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directional derivative

```
(%i1) kill(all);
(%o0) done
```

```
(%i1) %phi(x,y,z)=y^3*x+x;
(%o1) ϕ(x,y,z)=x y^3+x
```

```
(%i2) a:[1,2,3];
(%o2) [1,2,3]
```

```
(%i3) load(vect);
(%o3) C:/PROGRA~2/MAXIMA~1.1/share/maxima/5.21.1/share/vector/vect.mac
```

```
(%i4) scalefactors([x,y,z]);
(%o4) done
```

```
(%i5) gdf:grad(%phi(x,y,z));
(%o5) grad(ϕ(x,y,z))
```

```
(%i6) ev(express(gdf),diff);
(%o6) [d/dx ϕ(x,y,z),d/dy ϕ(x,y,z),d/dz ϕ(x,y,z)]
```

```
(%i7) define(gdf(x,y,z),%);
(%o7) gdf(x,y,z):=[d/dx ϕ(x,y,z),d/dy ϕ(x,y,z),d/dz ϕ(x,y,z)]
```

```
(%i8) (gdf(0,%pi,%pi).a/sq(a.a));
Attempt to differentiate with respect to a number:
0
#0: gdf(x=0,y=%pi,z=%pi)
 -- an error. To debug this try: debugmode(true);
```

angle between two surfaces.

```
(%i9) kill(all;);
incorrect syntax: Missing )
kill(all;
       ^
```

```
(%i9) kill(all);
(%o0) done
```

```
(%i1) %phi(x,y,z):=x^2+y^2+z^2-400;
(%o1) ϕ(x,y,z):=x^2+y^2+z^2-400
```

```
(%i2) %psi(x,y,z):=y^3-z;
(%o2) ψ(x,y,z):=y^3-z
```

```
(%i3) scalefactors([x,y,z]);
(%o3) scalefactors([x,y,z])
```

```
(%i4) gdf1:grad(%phi(x,y,z));
(%o4) grad(z^2+y^2+x^2-400)
```

```
(%i5) ev(express(gdf1),diff);
(%o5) express(grad(z^2+y^2+x^2-400))
```

```
(%i7) define(gdf1(x,y,z),%);
(%o7) gdf1(x,y,z):=express(grad(z^2+y^2+x^2-400))
```

```
(%i10) gdf2:grad(%psi(x,y,z));
(%o10) grad(y^3-z)
```

```
(%i11) ev(express(gdf2),diff);
(%o11) express(grad(y^3-z))
```

```
(%i12) define(gdf2(x,y,z),%);
(%o12) gdf2(x,y,z):=express(grad(y^3-z))
```

```
(%i13) solve([%phi1(x,y,z),%phi2(x,y,z)],[x,y,z]);
(%o13) []
```

```
 -->  mag_u:sqrt(gdf1(%r1,-sqrt(-2.%r1^2+sqrt(101)-1)/sqrt(2).(sqrt(101)-1)/2)
      mag_v:sqrt(gdf1(%r1,-sqrt(-2.%r1^2+sqrt(101)-1)/sqrt(2).(sqrt(101)-1)/2)
      theta:acos(gdf1(%r1,-sqrt(-2.%r1^2+sqrt(101)-1)/sqrt(2).(sqrt(101)-1)/2)
      /(mag_u.mag_v));
```

```
(%i14) load(draw);
(%o14) C:/PROGRA~2/MAXIMA~1.1/share/maxima/5.21.1/share/draw/draw.lisp
```

```
 -->  gimp:implicit(%phi1(x,y,z),x,-7,7,y,-7,7,z,-7,7);
      gimp:implicit(%phi2(x,y,z),x,-7,7,y,-7,7,z,-7,7);
      wxdraw3d(proportional_axes=xyz,xyplane=0,enhanced3d=true,color=red,gimp
```

curl of a vector field

```
(%i15) kill(all);
(%o0) done
```

```
(%i1) load(vect);
(%o1) C:/PROGRA~2/MAXIMA~1.1/share/maxima/5.21.1/share/vector/vect.mac
```

```
(%i2) F(x,y,z):=([x^2*z,y^2*x,z^2*y]);
```

$$\mathrm{F}(x,y,z):=[x^2\,z,y^2\,x,z^2\,y]$$

```
(%i3) scalefactors([x,y,z]);
(%o3) done
```

```
(%i4) curl(F(x,y,z));
```

