Obroty - FCC

st = Degree

°

Obroty - fcc

Clear[rotations]

rotations = {};

AppendTo[rotations, IdentityMatrix[3]]

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}}

i = 0;

Wokół x o 90, 180 i 270 (3):

```
AppendTo[rotations,
 {
  {1, 0, 0},
  {0, Cos[90 st], -Sin[90 st]},
  {0, Sin[90 st], Cos[90 st]}
 }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}}

```
AppendTo[rotations,
 {
  {1, 0, 0},
  {0, Cos[180 st], -Sin[180 st]},
  {0, Sin[180 st], Cos[180 st]}
 }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}}

```
AppendTo[rotations,
 {
  {1, 0, 0},
  {0, Cos[270 st], -Sin[270 st]},
  {0, Sin[270 st], Cos[270 st]}
 }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}}

i += 3;

Wokół y o 90, 180 i 270 (3):

```
AppendTo[rotations,
 {
  {Cos[90 st], 0, Sin[90 st]},
  {0, 1, 0},
  {-Sin[90 st], 0, Cos[90 st]}
 }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}}

```
AppendTo[rotations,
 {
  {Cos[180 st], 0, Sin[180 st]},
  {0, 1, 0},
  {-Sin[180 st], 0, Cos[180 st]}
 }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}}

```
AppendTo[rotations,
 {
  {Cos[270 st], 0, Sin[270 st]},
  {0, 1, 0},
  {-Sin[270 st], 0, Cos[270 st]}
 }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}}

```
i += 3;
```

Wokół z o 90, 180 i 270 (3):

```
AppendTo[rotations,
 {
  {Cos[90 st], -Sin[90 st], 0},
  {Sin[90 st], Cos[90 st], 0},
  {0, 0, 1}
 }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}}

```
AppendTo[rotations,
  {
    {Cos[180 st], -Sin[180 st], 0},
    {Sin[180 st], Cos[180 st], 0},
    {0, 0, 1}
  }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}}

```
AppendTo[rotations,
  {
    {Cos[270 st], -Sin[270 st], 0},
    {Sin[270 st], Cos[270 st], 0},
    {0, 0, 1}
  }]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}}

```
i += 3;
```

Wokół [110] o 180 (1):

```
rot[u_, th_] := IdentityMatrix[3] * Cos[th] +
  Sin[th] * {{0, -u[[3]], u[[2]]}, {u[[3]], 0, -u[[1]]}, {-u[[2]], u[[1]], 0}} +
  (1 - Cos[th]) * Table[u[[i]] u[[j]], {i, 1, 3}, {j, 1, 3}]
```

```
rot[{1, 1, 0}, 180 st]
```

{{1, 2, 0}, {2, 1, 0}, {0, 0, -1}}

```
AppendTo[rotations, rot[Normalize[{1, 1, 0}], 180 st]]
```

{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}},
 {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}, {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}}

```
i += 1;
```

Wokół [-110] o 180 (1):

```
AppendTo[rotations, rot[Normalize[{-1, 1, 0}], 180 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}},
 {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}, {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}}}
```

```
i += 1;
```

Wokół [101] o 180 (1):

```
AppendTo[rotations, rot[Normalize[{1, 0, 1}], 180 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}},
 {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}, {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}},
 {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}}, {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}}}
```

```
i += 1;
```

Wokół [011] o 180 (1):

```
AppendTo[rotations, rot[Normalize[{0, 1, 1}], 180 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}},
 {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}, {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}},
 {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}}, {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}}}
```

```
i += 1;
```

Wokół [-101] o 180 (1):

```
AppendTo[rotations, rot[Normalize[{-1, 0, 1}], 180 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}},
 {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}, {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}},
 {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}}, {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}},
 {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}}, {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}}}
```

```
i += 1;
```

Wokół [0-11] o 180 (1):

```
AppendTo[rotations, rot[Normalize[{0, -1, 1}], 180 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}},
 {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}, {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}},
 {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}}, {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}},
 {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}}}
```

```
i += 1;
```

Wokół [111] o 120 i 240 (2):

```
AppendTo[rotations, rot[Normalize[{1, 1, 1}], 120 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}},
 {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}, {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}},
 {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}}, {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}},
 {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}}, {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}}, {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}}}
```

```
AppendTo[rotations, rot[Normalize[{1, 1, 1}], 240 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}},
 {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}, {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}},
 {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}}, {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}},
 {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}},
 {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}}, {{0, 1, 0}, {0, 0, 1}, {1, 0, 0}}}
```

```
i += 2;
```

Wokół [-111] o 120 i 240 (2):

```
AppendTo[rotations, rot[Normalize[{-1, 1, 1}], 120 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}},
 {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}, {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}},
 {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}}, {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}},
 {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}}, {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}}, {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}},
 {{0, 1, 0}, {0, 0, 1}, {1, 0, 0}}, {{0, -1, 0}, {0, 0, 1}, {-1, 0, 0}}}
```

