generalized forces

In[1]:=
```
f = {dx0, dy0, dz0, dx1, dy1, dz1};
MatrixForm[f]
```

Out[2]//MatrixForm=

$$\begin{pmatrix} dx0 \\ dy0 \\ dz0 \\ dx1 \\ dy1 \\ dz1 \end{pmatrix}$$

function

In[3]:=
```
V = (1/2 * k * (Sqrt[{Subscript[x, 1] - Subscript[x, 0], Subscript[y, 1] - Subscript[y, 0],
        Subscript[z, 1] - Subscript[z, 0]} . {Subscript[x, 1] - Subscript[x, 0],
        Subscript[y, 1] - Subscript[y, 0], Subscript[z, 1] - Subscript[z, 0]}] - l)^2)
```

Out[3]=

$$\frac{1}{2} k \left(-l + \sqrt{(-x_0 + x_1)^2 + (-y_0 + y_1)^2 + (-z_0 + z_1)^2}\right)^2$$

derivatives

In[4]:=
```
dx0 = D[V, Subscript[x, 0]]
dx0 = dx0 /.
   Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 + (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → n;
dx0 = dx0 /. 1/Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 +
      (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → 1/n
```

Out[4]=

$$-\frac{k (-x_0 + x_1) \left(-l + \sqrt{(-x_0 + x_1)^2 + (-y_0 + y_1)^2 + (-z_0 + z_1)^2}\right)}{\sqrt{(-x_0 + x_1)^2 + (-y_0 + y_1)^2 + (-z_0 + z_1)^2}}$$

Out[6]=

$$-\frac{k (-l + n) (-x_0 + x_1)}{n}$$

In[7]:=
```
dy0 = D[V, Subscript[y, 0]]
dy0 = dy0 /.
   Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 + (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → n;
dy0 = dy0 /. 1/Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 +
      (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → 1/n
```

Out[7]= $$-\frac{k(-y_0+y_1)\left(-l+\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}\right)}{\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}}$$

Out[9]= $$-\frac{k(-l+n)(-y_0+y_1)}{n}$$

In[10]:=
```
dz0 = D[V, Subscript[z, 0]]
dz0 = dz0 /.
   Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 + (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → n;
dz0 = dz0 /. 1/Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 +
      (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → 1/n
```

Out[10]= $$-\frac{k(-z_0+z_1)\left(-l+\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}\right)}{\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}}$$

Out[12]= $$-\frac{k(-l+n)(-z_0+z_1)}{n}$$

In[13]:=
```
dx1 = D[V, Subscript[x, 1]]
dx1 = dx1 /.
   Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 + (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → n;
dx1 = dx1 /. 1/Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 +
      (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → 1/n
```

Out[13]= $$\frac{k(-x_0+x_1)\left(-l+\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}\right)}{\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}}$$

Out[15]= $$\frac{k(-l+n)(-x_0+x_1)}{n}$$

In[16]:=
```
dy1 = D[V, Subscript[y, 1]]
dy1 = dy1 /.
   Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 + (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → n;
dy1 = dy1 /. 1/Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 +
      (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → 1/n
```

Out[16]=
$$\frac{k(-y_0+y_1)\left(-l+\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}\right)}{\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}}$$

Out[18]=
$$\frac{k(-l+n)(-y_0+y_1)}{n}$$

In[19]:=
```
dz1 = D[V, Subscript[z, 1]]
dz1 = dz1 /.
   Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 + (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → n;
dz1 = dz1 /. 1/Sqrt[(-Subscript[x, 0] + Subscript[x, 1])^2 +
      (-Subscript[y, 0] + Subscript[y, 1])^2 +
      (-Subscript[z, 0] + Subscript[z, 1])^2] → 1/n
```

Out[19]=
$$\frac{k(-z_0+z_1)\left(-l+\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}\right)}{\sqrt{(-x_0+x_1)^2+(-y_0+y_1)^2+(-z_0+z_1)^2}}$$

Out[21]=
$$\frac{k(-l+n)(-z_0+z_1)}{n}$$

final

In[22]:=
```
MatrixForm[f]
```

Out[22]//MatrixForm=
$$\begin{pmatrix} -\frac{k(-l+n)(-x_0+x_1)}{n} \\ -\frac{k(-l+n)(-y_0+y_1)}{n} \\ -\frac{k(-l+n)(-z_0+z_1)}{n} \\ \frac{k(-l+n)(-x_0+x_1)}{n} \\ \frac{k(-l+n)(-y_0+y_1)}{n} \\ \frac{k(-l+n)(-z_0+z_1)}{n} \end{pmatrix}$$