Lenses and Mirrors: PST-optic v0.9 Examples

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Introduction

`pstricks` writes pure PostScript[**?**] code, so it is not possible to run TEX files with pdfLATEX 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.

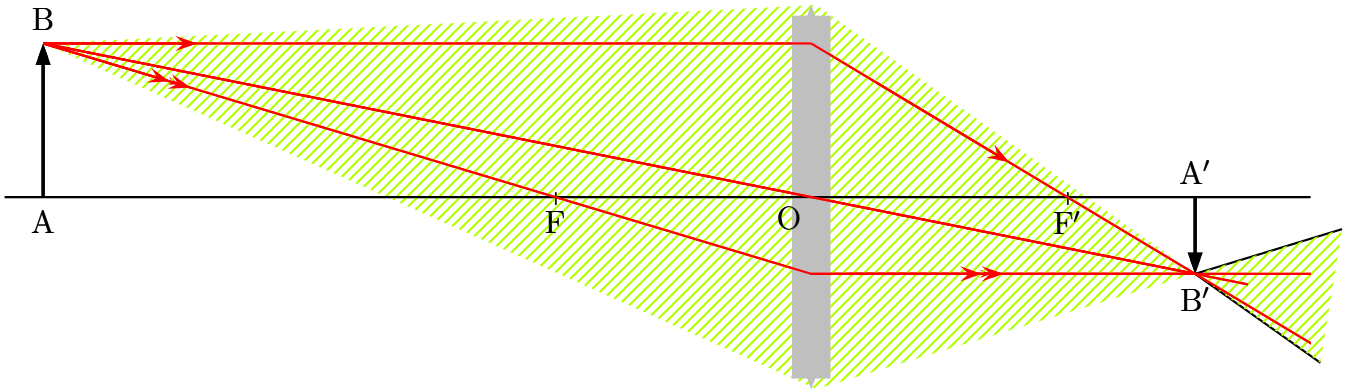
For more informations have a look into the documentations.

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

Part I
Lenses

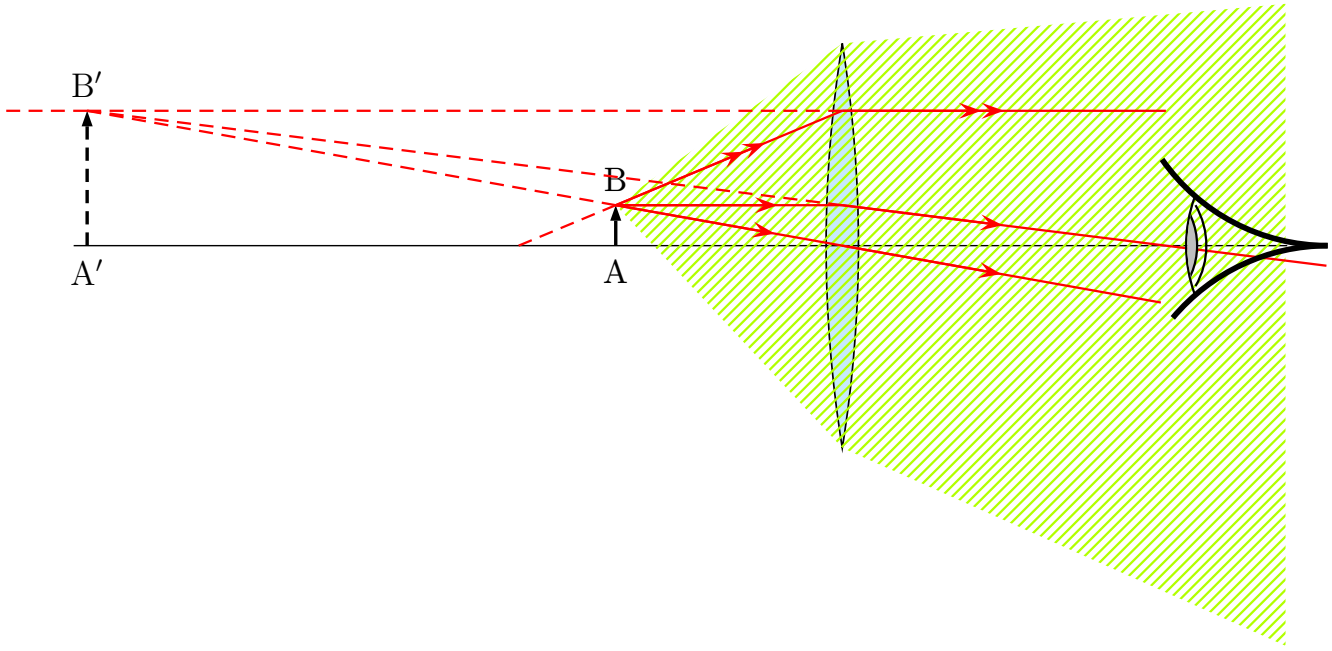
1 A simple colored System

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




```
\begin{pspicture}(-8.5,-3)(8.5,3)
\rput(0,0){%
 \lens[focus=3.333,%
  OA=-10,AB=2,XO=2,%
  xLeft=-8.5,xRight=8.5,%
  rayColor=red]%
}
\pnode(!XO 2.5){L1}%extrémité supérieure de la lentille
\pnode(!XO -2.5){L2}%extrémité inférieure de la lentille
\psOutLine[length=2](L1)(B'){END}
\psBeforeLine[length=2](B')(L2){START}
\pspolygon[style=rayuresJaunes,linestyle=none](B)(L1)(END)(START)(L2)
\rput(0,0){%
 \lens[%
  focus=3.333,%
  OA=-10,AB=2,%
  XO=2,%
  xLeft=-8.5,xRight=8.5,%
  rayColor=red,arrowsize=0.2]%
}
\end{pspicture}
```

2 A Magnifier



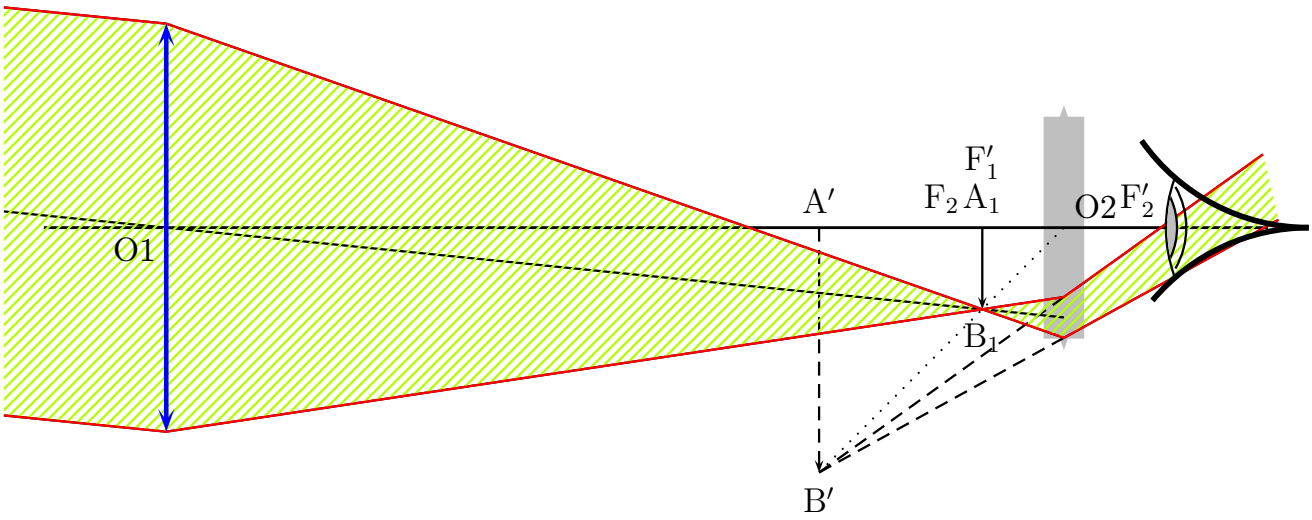

```
\begin{pspicture}(-8,-5)(8,3)
\rput(0,0){%
  \lens[%
    lensGlass=true,lensWidth=0.4,%
    focus=4,AB=0.5,OA=-2.8,XO=2,drawing=false]%
  \psline[linewidth=0.5pt](xLeft)(xRight)}
\pnode(!XO 2.5){L1}% extrmitsuprieuredelalentille
\pnode(!XO -2.5){L2}% extrmitinfrieuredelalentille
\psOutLine[length=5.5,linestyle=none](B')(L1){END1}
\psBeforeLine[length=6,linestyle=none](L2)(B'){START}
\pspolygon[style=rayuresJaunes,linestyle=none](B)(L1)(END1)(START)(L2)
\psline[linewidth=1.5\pslinewidth,arrowinset=0]{->}(A)(B)
\uput[270](A){A}
\uput[90](B){B}
\psline[linewidth=1.5\pslinewidth,arrowinset=0,%
  linestyle=dashed]{->}(A')(B')
\uput[270](A'){$\mathrm{A'}$}
\uput[90](B'){$\mathrm{B'}$}
\psset{linecolor=red,arrowsize=0.2}
\pcline[nodesepB=-4](B)(O)%   Mittelpunktstrahl
\psline[linecolor=red,linestyle=dashed](B)(B')% ruckwaertige Verlaengerung
\Arrows(B)(O)%     Mittelpunktstrahl
\psOutLine[length=2,arrows=->](B)(O){END6}% Mittelpunktstrahl
\psline(B)(I)(F')
\psOutLine(I)(F'){END2}
\Arrows(I)(F')
\Arrows(B)(I)
\psOutLine[length=1,linestyle=dashed](I')(B'){END3}
\psline[linestyle=dashed](B)(F)
\psline(B)(I')
\Arrows[arrows=->>](B)(I')
```

pst-optic-examples.tex

```
\psline[linestyle=dashed](B')(I')
\psline[linestyle=dashed](B')(I)
\psOutLine[length=2,arrows=->>](B')(I'){END4}
\psOutLine[length=4](B')(I'){END5}
\rput(8,0){\psset{linecolor=black}\eye}
\end{pspicture}
```

