

Lenses and Mirrors: PST-optic v0.9 Examples

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`pst-optic-examples.tex`

Introduction

pstricks writes pure PostScript[?] code, so it is not possible to run **T_EX** files with **pdfL_AT_EX** when there are pstricks macros in the document. If you still need a PDF output use the package **pdftricks.sty**[?] or the for Linux free available program **vlatex** (<http://www.micropress-inc.com/linux/>) or build the PDF with **ps2pdf** (**dvi**→**ps**→**pdf**).

If you need package **graphicx.sty** load it before any **pstricks** package. You do not need to load **pstricks.sty**, it will be done by **pst-optic** by default.

For more informations have a look into the documentations.

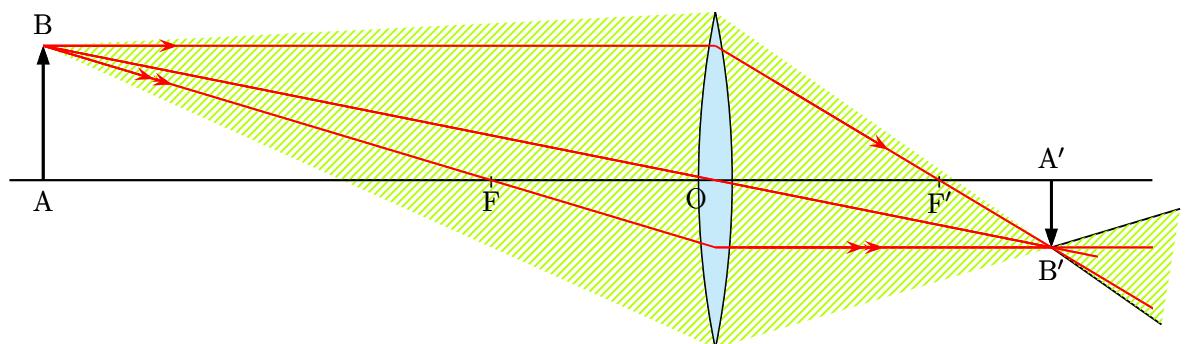
This PDF file was created with the **vlatex** program from the free available **V_Te_X/L_nx v7.530 - the V_Te_X distribution for Linux (x86)**.

Part I

Lenses

1 A simple colored System

- $\overline{AB} = 2 \text{ cm}$
- $\overline{OA} = -10 \text{ cm}$
- $\overline{OF'} = 3,333 \text{ cm}$
- $\overline{XO} = 2 \text{ cm}$



```

1 \begin{pspicture}(-8.5,-3)(8.5,3)
2 \rput(0,0){%
3     \lens[focus=3.333,%
4             OA=-10,AB=2,X0=2,% 
5             xLeft=-8.5,xRight=8.5,% 
6             rayColor=red]%
7 }
8 \pnode(!X0 2.5){L1}%extrémité supérieure de la lentille
9 \pnode(!X0 -2.5){L2}%extrémité inférieure de la lentille
10 \psOutLine[length=2](L1)(B')\{END}
11 \psBeforeLine[length=2](B')(L2)\{START}
12 \pspolygon[style=rayuresJaunes,linestyle=none](B)(L1)(END)(START)(L2)
13 \rput(0,0){%
14     \lens[% 
15             focus=3.333,% 
16             OA=-10,AB=2,% 
17             X0=2,% 

```

```

18      xLeft=-8.5,xRight=8.5,%  

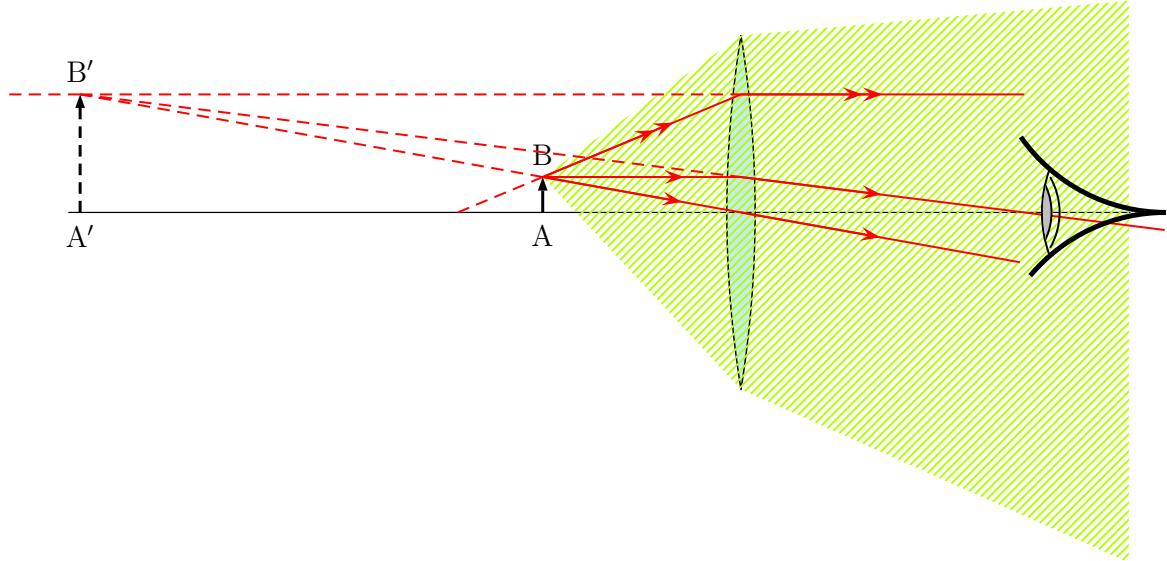
19      rayColor=red,arrowsize=0.2] %  

20  }  

21 \end{pspicture}

```

2 A Magnifier



```

1 \begin{pspicture}(-8,-5)(8,3)  

2 \rput(0,0){%  

3   \lens[%  

4     lensGlass=true,lensWidth=0.4,%  

5     focus=4,AB=0.5,OA=-2.8,X0=2,drawing=false] %  

6   \psline[linewidth=0.5pt](xLeft)(xRight)}  

7 \pnod(!X0 2.5){L1}%      extrmitsuprieure de la lentille  

8 \pnod(!X0 -2.5){L2}%      extrmitinfrieure de la lentille  

9 \psOutline[length=5.5,linestyle=none](B')(L1){END1}  

10 \psBeforeLine[length=6,linestyle=none](L2)(B'){START}  

11 \pspolygon[style=rayuresJaunes,linestyle=none](B)(L1)(END1)(START)(L2)  

12 \psline[linewidth=1.5\pslinewidth,arrowinset=0]{->}(A)(B)  

13 \uput[270](A){A}  

14 \uput[90](B){B}  

15 \psline[linewidth=1.5\pslinewidth,arrowinset=0,%  

16   linestyle=dashed]{->}(A')(B')  

17 \uput[270](A'){$\mathrm{A'}$}  

18 \uput[90](B'){$\mathrm{B'}$}  

19 \psset{linecolor=red,arrowsize=0.2}

```

`pst-optic-examples.tex`

3 TWO LENSES

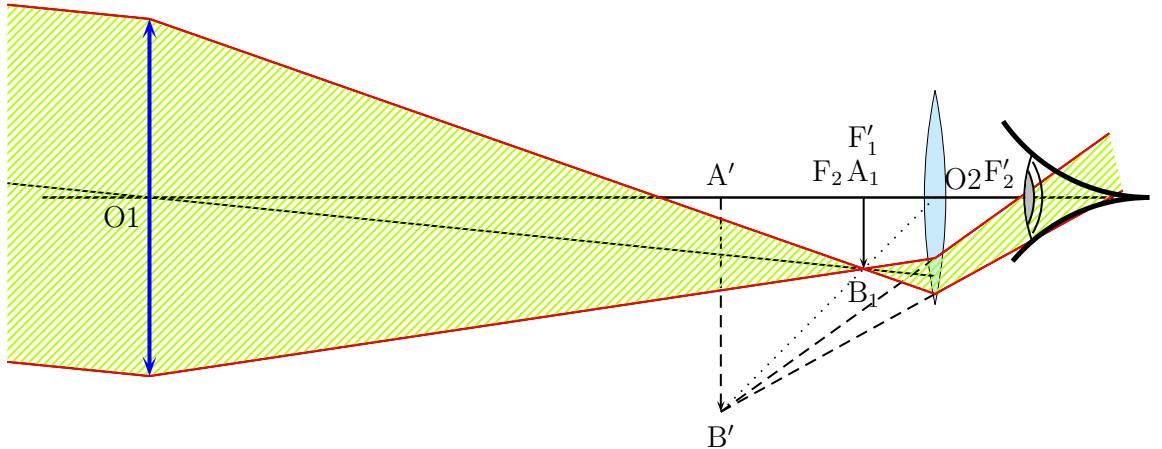
```

20 \pcline[nodesepB=-4](B)(0)% Mittelpunktstrahl
21 \psline[linecolor=red,linestyle=dashed](B)(B')% rückwärtige Verlängerung
22 \Arrows(B)(0)% Mittelpunktstrahl
23 \psOutLine[length=2,arrows=->](B)(0){END6}% Mittelpunktstrahl
24 \psline(B)(I)(F')
25 \psOutLine(I)(F'){END2}
26 \Arrows(I)(F')
27 \Arrows(B)(I)
28 \psOutLine[length=1,linestyle=dashed](I')(B'){END3}
29 \psline[linestyle=dashed](B)(F)
30 \psline(B)(I')
31 \Arrows[arrows=->>](B)(I')
32 \psline[linestyle=dashed](B')(I')
33 \psline[linestyle=dashed](B')(I)
34 \psOutLine[length=2,arrows=->>](B')(I'){END4}
35 \psOutLine[length=4](B')(I'){END5}
36 \rput(8,0){\psset{linecolor=black}\eye}
37 \end{pspicture}

```

3 Two Lenses

This is a simple system with two lenses, where the `\lens` macro is used only once. The second lens (the left one) is drawn by the `\psline` macro.



```

1 \begin{pspicture}(-8,-3)(8,3)
2 %on place l'oculaire dès le début

```

`pst-optic-examples.tex`

3 TWO LENSES

```

3      \rput(0,0){%
4          \lens[%
5              lensScale=0.6,drawing=false,%
6              focus=1.5,OA=-1,X0=5,nameF={},nameFi={},AB=-1]%
7              \psline[linewidth=1pt](xLeft)(xRight)
8          }
9 %image intermédiaire A1B1 au foyer F'1
10 \psline{->}(4,0)(4,-1)
11 %lentille 2
12 \psline[linewidth=2\pslinewidth, linecolor=blue]{<->}(5,1.5)(5,-1.5)
13 %On place les points essentiels
14 \pnode(-6,0){O1}
15 \pnode(-6,2.5){E1L1}%extrémité sup de L1
16 \pnode(-6,-2.5){E2L1}%extrémité inf de L1
17 \pnode(4,0){A1}
18 \pnode(4,-1){B1}
19 %intersection de O1 avec la lentille L2
20 \rayInterLens(O1)(B1){5}{Inter1L2}
21 %rayon venant de l'infini jusqu'à la lentille L2
22 \pcline[nodesepB=-2](Inter1L2)(O1)
23 %rayon parallèle au précédent et passant par E1L1
24 \Parallel(B1)(O1)(E1L1){B1infty}
25 %rayon parallèle au précédent et passant par E2L2
26 \Parallel(B1)(O1)(E2L1){B2infty}
27 %intersection de la droite passant par E1L1 et B1 avec la lentille L2
28 \rayInterLens(E1L1)(B1){5}{InterE1B1L2}
29 \psline(E1L1)(InterE1B1L2)
30 %intersection de la droite passant par E2L2 et B1 avec la lentille L2
31 \rayInterLens(E2L1)(B1){5}{InterE2B1L2}
32 \psline(E2L1)(InterE2B1L2)
33 \psline[linestyle=dashed]{->}(A')(B')
34 \psline[linestyle=dashed](InterE1B1L2)(B')
35 \psline[linestyle=dashed](InterE2B1L2)(B')
36 \psline[linestyle=dotted](B')(0)
37 \psOutline[length=3](B')(InterE1B1L2){END}
38 \psBeforeLine[length=3](InterE2B1L2)(B'){START}
39 \pspolygon[%
40     style=rayuresJaunes,%
41     linestyle=none]%
42     (B1infty)(E1L1)(InterE1B1L2)%
43     (END)(START)(InterE2B1L2)%
44     (E2L1)(B2infty)
45 \uput[90](A'){$\mathrm{A}'$}
46 \uput[270](B'){$\mathrm{B}'$}
47 \uput[90](A1){$\mathrm{A}_1$}
48 \uput[270](B1){$\mathrm{B}_1$}

