

```
def basic_multivector_operations_3D():
    Print_Function()
    (g3d,ex,ey,ez) = Ga.build('e*x|y|z')
    print 'g-{ij} =',g3d.g
    A = g3d.mv('A','mv')
    A.Fmt(1,'A')
    A.Fmt(2,'A')
    A.Fmt(3,'A')
    A.even().Fmt(1,'%A_{+}')
    A.odd().Fmt(1,'%A_{-}')
```

```
X = g3d.mv('X','vector')
Y = g3d.mv('Y','vector')
X.Fmt(1,'X')
Y.Fmt(1,'Y')
(X*Y).Fmt(2,'X*Y')
(X^Y).Fmt(2,'X^Y')
(X|Y).Fmt(2,'X|Y')
return
```

Code Output:

$$g_{ij} = \begin{bmatrix} (e_x \cdot e_x) & (e_x \cdot e_y) & (e_x \cdot e_z) \\ (e_x \cdot e_y) & (e_y \cdot e_y) & (e_y \cdot e_z) \\ (e_x \cdot e_z) & (e_y \cdot e_z) & (e_z \cdot e_z) \end{bmatrix}$$

$$A = A + A^xe_x + A^ye_y + A^ze_z + A^{xy}e_x \wedge e_y + A^{xz}e_x \wedge e_z + A^{yz}e_y \wedge e_z + A^{xyz}e_x \wedge e_y \wedge e_z$$

$$\begin{aligned} A = & A \\ & + A^xe_x + A^ye_y + A^ze_z \\ & + A^{xy}e_x \wedge e_y + A^{xz}e_x \wedge e_z + A^{yz}e_y \wedge e_z \\ & + A^{xyz}e_x \wedge e_y \wedge e_z \end{aligned}$$

$$\begin{aligned} A = & A \\ & + A^xe_x \\ & + A^ye_y \\ & + A^ze_z \\ & + A^{xy}e_x \wedge e_y \\ & + A^{xz}e_x \wedge e_z \\ & + A^{yz}e_y \wedge e_z \\ & + A^{xyz}e_x \wedge e_y \wedge e_z \end{aligned}$$

$$A_+ = A + A^{xy}e_x \wedge e_y + A^{xz}e_x \wedge e_z + A^{yz}e_y \wedge e_z$$

$$A_- = A^xe_x + A^ye_y + A^ze_z + A^{xyz}e_x \wedge e_y \wedge e_z$$

$$X = X^xe_x + X^ye_y + X^ze_z$$

$$Y = Y^xe_x + Y^ye_y + Y^ze_z$$

$$\begin{aligned} XY = & (X^xY^x(e_x \cdot e_x) + X^xY^y(e_x \cdot e_y) + X^xY^z(e_x \cdot e_z) + X^yY^x(e_y \cdot e_x) + X^yY^y(e_y \cdot e_y) + X^yY^z(e_y \cdot e_z) + X^zY^x(e_z \cdot e_x) + X^zY^y(e_z \cdot e_y) + X^zY^z(e_z \cdot e_z)) \\ & + (X^xY^y - X^yY^x)e_x \wedge e_y + (X^xY^z - X^zY^x)e_x \wedge e_z + (X^yY^z - X^zY^y)e_y \wedge e_z \end{aligned}$$

$$X \wedge Y = (X^xY^y - X^yY^x)e_x \wedge e_y + (X^xY^z - X^zY^x)e_x \wedge e_z + (X^yY^z - X^zY^y)e_y \wedge e_z$$

$$X \cdot Y = X^xY^x(e_x \cdot e_x) + X^xY^y(e_x \cdot e_y) + X^xY^z(e_x \cdot e_z) + X^yY^x(e_y \cdot e_x) + X^yY^y(e_y \cdot e_y) + X^yY^z(e_y \cdot e_z) + X^zY^x(e_z \cdot e_x) + X^zY^y(e_z \cdot e_y) + X^zY^z(e_z \cdot e_z)$$

```
def basic_multivector_operations_2D():
    Print_Function()
    (g2d,ex,ey) = Ga.build('e*x|y')
    print 'g-{ij} =',g2d.g
    X = g2d.mv('X','vector')
    A = g2d.mv('A','spinor')
    X.Fmt(1,'X')
    A.Fmt(1,'A')
    (X|A).Fmt(2,'X|A')
    (X<A).Fmt(2,'X<A')
    (A>X).Fmt(2,'A>X')
    return
```

Code Output:

$$g_{ij} = \begin{bmatrix} (e_x \cdot e_x) & (e_x \cdot e_y) \\ (e_x \cdot e_y) & (e_y \cdot e_y) \end{bmatrix}$$
$$X = X^x e_x + X^y e_y$$
$$A = A + A^{xy} e_x \wedge e_y$$
$$X \cdot A = -A^{xy} (X^x (e_x \cdot e_y) + X^y (e_y \cdot e_y)) e_x + A^{xy} (X^x (e_x \cdot e_x) + X^y (e_x \cdot e_y)) e_y$$
$$X|A = (AX^x - A^{xy} X^x (e_x \cdot e_y) - A^{xy} X^y (e_y \cdot e_y)) e_x + (AX^y + A^{xy} X^x (e_x \cdot e_x) + A^{xy} X^y (e_x \cdot e_y)) e_y$$
$$A|X = (AX^x + A^{xy} X^x (e_x \cdot e_y) + A^{xy} X^y (e_y \cdot e_y)) e_x + (AX^y - A^{xy} X^x (e_x \cdot e_x) - A^{xy} X^y (e_x \cdot e_y)) e_y$$