3 Two Lenses

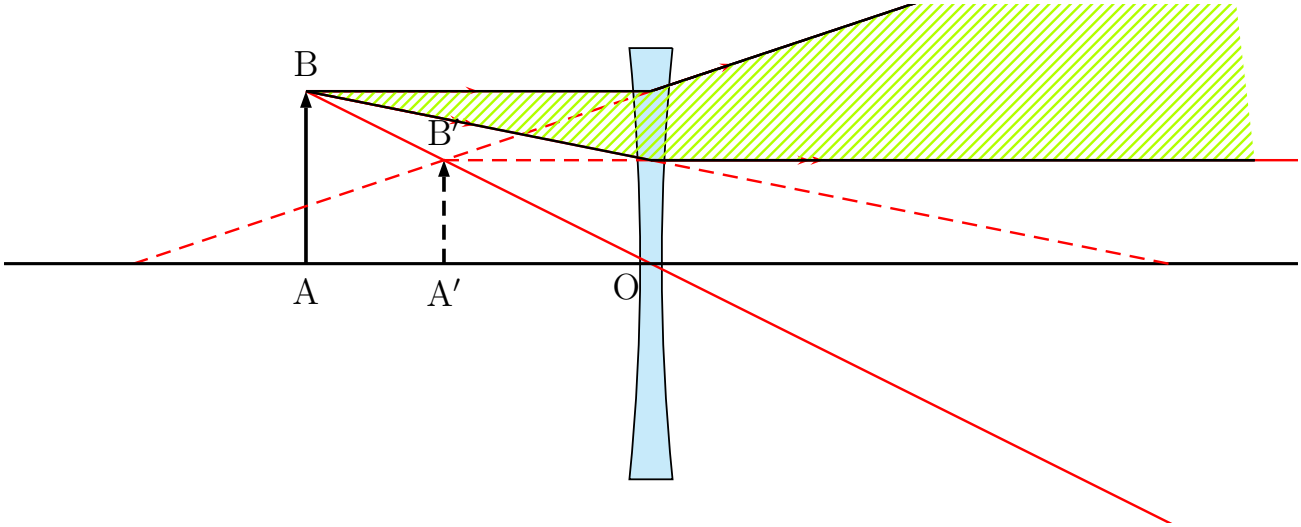
This is a simple system with two lenses, where the `\lens` macro is used only once. The second lense (the left one) is drawn by the `\psline` macro.




```
\begin{pspicture}(-8,-3)(8,3)
%on place l'oculaire dès le début
 \rput(0,0){%
  \lens[%
   lensScale=0.6,drawing=false,%
   focus=1.5,OA=-1,XO=5,nameF={},nameFi={},AB=-1]%
 \psline[linewidth=1pt](xLeft)(xRight)
 }
%image intermédiaire A1B1 au foyer F'1
 \psline{->}(4,0)(4,-1)
%lentille 2
% \psline[linewidth=2\pslinewidth,linecolor=blue]{<->}(5,1.5)(5,-1.5)
%On place les points essentiels
 \pnode(-6,0){O1}
 \pnode(-6,2.5){E1L1}%extrémité sup de L1
 \pnode(-6,-2.5){E2L1}%extrémité inf de L1
 \pnode(4,0){A1}
 \pnode(4,-1){B1}
%intersection de O1 avec la lentille L2
```

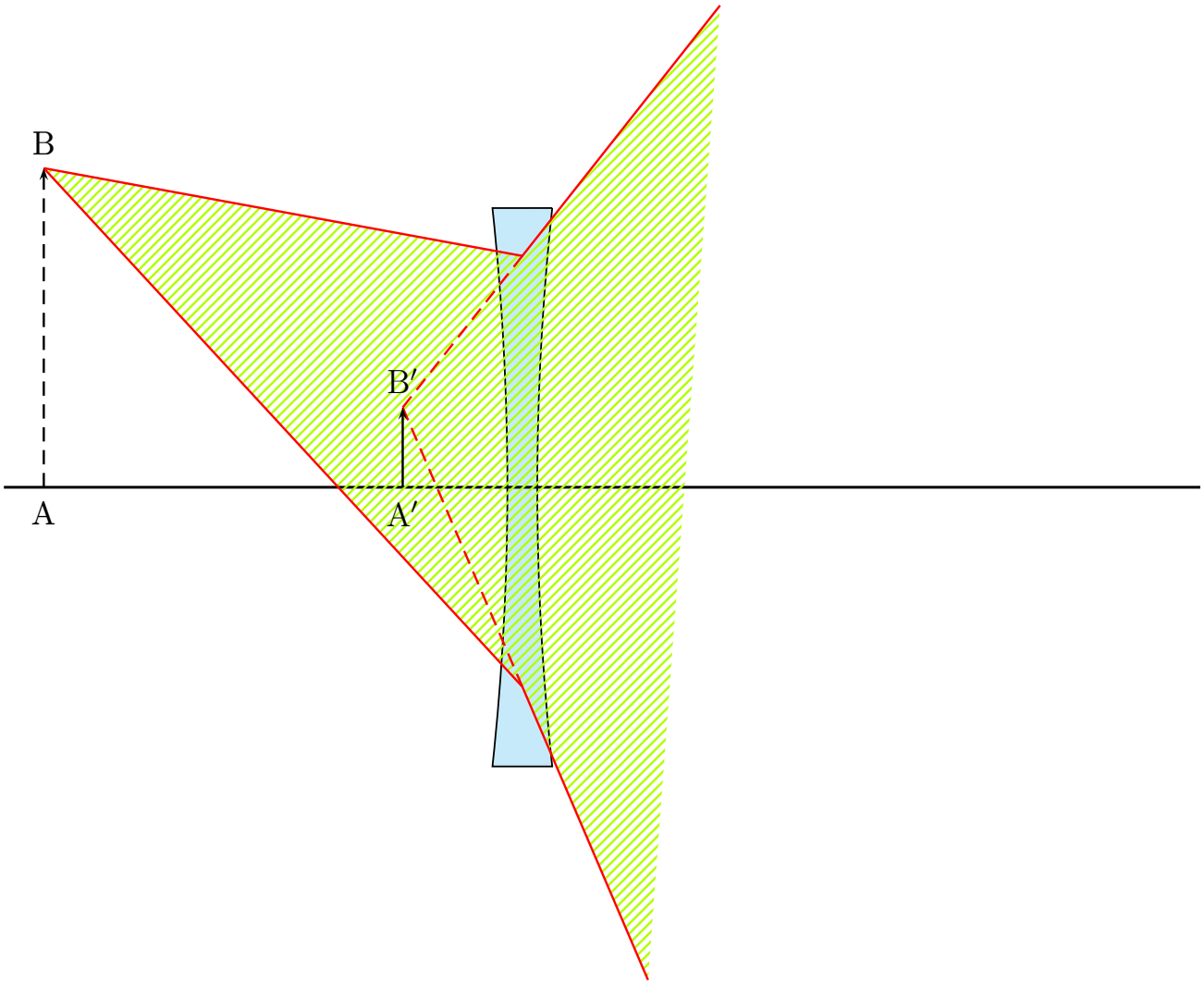
```
 \rayInterLens(O1)(B1){5}{Inter1L2}
%rayon venant de l'infini jusqu'à la lentille L2
 \pcline[nodesepB=-2](Inter1L2)(O1)
%rayon parallèle au précédent et passant par E1L1
 \Parallel(B1)(O1)(E1L1){B1infty}
%rayon parallèle au précédent et passant par E2L2
 \Parallel(B1)(O1)(E2L1){B2infty}
%intersection de la droite passant par E1L1 et B1 avec la lentille L2
 \rayInterLens(E1L1)(B1){5}{InterE1B1L2}
 \psline(E1L1)(InterE1B1L2)
%intersection de la droite passant par E2L2 et B1 avec la lentille L2
 \rayInterLens(E2L1)(B1){5}{InterE2B1L2}
 \psline(E2L1)(InterE2B1L2)
 \psline[linestyle=dashed]{->}(A')(B')
 \psline[linestyle=dashed](InterE1B1L2)(B')
 \psline[linestyle=dashed](InterE2B1L2)(B')
 \psline[linestyle=dotted](B')(O)
 \psOutLine[length=3](B')(InterE1B1L2){END}
 \psBeforeLine[length=3](InterE2B1L2)(B'){START}
 \pspolygon[%
  style=rayuresJaunes,%
  linestyle=none]%
  (B1infty)(E1L1)(InterE1B1L2)%
  (END)(START)(InterE2B1L2)%
  (E2L1)(B2infty)
 \uput[90](A'){$\mathrm{A'}$}
 \uput[270](B'){$\mathrm{B'}$}
 \uput[90](A1){$\mathrm{A_1}$}
 \uput[270](B1){$\mathrm{B_1}$}
 \uput[225](O1){O1}
 \uput[45](O){O2}
 \uput[90](F){$\mathrm{F_2}$}
 \uput{0.4}[150](F'){$\mathrm{F'_2}$}
 \uput{0.6}[90](A1){$\mathrm{F'_1}$}
 \psline[linecolor=red](B1infty)(E1L1)(InterE1B1L2)(END)
 \psline[linecolor=red](B2infty)(E2L1)(InterE2B1L2)(START)
 \rput(8,0){\eye}
%lentille 1
 \psline[%
  linewidth=2\pslinewidth,%
  linecolor=blue,%
  arrowsize=0.2,arrowinset=0.5]{<->}(-6,-2.5)(-6,2.5)
\end{pspicture}
```

4 Real Image




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

5 Virtual Image

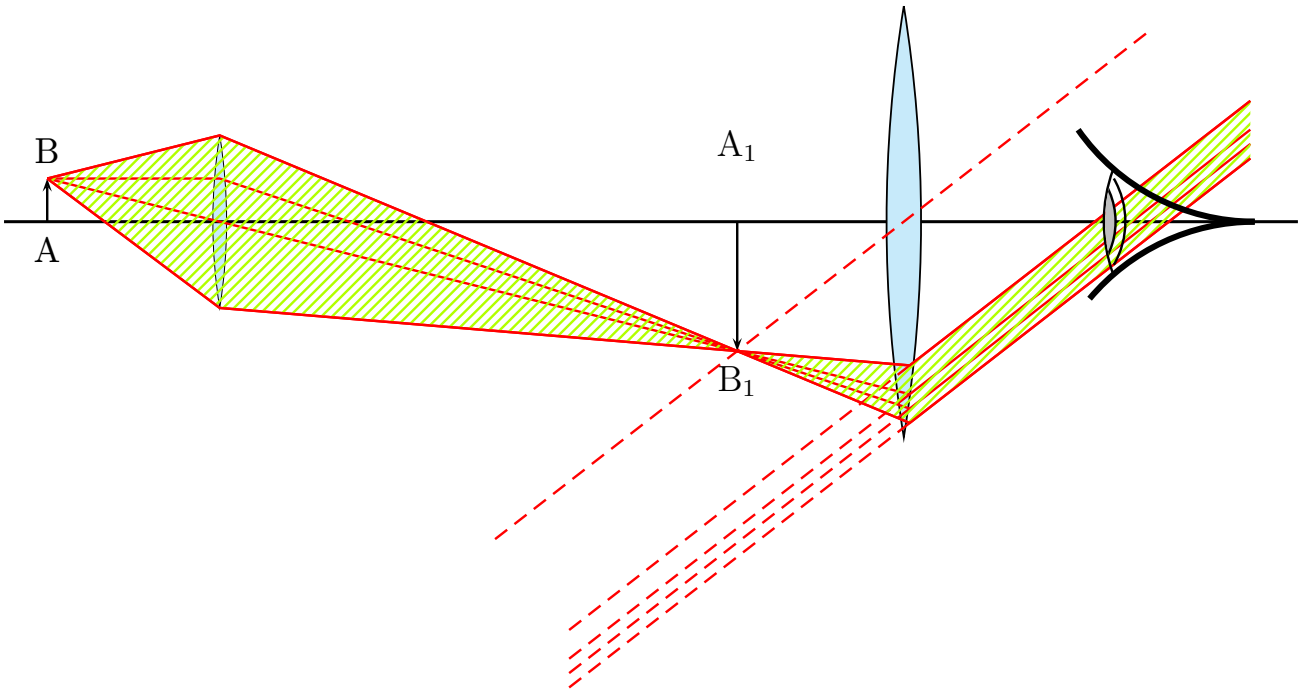



```
\begin{pspicture*}(-7.5,-6.5)(7.5,7.5)
\rput(0,0){%
  \lens[lensType=DVG,lensWidth=0.75,
        lensHeight=7,focus=-2,OA=-6,AB=4,XO=-1,lensGlass=true,%
        rayColor=red,yBottom=-5,yTop=5,drawing=false]%
  \psline[linewidth=1pt](xLeft)(xRight)}
\pnode(!XO 2.9){L1}% extrmitdelalentillesup
\pnode(!XO -2.5){L2}% extrmitdelalentilleinf
{%
  \psset{length=4,linestyle=none}
  \psOutLine(B')(L1){A1}
  \psOutLine(B')(L2){A2}
  \pspolygon[style=rayuresJaunes,linestyle=none](B)(L1)(A1)(A2)(L2)
```

pst-optic-examples.tex

```
  \psset{linecolor=red,linestyle=solid}
  \psline(B)(L1)(A1)
  \psline(B)(L2)(A2)%
  \psline[linestyle=dashed](B')(L1)
  \psline[linestyle=dashed](B')(L2)%
}
\psline[linestyle=dashed]{->}(A)(B)
\psline{->}(A')(B')
\uput[90](B){B}
\uput[90](B'){$\mathrm{B'}$}
\uput[270](A){A}
\uput[270](A'){$\mathrm{A'}$}
\end{pspicture*}
```

