Prescribe a displacement field with cross terms

In[1]:=
```
x1 = u1 + X1 /. {u1 → 1.2 * X1 * X3}
x2 = u2 + X2 /. {u2 → 0}
x3 = u3 + X3 /. {u3 → 1.5 * X1 * X3}
```

Out[1]= $X1 + 1.2\, X1\, X3$

Out[2]= $X2$

Out[3]= $X3 + 1.5\, X1\, X3$

Find the spatially varying deformation gradient

In[4]:=
```
F = {{D[x1, X1], D[x1, X2], D[x1, X3]},
    {D[x2, X1], D[x2, X2], D[x2, X3]}, {D[x3, X1], D[x3, X2], D[x3, X3]}};
```

In[5]:=
```
MatrixForm[F]
```

Out[5]//MatrixForm=

$$\begin{pmatrix} 1 + 1.2\, X3 & 0 & 1.2\, X1 \\ 0 & 1 & 0 \\ 1.5\, X3 & 0 & 1 + 1.5\, X1 \end{pmatrix}$$

In[6]:=
```
detJ = Det[F]
```

Out[6]= $1. + 1.5\, X1 + 1.2\, X3$

Find kinematic boundary conditions at nodesets

In[20]:=
```
nodeset10onNode1 =
 ({x1, x2, x3} - {X1, X2, X3}) /. {X1 → -0.5, X2 → -0.5, X3 → -0.5}
```

Out[20]= {0.3, 0, 0.375}

In[22]:=
```
nodeset7onNode2 = ({x1, x2, x3} - {X1, X2, X3}) /. {X1 → -0.5, X2 → -0.5, X3 → 0.5}
```

Out[22]= {−0.3, 0, −0.375}

In[23]:=
```
nodeset8onNode3 = ({x1, x2, x3} - {X1, X2, X3}) /. {X1 → 0.5, X2 → -0.5, X3 → 0.5}
```

Out[23]= {0.3, 0, 0.375}

In[24]:=
```
nodeset9onNode4 = ({x1, x2, x3} - {X1, X2, X3}) /. {X1 → 0.5, X2 → -0.5, X3 → -0.5}
```

Out[24]= {−0.3, 0, −0.375}

Find and average J (on plane in X1 and X3)

In[11]:=
```
X1D = 1 / 2 * (1 - xi) * (-1 / 2) + 1 / 2 * (1 + xi) * (1 / 2)
X1Dintpointminus = X1D /. {xi → -1.0 / Sqrt[3]}
X1Dintpointplus = X1D /. {xi → 1.0 / Sqrt[3]}
intpoints =
 {{-0.5, -0.5}, {-0.5, 0.5}, {0.5, 0.5}, {0.5, -0.5}} / (1 / 2) * X1Dintpointplus
```

Out[11]= $\frac{1}{4}(-1+\text{xi})+\frac{1+\text{xi}}{4}$

Out[12]= -0.288675

Out[13]= 0.288675

Out[14]= $\{\{-0.288675, -0.288675\}, \{-0.288675, 0.288675\}, \{0.288675, 0.288675\}, \{0.288675, -0.288675\}\}$

In[37]:=
```
Jintpoints = Table[0 * i, {i, 1, 4}];
Javg = 0.;
Do[Jintpoints[[i]] = detJ /. {X1 → intpoints[[i, 1]], X3 → intpoints[[i, 2]]};
  Javg = Javg + Log[Jintpoints[[i]]], {i, 1, 4}];
Javg = Exp[Javg / 4.]
MatrixForm[Jintpoints]
```

Out[40]= 0.790028

Out[41]//MatrixForm=

$$\begin{pmatrix} 0.220577 \\ 0.913397 \\ 1.77942 \\ 1.0866 \end{pmatrix}$$