```

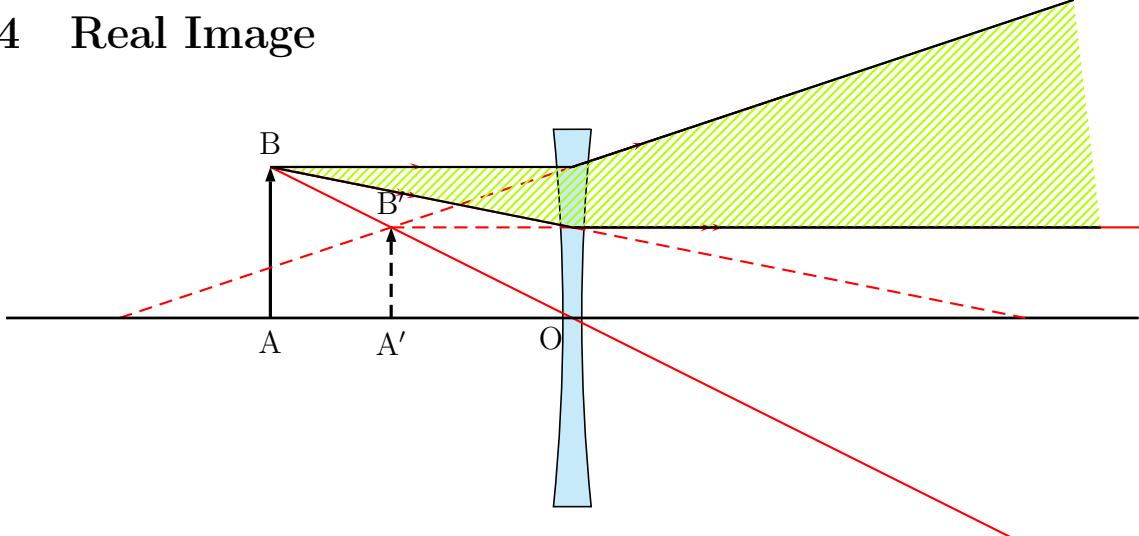
4 REAL IMAGE

```

49 \uput[225](01){01}
50 \uput[45](0){02}
51 \uput[90](F){$\mathrm{F}_2$}
52 \uput{0.4}[150](F'){$\mathrm{F}'_2$}
53 \uput{0.6}[90](A1){$\mathrm{F}'_1$}
54 \psline[linecolor=red](B1infty)(E1L1)(InterE1B1L2)(END)
55 \psline[linecolor=red](B2infty)(E2L1)(InterE2B1L2)(START)
56 \rput(8,0){\text{\texttt{\tiny eye}}}
57 %lentille 1
58 \psline[%
59     linewidth=2\pslinewidth,%
60     linecolor=blue,%
61     arrowsize=0.2,arrowinset=0.5]{<->}(-6,-2.5)(-6,2.5)
62 \end{pspicture}

```

4 Real Image



```

1 \begin{pspicture}*(-7.5,-3)(7.5,3)
2   \rput(0,0){%
3     \lens[lensGlass=true,lensWidth=0.5,lensType=DVG,%
4       X0=0,AB=2,OA=-4,focus=-6,spotAi=270,spotBi=90]%
5     \psline[linewidth=1pt](xLeft)(xRight)
6   }
7   \psline[linecolor=red,linestyle=dashed](I')(F)% Verlaengerung des Brennstrahls
8   \psOutLine[length=7](B')(I){END}
9 %pour prolonger au-delà de B' permet de définir END
10  \psBeforeLine[length=7](I')(B'){START}% permet de définir START
11  \pspolygon[style=rayuresJaunes,linestyle=none](B)(I)(END)(START)(I')
12  \psline(B)(I)(END)

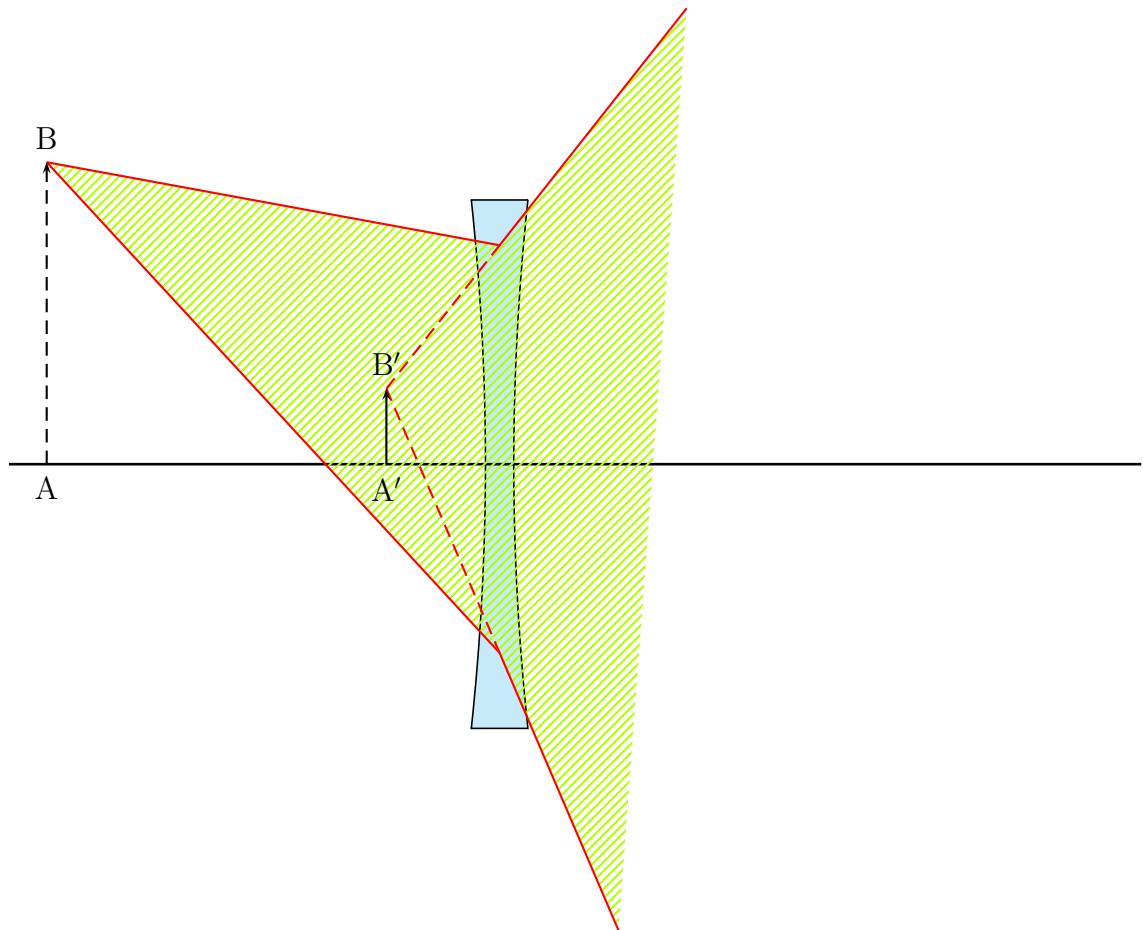
```

`pst-optic-examples.tex`

5 VIRTUAL IMAGE

```
13     \psline(B)(I')(START)
14 \end{pspicture}
```

5 Virtual Image



```
1 \begin{pspicture}*(-7.5,-6.5)(7.5,7.5)
2 \rput(0,0){%
3   \lens[lensType=DVG,lensWidth=0.75,
4       lensHeight=7, focus=-2,OA=-6,AB=4,X0=-1,lensGlass=true,%
5       rayColor=red,yBottom=-5,yTop=5,drawing=false]%
```

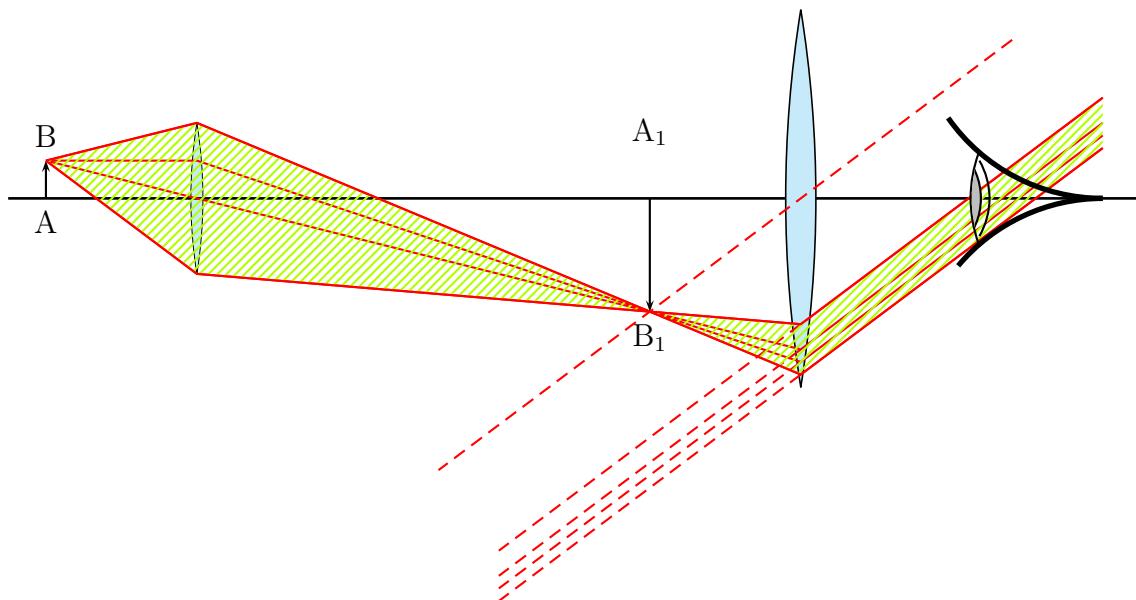
`pst-optic-examples.tex`

```

6   \psline[linewidth=1pt](xLeft)(xRight)
7   \pnode(!X0 2.9){L1}%
8   \pnode(!X0 -2.5){L2}%
9   {%
10   \psset{length=4,linestyle=none}
11   \psOutLine(B')(L1){A1}
12   \psOutLine(B')(L2){A2}
13   \pspolygon[style=rayuresJaunes,linestyle=none](B)(L1)(A1)(A2)(L2)
14   \psset{linecolor=red,linestyle=solid}
15   \psline(B)(L1)(A1)
16   \psline(B)(L2)(A2)%
17   \psline[linestyle=dashed](B')(L1)
18   \psline[linestyle=dashed](B')(L2)%
19   }
20 \psline[linestyle=dashed]{->}(A)(B)
21 \psline{->}(A')(B')
22 \uput[90](B){B}
23 \uput[90](B'){$\mathbf{B}'$}
24 \uput[270](A){A}
25 \uput[270](A'){$\mathbf{A}'$}
26 \end{pspicture*}

```

6 A Microscope



6 A MICROSCOPE

```

1 \begin{pspicture}(-7.5,-5.5)(7.5,3)
2 \rput(0,0){%
3     \lens[focus=1.5,OA=-2,AB=0.5,XO=-5,lensGlass=true,lensWidth=0.4,%
4         yBottom=-4,yTop=4,drawing=false,lensScale=0.4,%
5         nameF=F_1,nameFi=F'_1]%
6     \psline[linewidth=1pt](xLeft)(xRight)
7 }
8 \pnode(! XO 1){UPlens1}
9 \pnode(! XO -1){DOWNlens1}
10 \Transform
11 \rput(0,0){%
12     \lens[focus=2,XO=3,lensGlass=true,lensWidth=0.4,%
13         yBottom=-4,yTop=4,drawing=false,%
14         nameF=F_2,nameFi=F'_2,spotF=90,spotFi=90]%
15 }
16 \psline{->}(A1)(B1)
17 \psline{->}(A'1)(B'1)
18 \uput[270](A1){A}
19 \uput[90](B1){B}
20 \uput[270](B'1){$\mathrm{B}_1$}
21 \uput[0.7][90](A'1){$\mathrm{A}_1$}
22 {\psset{linecolor=red}
23 \rayInterLens(I11)(B'1){3}{Inter1L2}
24 \rayInterLens(B1)(01){3}{Inter2L2}
25 \rayInterLens(UPlens1)(B'1){3}{Inter3L2}
26 \rayInterLens(DOWNlens1)(B'1){3}{Inter4L2}
27 \psline(B1)(I11)(B'1)(Inter1L2)
28 \psline(B1)(Inter2L2)
29 \psline(B1)(UPlens1)(Inter3L2)
30 \psline(B1)(DOWNlens1)(Inter4L2)
31 \psset{length=5}
32 \Parallel(B'1)(0)(Inter3L2){B1inftyRigth}
33 \Parallel(B'1)(0)(Inter4L2){B2inftyRigth}
34 \Parallel(B'1)(0)(Inter2L2){B3inftyRigth}
35 \Parallel(B'1)(0)(Inter1L2){B3inftyRigth}
36 {\psset{length=-5,linestyle=dashed}
37 \Parallel(B'1)(0)(Inter3L2){B1inftyLeft}
38 \Parallel(B'1)(0)(Inter4L2){B2inftyLeft}
39 \Parallel(B'1)(0)(Inter2L2){B3inftyLeft}
40 \Parallel(B'1)(0)(Inter1L2){B3inftyLeft}
41 \pcline[nodesep=6](B'1)(0)}
42 \pspolygon[style=rayuresJaunes,linestyle=none]%
43     (B1)(UPlens1)(Inter3L2)%
44     (B1inftyRigth)(B2inftyRigth)(Inter4L2)(DOWNlens1)
45 \psline(B1)(UPlens1)(Inter3L2)(B1inftyRigth)
46 \psline(B2inftyRigth)(Inter4L2)(DOWNlens1)(B1)}

