3-X & 0 & 0 \\ -1 & 0 & 3-X & 1 \\ 0 & 1 & 0 & 3-X \end{vmatrix}$$

$$= (3-X)\begin{vmatrix} 3-X & 1 & 0 \\ 0 & 3-X & 0 \\ 0 & 1 & 3-X \end{vmatrix}$$

$$= (3-X)^2 \begin{vmatrix} 3-X & 1 \\ 0 & 3-X \end{vmatrix} = (3-X)^4$$

$\Rightarrow$ EW $\lambda = 3$, ~~V~~ algebr. VF: 4

b) ges.: ~~zu $\langle E^*, f(E)\rangle$ ähnl. Matrix in JNF~~

$\langle B^*, f(B)\rangle$ in JNF

Eigenraum zu $\lambda = 3$

x_1	x_2	x_3	x_4	
0	1	0	0	0
~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
-1	0	0	1	0
~~0~~	~~1~~	~~0~~	~~0~~	~~0~~

$$\Rightarrow a_{11} := \begin{pmatrix} 1 \\ 0 \\ 0 \\ 1 \end{pmatrix}, \quad a_{21} := \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}$$

Hauptraum

x_1	x_2	x_3	x_4		
0	1	0	0	1	0
~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
-1	0	0	1	0	1
~~0~~	~~1~~	~~0~~	~~0~~	~~1~~	~~0~~

$$\Rightarrow a_{12} := \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}, \quad a_{22} := \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}$$

$$\Rightarrow \langle \mathcal{B}^*, f(\mathcal{B})\rangle = \begin{pmatrix} \boxed{\begin{matrix} 3 & 1 \\ & 3 \end{matrix}} & \\ & \boxed{\begin{matrix} 3 & 1 \\ & 3 \end{matrix}} \end{pmatrix}$$

$$B = \langle \mathcal{E}^*, \mathcal{B}\rangle = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 \end{pmatrix}$$

d) $\mu_f(x) = (3-x)^2$

Aufgabe 2

$\langle E^*, f_{\mathbb{C}}(E)\rangle = \langle E^*, f(E)\rangle = \begin{pmatrix} 3 & 3 & -3 & 0 \\ -3 & 0 & 0 & 0 \\ 3 & 3 & -3 & 0 \\ -3 & 0 & 0 & 0 \end{pmatrix}$

a) ges.: $\chi_{f_{\mathbb{C}}}(x)$, EW v. $f_{\mathbb{C}}$

$\cancel{\chi_f}$

$\chi_{f_{\mathbb{C}}}(x) = \det(f_{\mathbb{C}} - x \cdot id_V) = \begin{vmatrix} 3-x & 3 & -3 & 0 \\ -3 & -x & 0 & 0 \\ 3 & 3 & -3-x & 0 \\ -3 & 0 & 0 & -x \end{vmatrix}$

$= -x \begin{vmatrix} 3-x & 3 & -3 \\ -3 & -x & 0 \\ 3 & 3 & -3-x \end{vmatrix}$

$\cancel{= -x\left((3-x)x(3+x) + 27 - 9x - 9(3+x)\right)}$

$\cancel{= (-x)(3+x)}$

$\cancel{= -x\left((3-x)x(3+x)\right.}$

$= -x\left((3-x)x(3+x) + 27 - 9x - 9(3+x)\right)$

$= -x\left((3-x)x(3+x) - 18x\right)$

$= -x^2\left(9 - x^2 - 18\right)$

$= +x^2\left(x^2+9\right)$

$\Rightarrow$ EW: $\chi_{f_{\mathbb{C}}}(x) = x^2(x^2+9) = 0$

$\Leftrightarrow x^2 = 0 \Leftrightarrow \lambda_{1,2} = 0$

$\Leftrightarrow x^2 + 9 = 0 \Leftrightarrow \lambda_3 = 3i$

$\lambda_4 = -3i$

b) ges.: C .. Basis v. $\mathbb{C}^{4\times 1}$ mit $\langle C^*, f_C(C)\rangle$ ist Diag.

