Mohr's Circle

Input stress tensor (generalized plane stress)

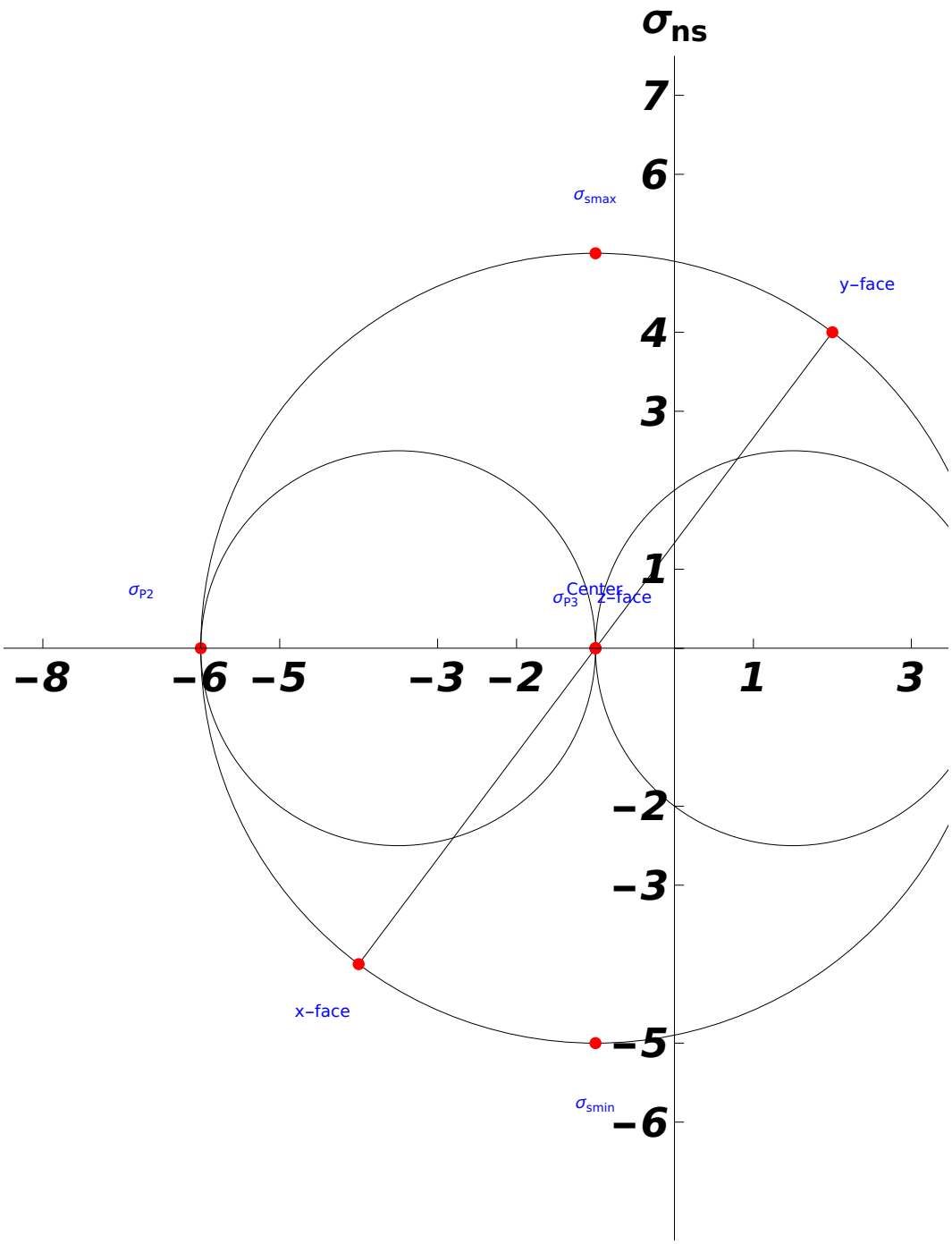
```
ClearAll["Global`*"]
sigma = {{7, 4, 0}, {4, 2, 0}, {0, 0, -1}};
sigma = {{-4, 4, 0}, {4, 2, 0}, {0, 0, -1}};
(*sigma={{4,5,0},{5,-3,0},{0,0,8}};
sigma={{-40,0,0},{0,-10,30},{0,30,-20}};
sigma={{-40,0,30},{0,-10,0},{30,0,-20}};
sigma=N[{{-40,0,30},{0,-10,0},{30,0,-20}}];
sigma={{4,5,0},{5,-3,0},{0,0,8}};
sigma=N[{{-40,0,30},{0,-10,0},{30,0,-20}}];
sigma=N[{{-4,0,6},{0,12,0},{6,0,8}}];
(*sigma=N[{{4,5,0},{5,-2,0},{0,0,8}}];*)
(*sigma=N[{{9,6,0},{6,-7,0},{0,0,-13}}];*)*)

If[sigma[[1, 2]] ≠ 0, plane = "xy"];
If[sigma[[1, 3]] ≠ 0, plane = "xz"];
If[sigma[[2, 3]] ≠ 0, plane = "yz"];

If[plane == "xy", {givenpoints = {{sigma[[1, 1]], -sigma[[1, 2]]},
      {sigma[[2, 2]], sigma[[1, 2]]}, {sigma[[3, 3]], 0}}, center = (sigma[[1, 1]] + sigma[[2, 2]]) / 2,
    radius = Sqrt[((sigma[[1, 1]] - sigma[[2, 2]]) / 2)^2 + sigma[[1, 2]]^2]}];
If[plane == "xz", {givenpoints = {{sigma[[1, 1]], sigma[[1, 3]]}, {sigma[[2, 2]], 0},
      {sigma[[3, 3]], -sigma[[1, 3]]}}, center = (sigma[[1, 1]] + sigma[[3, 3]]) / 2,
    radius = Sqrt[((sigma[[1, 1]] - sigma[[3, 3]]) / 2)^2 + sigma[[1, 3]]^2]}];
If[plane == "yz", {givenpoints = {{sigma[[1, 1]], 0}, {sigma[[2, 2]], -sigma[[2, 3]]},
      {sigma[[3, 3]], sigma[[2, 3]]}}, center = (sigma[[2, 2]] + sigma[[3, 3]]) / 2,
    radius = Sqrt[((sigma[[2, 2]] - sigma[[3, 3]]) / 2)^2 + sigma[[2, 3]]^2]}];

If[plane == "xy",
  {sigmaP1 = center + radius,
   sigmaP2 = center - radius,
   sigmaP3 = sigma[[3, 3]]}];
If[plane == "xz",
  {sigmaP1 = center + radius,
   sigmaP2 = sigma[[2, 2]],
   sigmaP3 = center - radius}];
If[plane == "yz",
  {sigmaP1 = sigma[[1, 1]],
   sigmaP2 = center + radius,
   sigmaP3 = center - radius}];
```

```
displaycenter = {(Min[sigmaP1 , sigmaP2 , sigmaP3] + Max[sigmaP1 , sigmaP2 , sigmaP3])/2, 0};
displaydim =
  1.5 * .5 * {Max[sigmaP1 , sigmaP2 , sigmaP3] - Min[sigmaP1 , sigmaP2 , sigmaP3], 2 * radius};
displayrange = {{displaycenter [[1]] - displaydim [[1]], displaycenter [[1]] + displaydim [[1]]},
   {displaycenter [[2]] - displaydim [[2]], displaycenter [[2]] + displaydim [[2]]}};
displayelement = .1 * ((displaydim [[1]] + displaydim [[2]])/2);

numticks = 10;
tickspacingx = Abs[ displayrange [[1, 2]] - displayrange [[1, 1]] ]/numticks ;
tickspacingy = Abs[ displayrange [[2, 2]] - displayrange [[2, 1]] ]/numticks ;

If[plane == "xy",
  circledata = {{center , 0, radius}, {(sigmaP2 + sigmaP3)/2, 0, Abs[sigmaP2 - sigmaP3]/2},