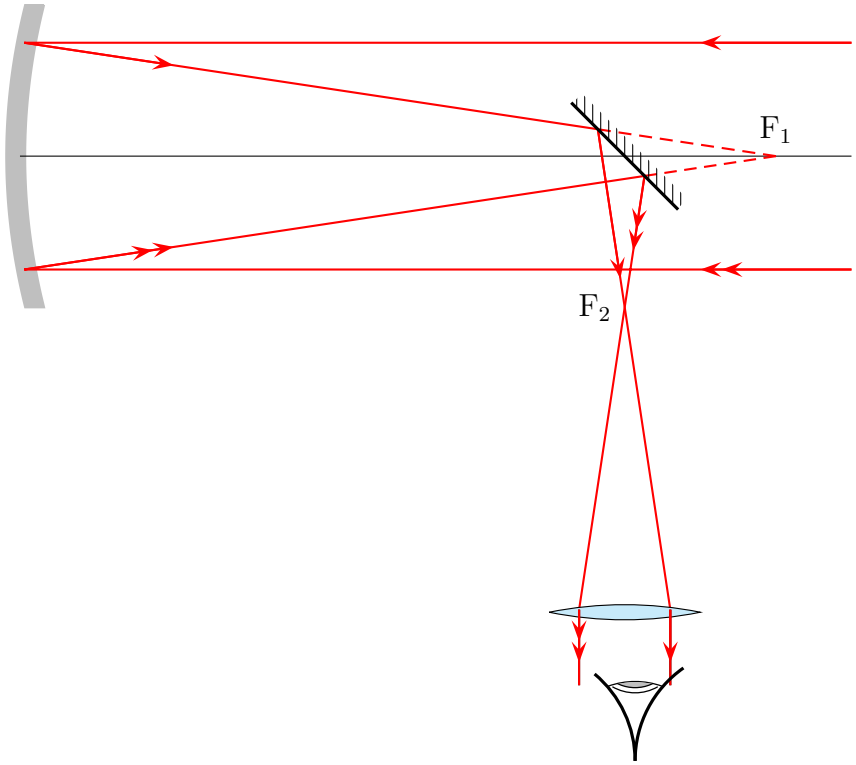
6 A Microscope



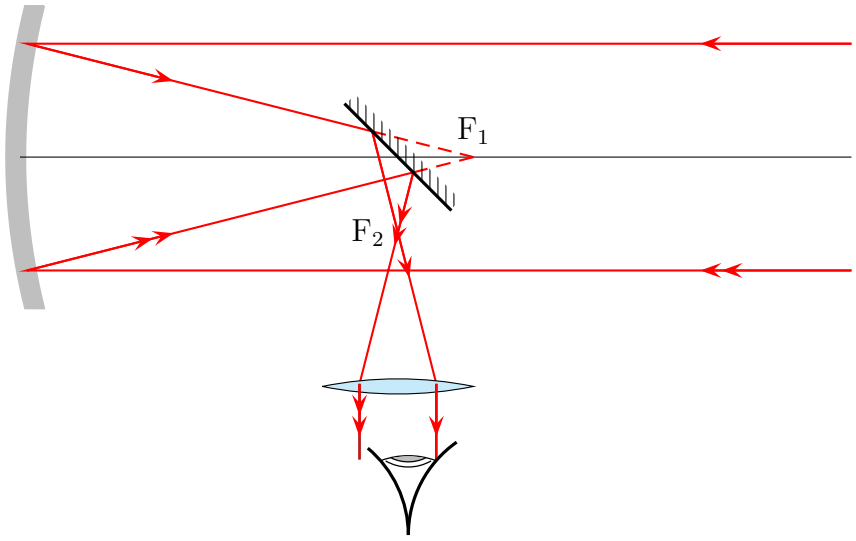

```
\begin{pspicture}(-7.5,-5.5)(7.5,3)
\rput(0,0){%
 \lens[focus=1.5,OA=-2,AB=0.5,XO=-5,lensGlass=true,lensWidth=0.4,%
  yBottom=-4,yTop=4,drawing=false,lensScale=0.4,%
  nameF=F_1,nameFi=F'_1]%
 \psline[linewidth=1pt](xLeft)(xRight)
}
\pnode(! XO 1){UPlens1}
\pnode(! XO -1){DOWNlens1}
\Transform
\rput(0,0){%
 \lens[focus=2,XO=3,lensGlass=true,lensWidth=0.4,%
```

```
  yBottom=-4,yTop=4,drawing=false,%
  nameF=F_2,nameFi=F'_2,spotF=90,spotFi=90]%
}
\psline{->}(A1)(B1)
\psline{->}(A'1)(B'1)
\uput[270](A1){A}
\uput[90](B1){B}
\uput[270](B'1){$\mathrm{B_1}$}
\uput{0.7}[90](A'1){$\mathrm{A_1}$}
{\psset{linecolor=red}
\rayInterLens(I11)(B'1){3}{Inter1L2}
\rayInterLens(B1)(O1){3}{Inter2L2}
\rayInterLens(UPlens1)(B'1){3}{Inter3L2}
\rayInterLens(DOWNlens1)(B'1){3}{Inter4L2}
\psline(B1)(I11)(B'1)(Inter1L2)
\psline(B1)(Inter2L2)
\psline(B1)(UPlens1)(Inter3L2)
\psline(B1)(DOWNlens1)(Inter4L2)
\psset{length=5}
\Parallel(B'1)(O)(Inter3L2){B1inftyRigth}
\Parallel(B'1)(O)(Inter4L2){B2inftyRigth}
\Parallel(B'1)(O)(Inter2L2){B3inftyRigth}
\Parallel(B'1)(O)(Inter1L2){B3inftyRigth}
{\psset{length=-5,linestyle=dashed}
\Parallel(B'1)(O)(Inter3L2){B1inftyLeft}
\Parallel(B'1)(O)(Inter4L2){B2inftyLeft}
\Parallel(B'1)(O)(Inter2L2){B3inftyLeft}
\Parallel(B'1)(O)(Inter1L2){B3inftyLeft}
\pcline[nodesep=6](B'1)(O)}
\pspolygon[style=rayuresJaunes,linestyle=none]%
 (B1)(UPlens1)(Inter3L2)%
 (B1inftyRigth)(B2inftyRigth)(Inter4L2)(DOWNlens1)
\psline(B1)(UPlens1)(Inter3L2)(B1inftyRigth)
\psline(B2inftyRigth)(Inter4L2)(DOWNlens1)(B1)}
\rput(7,0){\eye}
\end{pspicture}
```

7 Telescope



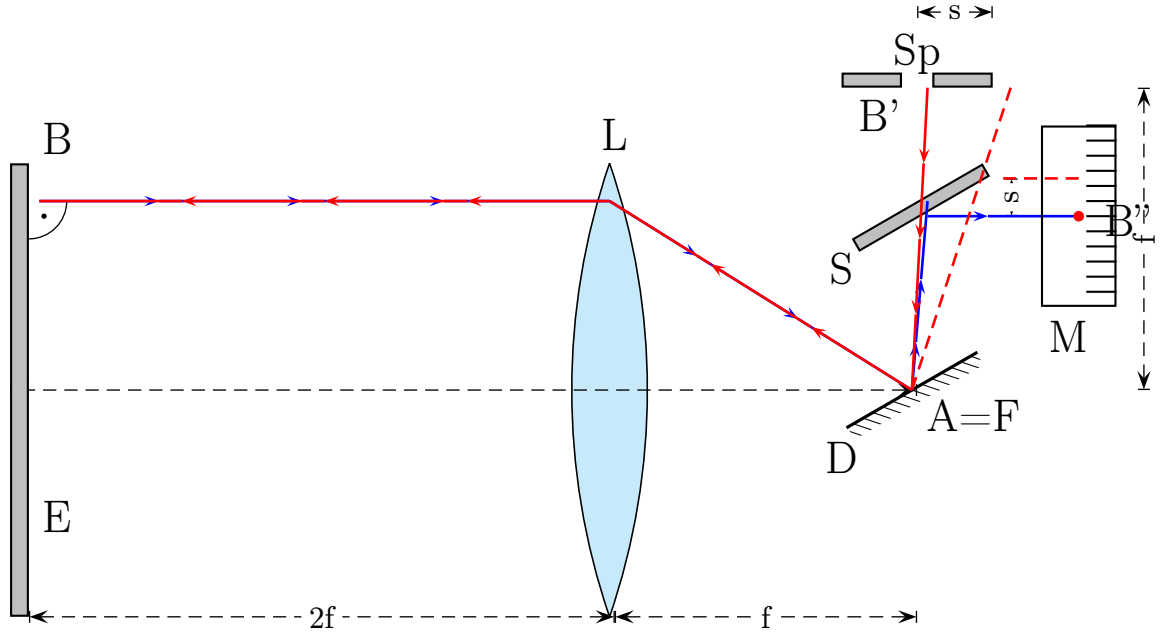

```
\telescope[mirrorFocus=10,posMirrorTwo=8,yBottom=-8]
```




```
\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

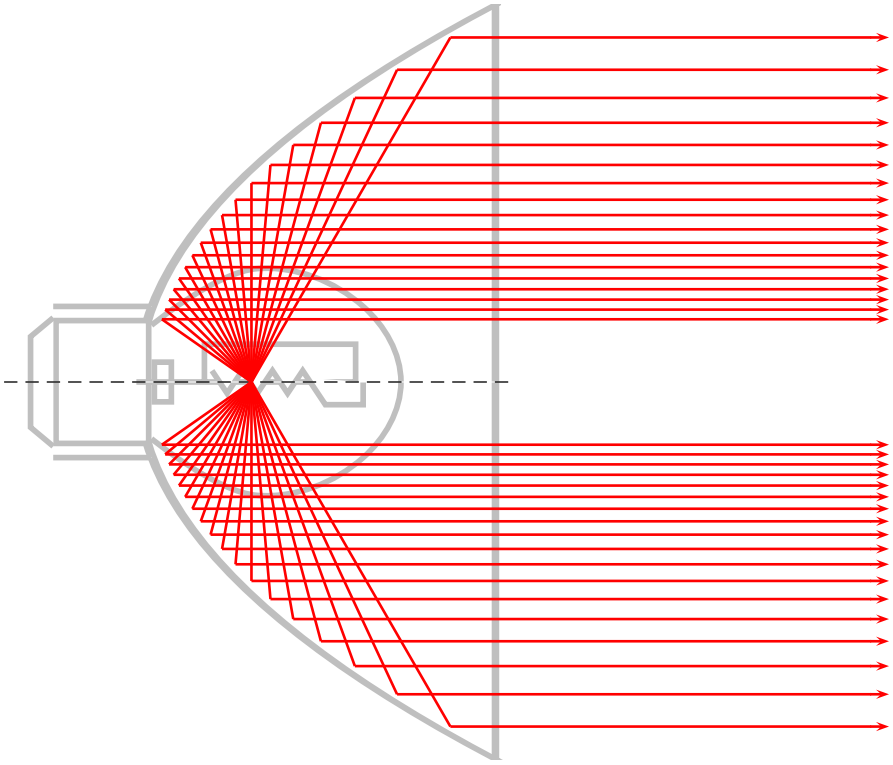
```
\begin{pspicture}(-8,-5)(7,6)
  \rput(0,0){\lens[lensWidth=1,lensGlass=true,%
    lensHeight=6,focus=4,drawing=false,AB=2.5]}
  {%
    \psset{linewidth=0.5pt,linestyle=dashed,arrowsize=5pt,arrows=|<->|}
    \psline(-8,0)(4,0)
    \pcline(-7.75,-3)(0,-3)
    \lput*{:U}{2f}
    \pcline(0,-3)(4,-3)
    \lput*{:U}{f}
    \pcline(7,0)(7,4)
    \lput*{:U}{f}
    \pcline(4,5)(5,5)
    \lput*{:U}{s}
    \pcline(5.25,2.3)(5.25,2.8)
    \lput*{:U}{s}
```

pst-optic-examples.tex