EV zu $\lambda_1, \lambda_2 = 0$

$$\begin{array}{cccc|c} x_1 & x_2 & x_3 & x_4 & \\ \hline 3 & 3 & -3 & 0 & 0 \\ -3 & 0 & 0 & 0 & 0 \\ \cancel{3} & \cancel{3} & \cancel{-3} & \cancel{0} & 0 \\ \cancel{-3} & \cancel{0} & \cancel{0} & \cancel{0} & 0 \\ \hline 0 & 1 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ & & 0 & & 0 \end{array}$$

$$\Rightarrow e_1 := \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix} \quad e_2 := \begin{pmatrix} 0 \\ 1 \\ 1 \\ 0 \end{pmatrix}$$

~~ER zu A~~

EV zu $\lambda_3 = 3i$: lt. Hinweis: $e_3 := \begin{pmatrix} i \\ -1 \\ i \\ -1 \end{pmatrix}$

$$\Rightarrow \text{EV zu } \lambda_4 = -3i : \quad e_4 := \overline{e_3} = \begin{pmatrix} i \\ 1 \\ i \\ 1 \end{pmatrix}$$

$$C = \begin{pmatrix} 0 & 0 & i & i \\ 0 & 1 & -1 & 1 \\ 0 & 1 & i & i \\ 1 & 0 & -1 & 1 \end{pmatrix} \quad ; \quad \langle C^*, f_C(C)\rangle = \begin{pmatrix} 0 & & & \\ & 0 & & \\ & & 3i & \\ & & & -3i \end{pmatrix}$$

c) ~~zu~~ $\langle B^*, f(B)\rangle$ in reellen JNF

$$\langle B^*, f(B)\rangle = \begin{pmatrix} 0 & & & \\ & 0 & & \\ & & 0 & -3 \\ & & 3 & 0 \end{pmatrix}$$

d)

$$B = \begin{pmatrix} 0 & 0 & 2 & 0 \\ 0 & 1 & 0 & -2 \\ 0 & 1 & 2 & 0 \\ 1 & 0 & 0 & -2 \end{pmatrix} \quad !$$

Aufgabe 3

$$G = \begin{pmatrix} 0 & -i & 0 \\ i & 0 & i \\ 0 & -i & 0 \end{pmatrix}$$

a) ges: $P \in GL_3(\mathbb{C})$ mit $A := P^T G P$, wobei A alt. Matrix in Normalform.

$$\begin{array}{c} \\ \\ \\ \\ \\ \cdot -i \\ \\ \end{array}
\begin{array}{ccc} & \cdot i & \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ \hline 0 & -i & 0 \\ i & 0 & i \\ 0 & -i & 0 \end{array}
\overset{Z}{\longmapsto} \overset{S}{\longmapsto}
\begin{array}{c} \\ \\ \\ \\ \\ \cdot -1 \\ \\ \end{array}
\begin{array}{ccc} & \cdot -1 & \\ 1 & 0 & 0 \\ 0 & -i & 0 \\ 0 & 0 & 1 \\ \hline 0 & -1 & 0 \\ +1 & 0 & +1 \\ 0 & -1 & 0 \end{array}
\overset{Z}{\longmapsto} \overset{S}{\longmapsto}
\begin{array}{ccc} 1 & 0 & -1 \\ 0 & -i & 0 \\ 0 & 0 & 1 \\ \hline 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{array}$$

$$\Rightarrow P = \begin{pmatrix} 1 & 0 & -1 \\ 0 & -i & 0 \\ 0 & 0 & 1 \end{pmatrix}; \quad A = \begin{pmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

b) ges: $Q \in GL_3(\mathbb{C})$ mit $H := \overline{Q}^T G Q$, wobei H herm. Matrix in Normalform.

$$\begin{array}{c} \\ \\ \\ \\ \\ \cdot i \\ \\ \end{array}
\begin{array}{ccc} & \cdot +i & \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ \hline 0 & -i & 0 \\ i & 0 & i \\ 0 & -i & 0 \end{array}
\overset{Z}{\longmapsto} \overset{S}{\longmapsto}
\begin{array}{ccc} 1 & 0 & 0 \\ 0 & +i & 0 \\ 0 & 0 & 1 \\ \hline 0 & 1 & 0 \\ +1 & 0 & 1 \\ 0 & 1 & 0 \end{array}
\overset{S}{\longmapsto}
\begin{array}{c} \\ \\ \\ \\ + \\ \\ \\ \end{array}
\begin{array}{ccc} 1 & 0 & 0 \\ i & i & 0 \\ 0 & 0 & 1 \\ \hline 1 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{array}$$