    {(sigmaP1 + sigmaP3)/2, 0, Abs[sigmaP1 - sigmaP3]/2}}];
If[plane == "xz",
  circledata = {{center , 0, radius}, {(sigmaP1 + sigmaP2)/2, 0, Abs[sigmaP1 - sigmaP2]/2},
    {(sigmaP2 + sigmaP3)/2, 0, Abs[sigmaP2 - sigmaP3]/2}}];
If[plane == "yz",
  circledata = {{center , 0, radius}, {(sigmaP1 + sigmaP2)/2, 0, Abs[sigmaP1 - sigmaP2]/2},
    {(sigmaP1 + sigmaP3)/2, 0, Abs[sigmaP1 - sigmaP3]/2}}];

largestcircle = 1;
rowmax = Dimensions[circledata , 1];
For[row = 1, row ≤ rowmax[[1]], row++,
 {
  If[circledata [[row, 3]] > circledata [[largestcircle , 3]], largestcircle = row]
 }
]

circle1 := Graphics[{Circle[{circledata [[1, 1]], circledata [[1, 2]]}, circledata [[1, 3]]],
    Circle[{circledata [[2, 1]], circledata [[2, 2]]}, circledata [[2, 3]]],
    Circle[{circledata [[3, 1]], circledata [[3, 2]]}, circledata [[3, 3]]]},
   Axes → True ,
   AxesLabel → {Subscript[σ, nn], Subscript[σ, ns]},
   LabelStyle → Directive[Large , Bold],
   Ticks → { Floor[ Table[tickspacingx * Floor[.5 * n] * (-1)^Floor[1.5 * n],
       {n, 0, Ceiling[(2 * Max[Abs[ displayrange [[1]] ]] + 1)/tickspacingx ]}] ],
     Floor[ Table[tickspacingy * Floor[.5 * n] * (-1)^Floor[1.5 * n],
       {n, 0, Ceiling[(2 * Max[Abs[ displayrange [[2]] ]] + 1)/tickspacingy ]}] ]},
   TicksStyle → Directive[Small , Italic],
   PlotRange → displayrange ,
   AspectRatio → 1];
```

```
If[plane == "xy",
  line1 := Graphics[Line[{givenpoints[[1]], givenpoints[[2]]}]];
If[plane == "xz",
  line1 := Graphics[Line[{givenpoints[[1]], givenpoints[[3]]}]];
If[plane == "yz",
  line1 := Graphics[Line[{givenpoints[[2]], givenpoints[[3]]}]];

pointsdata = {givenpoints[[1]], givenpoints[[2]],
   givenpoints[[3]], {center, 0}, {sigmaP1, 0}, {sigmaP2, 0}, {sigmaP3, 0},
   {circledata[[largestcircle, 1]], circledata[[largestcircle, 3]]},
   {circledata[[largestcircle, 1]], -circledata[[largestcircle, 3]]}};

points1 := Graphics[
   {PointSize[Large], Red, Point[pointsdata]}
  ];

r1 = N[pointsdata - ConstantArray[displaycenter, Dimensions[pointsdata, 1]]];
dim = Dimensions[r1, 1];
r1norm = N[Table[{Norm[r1[[i]]], Norm[r1[[i]]]}, {i, dim[[1]]}]];

r2 = ConstantArray[{0, 0}, dim[[1]]];
For[row = 1, row ≤ dim[[1]], row++,
 If[r1norm[[row, 1]] ≠ 0, r2[[row]] = displayelement * r1[[row]] / r1norm[[row]]]
]

annotationdata = ConstantArray[displaycenter, Dimensions[pointsdata, 1]] + r1 + r2;

dim = Dimensions[annotationdata, 1];
For[row = 1, row ≤ dim[[1]], row++, {