```

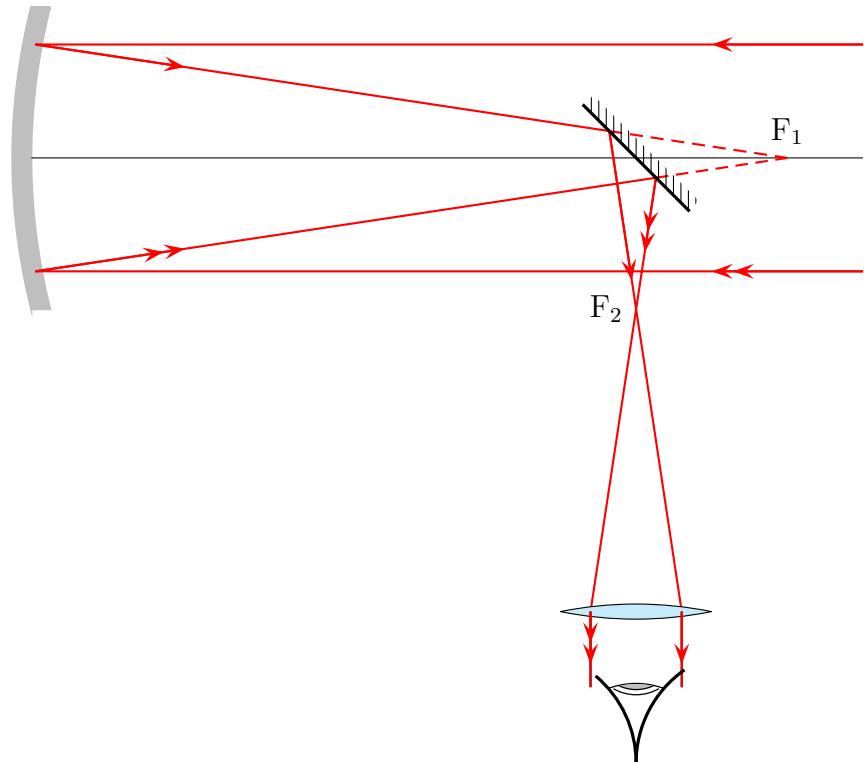
`pst-optic-examples.tex`

6 A MICROSCOPE

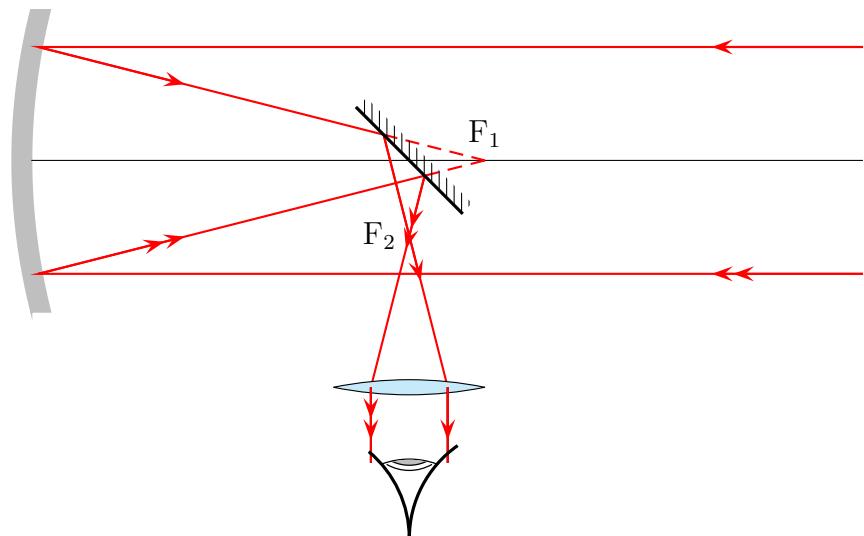
```
47 \rput(7,0){\eye}  
48 \end{pspicture}
```

`pst-optic-examples.tex`

7 Telescope



```
1 \telescope[mirrorFocus=10, posMirrorTwo=8, yBottom=-8]
```



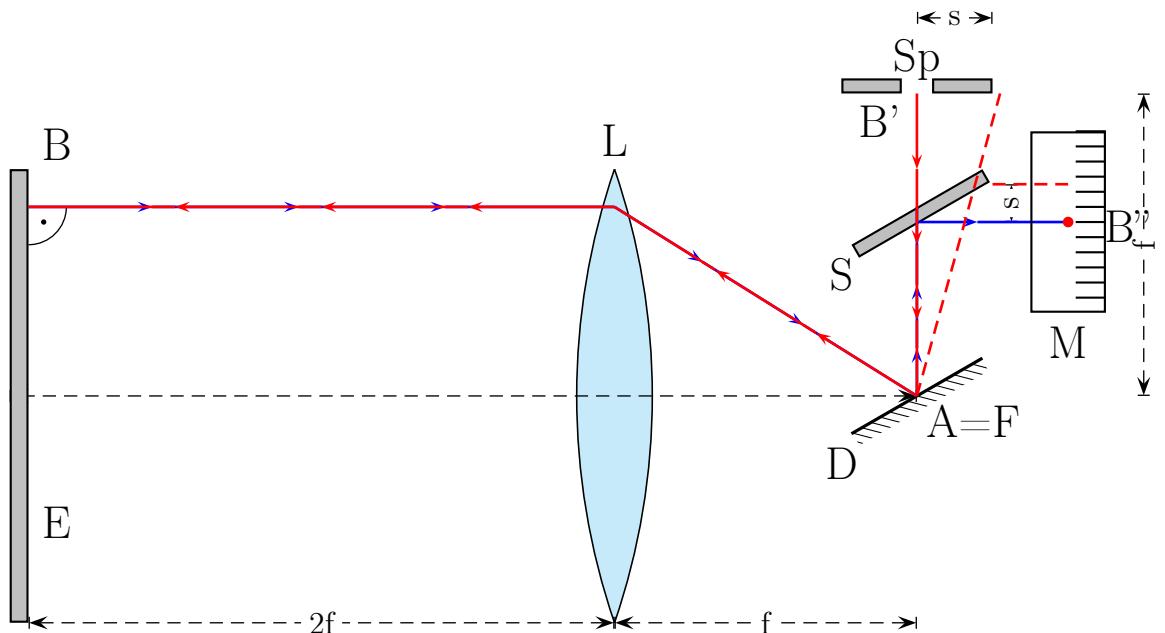
`pst-optic-examples.tex`

8 LIGHTSPEED MEASURED BY FOUCault

```
1 \telescope[mirrorFocus=6, posMirrorTwo=5, yBottom=-5]
```

8 Lightspeed measured by Foucault

1849 Foucault (1819-1868) determines with the following configuration the speed of the light.



Sp chink;
 D rotating mirror;
 L collecting lens;
 E end mirror;
 S half diaphanous mirror;
 M scale

```
1 \begin{pspicture}(-8,-5)(7,6)
2   \rput(0,0){\lens[lensWidth=1,lensGlass=true,%
3     lensHeight=6,focus=4,drawing=false,AB=2.5]}
4 {%
```

`pst-optic-examples.tex`

8 LIGHTSPEED MEASURED BY FOUCault

```
5  \psset{linewidth=0.5pt,linestyle=dashed,arrowsize=5pt,arrows=|<->|}
6  \psline(-8,0)(4,0)
7  \pcline(-7.75,-3)(0,-3)
8  \lput*{:U}{2f}
9  \pcline(0,-3)(4,-3)
10 \lput*{:U}{f}
11 \pcline(7,0)(7,4)
12 \lput*{:U}{f}
13 \pcline(4,5)(5,5)
14 \lput*{:U}{s}
15 \pcline(5.25,2.3)(5.25,2.8)
16 \lput*{:U}{s}
17 }
18 \uput[90](0,3){\Large L}
19 \uput[45](-7.7,3){\Large B}
20 \uput[45](-7.7,-2){\Large E}
21 \uput[270](3,-0.5){\Large D}
22 \uput[-45](4,0){\Large A=F}
23 \uput[270](3,2){\Large S}
24 \uput[90](4,4){\Large Sp}
25 \uput[90](3.5,3.25){\Large B'}
26 \uput[0](6.3,2.25){\Large B''}
27 \uput[-90](6,1.1){\Large M}
28 \psarc[linewidth=0.5pt](-7.75,2.5){0.5}{-90}{0}\qdisk(-7.55,2.3){1pt}
29 \rput{210}(F'){\mirrorTwo}
30 {%
31   \psset{fillstyle=solid,fillcolor=lightgray}
32   \rput{210}(4,2.5){\psframe(-1,0)(1,0.2)}
33   \psframe(-8,-3)(-7.75,3)
34   \psframe(3,4)(3.8,4.2)\psframe(4.2,4)(5,4.2)%
35 }{%
36   \psset{linewidth=1pt, linecolor=red, arrows=->,% 
37           arrowsize=5pt}
38   \arrowLine[linecolor=blue,arrowOffset=-0.2](F')(4,2.5){2}
39   \arrowLine[linecolor=blue,arrowOffset=-0.2](4,2.3)(6,2.3){1}
40   \qdisk(6,2.3){2pt}
41   \psline[linestyle=dashed,arrows=-](F')(5.1,4)
42   \psline[linestyle=dashed,arrows=-](5,2.8)(6,2.8)
43   \arrowLine(4,4)(F'){3}
44   \arrowLine[linecolor=blue,arrowOffset=-0.2](I)(F'){2}
45   \arrowLine(F')(I){2}
46   \arrowLine[linecolor=blue,arrowOffset=-0.3](-7.75,2.5)(I){3}
47   \arrowLine(I)(-7.75,2.5){3}
48 }
49 \psframe(5.5,1.1)(6.5,3.5)
50 \multido{\r=1.3+0.2}{12}{%
```

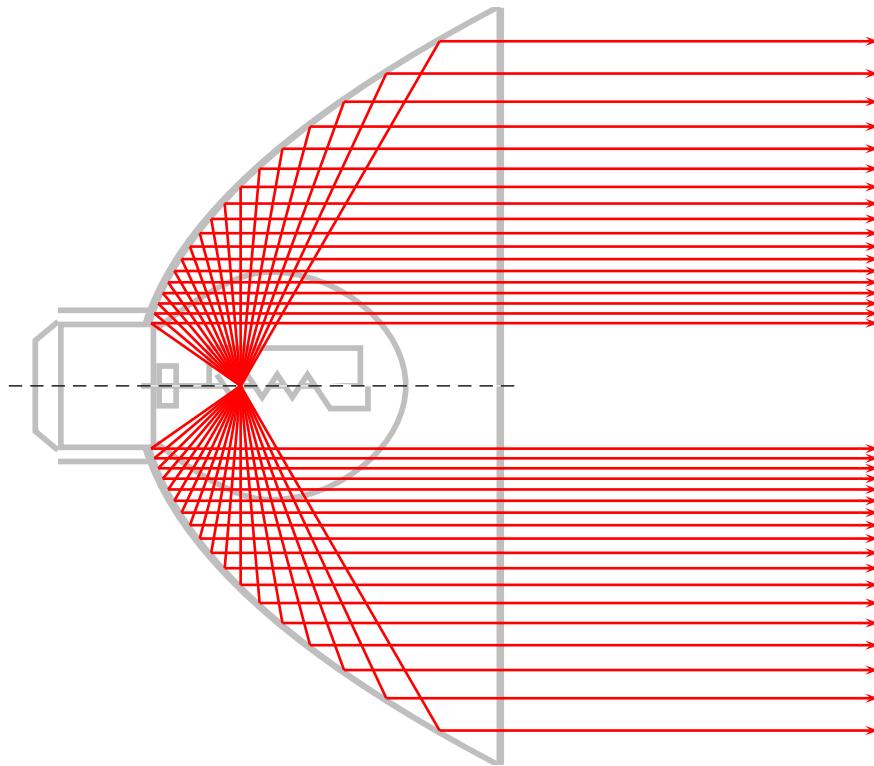
8 LIGHTSPEED MEASURED BY FOUCAULT

```
51      \psline(6.1,\r)(6.5,\r)%
52    }
53 \end{pspicture}
```

