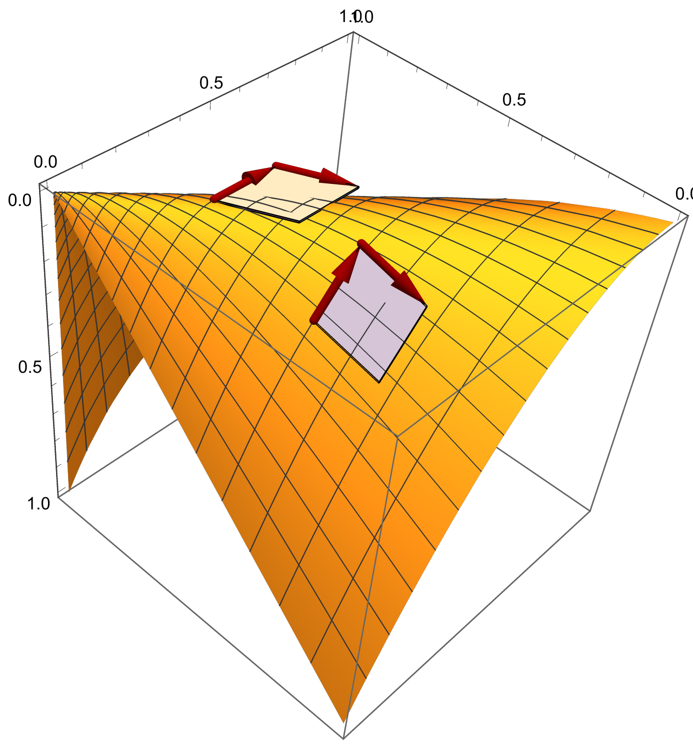
Figure: 2dmanifoldFig1.eps. CliffordBasic calculation of the basis elements above and the area element. Same calculation using my GA30.m package. Generation of mmacell text for the book showing the input and output cells for the CliffordBasic calculation.

```
<< peeters`

(*relative to ~/physicsplay*)
peeters`setGitDir["../project/figures/GAelectrodynamics"]
peeters`

/Users/pjoot/project/figures/GAelectrodynamics
```

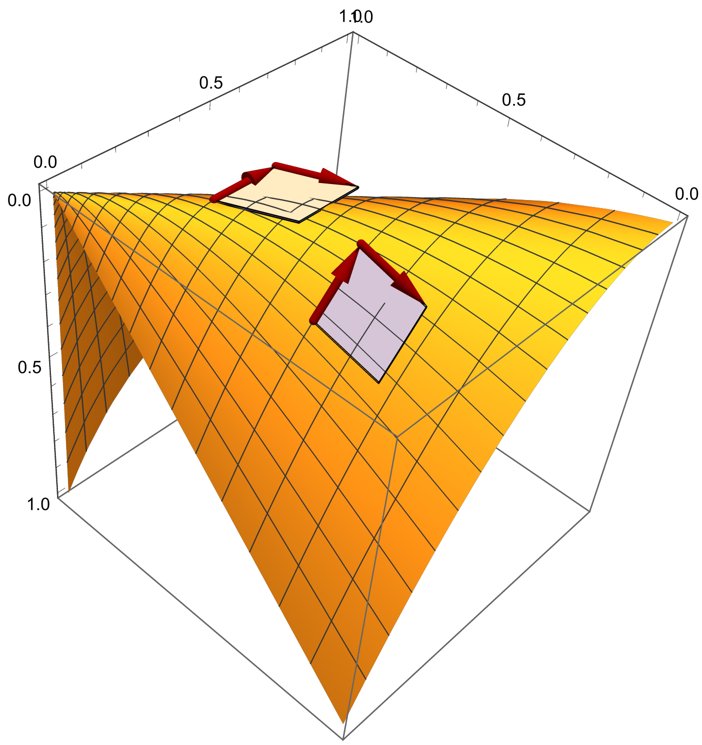
```
ClearAll[ e1, e2, e3, x1, x2, r1, r2, r, x, xp, plot1 ]

{e1, e2, e3} = IdentityMatrix[3];

xp :=  (a - b) ^2 e1 + (1 - b b) e2 + b a e3;
x[u_, v_] := xp /. {a → u, b → v};
x1[u_, v_] := D[xp, a] /. {a → u, b → v};
x2[u_, v_] := D[xp, b] /. {a → u, b → v};
x1[u1, u2]
x2[u1, u2]

plot1 = Module[{range, g, p1, x11, x21, n1, p2, x12, x22, n2},
  range = 1;
  p1 = x[.5, .5];
  x11 = (x1[.5, .5] // Normalize) / 5;
  x21 = (x2[.5, .5] // Normalize) / 5;
  n1 = (Cross[ x11, x21] // Normalize) / 200;

  p2 = x[.35, .75];
  x12 = (x1[.35, .75] // Normalize) / 5;
  x22 = (x2[.35, .75] // Normalize) / 5;
  n2 = (Cross[ x11, x21] // Normalize) / 200;

  g = Graphics3D[ {
     Parallelepiped[ p1, {x11, x21, n1}],
     Parallelepiped[ p2, {x12, x22, n2}],
     (*Thickness → 0.75,*)
     Red // Darker,
     Arrowheads[0.05],
     Arrow[Tube[{p1, p1 + x11}, 0.01]],
     Arrow[Tube[{p1 + x11, p1 + x11 + x21}, 0.01]],
     Arrow[Tube[{p2, p2 + x12}, 0.01]],
     Arrow[Tube[{p2 + x12, p2 + x12 + x22}, 0.01]]
    }];
  Show[{
    ParametricPlot3D[ x[u, v], {u, 0, range}, {v, 0, range}],
    g
   }]
 ]
```