   If[Abs[annotationdata[[row, 1]]] < displayelement,
    {annotationdata[[row, 1]] =
       displayelement * (2 * Ceiling[(Sign[annotationdata[[row, 1]]] + 1) / 2] - 1),
      r2[[row]] = annotationdata[[row]] - pointsdata[[row]]}
   ],
   If[Abs[annotationdata[[row, 2]]] < displayelement,
    {annotationdata[[row, 2]] =
       displayelement * (2 * Ceiling[(Sign[annotationdata[[row, 2]]] + 1) / 2] - 1),
      r2[[row]] = annotationdata[[row]] - pointsdata[[row]]}
   ]
  }];

duplicates = {};
```

```
temparray = annotationdata ;
dim = Dimensions[temparray , 1];
For[row1 = 1, row1 ≤ dim[[1]] - 1, row1 ++,
 {temp = {row1},
  For[row2 = row1 + 1, row2 ≤ dim[[1]], row2 ++,
   If[EuclideanDistance [ temparray [[row2]], temparray [[row1]] ] ≤ displayelement &&
     temparray [[row2]] ≠ {},
    {temp = Append[temp , row2], temparray [[row2]] = {}}
   ]
  ],
  If[ Length[temp] > 1, duplicates = Append[duplicates , temp] ]}
]

rmatrix[theta_] = {{Cos[theta], Sin[theta]}, {- Sin[theta], Cos[theta]}};
dim = Dimensions[duplicates , 1];
For[row = 1, row ≤ dim[[1]], row ++,
 {numcollisions = Length[ duplicates [[row]] ],
  If[ numcollisions > 1,
   {spread =
     (Pi / 6) * (Range[0, numcollisions - 1] - N[ Median[ Range[ 0, numcollisions - 1 ] ] ]),
    For[col = 1, col ≤ Length[ duplicates [[row]] ], col ++,
     r2[[ duplicates [[row, col]] ]] = r2[[ duplicates [[row, col]] ]].rmatrix[ spread[[col]] ]
    ]}
  ]}
]

annotationdata = ConstantArray [displaycenter , Dimensions [pointsdata , 1]] + r1 + r2;

annotation1 := Graphics[Text[Style["x-face", Larger , Blue], annotationdata [[1]] ]];
annotation2 := Graphics[Text[Style["y-face", Larger , Blue], annotationdata [[2]] ]];
annotation3 := Graphics[Text[Style["z-face", Larger , Blue], annotationdata [[3]] ]];
annotation4 := Graphics[Text[Style["Center ", Larger , Blue], annotationdata [[4]] ]];
annotation5 :=
  Graphics[Text[Style[Subscript[σ, P1], Larger , Blue], annotationdata [[5]] ]];
annotation6 := Graphics[Text[Style[Subscript[σ, P2], Larger , Blue],
    annotationdata [[6]] ]];
annotation7 := Graphics[Text[Style[Subscript[σ, P3], Larger , Blue],
    annotationdata [[7]] ]];
annotation8 := Graphics[Text[Style[Subscript[σ, smax], Larger , Blue],
    annotationdata [[8]] ]];
annotation9 := Graphics[Text[Style[Subscript[σ, smin], Larger , Blue],
    annotationdata [[9]] ]];
```

```
f1[x_] = .466 * x - 7;
f2[x_] = - .466 * x + 7;
region1 := Plot[{f1[x], f2[x]}, {x, displayrange [[1, 1]], displayrange [[1, 2]]}];