Part II

Mirrors

9 High Beam Light



```

1 \begin{pspicture}(-1.5,-5.5)(10,5.5)
2     \rput(0,0){%
3         \beamLight[drawing=false,%
4             mirrorDepth=4.75,%
5             mirrorWidth=0.1,%
6             mirrorHeight=10,%
7             linecolor=lightgray]}
8     \makeatletter
9     \pst@getcoor{Focus}\pst@tempf
10    \psset{linewidth=1pt, linecolor=red}
11    \multido{\n=60+5}{18}{%

```

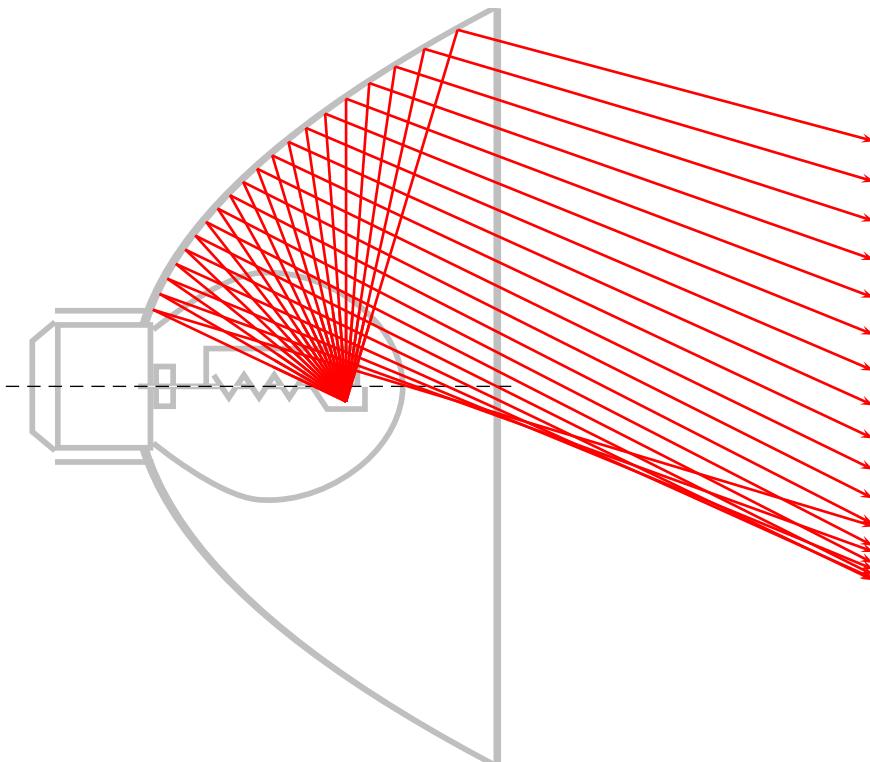
`pst-optic-examples.tex`

```

12   \mirrorCVGRay[linecolor=red,%
13     mirrorDepth=4.75,%
14     mirrorHeight=10,%
15     linewidth=1pt](Focus)(!%
16       /XF \pst@tempf pop \pst@number\psxunit div def
17         \n\space cos XF add \n\space sin neg){Endd1}
18   \psOutLine[arrows=->,length=.25](Endd1)(Endd1''){Endd2}%
19   \mirrorCVGRay[linecolor=red,%
20     mirrorDepth=4.75,%
21     mirrorHeight=10,%
22     linewidth=1pt](Focus)(!%
23       /XF \pst@tempf pop \pst@number\psxunit div def
24         \n\space cos XF add \n\space sin ){End1}
25   \psOutLine[arrows=->,length=.25](End1)(End1''){End2}%
26 }
27 \makeatletter
28 \end{pspicture}

```

10 Low Beam Light



10 LOW BEAM LIGHT

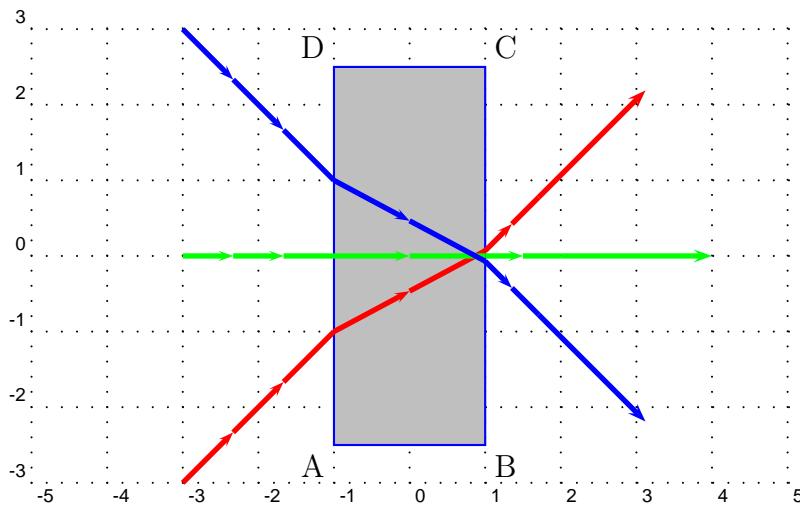
```
1 \begin{pspicture}(-1.5,-5)(10,5)
2     \rput(0,0){%
3         \beamLight[drawing=false,%
4             mirrorDepth=4.75,%
5             mirrorWidth=0.1,%
6             mirrorHeight=10,%
7             linecolor=lightgray]}
8     {%
9         \psset{linewidth=1pt, linecolor=red}
10        \multido{\n=70+5}{20}{%
11            \psline(2.75,-0.2)(! \n\space cos 2.75 add \n\space sin )
12            \mirrorCVGRay[linecolor=red,%
13                mirrorDepth=4.75,%
14                mirrorHeight=10,%
15                linewidth=1pt](2.75,-0.2)%
16                (! \n\space cos 2.75 add \n\space sin ){End1}
17            \psOutLine[arrows=->, length=.25](End1)(End1''){End2}%
18        }%
19    \end{pspicture}
```

Part III

Refraction

11 Vertical Medium

Refraction numbers are $n_1 = 1$ and $n_2 = 1.5$:



```

1 \begin{pspicture}(-5,-3)(5,3)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \pnode(-1,-2.5){A}
4     \pnode(1,-2.5){B}
5     \pnode(1,2.5){C}
6     \pnode(-1,2.5){D}
7     % \rotateFrame(A)(B)(C)(D){10}
8     \uput[-135](A){A}\uput[-45](B){B}
9     \uput[45](C){C}\uput[135](D){D}
10    \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
11    %
12    % 1.
13    %
14    \refractionRay(-3,-3)(-2,-2)(D)(A){1}{1.5}{END}
15    \psset{linecolor=red,linewidth=2pt,arrowsize=5pt,arrows=->}
16    \arrowLine(-3,-3)(END){2}
17    \ABinterCD(END')(C)(B){Out}
18    \arrowLine(END)(Out){1}
19    \refractionRay(END)(Out)(C)(B){1.5}{1}{Q}
20    \arrowLine(Q)(Q'){1}

```

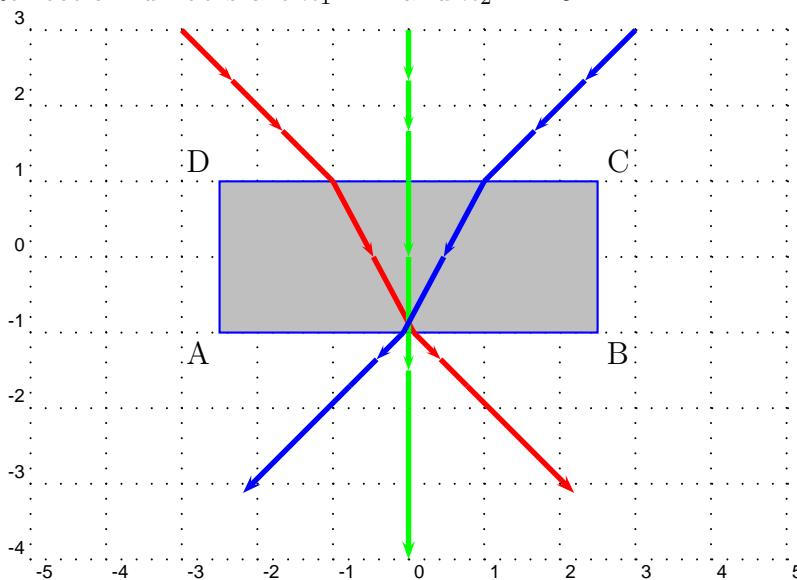
```

21 \psOutLine[length=2](Q)(Q'){End}
22 %
23 % 2.
24 \refractionRay(-3,0)(-2,0)(A)(D){1}{1.5}{END}
25 \psset{linecolor=green,linewidth=2pt,arrowsize=5pt,arrows=->}
26 \arrowLine(-3,0)(END){2}
27 \ABinterCD(END')(END')(C)(B){Out}
28 \arrowLine(END)(Out){1}
29 \refractionRay(END)(Out)(C)(B){1.5}{1}{Q}
30 \arrowLine(Q)(Q'){1}
31 \psOutLine[length=2](Q)(Q'){End}
32 %
33 % 3.
34 %
35 \refractionRay(-3,3)(-2,2)(D)(A){1}{1.5}{END}
36 \psset{linecolor=blue,linewidth=2pt,arrowsize=5pt,arrows=->}
37 \arrowLine(-3,3)(END){2}
38 \ABinterCD(END')(END')(C)(B){Out}
39 \arrowLine(END)(Out){1}
40 \refractionRay(END)(Out)(C)(B){1.5}{1}{Q}
41 \arrowLine(Q)(Q'){1}
42 \psOutLine[length=2](Q)(Q'){End}
43 \end{pspicture}

```

12 Horizontal Medium

Refraction numbers are $n_1 = 1$ and $n_2 = 1.5$:



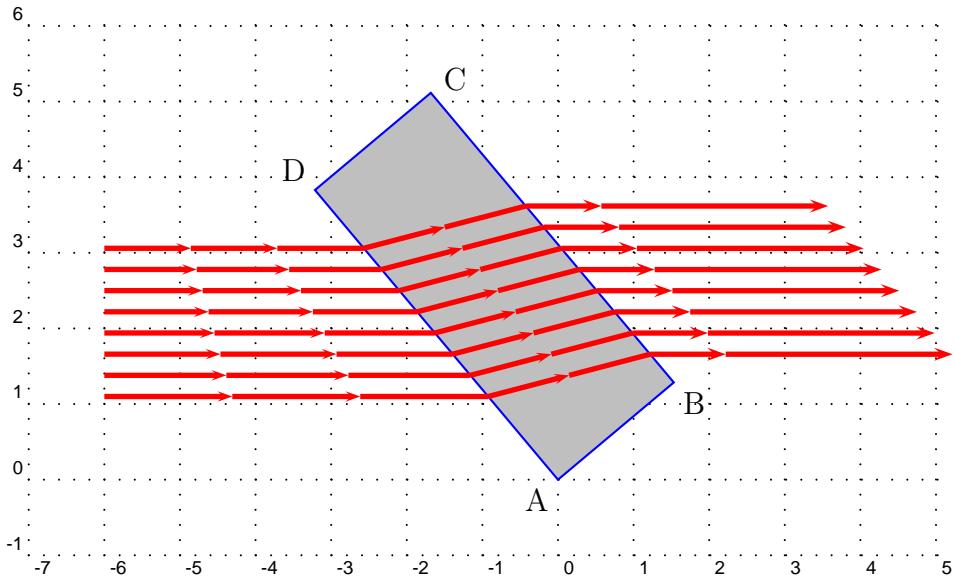
```

1 \begin{pspicture}(-5,-4)(5,3)
2   \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3   \pnode(-2.5,-1){A}
4   \pnode(2.5,-1){B}
5   \pnode(2.5,1){C}
6   \pnode(-2.5,1){D}
7   \uput[-135](A){A}\uput[-45](B){B}
8   \uput[45](C){C}\uput[135](D){D}
9   \pspolygon[fillcolor=lightgray ,fillstyle=solid, linecolor=blue](A)(B)(C)(D)
10 %
11 % 1.
12 %
13 \refractionRay(-3,3)(-2,2)(C)(D){1}{1.5}{END}
14 \psset{linecolor=red, linewidth=2pt, arrowsize=5pt, arrows=->}
15 \arrowLine(-3,3)(END){2}
16 \ABinterCD(END)(END')(B)(A){Out}
17 \arrowLine(END)(Out){1}
18 \refractionRay(END)(Out)(B)(A){1.5}{1}{Q}
19 \arrowLine(Q)(Q'){1}
20 \psOutLine[length=2](Q)(Q'){End}
21 %
22 % 2.
23 %
24 \refractionRay(0,3)(0,1)(C)(D){1}{1.5}{END}
25 \psset{linecolor=green, linewidth=2pt, arrowsize=5pt, arrows=->}
26 \arrowLine(0,3)(END){2}
27 \ABinterCD(END)(END')(A)(B){Out}
28 \arrowLine(END)(Out){1}
29 \refractionRay(END)(Out)(B)(A){1.5}{1}{Q}
30 \arrowLine(Q)(Q'){1}
31 \psOutLine[length=2](Q)(Q'){End}
32 %
33 % 3.
34 %
35 \refractionRay(3,3)(2,2)(C)(D){1}{1.5}{END}
36 \psset{linecolor=blue, linewidth=2pt, arrowsize=5pt, arrows=->}
37 \arrowLine(3,3)(END){2}
38 \ABinterCD(END)(END')(B)(A){Out}
39 \arrowLine(END)(Out){1}
40 \refractionRay(END)(Out)(B)(A){1.5}{1}{Q}
41 \arrowLine(Q)(Q'){1}
42 \psOutLine[length=2](Q)(Q'){End}
43 \end{pspicture}

```

13 Parallel Rays and a sloping medium

Refraction numbers are $n_1 = 1$ and $n_2 = 1.5$:



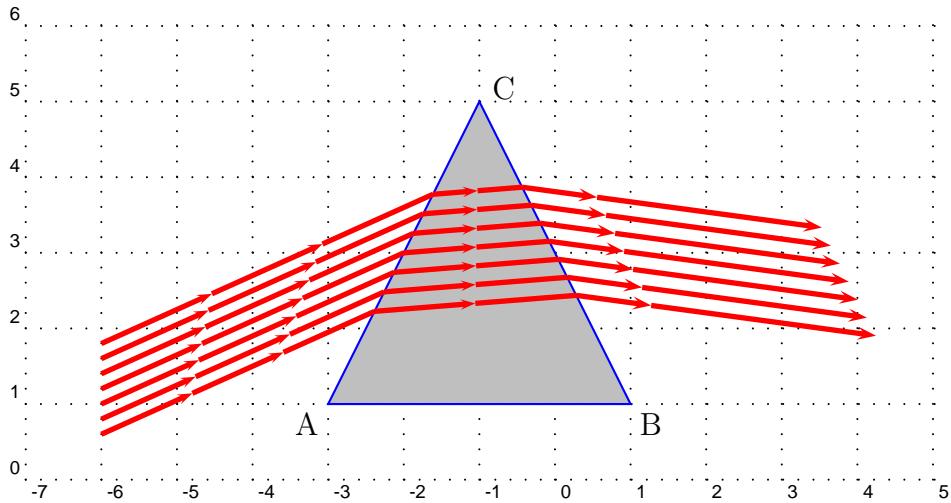
```

1 \begin{pspicture}(-7,-1)(5,6)
2   \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3   \pnode(0,0){A}
4   \pnode(2,0){B}
5   \pnode(2,5){C}
6   \pnode(0,5){D}
7   \rotateFrame(A)(B)(C)(D){45}
8   \uput[-135](A){A}\uput[-45](B){B}
9   \uput[30](C){C}\uput[135](D){D}
10  \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
11  \psset{linecolor=red,linewidth=2pt,arrowsize=5pt,arrows=->}
12  \multido{\r=3.0+-0.3}{8}{%
13    \refractionRay(-7,\r)(-4,\r)(D)(A){1}{1.25}{END}
14    \arrowLine(-7,\r)(END){2}
15    \ABinterCD(END)(END')(C)(B){Out}
16    \arrowLine(END)(Out){1}
17    \refractionRay(END)(Out)(C)(B){1.25}{1}{Q}
18    \psline(Q)(Q')
19    \psOutLine[length=3](Q)(Q'){End}%
20  }
21 \end{pspicture}

```

14 A Prisma

Refraction numbers are $n_1 = 1$ and $n_2 = 1.5$:



```

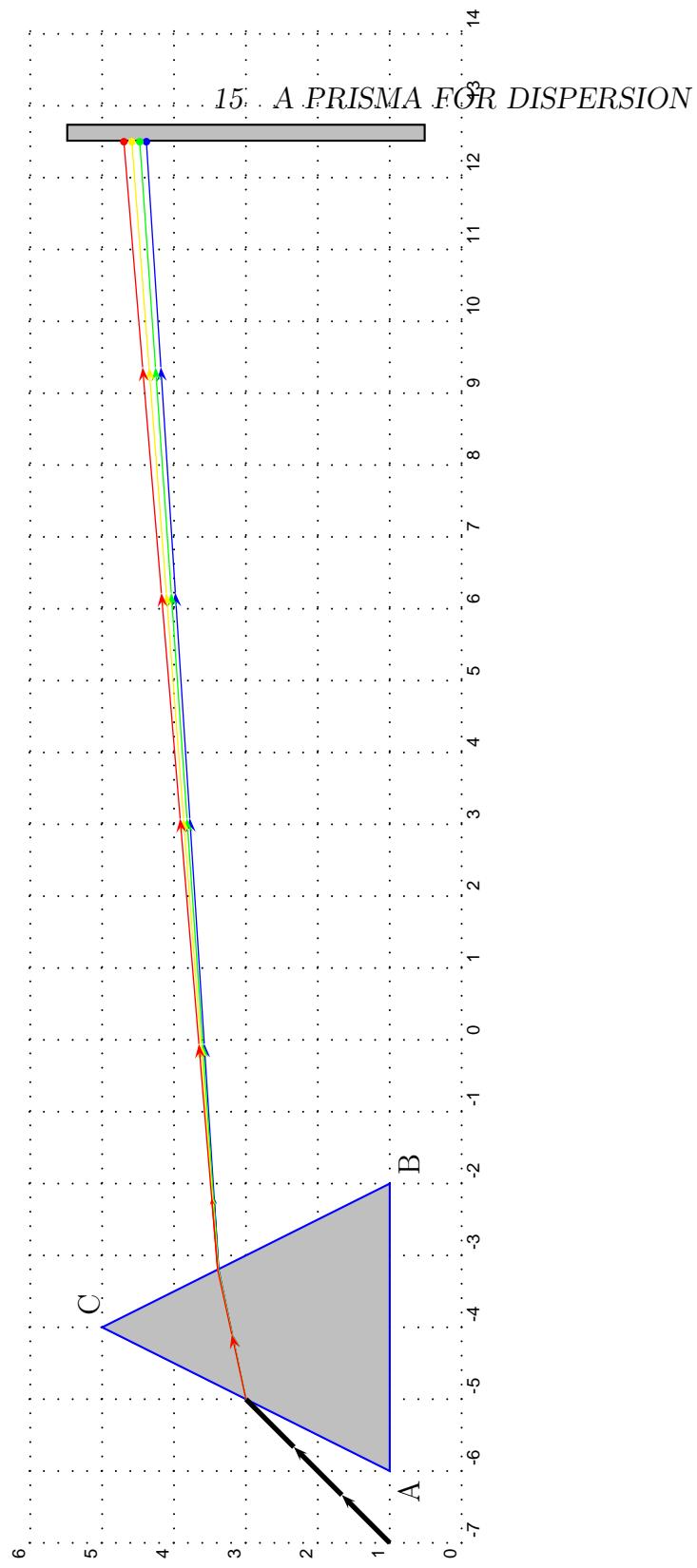
1 \begin{pspicture}(-7,0)(5,6)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \pnode(-3,1){A}\pnode(1,1){B}\pnode(-1,5){C}
4     \uput[-135](A){A}\uput[-45](B){B}\uput[30](C){C}
5     \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)
6     \psset{linecolor=red,linewidth=2pt,arrowsize=5pt,arrows=->}
7     \multido{\rA=0.6+0.2,\rB=1.5+0.2}{7}{%
8         \refractionRay(-6,\rA)(-4,\rB)(C)(A){1}{1.5}{END}
9         \arrowLine(-6,\rA)(END){2}
10        \ABinterCD(END')(C)(B){Out}
11        \arrowLine(END)(Out){1}
12        \refractionRay(END)(Out)(C)(B){1.5}{1}{Q}
13        \psline(Q)(Q')
14        \psOutLine[length=3](Q)(Q'){End}%
15    }
16 \end{pspicture}

```

15 A Prisma for Dispersion

The following figure shows the light dispersion with realistic values for the refractions numbers of the different light colors.

Color	Refraction number n for glass
dark blue	1.528
bluegreen	1.523
yellow	1.517
red	1.514
darkred	1.511



15 A PRISMA FOR DISPERSION

```

1 \begin{pspicture}(-7,0)(14,6)
2   \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3   \pnode(-6,1){A}\pnode(-2,1){B}\pnode(-4,5){C}
4   \uput[-135](A){A}\uput[-45](B){B}\uput[30](C){C}
5   \pnode(12.5,0.5){E1}\pnode(12.5,5.5){E2}
6   \psframe[fillcolor=lightgray,fillstyle=solid](E1)(12.75,5.5)
7   \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)
8   \psset{linecolor=black,linewidth=2pt,arrowsize=5pt,arrows=->}
9   \pnode(-7,1){P1}\pnode(-6,2){P2}
10  \ABinterCD(P1)(P2)(C)(A){END}
11  \arrowLine(P1)(END){2}
12 %
13 \psset{linecolor=blue,linewidth=0.5pt,arrowsize=2pt,}
14 \refractionRay(P1)(P2)(C)(A){1}{1.528}{END}
15 \ABinterCD(END')(C)(B){Out}
16 \arrowLine(END)(Out){1}
17 \refractionRay(END)(Out)(C)(B){1.528}{1}{Q}
18 \psline(Q)(Q')
19 \ABinterCD(Q)(Q')(E1)(E2){END}
20 \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
21 %
22 \psset{linecolor=green}
23 \refractionRay(P1)(P2)(C)(A){1}{1.523}{END}
24 \ABinterCD(END')(C)(B){Out}
25 \arrowLine(END)(Out){1}
26 \refractionRay(END)(Out)(C)(B){1.523}{1}{Q}
27 \psline(Q)(Q')
28 \ABinterCD(Q)(Q')(E1)(E2){END}
29 \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
30 %
31 \psset{linecolor=yellow}
32 \refractionRay(P1)(P2)(C)(A){1}{1.517}{END}
33 \ABinterCD(END')(C)(B){Out}
34 \arrowLine(END)(Out){1}
35 \refractionRay(END)(Out)(C)(B){1.517}{1}{Q}
36 \psline(Q)(Q')
37 \ABinterCD(Q)(Q')(E1)(E2){END}
38 \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
39 %
40 \psset{linecolor=red}
41 \refractionRay(P1)(P2)(C)(A){1}{1.511}{END}
42 \ABinterCD(END')(C)(B){Out}
43 \arrowLine(END)(Out){1}
44 \refractionRay(END)(Out)(C)(B){1.511}{1}{Q}
45 \psline(Q)(Q')
46 \ABinterCD(Q)(Q')(E1)(E2){END}

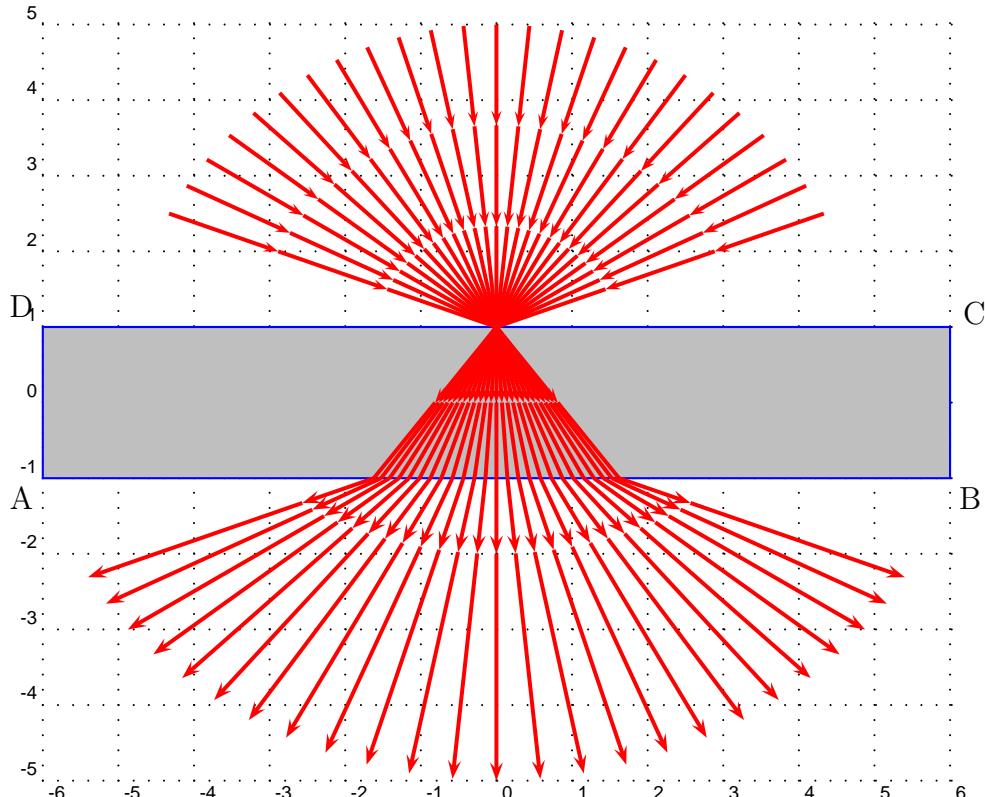
```