$\{2\ (u_1 - v_1),\ 0,\ v_1\}$

$\{-2(u_1 - v_1), -2v_1, u_1\}$



```
plot1 =
```




```
;
```

```
peeters`exportForLatex["2dmanifoldFig1", plot1]
```

```
{2dmanifoldFig1.eps, 2dmanifoldFig1pn.png}
```

CliffordBasic calculation of the basis elements above and the area element.

```
<< CliffordBasic`;
$SetSignature = {3, 0};
```

```
ClearAll[xp, x, x1, x2]
(*use dummy parameter values for the derivatives,
and then switch them to function parameter values.*)
xp :=  (a - b) ^2 e[1] + (1 - b b) e[2] + b a e[3];
x[u_, v_] := xp /. {a → u, b → v};
x1[u_, v_] := D[xp, a] /. {a → u, b → v};
x2[u_, v_] := D[xp, b] /. {a → u, b → v};

x1[u, v]
x2[u, v]
(*CliffordBasic display of wedge doesn't
 currently group by the wedge basis bivectors.*)
OuterProduct[x1[u, v], x2[u, v]] // GFactor
```

$2 (u - v)\, e[1] + v\, e[3]$

$-2 (u - v)\, e[1] - 2 v\, e[2] + u\, e[3]$

$\left(-4 u v + 4 v^2\right) e[1, 2] + \left(2 u^2 - 2 v^2\right) e[1, 3] + 2 v^2 e[2, 3]$

Curvilinear calculation and area element using my GA30 package.

```
<< GA30`;
```

```
xp :=  (a - b) ^2 Vector[1, 1] + (1 - b b) Vector[1, 2] + b a Vector[1, 3];
x[u_, v_] := xp /. {a → u, b → v};
x1[u_, v_] := D[xp, a] /. {a → u, b → v};
x2[u_, v_] := D[xp, b] /. {a → u, b → v};

x1[u1, u2]
x2[u1, u2]
x1[u1, u2] ∧ x2[u1, u2]
```

$2 (u_1 - u_2)\, \mathrm{Vector}[1, 1] + u_2\, \mathrm{Vector}[1, 3]$

$-2 (u_1 - u_2)\, \mathrm{Vector}[1, 1] - 2 u_2\, \mathrm{Vector}[1, 2] + u_1\, \mathrm{Vector}[1, 3]$

$(2 (u_1 - u_2)\, \mathrm{Vector}[1, 1] + u_2\, \mathrm{Vector}[1, 3]) \wedge$
$(-2 (u_1 - u_2)\, \mathrm{Vector}[1, 1] - 2 u_2\, \mathrm{Vector}[1, 2] + u_1\, \mathrm{Vector}[1, 3])$

CellToTeX output for the CliffordBasic calculations above.

```
Import[
 "https://raw.githubusercontent.com/jkuczm/MathematicaCellsToTeX/master/NoInstall.
   m"]
```