```
AppendTo[rotations, rot[Normalize[{-1, 1, 1}], 240 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}},
 {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}, {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}},
 {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}}, {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}},
 {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}},
 {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}}, {{0, 1, 0}, {0, 0, 1}, {1, 0, 0}},
 {{0, -1, 0}, {0, 0, 1}, {-1, 0, 0}}, {{0, 0, -1}, {-1, 0, 0}, {0, 1, 0}}}
```

```
i += 2;
```

Wokół [-1-11] o 120 i 240 (2):

```
AppendTo[rotations, rot[Normalize[{-1, -1, 1}], 120 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}},
 {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}, {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}},
 {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}}, {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}},
 {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}}, {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}}, {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}},
 {{0, 1, 0}, {0, 0, 1}, {1, 0, 0}}, {{0, -1, 0}, {0, 0, 1}, {-1, 0, 0}},
 {{0, 0, -1}, {-1, 0, 0}, {0, 1, 0}}, {{0, 0, -1}, {1, 0, 0}, {0, -1, 0}}}
```

```
AppendTo[rotations, rot[Normalize[{-1, -1, 1}], 240 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}},
 {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}, {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}},
 {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}}, {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}},
 {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}},
 {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}}, {{0, 1, 0}, {0, 0, 1}, {1, 0, 0}},
 {{0, -1, 0}, {0, 0, 1}, {-1, 0, 0}}, {{0, 0, -1}, {-1, 0, 0}, {0, 1, 0}},
 {{0, 0, -1}, {1, 0, 0}, {0, -1, 0}}, {{0, 1, 0}, {0, 0, -1}, {-1, 0, 0}}}
```

```
i += 2;
```

Wokół [1-11] o 120 i 240 (2):

```
AppendTo[rotations, rot[Normalize[{1, -1, 1}], 120 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}},
 {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}}, {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}},
 {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}}, {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}}, {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}},
 {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}}, {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}},
 {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}}, {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}},
 {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}}, {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}},
 {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}}, {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}},
 {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}}, {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}},
 {{0, 1, 0}, {0, 0, 1}, {1, 0, 0}}, {{0, -1, 0}, {0, 0, 1}, {-1, 0, 0}},
 {{0, 0, -1}, {-1, 0, 0}, {0, 1, 0}}, {{0, 0, -1}, {1, 0, 0}, {0, -1, 0}},
 {{0, 1, 0}, {0, 0, -1}, {-1, 0, 0}}, {{0, -1, 0}, {0, 0, -1}, {1, 0, 0}}}
```

```
AppendTo[rotations, rot[Normalize[{1, -1, 1}], 240 st] ]
```

```
{{{1, 0, 0}, {0, 1, 0}, {0, 0, 1}}, {{1, 0, 0}, {0, 0, -1}, {0, 1, 0}},
 {{1, 0, 0}, {0, -1, 0}, {0, 0, -1}}, {{1, 0, 0}, {0, 0, 1}, {0, -1, 0}},
 {{0, 0, 1}, {0, 1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 1, 0}, {0, 0, -1}},
 {{0, 0, -1}, {0, 1, 0}, {1, 0, 0}}, {{0, -1, 0}, {1, 0, 0}, {0, 0, 1}},
 {{-1, 0, 0}, {0, -1, 0}, {0, 0, 1}}, {{0, 1, 0}, {-1, 0, 0}, {0, 0, 1}},
 {{0, 1, 0}, {1, 0, 0}, {0, 0, -1}}, {{0, -1, 0}, {-1, 0, 0}, {0, 0, -1}},
 {{0, 0, 1}, {0, -1, 0}, {1, 0, 0}}, {{-1, 0, 0}, {0, 0, 1}, {0, 1, 0}},
 {{0, 0, -1}, {0, -1, 0}, {-1, 0, 0}}, {{-1, 0, 0}, {0, 0, -1}, {0, -1, 0}},
 {{0, 0, 1}, {1, 0, 0}, {0, 1, 0}}, {{0, 1, 0}, {0, 0, 1}, {1, 0, 0}},
 {{0, -1, 0}, {0, 0, 1}, {-1, 0, 0}}, {{0, 0, -1}, {-1, 0, 0}, {0, 1, 0}},
 {{0, 0, -1}, {1, 0, 0}, {0, -1, 0}}, {{0, 1, 0}, {0, 0, -1}, {-1, 0, 0}},
 {{0, -1, 0}, {0, 0, -1}, {1, 0, 0}}, {{0, 0, 1}, {-1, 0, 0}, {0, -1, 0}}}
```

```
Dimensions[rotations]
```

```
{24, 3, 3}
```