15 A PRISMA FOR DISPERSION

```
47           \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
48 \end{pspicture}
```

16 Refraction with different Angles

Refraction numbers are $n_1 = 1$ and $n_2 = 1.5$:



```

1 \begin{pspicture}(-6,-5)(6,5)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \pnode(-6,-1){A}\pnode(6,-1){B}\pnode(6,1){C}\pnode(-6,1){D}
4     \uput[-135](A){A}\uput[-45](B){B}
5     \uput[30](C){C}\uput[135](D){D}
6     \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
7     \psline[linewidth=0.5pt](0,-5)(0,5)
8     \psset{linecolor=red,linewidth=1.5pt,arrowsize=5pt,arrows=->}
9     \multido{\n=30+5}{25}{%
10         \refractionRay(5;\n)(0,1)(C)(D){1}{1.5}{END}
11         \arrowLine(5;\n)(END){2}
12         \ABinterCD(END)(END')(B)(A){Out}
13         \arrowLine(END)(Out){1}
14         \refractionRay(END)(Out)(B)(A){1.5}{1}{Q}
15         \psline(Q)(Q')
16         \psOutline[length=3](Q)(Q'){End}%
17     }

```

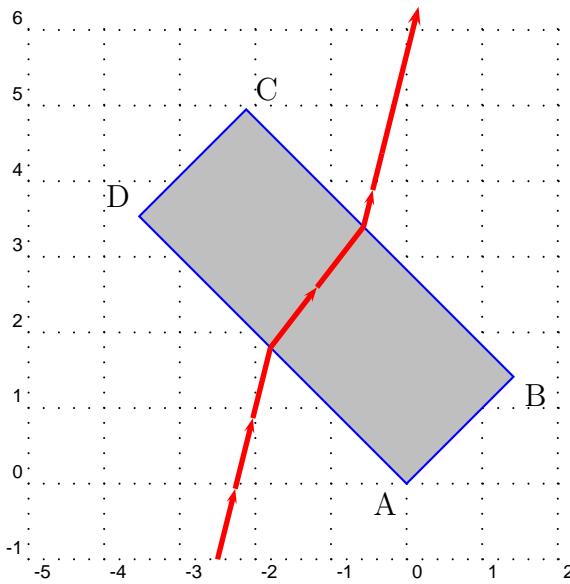
16 REFRACTION WITH DIFFERENT ANGLES

18 \end{pspicture}

pst-optic-examples.tex

17 Great difference in the Refractionsnumbers

Refractionnumbers are $n_1 = 1$ and $n_2 = 4$:



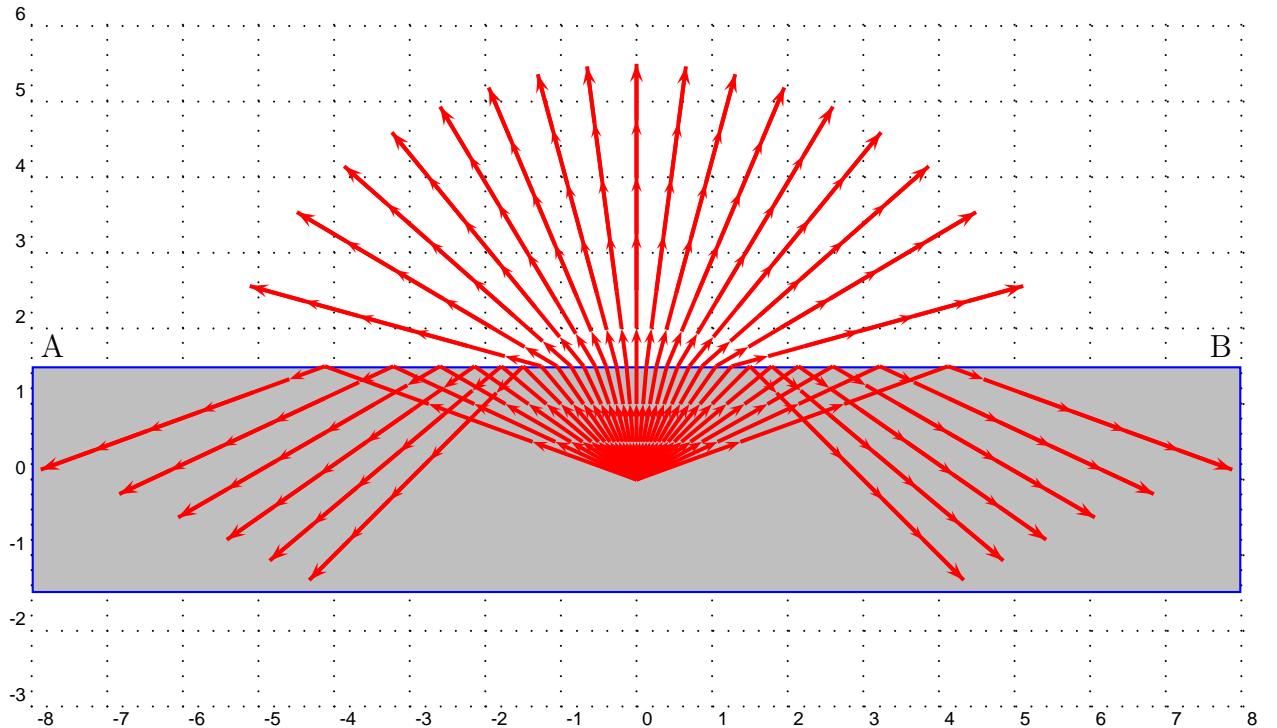
```

1 \begin{pspicture}(-5,-1)(2,6)
2   \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3   \pnode(0,0){A}
4   \pnode(2,0){B}
5   \pnode(2,5){C}
6   \pnode(0,5){D}
7   \rotateFrame(A)(B)(C)(D){45}
8   \uput[-135](A){A}\uput[-40](B){B}
9   \uput[45](C){C}\uput[135](D){D}
10  \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
11  \refractionRay(-2.5,-1)(-2,1)(D)(A){1}{4}{END}
12  \psset{linecolor=red,linewidth=2pt,arrowsize=5pt,arrows=->}
13  \arrowLine(-2.5,-1)(END){2}
14  \ABinterCD(END')(C)(B){Out}
15  \arrowLine(END)(Out){1}
16  \refractionRay(END)(Out)(C)(B){4}{1}{Q}
17  \arrowLine(Q)(Q'){1}
18  \psOutLine[length=2](Q)(Q'){End}
19 \end{pspicture}

```

18 Total Reflection

Refraction numbers are $n_1 = 2$ and $n_2 = 1$:



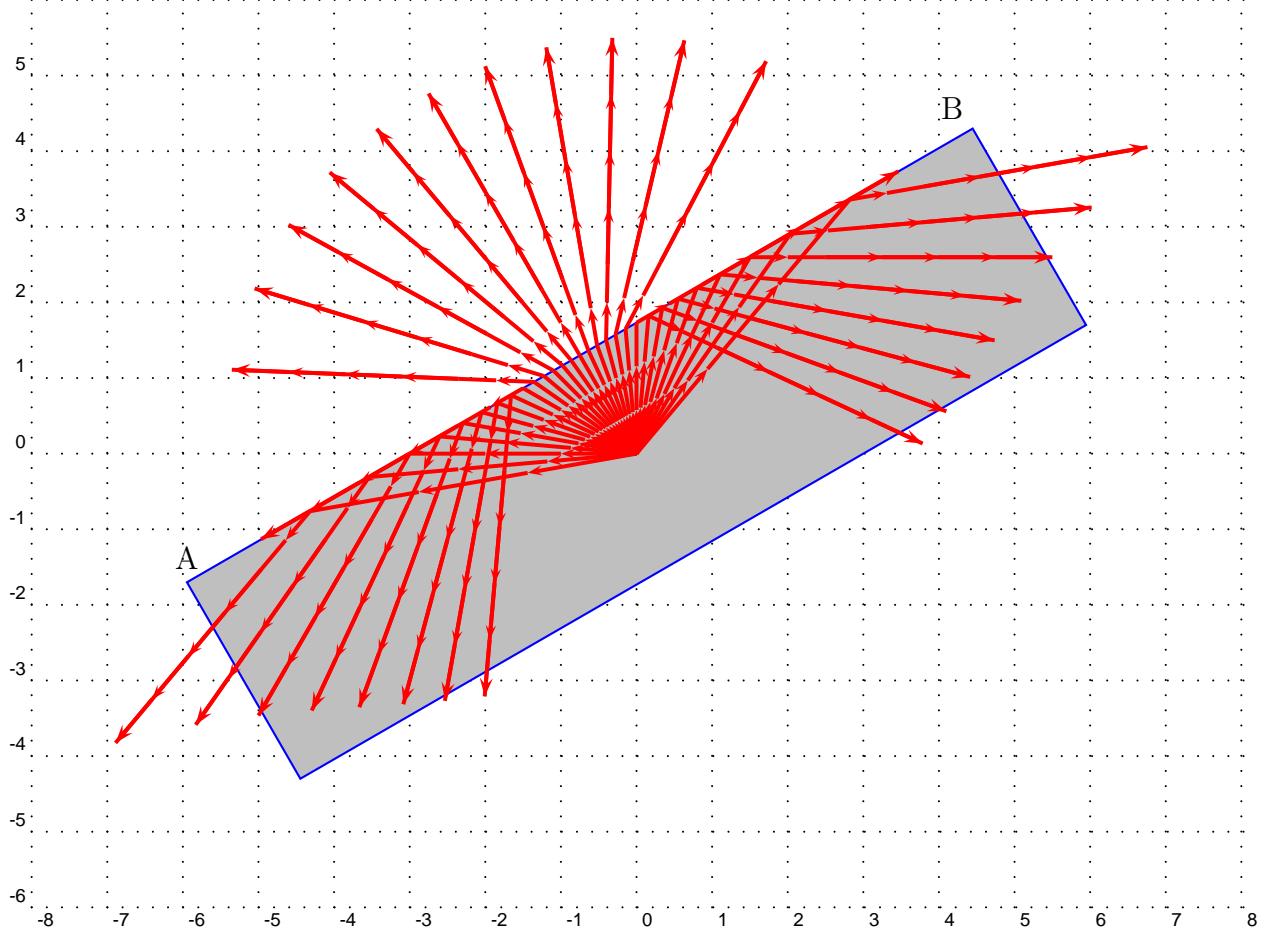
```

1 \begin{pspicture}(-8,-3)(8,6)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \pnode(-8,1.5){A}\pnode(8,1.5){B}
4     \uput[45](A){A}\uput[135](B){B}
5     \pnode(0,0){START}
6     \psframe[fillcolor=lightgray,fillstyle=solid,linecolor=blue](-8,-1.5)(B)
7     \psset{linecolor=red,linewidth=1.5pt,arrows=->}
8     \multido{\n=20+5}{29}{%
9         \refractionRay(START)(1;\n)(A)(B){2}{1}{END}
10        \arrowLine(START)(END){2}
11        \arrowLine(END)(END'){1}
12        \psOutLine[length=3](END)(END'){Q}
13        \arrowLine(END')(Q){3}
14    }
15 \end{pspicture}