$$\overset{Z}{\longmapsto}
\begin{array}{ccc} & \times & \\ \hline 2 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ & \cdot -\frac{1}{2} \quad \cdot -\frac{1}{2} & \end{array}
\overset{S}{\longmapsto}
\begin{array}{c} \\ \\ \\ \\ \cdot -\frac{1}{2} \\ \cdot -\frac{1}{2} \end{array}
\begin{array}{ccc} 1 & -\frac{1}{2} & -\frac{1}{2} \\ i & \frac{i}{2} & -\frac{i}{2} \\ 0 & 0 & 1 \\ \hline 2 & 0 & 0 \\ 1 & -\frac{1}{2} & \frac{1}{2} \\ 1 & \frac{1}{2} & -\frac{1}{2} \end{array}$$

$$\begin{array}{c} X \\ \hline \begin{array}{cccc} & 2 & 0 & 0 \\ \cdot 2 & 0 & -\frac{1}{2} & \frac{1}{2} \\ \cdot 2 & 0 & \frac{1}{2} & -\frac{1}{2} \\ & & \cdot 2 & \cdot 2 \end{array} \end{array} \overset{s}{\longmapsto} \overset{z}{\longmapsto} \begin{array}{ccc} 1 & -1 & -1 \\ i & i & -i \\ 0 & 0 & 1 \\ \hline 2 & 0 & 0 \\ 0 & -2 & 2 \\ 0 & 2 & -2 \end{array} \overset{z}{\longmapsto} \overset{s}{\longmapsto} \begin{array}{cccc} 1 & -1 & -2 & \\ i & i & 0 & \\ 0 & 0 & 2 & \\ \hline 2 & 0 & 0 & \\ 0 & -2 & 0 & \cdot \frac{1}{\sqrt{2}i} \\ 0 & 0 & 0 & \\ & \cdot \frac{1}{\sqrt{2}i} & & \end{array}$$

$$\overset{z}{\longmapsto} \overset{s}{\longmapsto} \begin{array}{c} Q \\ \hline \left.\begin{array}{ccc} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{array}\right\} =: H \end{array}$$

$$Q = \begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}i} & -2 \\ \frac{i}{\sqrt{2}} & \cancel{\frac{i}{\sqrt{2}i}} & 0 \\ 0 & 0 & 2 \end{pmatrix}$$

$$= \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & i & -2\sqrt{2} \\ i & 1 & 0 \\ 0 & 0 & 2\sqrt{2} \end{pmatrix}$$

$$-\frac{1}{i} = \frac{\cancel{1} \cdot i}{\cancel{i}}$$

$$2\sqrt{2}$$

$$\cancel{(-2)\left(-\frac{1}{\sqrt{2}i}\right) \frac{1}{\sqrt{2}i} = -1}$$

$$-1$$

$$\frac{1}{\sqrt{-2}} = \frac{1}{\sqrt{-1}\sqrt{2}} = \frac{1}{\sqrt{2}i} = -\frac{i}{\sqrt{2}}$$

$$(-2)\left(-\frac{1}{\sqrt{2}i\sqrt{2}i}\right) = \cancel{2} \frac{1}{\cancel{2}i^2} = -1$$

$$(x_1, x_2, x_3)\begin{pmatrix}0 & -i & 0\\ i & 0 & i\\ 0 & -i & 0\end{pmatrix} = (i x_2, -i(x_1+x_3), i x_2) = (0,0,0)$$

c)

$$\Leftrightarrow \quad x_2 = 0$$

$$\cancel{x_1 + x_3 = 0}$$

$\Rightarrow$ Basis: $\cancel{\begin{pmatrix}1\\0\\0\end{pmatrix}}, \begin{pmatrix}1\\0\\+1\end{pmatrix}$

d) <u>indefinit</u>

Aufgabe 4

$$\sigma_1(E,E) \approx \begin{pmatrix} 1 & 0 & 1 \\ 0 & -1 & -1 \\ 1 & -1 & 0 \end{pmatrix}$$

$$\sigma_2(E,E) = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 2 & 1 \\ 0 & 1 & 1 \end{pmatrix}$$

a)

$$\begin{matrix} 1 & 0 & 1 \\ 0 & -1 & -1 \\ 1 & -1 & 0 \end{matrix} \overset{\cdot -1}{} \xmapsto{S} \begin{matrix} 1 & 0 & 0 \\ 0 & -1 & -1 \\ 1 & -1 & -1 \end{matrix} \cdot -1 \xmapsto{Z} \begin{matrix} 1 & 0 & 0 \\ 0 & -1 & -1 \\ 0 & -1 & -1 \end{matrix} \cdot -1$$