```
  }
  \uput[90](0,3){\Large L}
  \uput[45](-7.7,3){\Large B}
  \uput[45](-7.7,-2){\Large E}
  \uput[270](3,-0.5){\Large D}
  \uput[-45](4,0){\Large A=F}
  \uput[270](3,2){\Large S}
  \uput[90](4,4){\Large Sp}
  \uput[90](3.5,3.25){\Large B'}
  \uput[0](6.3,2.25){\Large B''}
  \uput[-90](6,1.1){\Large M}
  \psarc[linewidth=0.5pt](-7.75,2.5){0.5}{-90}{0}\qdisk(-7.55,2.3){1pt}
  \rput{210}(F'){\mirrorTwo}
  {%
    \psset{fillstyle=solid,fillcolor=lightgray}
    \rput{210}(4,2.5){\psframe(-1,0)(1,0.2)}
    \psframe(-8,-3)(-7.75,3)
    \psframe(3,4)(3.8,4.2)\psframe(4.2,4)(5,4.2)%
  }{%
    \psset{linewidth=1pt,linecolor=red,arrows=->,%
      arrowsize=5pt}
    \arrowLine[linecolor=blue,arrowOffset=-0.2](F')(4,2.5){2}
    \arrowLine[linecolor=blue,arrowOffset=-0.2](4,2.3)(6,2.3){1}
    \qdisk(6,2.3){2pt}
    \psline[linestyle=dashed,arrows=-](F')(5.1,4)
    \psline[linestyle=dashed,arrows=-](5,2.8)(6,2.8)
    \arrowLine(4,4)(F'){3}
    \arrowLine[linecolor=blue,arrowOffset=-0.2](I)(F'){2}
    \arrowLine(F')(I){2}
    \arrowLine[linecolor=blue,arrowOffset=-0.3](-7.75,2.5)(I){3}
    \arrowLine(I)(-7.75,2.5){3}
  }
  \psframe(5.5,1.1)(6.5,3.5)
  \multido{\r=1.3+0.2}{12}{%
    \psline(6.1,\r)(6.5,\r)%
  }
\end{pspicture}
```

Part II
Mirrors

9 High Beam Light

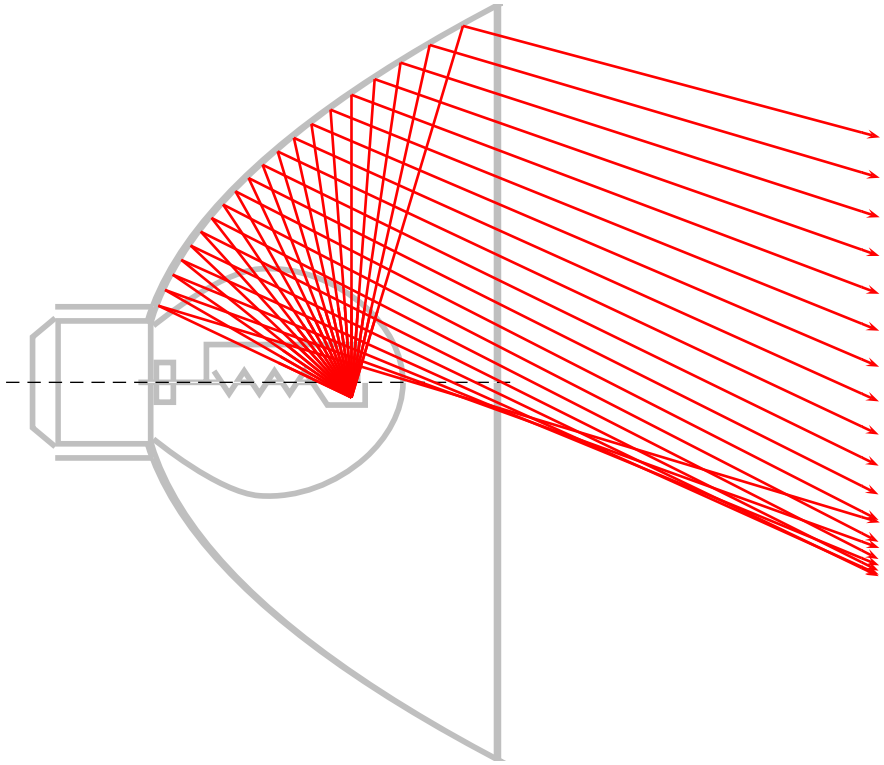


```
\begin{pspicture}(-1.5,-5.5)(10,5.5)
 \rput(0,0){%
  \beamLight[drawing=false,%
   mirrorDepth=4.75,%
   mirrorWidth=0.1,%
   mirrorHeight=10,%
   linecolor=lightgray]}
 \makeatletter
 \pst@getcoor{Focus}\pst@tempf
 \psset{linewidth=1pt,linecolor=red}
 \multido{\n=60+5}{18}{%
  \mirrorCVGRay[linecolor=red,%
   mirrorDepth=4.75,%
   mirrorHeight=10,%
   linewidth=1pt](Focus)(!%
    /XF \pst@tempf pop \pst@number\psxunit div def
    \n\space cos XF add \n\space sin neg){Endd1}
  \psOutLine[arrows=->,length=.25](Endd1)(Endd1'')}{Endd2}%
  \mirrorCVGRay[linecolor=red,%
```

pst-optic-examples.tex

```
    mirrorDepth=4.75,%
    mirrorHeight=10,%
    linewidth=1pt](Focus)(!%
     /XF \pst@tempf pop \pst@number\psxunit div def
     \n\space cos XF add \n\space sin ){End1}
  \psOutLine[arrows=->,length=.25](End1)(End1'')){End2}%
 }
 \makeatletter
\end{pspicture}
```

10 Low Beam Light



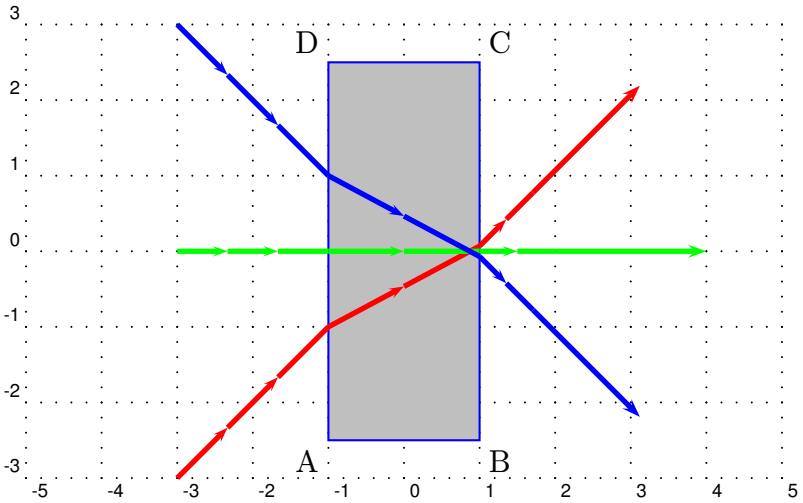
```
\begin{pspicture}(-1.5,-5)(10,5)
 \rput(0,0){%
  \beamLight[drawing=false,%
   mirrorDepth=4.75,%
   mirrorWidth=0.1,%
   mirrorHeight=10,%
   linecolor=lightgray]}
 {%
 \psset{linewidth=1pt,linecolor=red}
 \multido{\n=70+5}{20}{%
  \psline(2.75,-0.2)(! \n\space cos 2.75 add \n\space sin )
  \mirrorCVGRay[linecolor=red,%
   mirrorDepth=4.75,%
   mirrorHeight=10,%
   linewidth=1pt](2.75,-0.2)%
```

```
    (!  \n\space cos 2.75 add \n\space sin ){End1}
   \psOutLine[arrows=->,length=.25](End1)(End1'')}{End2}%
 }}
\end{pspicture}
```

Part III
Refraction

11 Vertical Medium

Refrectionnumbers are $n_1 = 1$ and $n_2 = 1.5$:



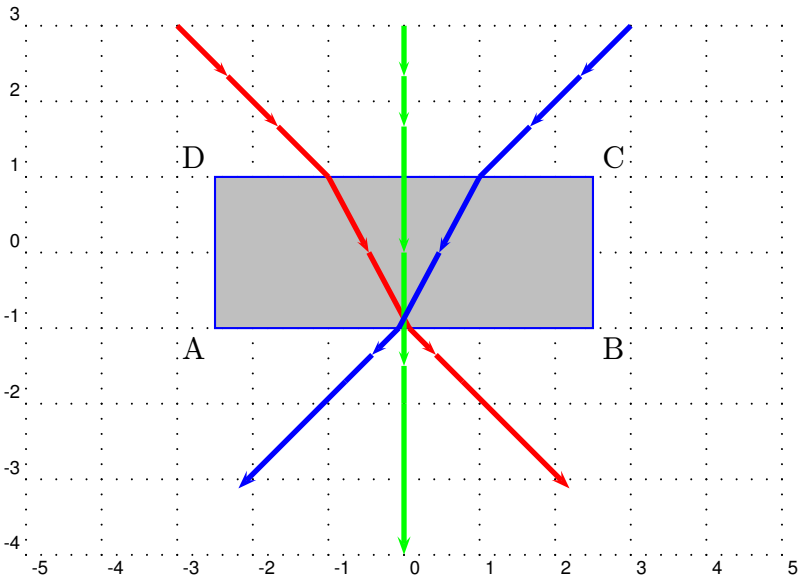

```
\begin{pspicture}(-5,-3)(5,3)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
 \pnode(-1,-2.5){A}
 \pnode(1,-2.5){B}
 \pnode(1,2.5){C}
 \pnode(-1,2.5){D}
% \rotateFrame(A)(B)(C)(D){10}
 \uput[-135](A){A}\uput[-45](B){B}
 \uput[45](C){C}\uput[135](D){D}
 \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
%
% 1.
%
 \refractionRay(-3,-3)(-2,-2)(D)(A){1}{1.5}{END}
 \psset{linecolor=red,linewidth=2pt,arrowsize=5pt,arrows=->}
 \arrowLine(-3,-3)(END){2}
 \ABinterCD(END)(END')(C)(B){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(C)(B){1.5}{1}{Q}
 \arrowLine(Q)(Q'){1}
 \psOutLine[length=2](Q)(Q'){End}
%
% 2.
 \refractionRay(-3,0)(-2,0)(A)(D){1}{1.5}{END}
 \psset{linecolor=green,linewidth=2pt,arrowsize=5pt,arrows=->}
 \arrowLine(-3,0)(END){2}
 \ABinterCD(END)(END')(C)(B){Out}
 \arrowLine(END)(Out){1}
```

pst-optic-examples.tex

