



TikZ in Physics

\LaTeX Workshop 2017

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for the gifted**

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Outline

- 1 Tikz in Physics
- 2 Using Variables
- 3 3D image onto 2D space

Tikz in
Physics

Using
Variables

3D image
onto 2D space

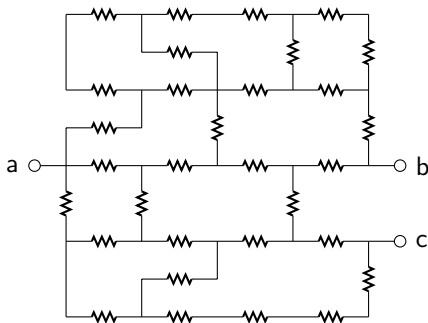
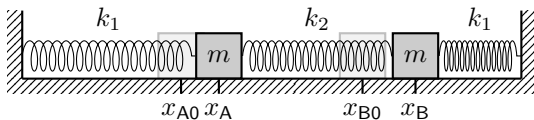


Tikz in Physics

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Tikz in Physics

In the preamble,

```
\usetikzlibrary{decorations.pathmorphing}
```

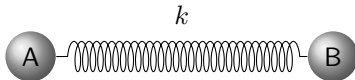
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In the document,

```
\begin{tikzpicture}  
\node[circle,shade,shading=ball,ball color=black!20] (A)  
  at (0,0) {A};  
\node[circle,shade,shading=ball,ball color=black!20] (B)  
  at (4,0) {B};  
\draw[decoration={coil,aspect=0.3,segment length=1mm,  
  amplitude=2mm,pre length=1.5mm,post length=1mm},  
  decorate] (A) -- (B) node[pos=0.5,above=3mm] {$k$};  
\end{tikzpicture}
```





Tikz in Physics

In the preamble,

```
\usepackage{circuitikz}
```

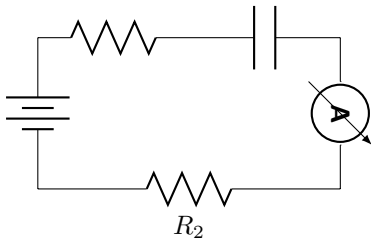
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In the document,

```
\begin{circuitikz}  
\draw (0,0) to[battery] (0,2) to[R] (2,2) to[capacitor]  
      (4,2) to[ammeter] (4,0) to[R= $R_2$ ] (0,0);  
\end{circuitikz}
```



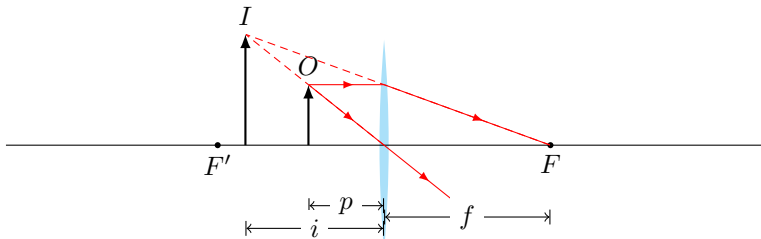
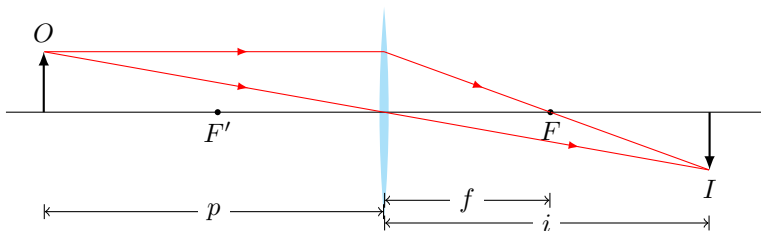


Using Variables

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$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f} \quad (\text{Lens law})$$



Using Variables

Let's make a macro in the preamble:

```
\newcommand{\ConvLens}[3]
% {<focal length>}{<object distance>}{<object height>}
\begin{tikzpicture}
% drawing here~~
\end{tikzpicture}
}% end of newcommand
```

Then write the defined command in the document as follows

```
\begin{document}
\ConvLens{2.2}{4.5}{0.8}
\end{document}
```



Using Variables

First of all, we define additional parameters in the tikzpicture environment (in 'ConvLens' newcommand).

```
%% [1] variables %%
\def\R{16} % curvature radius of lens
\def\tht{5} % angular size of lens[degree]
\def\img{#2*#1/(#2 - #1)} % image's distance from lens
\def\h{-#3*#1/(#2 - #1)} % image height
```

Then focal point, object's position, and image's position are named as 'F', 'O', 'I' for simplicity:

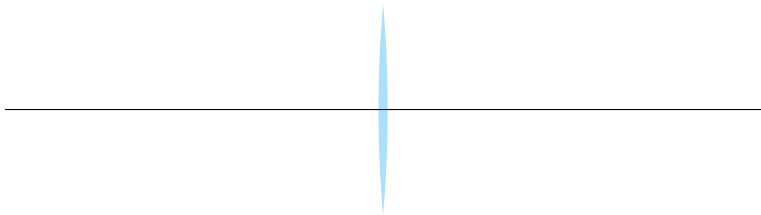
```
%% [2] positions %%
\node[inner sep=0cm,minimum size=0cm]
      (F) at (#1,0) {}; % focal point
\node[inner sep=0cm,minimum size=0cm]
      (O) at (-#2,#3) {}; % object
\node[inner sep=0cm,minimum size=0cm]
      (I) at ({\img},{\h}) {}; % image
```




Using Variables

Drawing the converging lens and the central line:

```
%% [3] lens %%  
\fill[cyan!30] (0,{\R*\sin(\tht)})  
    arc ({180-\tht}:{180+\tht}:\R)  
    arc (-\tht:\tht:\R); % converging lens  
\draw (-5,0) -- (5,0); % central line
```

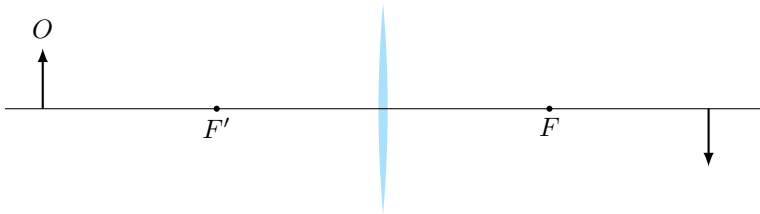




Using Variables

Drawing symbols:

```
%% [4] symbols %%  
\fill[black] (F) circle (0.04)  
    node[below]{$F$}; % focal point  
\fill[black] (-#1,0) circle (0.04)  
    node[below] {$F^\prime$}; % focal point 2  
\draw[-latex,thick] (-#2,0) -- ++(0,#3)  
    node[pos=1,anchor=south] {$O$}; % object  
\draw[-latex,thick] ({\i},0) -- ++(0,{\h}); % image
```



The location of letter 'I' is different depending on the image's orientation.

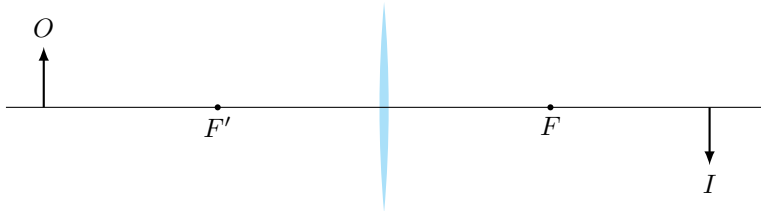


Using Variables

Inserting the letter ' I ' using 'ifthenelse':

- Write `\usepackage{ifthen}` in the preamble.
- In the tikzpicture environment, write follows

```
%% [4-1] 'I' automatic positioning %%  
\ifthenelse{\lengthtest{#2 cm < #1 cm}}  
  {\node[above] at (I) { $I$ };}  
  {\node[below] at (I) { $I$ };}
```





Using Variables

Before drawing rays, we'll define a new arrow 'middlearrow'. In the preamble, write that

```
\usetikzlibrary{decorations.markings}
\tikzset{middlearrow/.style={
  decoration={markings,
    mark=at position 0.6 with {\arrow{latex}}},
  postaction={decorate}
}}
```

then we can obtain a line with the arrow head near the mid-point:

```
\begin{tikzpicture}
\draw[middlearrow,red] (0,0) -- (4,0);
\end{tikzpicture}
```