```

19 Total Reflection with a sloping medium

Refraction numbers are $n_1 = 2$ and $n_2 = 1$:



```

1 \begin{pspicture}(-8,-6)(8,6)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \pnode(-6,1.5){A}\pnode(6,1.5){B}
4     \pnode(6,-1.5){C}\pnode(-6,-1.5){D}
5     \rotateFrame(A)(B)(C)(D){30}
6     \uput[90](A){A}\uput[135](B){B}
7     \pnode(0,0){START}
8     \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
9     \psset{linecolor=red,linewidth=1.5pt,arrows=->}
10    \multido{\n=50+5}{29}{%
11        \refractionRay(START)(1;\n)(A)(B){2}{1}{END}
12        \arrowLine(START)(END){2}
13        \arrowLine(END)(END'){1}

```

19 TOTAL REFLECTION WITH A SLOPING MEDIUM

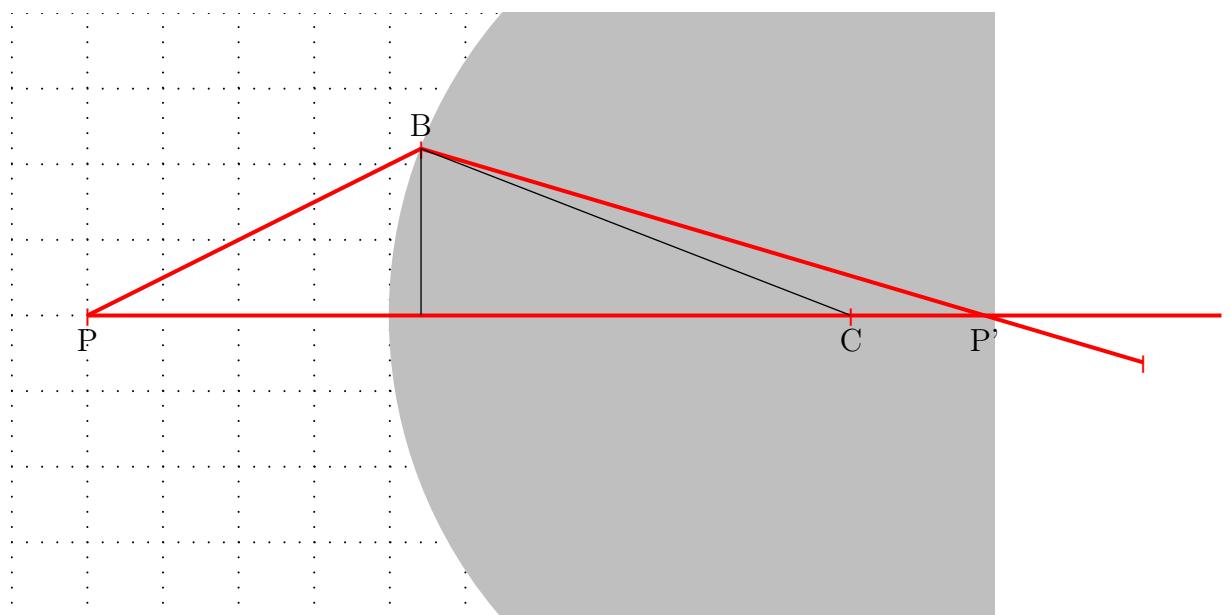
```
14          \psOutLine[length=3](END)(END')\{Q}
15          \arrowLine(END')(Q)\{3}
16      }
17 \end{pspicture}
```

Part IV

Spherical Optic

20 Refraction at a Spherical Surface

20.1 Construction for finding the position of the image point P' of a point object P formed by refraction at a spherical surface



```

1 \begin{pspicture}*(-10,-4)(3,4)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \rput(0,0){\lensSPH[
4         lensType=CVG,
5         lensHeight=12,
6         lensWidth=10,
7         yBottom=-4,yTop=4,xLeft=-5,xRight=5,
8         drawing=false]}
9     \psset{linecolor=red,linewidth=1.5pt,dotstyle=|}
10    \pnode(-9,0){P}\psdots(P)\uput[-90](P){P}
11    \psline(P)(xRight)
12    \lensSPHRay(P)(-5,2){1}{9}{Q}%
13    \psline(P)(Q)(Q')

```

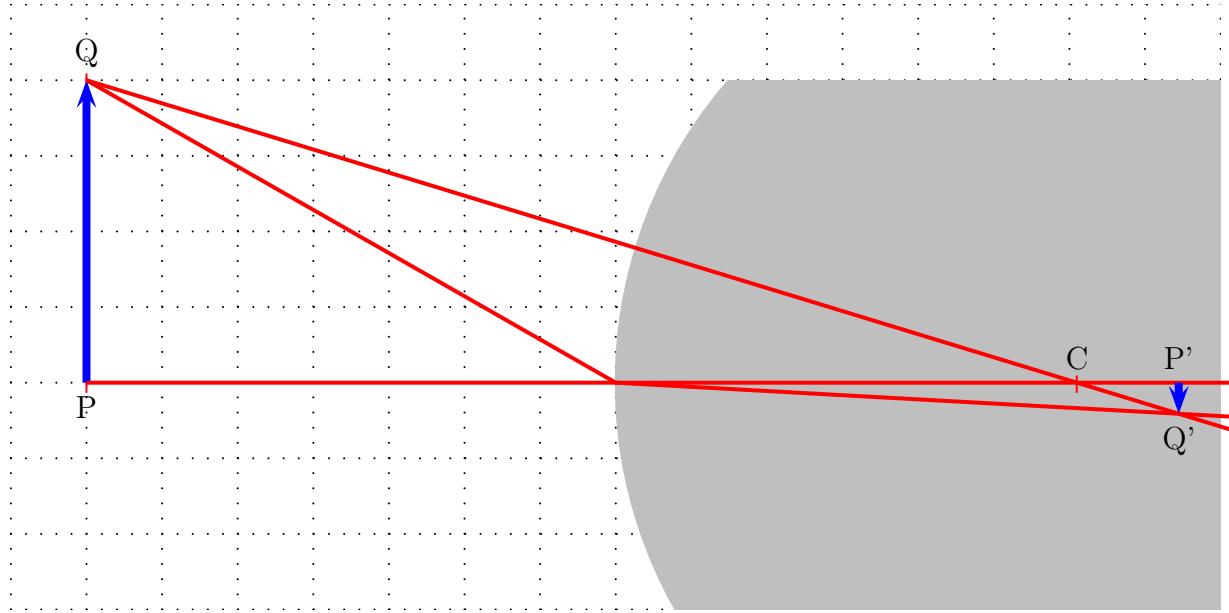
`pst-optic-examples.tex`

```

14 \psdots(Q)\uput[90](Q){B}
15 \ABinterCD(Q)(Q')(0,0)(5,0){P'}
16 \psdots(Q')\uput[-90](P'){P'}
17 \psline[linewidth=0.5pt, linecolor=black](Center')(Q)
18 \psline[linewidth=0.5pt, linecolor=black](Q)(Q|0,0)
19 \psdots(Center')\uput[-90](Center'){C}
20 \end{pspicture}

```

20.2 Construction for determining the height of an image formed by refraction at a spherical surface



```

1 \begin{pspicture}*(-13,-3)(3,5)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \rput(0,0){\lensSPH[%%
4         lensType=CVG,%%
5         lensHeight=12,%%
6         lensWidth=10,%%
7         yBottom=-4,yTop=4,xLeft=-5,xRight=5,%%
8         drawing=false]}
9     \psset{linecolor=red,linewidth=1.5pt,dotstyle=|}
10    \pnode(-12,0){P}\psdots(P)\uput[-90](P){P}
11    \pnode(-12,4){Q}\psdots(Q)\uput[90](Q){Q}
12    \psline[linecolor=blue,linewidth=3pt,arrows=->](P)(Q)
13    \psline(P)(xRight)

```

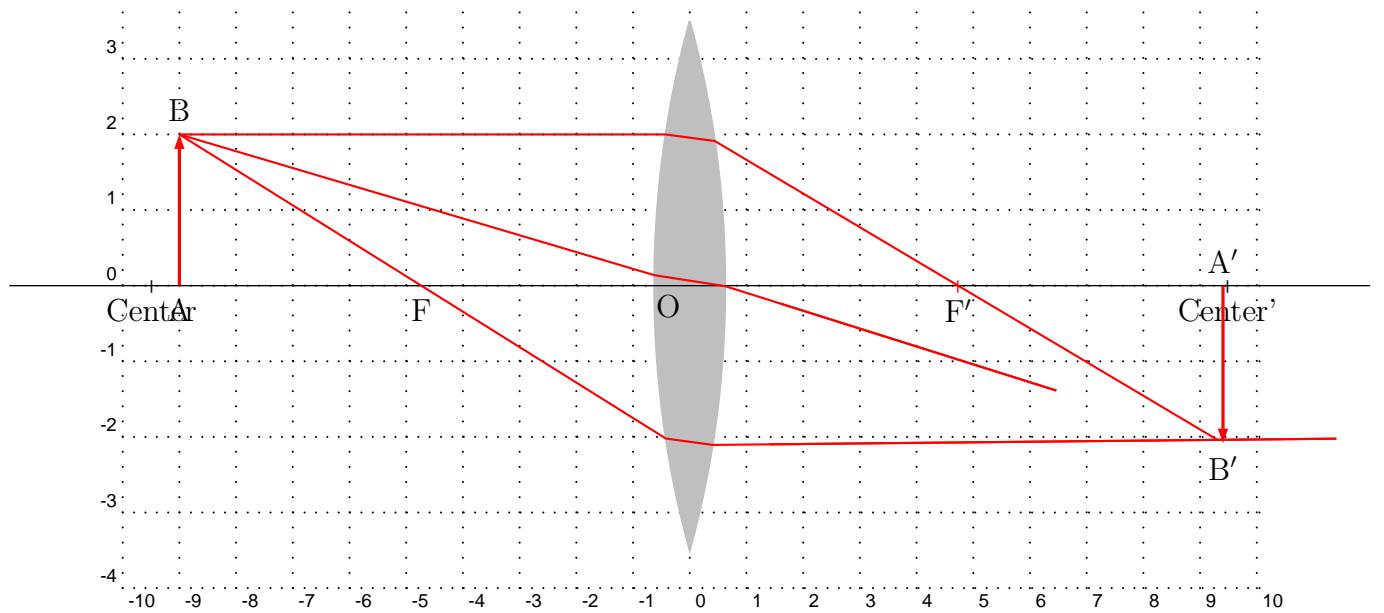
```

14 \lensSPHRay(Q)(Center'){1}{9}{S1}%
15 \lensSPHRay(Q)(-5,0){1}{9}{S2}%
16 \psline(Q)(S1')
17 \psline(Q)(S2)(S2')
18 \ABinterCD(Q)(S1')(S2)(S2'){Q'}
19 \pnode(Q'|0,0){P'}
20 \psline[linecolor=blue,linewidth=3pt,arrows=->](P')(Q')
21 \uput[90](P'){P'}
22 \uput[-90](Q'){Q'}
23 \psdots(Center')\uput[90](Center'){C}
24 \end{pspicture}