```
 \refractionRay(END)(Out)(C)(B){1.5}{1}{Q}
 \arrowLine(Q)(Q')){1}
 \psOutLine[length=2](Q)(Q')){End}
%
% 3.
%
 \refractionRay(-3,3)(-2,2)(D)(A){1}{1.5}{END}
 \psset{linecolor=blue,linewidth=2pt,arrowsize=5pt,arrows=->}
 \arrowLine(-3,3)(END){2}
 \ABinterCD(END)(END')(C)(B){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(C)(B){1.5}{1}{Q}
 \arrowLine(Q)(Q')){1}
 \psOutLine[length=2](Q)(Q')){End}
\end{pspicture}
```

12 Horizontal Medium

Refrectionnumbers are $n_1 = 1$ and $n_2 = 1.5$:



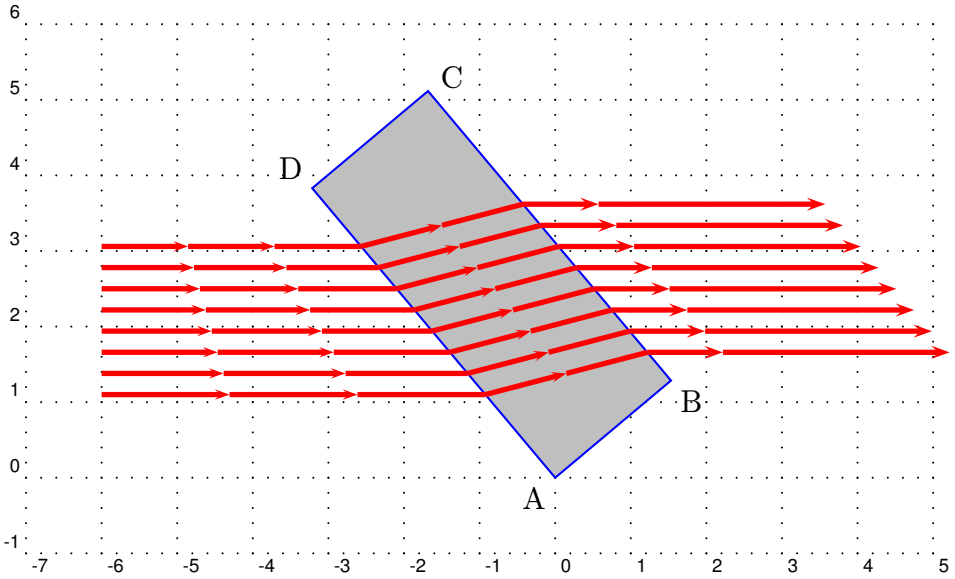

```
\begin{pspicture}(-5,-4)(5,3)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
 \pnode(-2.5,-1){A}
 \pnode(2.5,-1){B}
 \pnode(2.5,1){C}
 \pnode(-2.5,1){D}
 \uput[-135](A){A}\uput[-45](B){B}
 \uput[45](C){C}\uput[135](D){D}
 \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
%
% 1.
%
 \refractionRay(-3,3)(-2,2)(C)(D){1}{1.5}{END}
 \psset{linecolor=red,linewidth=2pt,arrowsize=5pt,arrows=->}
 \arrowLine(-3,3)(END){2}
```

pst-optic-examples.tex

```
 \ABinterCD(END)(END')(B)(A){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(B)(A){1.5}{1}{Q}
 \arrowLine(Q)(Q'){1}
 \psOutLine[length=2](Q)(Q'){End}
%
% 2.
%
 \refractionRay(0,3)(0,1)(C)(D){1}{1.5}{END}
 \psset{linecolor=green,linewidth=2pt,arrowsize=5pt,arrows=->}
 \arrowLine(0,3)(END){2}
 \ABinterCD(END)(END')(A)(B){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(B)(A){1.5}{1}{Q}
 \arrowLine(Q)(Q'){1}
 \psOutLine[length=2](Q)(Q'){End}
%
% 3.
%
 \refractionRay(3,3)(2,2)(C)(D){1}{1.5}{END}
 \psset{linecolor=blue,linewidth=2pt,arrowsize=5pt,arrows=->}
 \arrowLine(3,3)(END){2}
 \ABinterCD(END)(END')(B)(A){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(B)(A){1.5}{1}{Q}
 \arrowLine(Q)(Q'){1}
 \psOutLine[length=2](Q)(Q'){End}
\end{pspicture}
```

13 Parallel Rays and a sloping medium

Refrectionnumbers are $n_1 = 1$ and $n_2 = 1.5$:



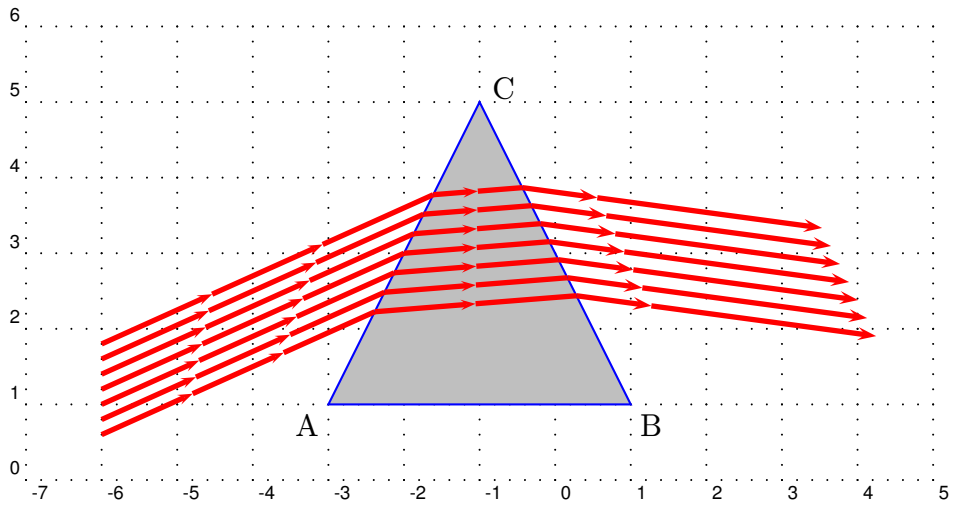

```
\begin{pspicture}(-7,-1)(5,6)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
```

pst-optic-examples.tex

```
 \pnode(0,0){A}
 \pnode(2,0){B}
 \pnode(2,5){C}
 \pnode(0,5){D}
 \rotateFrame(A)(B)(C)(D){45}
 \uput[-135](A){A}\uput[-45](B){B}
 \uput[30](C){C}\uput[135](D){D}
 \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)
 \psset{linecolor=red,linewidth=2pt,arrowsize=5pt,arrows=->}
 \multido{\r=3.0+-0.3}{8}{%
  \refractionRay(-7,\r)(-4,\r)(D)(A){1}{1.25}{END}
  \arrowLine(-7,\r)(END){2}
  \ABinterCD(END)(END')(C)(B){Out}
  \arrowLine(END)(Out){1}
  \refractionRay(END)(Out)(C)(B){1.25}{1}{Q}
  \psline(Q)(Q')
  \psOutLine[length=3](Q)(Q'){End}%
 }
\end{pspicture}
```

14 A Prisma

Refrectionnumbers are $n_1 = 1$ and $n_2 = 1.5$:




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

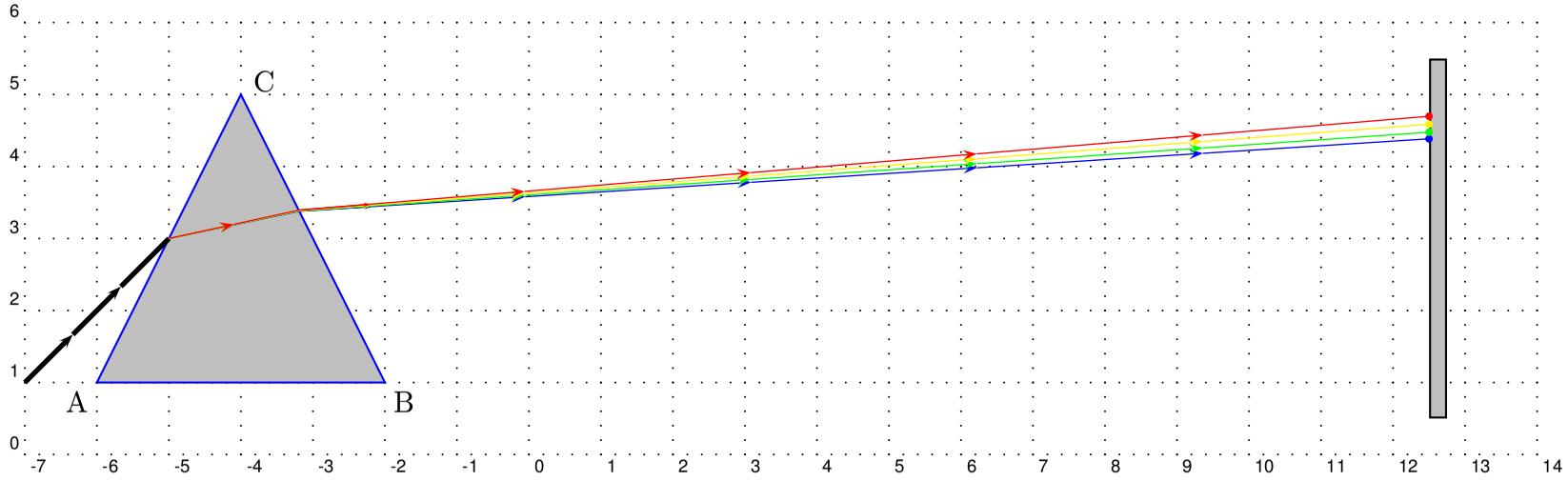
pst-optic-examples.tex

```
    \psline(Q)(Q')
    \psOutLine[length=3](Q)(Q'){End}%
  }
\end{pspicture}
```

15 A Prisma for Dispersion

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

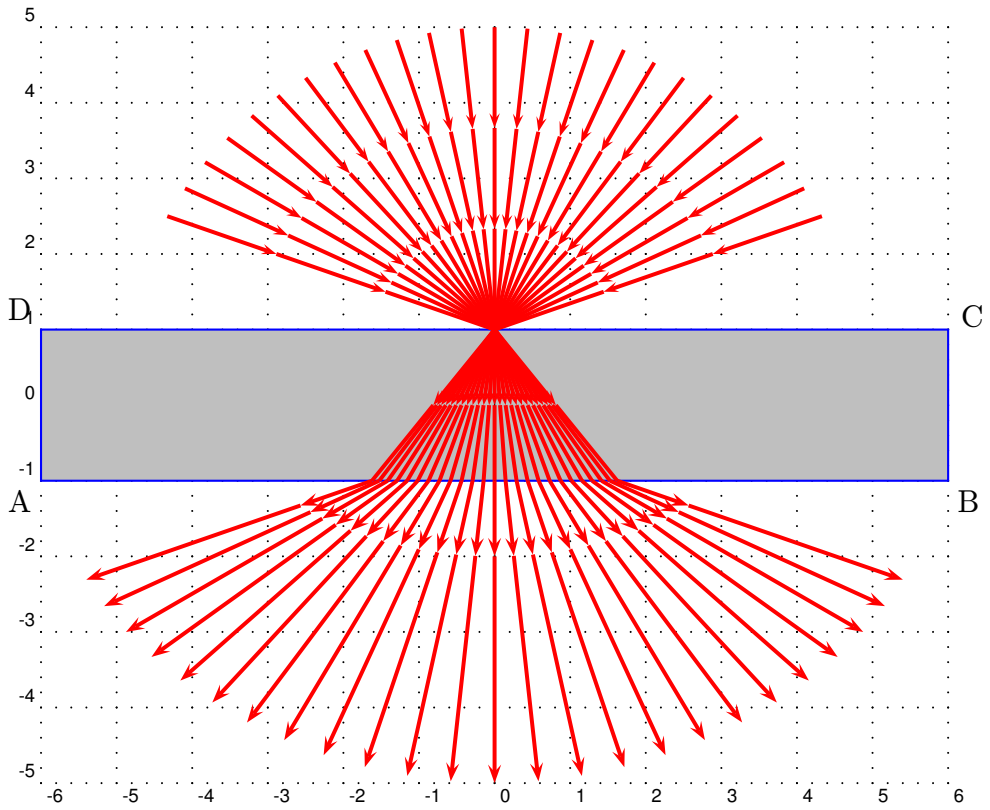
Color	Refraction number n for glass
dark blue	1.528
bluegreen	1.523
yellow	1.517
red	1.514
darkred	1.511