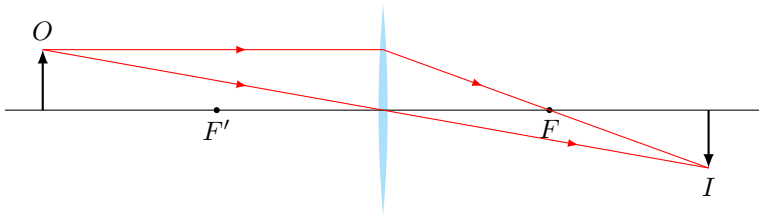
Using Variables

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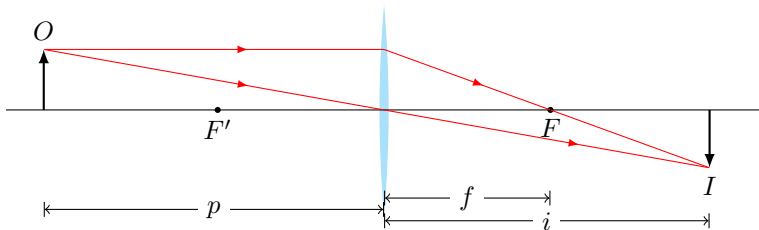
```
%% [5] drawing rays %%
\draw[middlearrow,red] (0) -- (0,0);
\draw[middlearrow,red] (0) -- (0,#3);
\draw[middlearrow,red] (0,#3) -- (F);
\ifthenelse{\lengthtest{#2 cm < #1 cm}}
  {\draw[densely dashed,red] (0,0) -- (I);
   \draw[densely dashed,red] (F) -- (I);
   \draw[middlearrow,red] (0,0) -- (#2,-#3);}
  {\draw[middlearrow,red] (0,0) -- (I);
   \draw[red] (F) -- (I);}
```





Using Variables

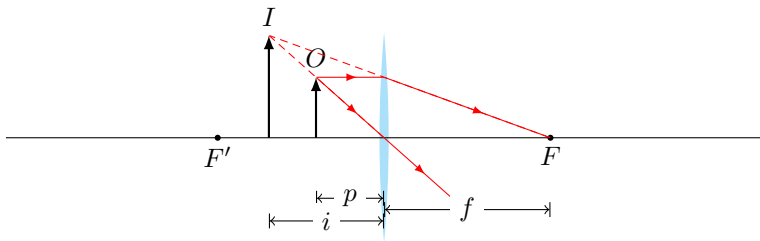
```
%% [6] description of lenth; p, i, f %%
\ifthenelse{\lengthtest{#2 cm < #1 cm}}
{\draw [|<->|] (0,-#3) -- ++(-#2,0)
  node[pos=0.5,fill=white]{$p$};
  \draw [|<->|] (0,{-#3 - 0.3}) -- ++({\i},0)
  node[pos=0.5,fill=white]{$i$};
  \draw [|<->|] (0,{-#3 - 0.15}) -- ++(#1,0)
  node[pos=0.5,fill=white]{$f$};}
{\draw [|<->|] (0,{\h - 0.55}) -- ++(-#2,0)
  node[pos=0.5,fill=white]{$p$};
  \draw [|<->|] (0,{\h - 0.7}) -- ++({\i},0)
  node[pos=0.5,fill=white]{$i$};
  \draw [|<->|] (0,{\h - 0.4}) -- ++(#1,0)
  node[pos=0.5,fill=white]{$f$};}
```



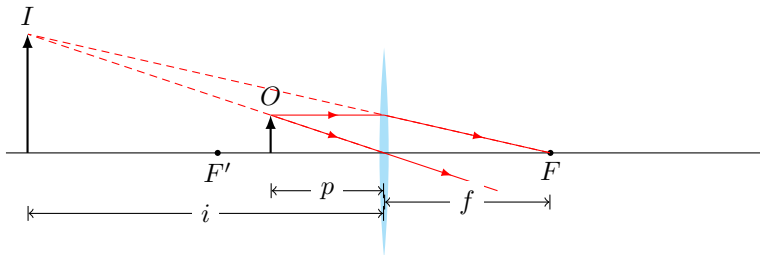


Using Variables

`\ConvLens {2.2}{0.9}{0.8}`



`\ConvLens {2.2}{1.8}{0.5}`



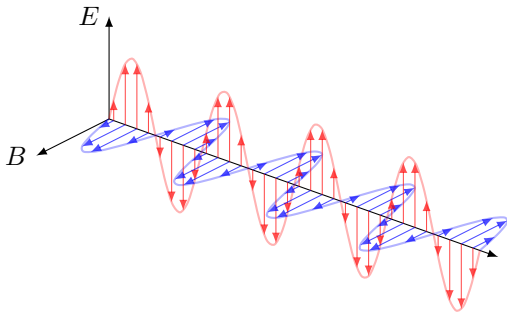
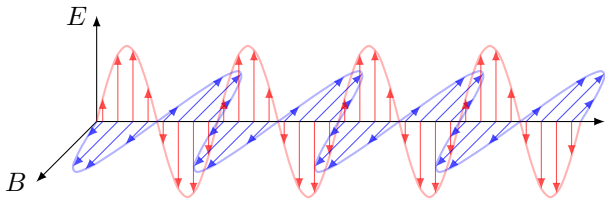


3D image onto 2D space

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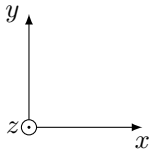
3D image
onto 2D space





3D image onto 2D space

3D rectangular coordinate axes on 2D screen is

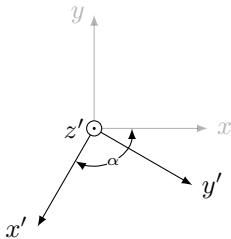


Tikz in
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Coordinates' rotation will be performed twice. At first, rotation $-\alpha$ about z -axis. ($\alpha \sim 120^\circ$ is recommended.)