```

21 Thin Convergent Lenses

If the two spherical surfaces are close enough we can call such a lens a **thin lens**. The following figure shows the behaviour of such a lens with real rays.



```

1 \psset{xunit=0.75cm}
2 \begin{pspicture}(-10,-4)(10,4)
3     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
4     \rput(0,0){\lensSPH[
5         lensType=CVG,
6         lensHeight=7,
7         lensWidth=1.25,

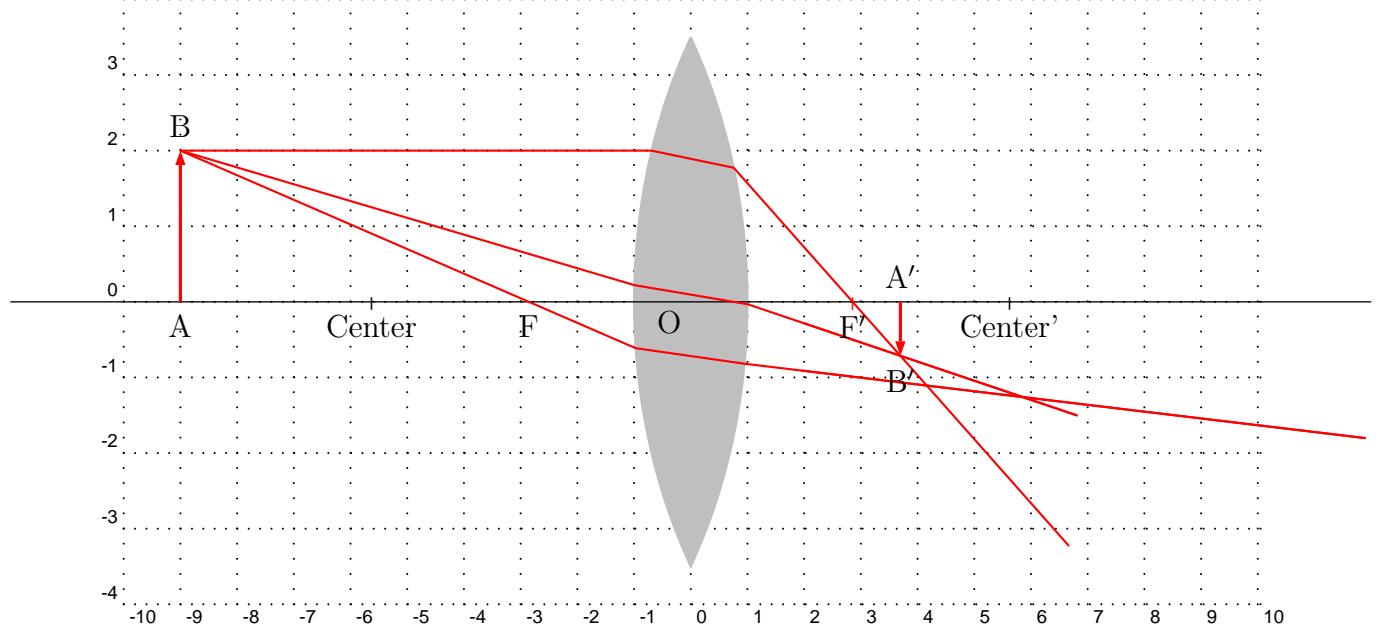
```

21 THIN CONVERGENT LENSES

```
8      yBottom=-5,yTop=5,xLeft=-12,xRight=12,%  
9      AB=2,OA=-9,%  
10     refractA=1,refractB=2,%  
11     drawing=true,%  
12     rayColor=red]}  
13 \end{pspicture}
```

22 Thick Convergent Lenses

There is no real image possible.



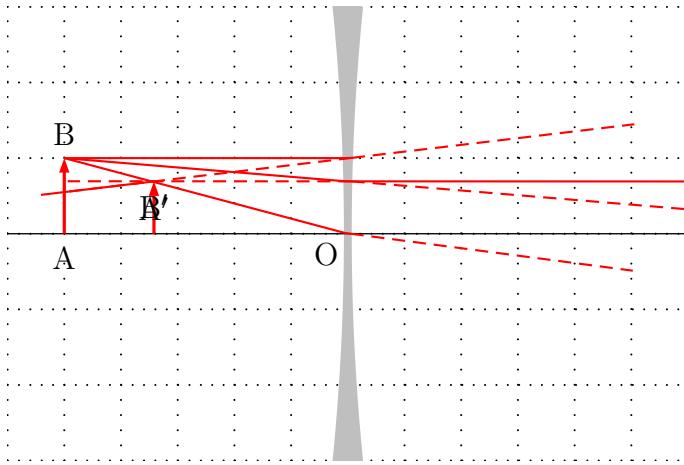
```

1 \begin{pspicture}(-10,-4)(10,4)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \rput(0,0){\lensSPH[%
4         lensType=CVG,%
5         lensHeight=7,%
6         lensWidth=2,%
7         yBottom=-5,yTop=5,xLeft=-12,xRight=12,%
8         AB=2,OA=-9,%
9         refractA=1,refractB=2,%
10        drawing=true,%
11        rayColor=red]}
12 \end{pspicture}

```

23 Thin Divergent Lenses

If the two spherical surfaces are close enough we can call such a lens a **thin lens**. The following figure shows the behaviour of such a lens with real rays.



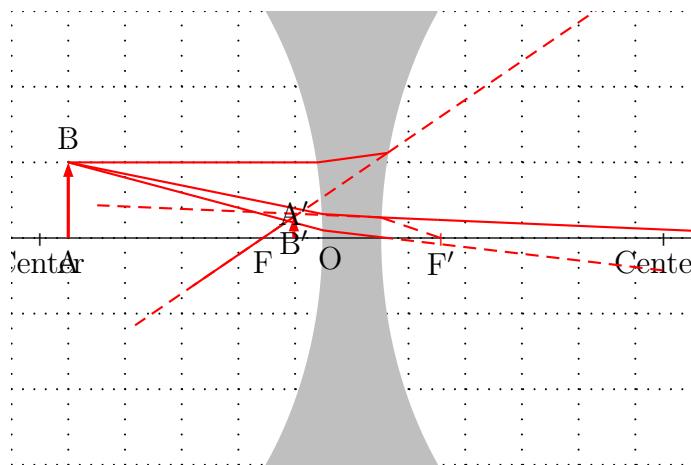
```

1 \begin{pspicture*}(-6,-3)(6,3)
2   \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3   \rput(0,0){\lensSPH[%
4     lensType=DVG,%
5     lensWidth=0.1,%
6     lensDepth=0.2,%
7     AB=1,OA=-5,%
8     drawing=true,%
9     rayColor=red]}
10 \end{pspicture*}

```

24 Thick Divergent Lenses

There is no real image possible.

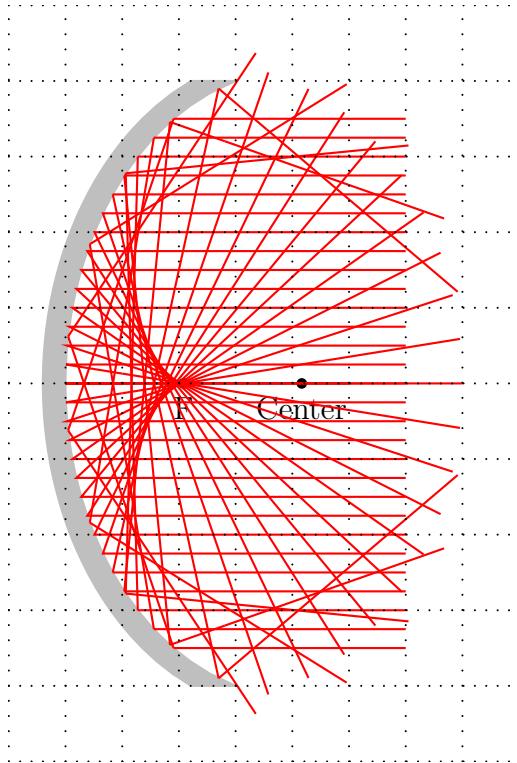


```

1 \begin{pspicture*}(-6,-3)(6,3)
2     \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
3     \rput(0,0){\lensSPH[%
4         lensType=DVG,%
5         lensWidth=1,%
6         lensDepth=1,%
7         AB=1,OA=-5,%
8         drawing=true,%
9         rayColor=red]}
10 \end{pspicture*}

```

25 \mirrorCVG



```

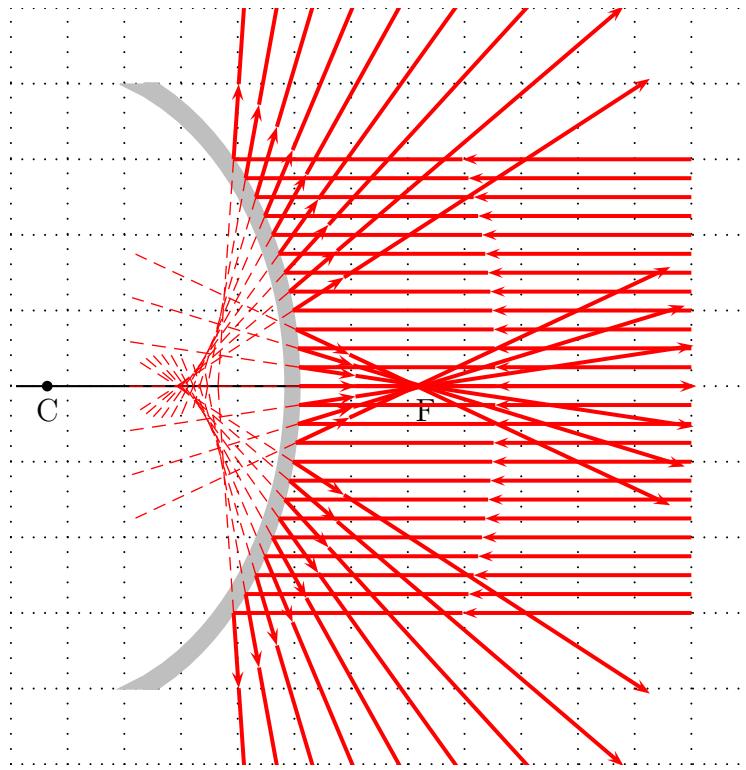
1 \begin{pspicture*}(-1,-5)(8,5)
2     \rput(0,0){%
3         \mirrorCVG[%
4             mirrorType=SPH,% 
5             drawing=false,% 
6             yBottom=-4,yTop=4,% 
7             mirrorHeight=8,% 
8             mirrorDepth=3]%
9             \qdisk(Center){2pt}\qdisk(Focus){2pt}
10            \uput[-90](Center){Center}\uput[-90](Focus){F}
11            \psline(0)(xRight)
12        }
13        \multido{\rA=-3.50+0.25}{5}{%
14            \mirrorCVGRay[mirrorType=SPH, linecolor=red](8,\rA)(4,\rA){E}
15            \psOutLine[linecolor=red, length=4](E')(E''){EEnd}
16        }
17        \multido{\rA=-2.25+0.25}{19}{%
18            \ABinterSPHLens(8,\rA)(4,\rA)(Center){Ptemp}
19            \reflectionRay[mirrorType=CVG-SPH](5,\rA)(Ptemp){E}

```

```

20          \psline[linecolor=red](8,\rA)(Ptemp)(E)
21          \psOutLine[linecolor=red,length=6](Ptemp)(E){EEnd}
22      }
23      \multido{\rA=2.50+0.25}{5}{%
24          \mirrorCVGRay[mirrorType=SPH, linecolor=red](8,\rA)(4,\rA){E}
25          \psOutLine[linecolor=red,length=4](E')(E''){EEnd}
26      }
27      \psgrid
28 \end{pspicture*}
```

26 \mirrorDVG



```

1 \begin{pspicture*}(-5,-5)(8,5)
2     \psgrid
3     \rput(0,0){%
4         \mirrorDVG[%
5             mirrorType=SPH,%
6             drawing=false,%
7             yBottom=-4,yTop=4,%
8             mirrorHeight=8,%
```

```

9          mirrorWidth=0.25,%  

10         mirrorDepth=2.5] %  

11         \qdisk(Center){2pt}\qdisk(Focus){2pt}  

12         \uput[-90](Center){C}\uput[-90](Focus){F}  

13         \psline(xLeft)(xRight)  

14     }  

15     \multido{\rA=-3.00+0.25}{25}{%  

16         \ABinterSPHLens(7,\rA)(4,\rA)(Center){Ptemp}  

17         \reflectionRay[mirrorType=SPH](5,\rA)(Ptemp){E}  

18         \arrowLine[linecolor=red,linewidth=1.5pt](7,\rA)(Ptemp){1}  

19         \psline[linecolor=red,arrows=->, linewidth=1.5pt](Ptemp)(E)  

20         \psOutLine[linecolor=red,%  

21             length=6, linewidth=1.5pt,%  

22             arrows=->](Ptemp)(E){EEnd}  

23         \psOutLine[linecolor=red,%  

24             length=3, linestyle=dashed,%  

25             linewidth=0.5pt](E)(Ptemp){EEnd}  

26     }  

27 \end{pspicture*}

```