```
> restart:with(linalg):with(plots):
```

```
Warning, the protected names norm and trace have been redefined and
unprotected

Warning, the name changecoords has been redefined
```

```
> rm:=matrix(4,4,[c0^2+c1^2+c2^2+c3^2,0,0,0,0,c0^2+c1^2-c2^2-c3^2,2*(c1
> *c2-c0*c3),2*(c1*c3+c0*c2),0,2*(c2*c1+c0*c3),c0^2-c1^2+c2^2-c3^3,2*(c2
> *c3-c0*c1),0,2*(c3*c1-c0*c2),2*(c3*c2+c0*c1),c0^2-c1^2-c2^2+c3^2]);
```

$$rm := \begin{bmatrix} c0^2 + c1^2 + c2^2 + c3^2 ,\, 0 ,\, 0 ,\, 0 \\ 0 ,\, c0^2 + c1^2 - c2^2 - c3^2 ,\, 2\, c1\, c2 - 2\, c0\, c3 ,\, 2\, c1\, c3 + 2\, c0\, c2 \\ 0 ,\, 2\, c1\, c2 + 2\, c0\, c3 ,\, c0^2 - c1^2 + c2^2 - c3^3 ,\, 2\, c2\, c3 - 2\, c0\, c1 \\ 0 ,\, 2\, c1\, c3 - 2\, c0\, c2 ,\, 2\, c2\, c3 + 2\, c0\, c1 ,\, c0^2 - c1^2 - c2^2 + c3^2 \end{bmatrix}$$

```
> c0:=cp2:c1:=ca*sp2:c2:=cb*sp2:c3:=cg*sp2:q:=<cos(phi/2),cos(alpha)*si
> n(phi/2),cos(beta)*sin(phi/2),cos(gamma)*sin(phi/2)>;
```

$$q := \begin{bmatrix} \cos(\frac{\phi}{2}) \\ \cos(\alpha)\sin(\frac{\phi}{2}) \\ \cos(\beta)\sin(\frac{\phi}{2}) \\ \cos(\gamma)\sin(\frac{\phi}{2}) \end{bmatrix}$$

```
> ca:=0:cb:=0:cg:=1:cp2:=sqrt((1+1/sqrt(2))/2):sp2:=sqrt((1-1/sqrt(2))/
> 2):
> Rm:=matrix(4,4,[c0^2+c1^2+c2^2+c3^2,0,0,0,0,c0^2+c1^2-c2^2-c3^2,-sqrt
> (2)/2,2*(c1*c3+c0*c2),0,sqrt(2)/2,c0^2-c1^2+c2^2-c3^2,2*(c2*c3-c0*c1),
> 0,2*(c3*c1-c0*c2),2*(c3*c2+c0*c1),c0^2-c1^2-c2^2+c3^2]);
```

$$Rm := \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & 0 \\ 0 & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

```
> ca:=-1:cb:=0:cg:=0:cp2:=sqrt((1+1/sqrt(3))/2):sp2:=sqrt((1-1/sqrt(3))
> /2):
> Rn:=matrix(4,4,[c0^2+c1^2+c2^2+c3^2,0,0,0,0,c0^2+c1^2-c2^2-c3^2,2*(c1
> *c2-c0*c3),2*(c1*c3+c0*c2),0,2*(c2*c1+c0*c3),c0^2-c1^2+c2^2-c3^3,sqrt(
> 6)/3,0,2*(c3*c1-c0*c2),-sqrt(6)/3,c0^2-c1^2-c2^2+c3^2]);
```

$$Rn := \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \frac{\sqrt{3}}{3} & \frac{\sqrt{6}}{3} \\ 0 & 0 & -\frac{\sqrt{6}}{3} & \frac{\sqrt{3}}{3} \end{bmatrix}$$

```
> Dr:=multiply(Rn,Rm);multiply(Dr,transpose(Dr));det(Dr);
```