```
\begin{pspicture}(-7,0)(14,6)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
 \pnode(-6,1){A}\pnode(-2,1){B}\pnode(-4,5){C}
 \uput[-135](A){A}\uput[-45](B){B}\uput[30](C){C}
 \pnode(12.5,0.5){E1}\pnode(12.5,5.5){E2}
 \psframe[fillcolor=lightgray,fillstyle=solid](E1)(12.75,5.5)
 \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)
 \psset{linecolor=black,linewidth=2pt,arrowsize=5pt,arrows=->}
 \pnode(-7,1){P1}\pnode(-6,2){P2}
 \ABinterCD(P1)(P2)(C)(A){END}
 \arrowLine(P1)(END){2}
%
 \psset{linecolor=blue,linewidth=0.5pt,arrowsize=2pt,}
 \refractionRay(P1)(P2)(C)(A){1}{1.528}{END}
 \ABinterCD(END)(END')(C)(B){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(C)(B){1.528}{1}{Q}
 \psline(Q)(Q')
 \ABinterCD(Q)(Q')(E1)(E2){END}
 \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
%
 \psset{linecolor=green}
 \refractionRay(P1)(P2)(C)(A){1}{1.523}{END}
 \ABinterCD(END)(END')(C)(B){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(C)(B){1.523}{1}{Q}
 \psline(Q)(Q')
 \ABinterCD(Q)(Q')(E1)(E2){END}
 \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
%
 \psset{linecolor=yellow}
 \refractionRay(P1)(P2)(C)(A){1}{1.517}{END}
 \ABinterCD(END)(END')(C)(B){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(C)(B){1.517}{1}{Q}
 \psline(Q)(Q')
 \ABinterCD(Q)(Q')(E1)(E2){END}
 \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
%
 \psset{linecolor=red}
 \refractionRay(P1)(P2)(C)(A){1}{1.511}{END}
 \ABinterCD(END)(END')(C)(B){Out}
 \arrowLine(END)(Out){1}
 \refractionRay(END)(Out)(C)(B){1.511}{1}{Q}
 \psline(Q)(Q')
 \ABinterCD(Q)(Q')(E1)(E2){END}
 \arrowLine(Q)(END){4}\qdisk(END){1.5pt}
\end{pspicture}
```

16 Refration with different Angles

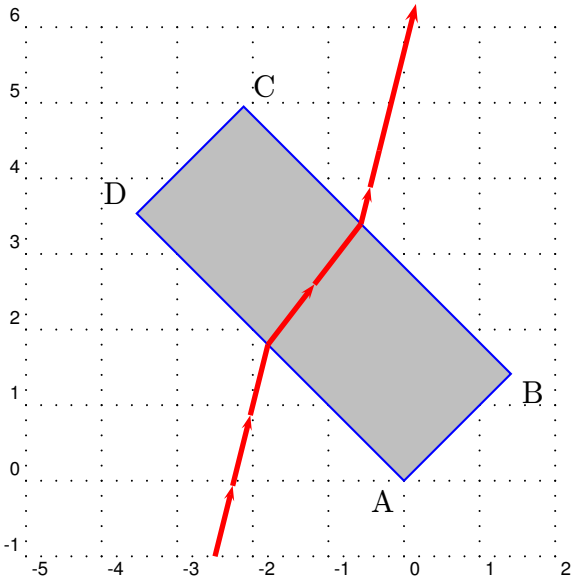
Refrectionnumbers are $n_1 = 1$ and $n_2 = 1.5$:




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

17 Great difference in the Refractionsnumbers

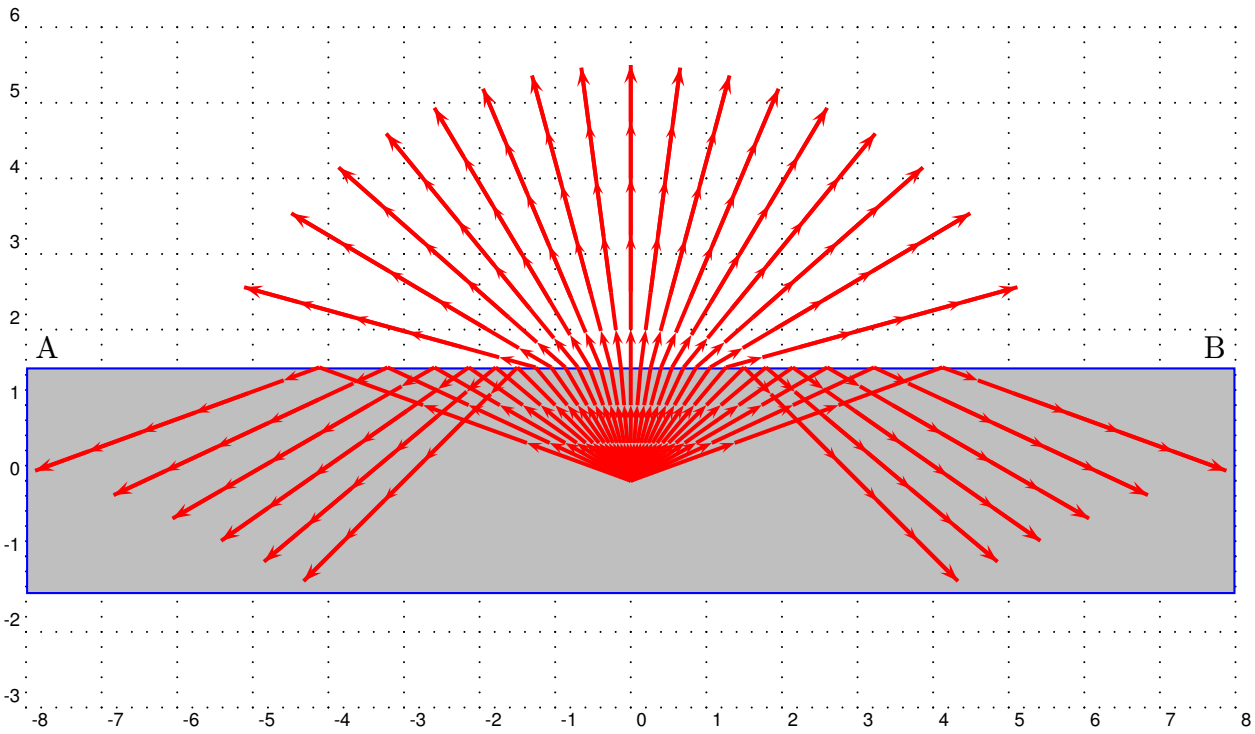
Refrectionnumbers are $n_1 = 1$ and $n_2 = 4$:




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

18 Total Reflection

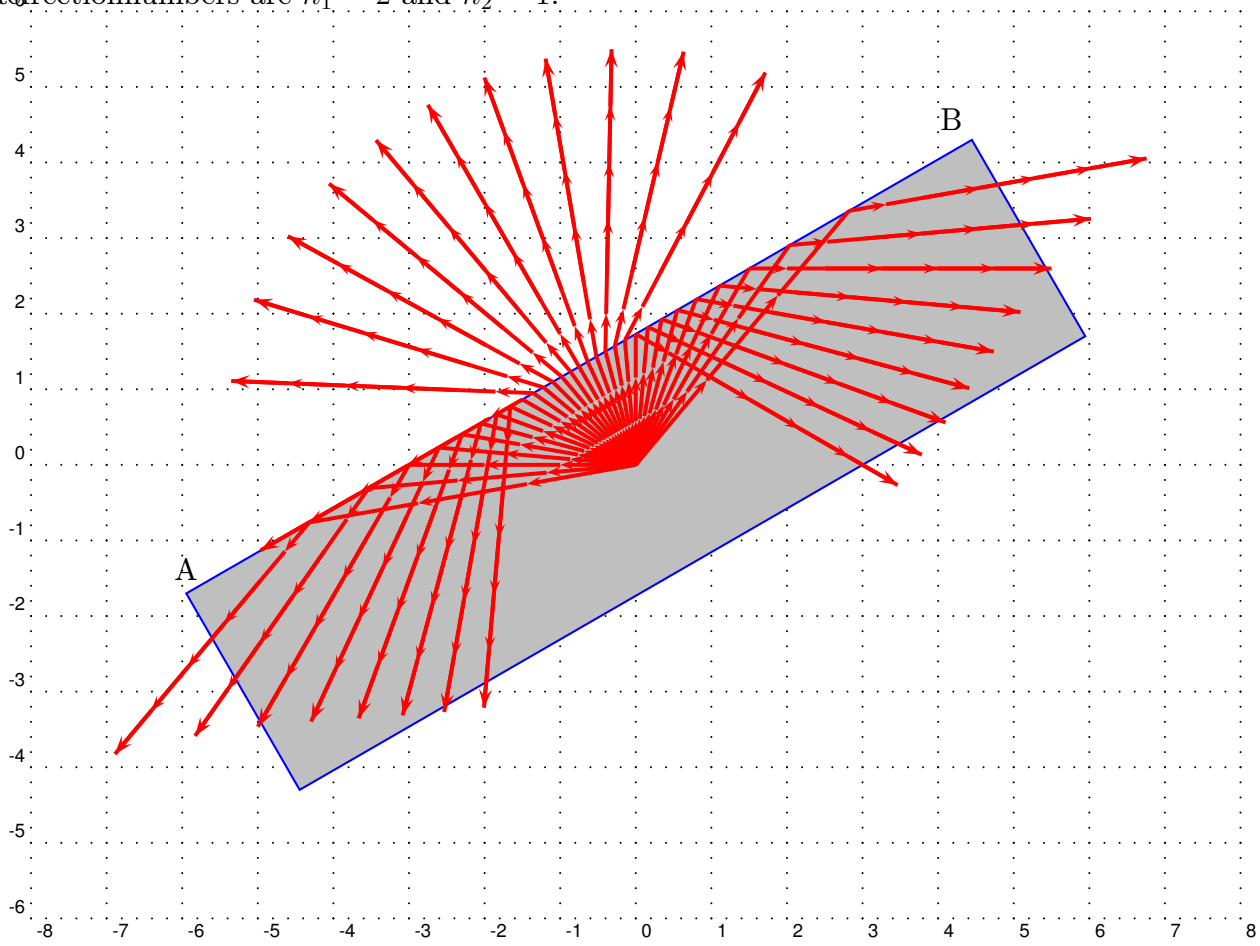
Refrectionnumbers are $n_1 = 2$ and $n_2 = 1$:




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

19 Total Reflection with a sloping medium

Refrectionnumbers are $n_1 = 2$ and $n_2 = 1$:

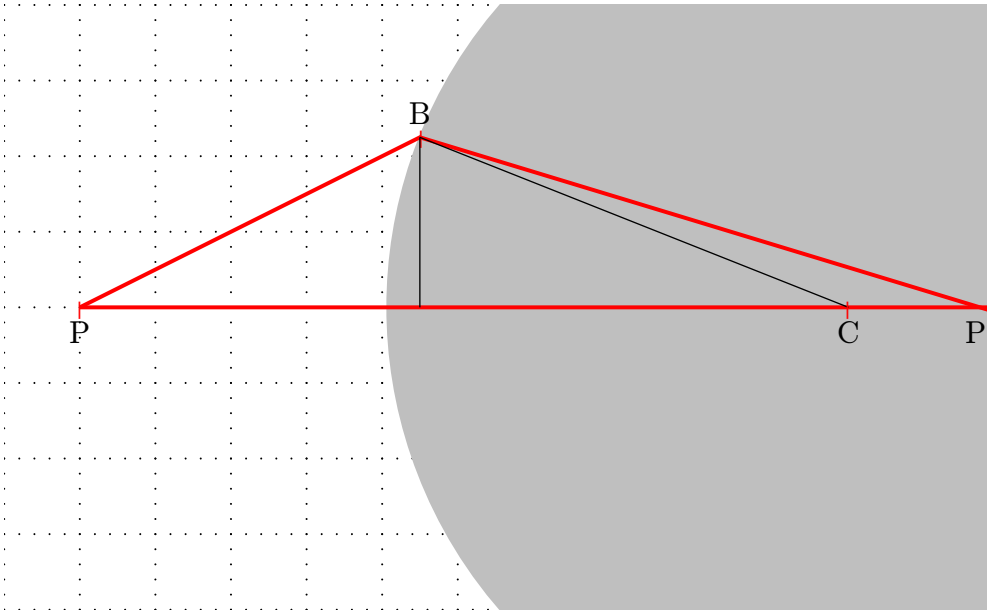