Show[circle1 , line1 , points1 , annotation1 , annotation2 , annotation3 ,
 annotation4 , annotation5 , annotation6 , annotation7 , annotation8 , annotation9 ]

{{{"σ = ", N[sigma] // MatrixForm }} // MatrixForm ,
 {{"x-face", pointsdata [[1]]},
    {"y-face", pointsdata [[2]]},
    {"z-face", pointsdata [[3]]},
    {"Center ", pointsdata [[4]]},
    {Subscript [σ, P1], pointsdata [[5]]},
    {Subscript [σ, P2], pointsdata [[6]]},
    {Subscript [σ, P3], pointsdata [[7]]},
    {Subscript [σ, smax], pointsdata [[8]]},
    {Subscript [σ, smin], pointsdata [[9]]}
  } // MatrixForm , N[{{"x-face", pointsdata [[1]]},
     {"y-face", pointsdata [[2]]},
     {"z-face", pointsdata [[3]]},
     {"Center ", pointsdata [[4]]},
     {Subscript [σ, P1], pointsdata [[5]]},
     {Subscript [σ, P2], pointsdata [[6]]},
     {Subscript [σ, P3], pointsdata [[7]]},
     {Subscript [σ, smax], pointsdata [[8]]},
     {Subscript [σ, smin], pointsdata [[9]]}
    }] // MatrixForm }
```


σns
7
6
σsmax
y–face
4
3
1
σP2
Center
σP3
z–face
−8
−6
−5
−3
−2
1
3
−2
−3
x–face
−5
σsmin
−6

$$\left\{\left(\sigma = \begin{pmatrix} -4. & 4. & 0. \\ 4. & 2. & 0. \\ 0. & 0. & -1. \end{pmatrix}\right), \begin{pmatrix} \text{x-face} & \{-4, -4\} \\ \text{y-face} & \{2, 4\} \\ \text{z-face} & \{-1, 0\} \\ \text{Center} & \{-1, 0\} \\ \sigma_{P1} & \{4, 0\} \\ \sigma_{P2} & \{-6, 0\} \\ \sigma_{P3} & \{-1, 0\} \\ \sigma_{smax} & \{-1, 5\} \\ \sigma_{smin} & \{-1, -5\} \end{pmatrix}, \begin{pmatrix} \text{x-face} & \{-4., -4.\} \\ \text{y-face} & \{2., 4.\} \\ \text{z-face} & \{-1., 0.\} \\ \text{Center} & \{-1., 0.\} \\ \sigma_{P1} & \{4., 0.\} \\ \sigma_{P2} & \{-6., 0.\} \\ \sigma_{P3} & \{-1., 0.\} \\ \sigma_{smax} & \{-1., 5.\} \\ \sigma_{smin} & \{-1., -5.\} \end{pmatrix}\right\}$$

$$\left\{\left(\sigma = \begin{pmatrix} 9. & 6. & 0. \\ 6. & -7. & 0. \\ 0. & 0. & -13. \end{pmatrix}\right), \begin{pmatrix} \text{x-face} & \{9., -6.\} \\ \text{y-face} & \{-7., 6.\} \\ \text{z-face} & \{-13., 0\} \\ \text{Center} & \{1., 0\} \\ \sigma_{P1} & \{11., 0\} \\ \sigma_{P2} & \{-9., 0\} \\ \sigma_{P3} & \{-13., 0\} \\ \sigma_{smax} & \{-1., 12.\} \\ \sigma_{smin} & \{-1., -12.\} \end{pmatrix}, \begin{pmatrix} \text{x-face} & \{9., -6.\} \\ \text{y-face} & \{-7., 6.\} \\ \text{z-face} & \{-13., 0.\} \\ \text{Center} & \{1., 0.\} \\ \sigma_{P1} & \{11., 0.\} \\ \sigma_{P2} & \{-9., 0.\} \\ \sigma_{P3} & \{-13., 0.\} \\ \sigma_{smax} & \{-1., 12.\} \\ \sigma_{smin} & \{-1., -12.\} \end{pmatrix}\right\}$$