$$Dr := \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \frac{\sqrt{2}}{2} & -\frac{\sqrt{2}}{2} & 0 \\ 0 & \frac{\sqrt{3}\,\sqrt{2}}{6} & \frac{\sqrt{3}\,\sqrt{2}}{6} & \frac{\sqrt{6}}{3} \\ 0 & -\frac{\sqrt{6}\,\sqrt{2}}{6} & -\frac{\sqrt{6}\,\sqrt{2}}{6} & \frac{\sqrt{3}}{3} \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$1$$

```
> A:=<1,-1,-1,-1>:B:=<1,1,-1,-1>:C:=<1,1,-1,1>:DD:=<1,-1,-1,1>:E:=<1,-1
> ,1,-1>:F:=<1,1,1,-1>:G:=<1,1,1,1>:H:=<1,-1,1,1>:
> AI:=evalf(multiply(Rn,Rm,A));BI:=evalf(multiply(Rn,Rm,B));CI:=evalf(m
> ultiply(Rn,Rm,C));DI:=evalf(multiply(Rn,Rm,DD));EI:=evalf(multiply(Rn,
> Rm,E));FI:=evalf(multiply(Rn,Rm,F));GI:=evalf(multiply(Rn,Rm,G));HI:=e
> valf(multiply(Rn,Rm,H));
```

$$AI := [1., 0., -1.632993162, 0.5773502687]$$

$$BI := [1., 1.414213562, -0.8164965809, -0.5773502693]$$

$$CI := [1., 1.414213562, 0.8164965809, 0.5773502693]$$

$$DI := [1., 0., 0., 1.732050807]$$

$$EI := [1., -1.414213562, -0.8164965809, -0.5773502693]$$

$$FI := [1., 0., 0., -1.732050807]$$

$$GI := [1., 0., 1.632993162, -0.5773502687]$$

$$HI := [1., -1.414213562, 0.8164965809, 0.5773502693]$$

```
> pp1:=pointplot({[AI[2],AI[3]],[BI[2],BI[3]]
> },connect=true,scaling=constrained):
> pp2:=pointplot({[BI[2],BI[3]],[CI[2],CI[3]]
> },connect=true,scaling=constrained):
> pp3:=pointplot({[CI[2],CI[3]],[DI[2],DI[3]]
> },connect=true,scaling=constrained):
> pp4:=pointplot({[DI[2],DI[3]],[AI[2],AI[3]]
> },connect=true,scaling=constrained):
> pp5:=pointplot({[AI[2],AI[3]],[EI[2],EI[3]]
> },connect=true,scaling=constrained):
> pp6:=pointplot({[EI[2],EI[3]],[FI[2],FI[3]]
> },connect=true,scaling=constrained):
> pp7:=pointplot({[FI[2],FI[3]],[GI[2],GI[3]]
> },connect=true,scaling=constrained):
```

```
> pp8:=pointplot({[GI[2],GI[3]],[HI[2],HI[3]]
> },connect=true,scaling=constrained):
> pp9:=pointplot({[HI[2],HI[3]],[EI[2],EI[3]]
> },connect=true,scaling=constrained):
> ppA:=pointplot({[BI[2],BI[3]],[FI[2],FI[3]]
> },connect=true,scaling=constrained):
> ppB:=pointplot({[CI[2],CI[3]],[GI[2],GI[3]]
> },connect=true,scaling=constrained):
> ppC:=pointplot({[DI[2],DI[3]],[HI[2],HI[3]]
> },connect=true,scaling=constrained):
> display(pp1,pp2,pp3,pp4,pp5,pp6,pp7,pp8,pp9,ppA,ppB,ppC);
```

Isometric projection of the corners A,B,C,DD,E,F,G,H of an axis-aligned unit cube centred on the origin is accomplished by a right rotation of 45deg. in the positive sense about the z-axis followed by a right hand rotation through an angle, whose cosine is 1/sqrt(3), about the negative x-axis. In both cases the Cartesian axes are fixed. The product of these two rotation matrices Rn and Rm is Dr. Dr represents a proper rotation since its transpose is its inverse and its determinant has a value of unity. The geometric nature of Dr is not evidents, i.e., where's the single rotation axis and what's the angle? (MECH289)IPCUC72b.mws