```
\begin{pspicture}(-8,-6)(8,6)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
 \pnode(-6,1.5){A}\pnode(6,1.5){B}
 \pnode(6,-1.5){C}\pnode(-6,-1.5){D}
 \rotateFrame(A)(B)(C)(D){30}
 \uput[90](A){A}\uput[135](B){B}
 \pnode(0,0){START}
 \pspolygon[fillcolor=lightgray,fillstyle=solid,linecolor=blue](A)(B)(C)(D)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

Part IV
Spherical Optic

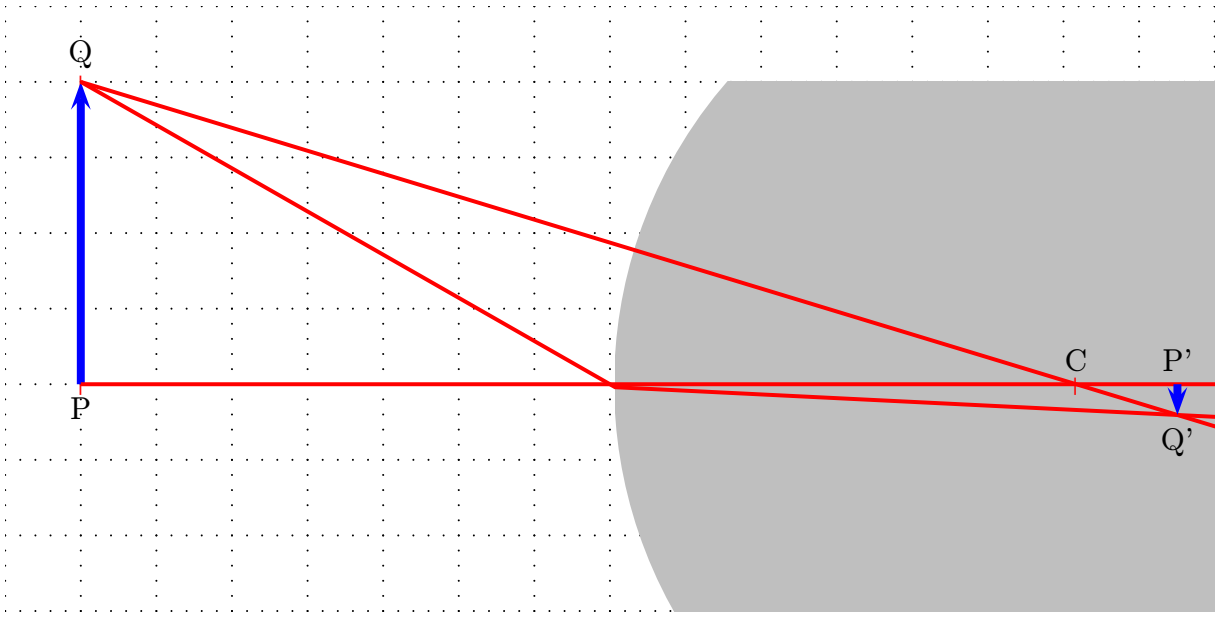
20 Refraction at a Spherical Surface

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




```
\begin{pspicture}*(-10,-4)(3,4)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
 \rput(0,0){\lensSPH[%
  lensType=CVG,%
  lensHeight=12,%
  lensWidth=10,%
  yBottom=-4,yTop=4,xLeft=-5,xRight=5,%
  drawing=false]}
 \psset{linecolor=red,linewidth=1.5pt,dotstyle=|}
 \pnode(-9,0){P}\psdots(P)\uput[-90](P){P}
 \psline(P)(xRight)
 \lensSPHRay(P)(-5,2){1}{9}{Q}%
 \psline(P)(Q)(Q')
 \psdots(Q)\uput[90](Q){B}
 \ABinterCD(Q)(Q')(0,0)(5,0){P'}
 \psdots(Q')\uput[-90](P'){P'}
 \psline[linewidth=0.5pt,linecolor=black](Center')(Q)
 \psline[linewidth=0.5pt,linecolor=black](Q)(Q|0,0)
 \psdots(Center')\uput[-90](Center'){C}
\end{pspicture}
```

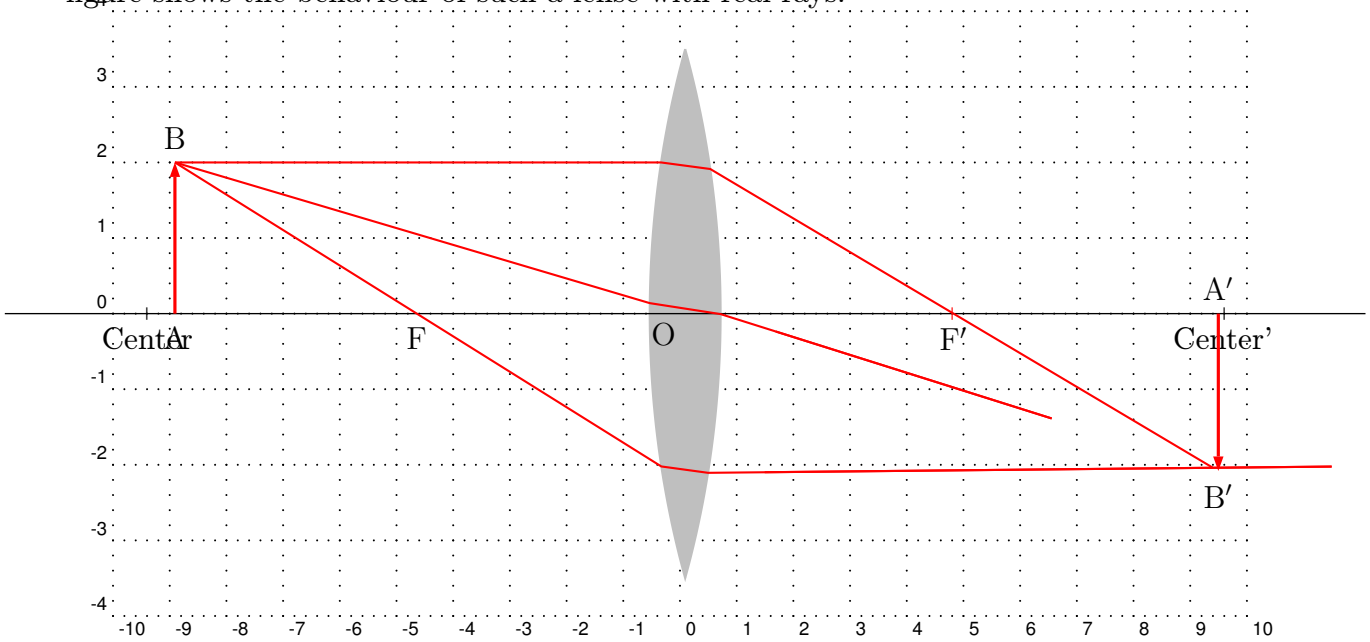
20.2 Construction for determining the height of an image formed by refraction at a sperical surface




```
\begin{pspicture}*(-13,-3)(3,5)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
 \rput(0,0){\lensSPH[%
  lensType=CVG,%
  lensHeight=12,%
  lensWidth=10,%
  yBottom=-4,yTop=4,xLeft=-5,xRight=5,%
  drawing=false]}
 \psset{linecolor=red,linewidth=1.5pt,dotstyle=|}
 \pnode(-12,0){P}\psdots(P)\uput[-90](P){P}
 \pnode(-12,4){Q}\psdots(Q)\uput[90](Q){Q}
 \psline[linecolor=blue,linewidth=3pt,arrows=->](P)(Q)
 \psline(P)(xRight)
 \lensSPHRay(Q)(Center')\{1}{9}{S1}%
 \lensSPHRay(Q)(-5,0){1}{9}{S2}%
 \psline(Q)(S1')
 \psline(Q)(S2)(S2')
 \ABinterCD(Q)(S1')(S2)(S2'){Q'}
 \pnode(Q'|0,0){P'}
 \psline[linecolor=blue,linewidth=3pt,arrows=->](P')(Q')
 \uput[90](P'){P'}
 \uput[-90](Q'){Q'}
 \psdots(Center')\uput[90](Center'){C}
\end{pspicture}
```

