Program:

```
from sympy import expand,simplify
from sympy.galgebra.printer import Format,xpdf
from sympy.galgebra.ga import Ga

g = '1 # #,'+ \
    '# 1 #,'+ \
    '# # 1'

Format()

ng3d = Ga('e1 e2 e3',g=g)
(e1,e2,e3) = ng3d.mv()
print 'g_{ij} =',ng3d.g
E = e1^e2^e3
Esq = (E*E).scalar()
print 'E =',E
print '%E^{2} =',Esq
Esq_inv = 1/Esq
E1 = (e2^e3)*E
E2 = (-1)*(e1^e3)*E
E3 = (e1^e2)*E
print 'E1 = (e2^e3)*E =',E1
print 'E2 =-(e1^e3)*E =',E2
print 'E3 = (e1^e2)*E =',E3
w = (E1|e2)
w = w.expand()
print 'E1|e2 =',w
w = (E1|e3)
w = w.expand()
print 'E1|e3 =',w
w = (E2|e1)
w = w.expand()
print 'E2|e1 =',w
w = (E2|e3)
w = w.expand()
print 'E2|e3 =',w
w = (E3|e1)
w = w.expand()
print 'E3|e1 =',w
w = (E3|e2)
w = w.expand()
print 'E3|e2 =',w
w = (E1|e1)
w = (w.expand()).scalar()
```

```
Esq = expand(Esq)
print '%(E1\\cdot e1)/E^{2} =',simplify(w/Esq)
w = (E2|e2)
w = (w.expand()).scalar()
print '%(E2\\cdot e2)/E^{2} =',simplify(w/Esq)
w = (E3|e3)
w = (w.expand()).scalar()
print '%(E3\\cdot e3)/E^{2} =',simplify(w/Esq)
xpdf(paper='letter',prog=True)
```

Code Output:

$$g_{ij} = \begin{bmatrix} 1 & (e_1 \cdot e_2) & (e_1 \cdot e_3) \\ (e_1 \cdot e_2) & 1 & (e_2 \cdot e_3) \\ (e_1 \cdot e_3) & (e_2 \cdot e_3) & 1 \end{bmatrix}$$

$$E = \boldsymbol{e_1} \wedge \boldsymbol{e_2} \wedge \boldsymbol{e_3}$$

$$E^2 = (e_1 \cdot e_2)^2 - 2\,(e_1 \cdot e_2)\,(e_1 \cdot e_3)\,(e_2 \cdot e_3) + (e_1 \cdot e_3)^2 + (e_2 \cdot e_3)^2 - 1$$

$$E1 = (e2 \wedge e3)E = \left((e_2 \cdot e_3)^2 - 1\right)\boldsymbol{e_1} + ((e_1 \cdot e_2) - (e_1 \cdot e_3)\,(e_2 \cdot e_3))\,\boldsymbol{e_2} + (-(e_1 \cdot e_2)\,(e_2 \cdot e_3) + (e_1 \cdot e_3))\,\boldsymbol{e_3}$$

$$E2 = -(e1 \wedge e3)E = ((e_1 \cdot e_2) - (e_1 \cdot e_3)\,(e_2 \cdot e_3))\,\boldsymbol{e_1} + \left((e_1 \cdot e_3)^2 - 1\right)\boldsymbol{e_2} + (-(e_1 \cdot e_2)\,(e_1 \cdot e_3) + (e_2 \cdot e_3))\,\boldsymbol{e_3}$$

$$E3 = (e1 \wedge e2)E = (-(e_1 \cdot e_2)\,(e_2 \cdot e_3) + (e_1 \cdot e_3))\,\boldsymbol{e_1} + (-(e_1 \cdot e_2)\,(e_1 \cdot e_3) + (e_2 \cdot e_3))\,\boldsymbol{e_2} + \left((e_1 \cdot e_2)^2 - 1\right)\boldsymbol{e_3}$$

$$E1 \cdot e2 = 0$$

$$E1 \cdot e3 = 0$$

$$E2 \cdot e1 = 0$$

$$E2 \cdot e3 = 0$$

$$E3 \cdot e1 = 0$$

$$E3 \cdot e2 = 0$$

$$(E1 \cdot e1)/E^2 = 1$$

$$(E2 \cdot e2)/E^2 = 1$$

$$(E3 \cdot e3)/E^2 = 1$$