$$\xmapsto{S} \xmapsto{Z} \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$\begin{matrix} 0 & 0 & 0 \\ 0 & 2 & 1 \\ 0 & 1 & 1 \end{matrix} \cdot -1 \xmapsto{S} \xmapsto{Z} \begin{matrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{matrix} \xmapsto{S} \xmapsto{Z} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

b) $(+,-,0)$

$(+,+,0)$

c) n. kongruent, da versch. Signatur

d) $$(\sigma_1)_{\mathbb{C}} \approx \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{pmatrix} \cdot i \xmapsto{S} \xmapsto{Z} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$$(\sigma_2)_{\mathbb{C}} \approx \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

e) ja, da kongr. zu selber Matrix in Normalform

(da selben Rang)

Aufgabe 5

$$\sigma(E,E) = \begin{pmatrix} 0 & i & -i \\ -i & 0 & -i \\ i & i & 0 \end{pmatrix} \qquad \omega = -$$

a)

$$\begin{array}{ccc} \cancel{0} & \cancel{i} & \cancel{-i} \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ \hline 0 & i & -i \\ -i & 0 & -i \\ i & i & 0 \end{array} \begin{array}{l} \\ \\ \\ \\ \\ \\ \cdot i \\ \\ \end{array} \overset{Z}{\longmapsto} \overset{S}{\longmapsto} \begin{array}{ccc} 1 & 0 & 0 \\ 0 & -i & 0 \\ 0 & 0 & 1 \\ \hline 0 & 1 & -i \\ 1 & 0 & 1 \\ i & 1 & 0 \end{array} \overset{S}{\longmapsto} \begin{array}{ccc} 1 & 0 & 0 \\ -i & -i & 0 \\ 0 & 0 & 1 \\ \hline 1 & 1 & -i \\ 1 & 0 & 1 \\ 1+i & 1 & 0 \end{array}$$

$$\overset{Z}{\longmapsto} \begin{array}{ccc} & \times & \\ \hline 2 & 1 & 1-i \\ 1 & 0 & 1 \\ 1+i & 1 & 0 \end{array} \quad \cdot i \quad \overset{S}{\longmapsto} \begin{array}{ccc} 1 & 0 & 0 \\ -i & -i & 1 \\ 0 & 0 & 1 \\ \hline 2 & 1 & 1 \\ 1 & 0 & \cancel{1} \\ 1+i & 1 & i \end{array} \cdot -i$$

$$\overset{Z}{\longmapsto} \begin{array}{ccc} & \times & \\ \hline 2 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 1 & 0 \end{array} \quad \cdot -\tfrac{1}{2} \quad \cdot -\tfrac{1}{2} \quad \overset{S}{\longmapsto} \begin{array}{ccc} 1 & -\tfrac{1}{2} & -\tfrac{1}{2} \\ -i & -\tfrac{i}{2} & 1+\tfrac{i}{2} \\ 0 & 0 & 1 \\ \hline 2 & 0 & 0 \\ 1 & -\tfrac{1}{2} & \tfrac{1}{2} \\ 1 & \tfrac{1}{2} & \cancel{1}-\tfrac{1}{2} \end{array} \cdot -\tfrac{1}{2} \quad \cdot -\tfrac{1}{2}$$

$$\overset{Z}{\longmapsto} \begin{array}{ccc} & \times & \\ \hline 2 & 0 & 0 \\ 0 & -\tfrac{1}{2} & \tfrac{1}{2} \\ 0 & \tfrac{1}{2} & \cancel{1}-\tfrac{1}{2} \\ & \cdot 2 & \cdot 2 \end{array} \begin{array}{l} \\ \\ \cdot 2 \\ \cdot 2 \\ \\ \end{array} \overset{S}{\longmapsto} \begin{array}{ccc} 1 & -1 & -1 \\ -i & -i & 2+i \\ 0 & 0 & 2 \\ \hline 2 & 0 & 0 \\ 0 & -2 & 2 \\ 0 & 2 & \cancel{2}-2 \end{array} +$$