21 Thin Convergent Lenses

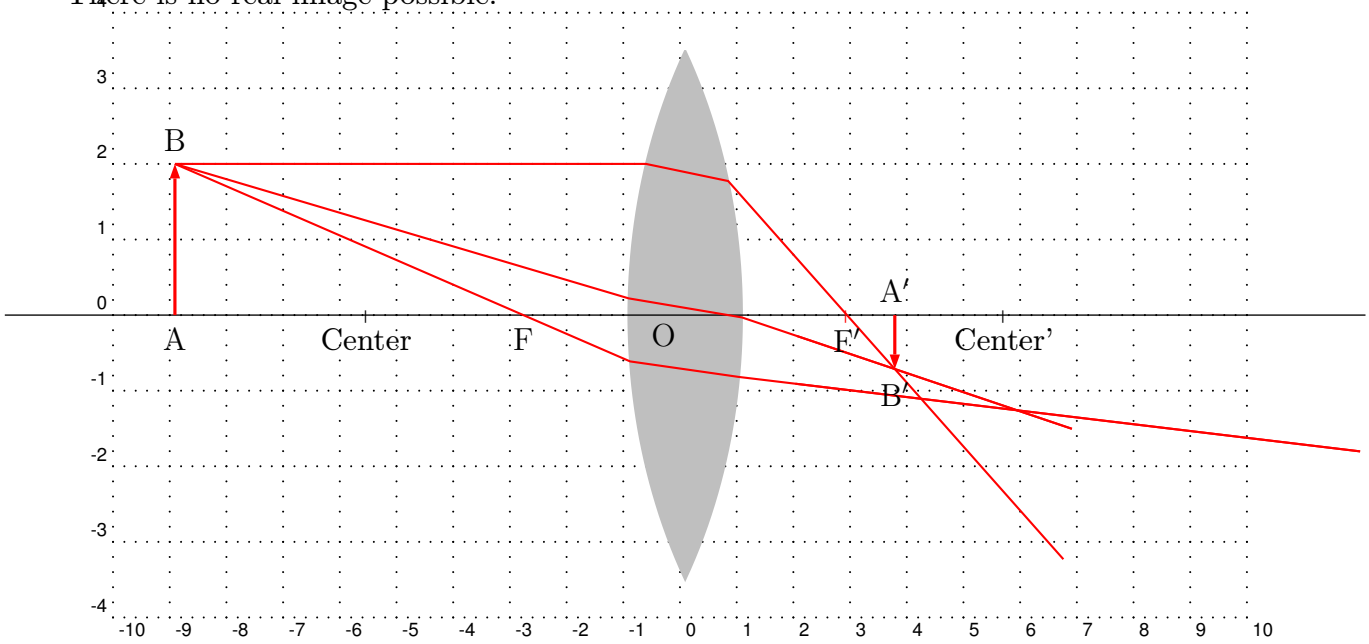
If the two spherical surfaces are close enough we can call such a lense a **thin lens**. The following figure shows the behaviour of such a lense with real rays.




```
\psset{xunit=0.75cm}
\begin{pspicture}(-10,-4)(10,4)
 \psgrid[subgriddiv=0,griddots=5,gridlabels=7pt]
 \rput(0,0){\lensSPH[%
  lensType=CVG,%
  lensHeight=7,%
  lensWidth=1.25,%
  yBottom=-5,yTop=5,xLeft=-12,xRight=12,%
  AB=2,OA=-9,%
  refractA=1,refractB=2,%
  drawing=true,%
  rayColor=red]}
\end{pspicture}
```

22 Thick Convergent Lenses

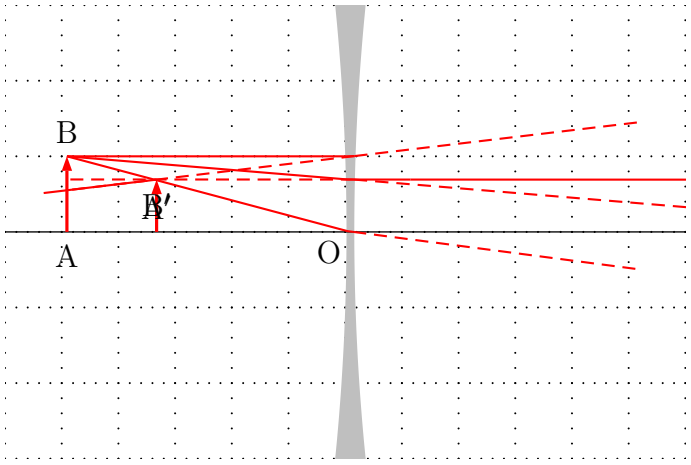
There is no real image possible.




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

23 Thin Divergent Lenses

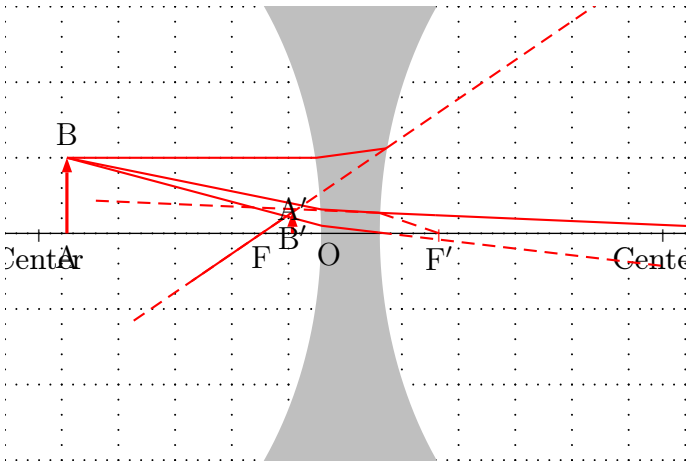
If the two spherical surfaces are close enough we can call such a lense a **thin lens**. The following figure shows the behaviour of such a lense with real rays.




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

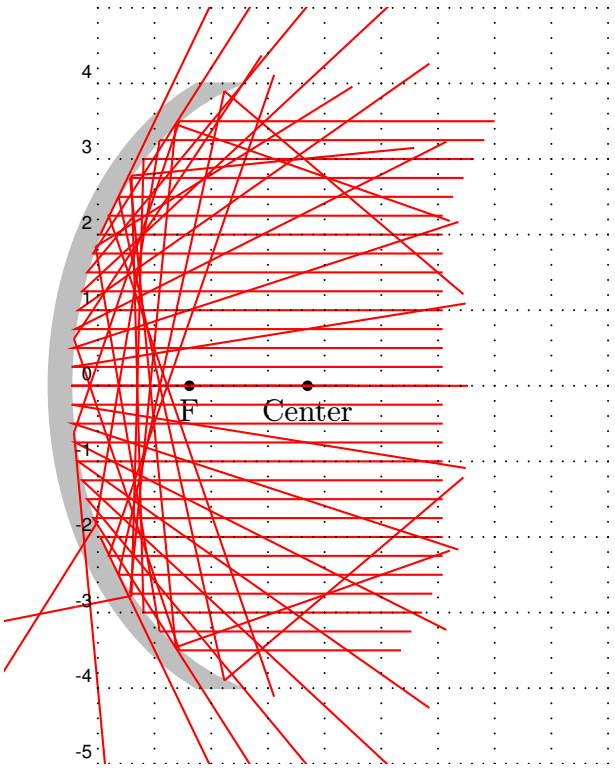
24 Thick Divergent Lenses

There is no real image possible.




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

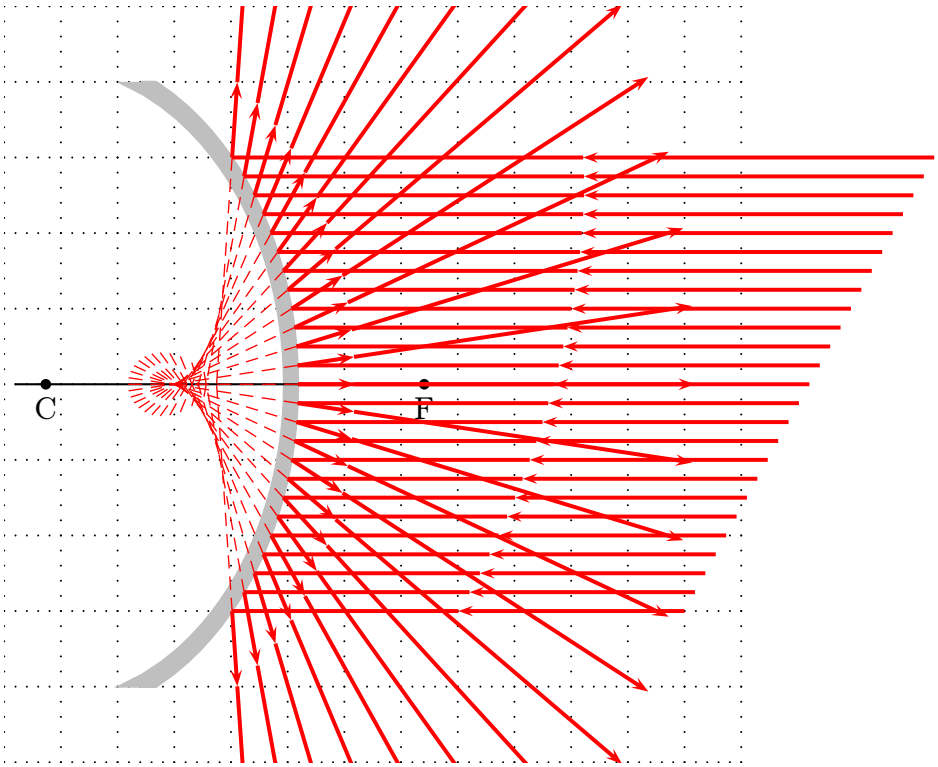
25 \mirrorCVG




```
\begin{pspicture*}(-1,-5)(8,5)
 \rput(0,0){%
  \mirrorCVG[%
   mirrorType=SPH,%
   drawing=false,%
   yBottom=-4,yTop=4,%
   mirrorHeight=8,%
   mirrorDepth=3]%
  \qdisk(Center){2pt}\qdisk(Focus){2pt}
  \uput[-90](Center){Center}\uput[-90](Focus){F}
  \psline(0)(xRight)
 }
 \multido{\rA=-3.50+0.25}{5}{%
  \mirrorCVGRay[mirrorType=SPH,linecolor=red](8,\rA)(4,\rA){E}
  \psOutLine[linecolor=red,length=4](E')(E''){EEnd}
 }
 \multido{\rA=-2.25+0.25}{19}{%
  \ABinterSPHLens(8,\rA)(4,\rA)(Center){Ptemp}
  \reflectionRay[mirrorType=CVG-SPH](5,\rA)(Ptemp){E}
  \psline[linecolor=red](8,\rA)(Ptemp)(E)
  \psOutLine[linecolor=red,length=6](Ptemp)(E){EEnd}
 }
 \multido{\rA=2.50+0.25}{5}{%
  \mirrorCVGRay[mirrorType=SPH,linecolor=red](8,\rA)(4,\rA){E}
  \psOutLine[linecolor=red,length=4](E')(E''){EEnd}
 }
 \psgrid
```

```
\end{pspicture*}
```

26 \mirrorDVG




```
\begin{pspicture*}(-5,-5)(8,5)
 \psgrid
 \rput(0,0){%
  \mirrorDVG[%
   mirrorType=SPH,%
   drawing=false,%
   yBottom=-4,yTop=4,%
   mirrorHeight=8,%
   mirrorWidth=0.25,%
   mirrorDepth=2.5]%
  \qdisk(Center){2pt}\qdisk(Focus){2pt}
  \uput[-90](Center){C}\uput[-90](Focus){F}
  \psline(xLeft)(xRight)
 }
 \multido{\rA=-3.00+0.25}{25}{%
  \ABinterSPHLens(7,\rA)(4,\rA)(Center){Ptemp}
  \reflectionRay[mirrorType=SPH](5,\rA)(Ptemp){E}
  \arrowLine[linecolor=red,linewidth=1.5pt](7,\rA)(Ptemp){1}
  \psline[linecolor=red,arrows=->,linewidth=1.5pt](Ptemp)(E)
  \psOutLine[linecolor=red,%
   length=6,linewidth=1.5pt,%
   arrows=->](Ptemp)(E){EEnd}
  \psOutLine[linecolor=red,%
   length=3,linestyle=dashed,%
```

```
    linewidth=0.5pt](E)(Ptemp){EEnd}
  }
\end{pspicture*}
```