$$\mathrm{curl}([x^2\,z,x\,y^2,y\,z^2])$$

```
(%i5) express(%);
```

$$[\frac{\mathrm{d}}{\mathrm{d}\,y}(y\,z^2)-\frac{\mathrm{d}}{\mathrm{d}\,z}(x\,y^2),\frac{\mathrm{d}}{\mathrm{d}\,z}(x^2\,z)-\frac{\mathrm{d}}{\mathrm{d}\,x}(y\,z^2),\frac{\mathrm{d}}{\mathrm{d}\,x}(x\,y^2)-\frac{\mathrm{d}}{\mathrm{d}\,y}(x^2\,z)]$$

```
(%i6) ev(%,diff);
```

$$[z^2,x^2,y^2]$$

```
(%i7) coord:settify(makelist(k,k,-2,2));
```

$$\mathrm{settify}([-2,-1,0,1,2])$$

```
 -->  points3d:listify(cartesian_product(coord,coord,coord));
      vf3d(x,y,z):=vector([x,y,z],[x^2*z,y^2*x,z^2*y]/10);
      apply(wxdraw3d,append([head_length=0.1,color=blue],vect3));
```

divergence of a vector point function

```
(%i9) kill(all);
(%o0) done
```

```
(%i1) load(vect);
(%o1) C:/PROGRA~2/MAXIMA~1.1/share/maxima/5.21.1/share/vector/vect.mac
```

```
(%i2) F(x,y,z):=([x^2,y^2,z^2]);
```

$$\mathrm{F}(x,y,z):=[x^2,y^2,z^2]$$

```
(%i3) scalefactors([x,y,z]);
(%o3) done

(%i4) div(F(x,y,z));
(%o4) div([x^2,y^2,z^2])

(%i5) ev(express(%),diff);
(%o5) 2 z+2 y+2 x

(%i6) coord:setify(makelist(k,k,-2,2));
(%o6) {-2,-1,0,1,2}

(%i7) points3d:listify(cartesian_product(coord,coord,coord));
(%o7) [[-2,-2,-2],[-2,-2,-1],[-2,-2,0],[-2,-2,1],[-2,-2,2],[
-2,-1,-2],[-2,-1,-1],[-2,-1,0],[-2,-1,1],[-2,-1,2],[-2,0,-2]
,[-2,0,-1],[-2,0,0],[-2,0,1],[-2,0,2],[-2,1,-2],[-2,1,-1],[-
2,1,0],[-2,1,1],[-2,1,2],[-2,2,-2],[-2,2,-1],[-2,2,0],[-2,2,
1],[-2,2,2],[-1,-2,-2],[-1,-2,-1],[-1,-2,0],[-1,-2,1],[-1,-2
,2],[-1,-1,-2],[-1,-1,-1],[-1,-1,0],[-1,-1,1],[-1,-1,2],[-1,
0,-2],[-1,0,-1],[-1,0,0],[-1,0,1],[-1,0,2],[-1,1,-2],[-1,1,-
1],[-1,1,0],[-1,1,1],[-1,1,2],[-1,2,-2],[-1,2,-1],[-1,2,0],[
-1,2,1],[-1,2,2],[0,-2,-2],[0,-2,-1],[0,-2,0],[0,-2,1],[0,-2
,2],[0,-1,-2],[0,-1,-1],[0,-1,0],[0,-1,1],[0,-1,2],[0,0,-2],
[0,0,-1],[0,0,0],[0,0,1],[0,0,2],[0,1,-2],[0,1,-1],[0,1,0],[
0,1,1],[0,1,2],[0,2,-2],[0,2,-1],[0,2,0],[0,2,1],[0,2,2],[1,
-2,-2],[1,-2,-1],[1,-2,0],[1,-2,1],[1,-2,2],[1,-1,-2],[1,-1,
-1],[1,-1,0],[1,-1,1],[1,-1,2],[1,0,-2],[1,0,-1],[1,0,0],[1,
0,1],[1,0,2],[1,1,-2],[1,1,-1],[1,1,0],[1,1,1],[1,1,2],[1,2,
-2],[1,2,-1],[1,2,0],[1,2,1],[1,2,2],[2,-2,-2],[2,-2,-1],[2,
-2,0],[2,-2,1],[2,-2,2],[2,-1,-2],[2,-1,-1],[2,-1,0],[2,-1,1
],[2,-1,2],[2,0,-2],[2,0,-1],[2,0,0],[2,0,1],[2,0,2],[2,1,-2
],[2,1,-1],[2,1,0],[2,1,1],[2,1,2],[2,2,-2],[2,2,-1],[2,2,0]
,[2,2,1],[2,2,2]]

(%i8) vf3d(x,y,z):=vector;
(%o8) vf3d(x,y,z):=vector

(%i9) vf3d(x,y,z):=vector([x,y,z],[x^2,y^2,z^2]/10);
(%o9) vf3d(x,y,z):=vector([x,y,z],[x^2,y^2,z^2]/10)

 -->  apply(wxdraw3d,append([head_length=0.1,color=red],vect));
```