$$
\begin{array}{ccc}
1 & -1 & -2 \\
-i & -i & 2 \\
0 & 0 & 2 \\
\hline
2 & 0 & 0 \\
0 & -2 & 0 \\
0 & 0 & 0
\end{array}
\quad \overset{S}{\mapsto} \overset{Z}{\mapsto} \quad
\begin{array}{ccc}
 & P & \\
\hline
1 & 0 & 0 \\
0 & -1 & 0 \\
0 & 0 & 0
\end{array}
\Bigg\} =: G
$$

$$\cancel{\frac{1}{\sqrt{4i}} = \frac{1}{2\sqrt{i}} = \frac{1}{2\sqrt{\sqrt{-1}}} = \frac{1}{2\sqrt[4]{-1}}}$$

$$\cancel{= \frac{1}{2(-i)} = \frac{i}{2}}$$

$$P := \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & -1 & -2\sqrt{2} \\ -i & -i & 2\sqrt{2} \\ 0 & 0 & 2\sqrt{2} \end{pmatrix}$$

b) indefinit

c) nein, da nicht radikalfrei

d) $(3-2i, -i, -1) \begin{pmatrix} 0 & i & -i \\ -i & 0 & -i \\ i & i & 0 \end{pmatrix} = (-1-i, 2i+2, -3i-3) \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$

$= -(1+i)x_1 + 2(i+1)x_2 - 3(i+1)x_3 = (i+1)(x_1 - 2x_2 + 3x_3) = 0$

$\Leftrightarrow x_1 - 2x_2 + 3x_3 = 0$

Aufgabe 6

$$G = \begin{pmatrix} 1 & i & 0 \\ -i & 2 & -i \\ 0 & i & 2 \end{pmatrix}$$

a) $G_{(1)} = 1$

$$G_{(1,2)} = \begin{vmatrix} 1 & i \\ -i & 2 \end{vmatrix} = 1$$

$$G_{(1,3)} = \begin{vmatrix} 1 & i & 0 \\ -i & 2 & -i \\ 0 & i & 2 \end{vmatrix} = 4 - 1 - 2 = 1$$

b) $\operatorname{rg} G = 3$, da $\det G \neq 0$

c) G pos. def., da alle Hauptminoren > 0

d)

$$\begin{array}{ccc} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ \hline 1 & i & 0 \\ -i & 2 & -i \\ 0 & i & 2 \end{array} \overset{S}{\longmapsto} \begin{array}{ccc} 1 & \cancel{0}\,-i & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ \hline 1 & 0 & 0 \\ -i & 1 & -i \\ 0 & i & 2 \end{array} \cdot +i \overset{Z}{\longmapsto} \begin{array}{ccc} & \times & \\ \hline 1 & 0 & 0 \\ 0 & 1 & -i \\ 0 & i & 2 \end{array} \cdot -i$$

$\cdot -i$

$$\overset{S}{\longmapsto} \begin{array}{ccc} 1 & -i & 1 \\ 0 & 1 & i \\ 0 & 0 & 1 \\ \hline 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array} \Big\} =: Q \quad \overset{S}{\longmapsto}\overset{Z}{\longmapsto} \cancel{\begin{array}{ccc} 1 & -i & \frac{1}{\sqrt{2}} \\ 0 & 1 & \frac{i}{\sqrt{2}} \\ 0 & 0 & \frac{1}{\sqrt{2}} \\ \hline 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array}} \Big\} =: Q$$

$$E_n = \overline{Q}^T \cdot G \cdot Q \iff G = (\overline{Q}^T)^{-1} \cdot E_n \cdot Q^{-1}$$

$$= \overline{(Q^{-1})}^T \cdot E_n \cdot \underbrace{Q^{-1}}_{=:P}$$

$$\Rightarrow G = \overline{P}^T \cdot E_n \cdot P$$

$$\begin{array}{ccc} 1 & \cdot(-i) & \cancel{} \\ 0 & 1 & \cancel{} \\ 0 & 0 & \cancel{} \\ \hline 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array} \longrightarrow \begin{array}{ccc} 1 & 0 & 0 \\ 0 & 1 & i \\ 0 & 0 & 1 \\ \hline 1 & i & -1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array} \longmapsto \begin{array}{ccc} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ \hline 1 & i & 0 \\ 0 & 1 & \cdot(-i) \\ 0 & 0 & 1 \end{array} \Bigg\} =: P$$

$\cdot i$

$\cdot -1$