$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} \cos \alpha & \sin \alpha & 0 \\ -\sin \alpha & \cos \alpha & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix}$$

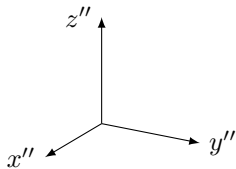
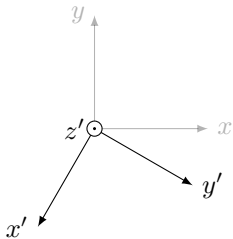


3D image onto 2D space

Next, rotation $-\beta$ about x -axis. ($\beta \sim 70^\circ$ is recommended.)

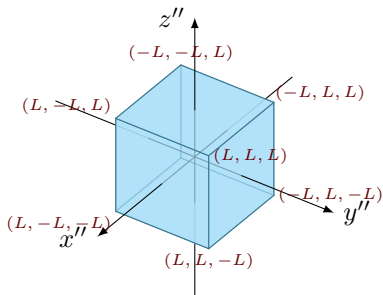
$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos \beta & \sin \beta \\ 0 & -\sin \beta & \cos \beta \end{pmatrix} \begin{pmatrix} x'' \\ y'' \\ z'' \end{pmatrix}$$

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} x'' \cos \alpha + y'' \sin \alpha \\ -x'' \sin \alpha \cos \beta + y'' \cos \alpha \cos \beta + z'' \sin \beta \\ x'' \sin \alpha \sin \beta - y'' \cos \alpha \sin \beta + z'' \cos \beta \end{pmatrix}$$





3D image onto 2D space



3-dim. coords.

$$(L, L, L)$$

2-dim. coords.

$$\left(\{L \cos \alpha + L \sin \alpha\}, \right. \\ \left. \{-L \sin \alpha \cos \beta + L \cos \alpha \cos \beta + L \sin \beta\} \right)$$



3D image onto 2D space

In preamble,

```
\newcommand{\MyCube}[6]{
%{<edge length>}{<rot-alpha>}{<rot-beta>}
%{<color-x>}{<color-y>}{<color-z>}
\begin{tikzpicture}
\draw[fill=#4] ({0.5*#1*cos(#2)+0.5*#1*sin(#2)},{-0.5*#1*
sin(#2)*cos(#3)+0.5*#1*cos(#2)*cos(#3)+0.5*#1*sin(#3)
}) -- ++({-#1*sin(#2)},{-#1*cos(#2)*cos(#3)}) --
++(0,{-#1*sin(#3)}) -- ++({#1*sin(#2)},{#1*cos(#2)*
cos(#3)}) -- cycle;
\draw[fill=#5] ({0.5*#1*cos(#2)+0.5*#1*sin(#2)},{-0.5*#1*
sin(#2)*cos(#3)+0.5*#1*cos(#2)*cos(#3)+0.5*#1*sin(#3)
}) -- ++({-#1*cos(#2)},{#1*sin(#2)*cos(#3)}) -- ++(0,
{-#1*sin(#3)}) -- ++({#1*cos(#2)},{-#1*sin(#2)*cos(#
3)}) -- cycle;
\draw[fill=#6] ({0.5*#1*cos(#2)+0.5*#1*sin(#2)},{-0.5*#1*
sin(#2)*cos(#3)+0.5*#1*cos(#2)*cos(#3)+0.5*#1*sin(#3)
}) -- ++({-#1*cos(#2)},{#1*sin(#2)*cos(#3)}) -- ++({-
#1*sin(#2)},{-#1*cos(#2)*cos(#3)}) -- ++({#1*cos(#2)}
,{-#1*sin(#2)*cos(#3)}) -- cycle;
\end{tikzpicture}
}% end of newcommand 'MyCube'
```

Tikz in
Physics

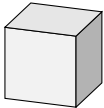
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3D image onto 2D space

```
\MyCube{1}{110}{70}{black!5}{black!30}{black!10}
```

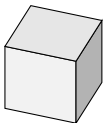


Tikz in
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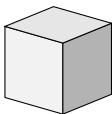
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```
\MyCube{1}{110}{55}{black!5}{black!30}{black!10}
```



```
\MyCube{1}{130}{70}{black!5}{black!30}{black!10}
```





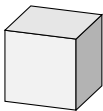
3D image—‘tikz-3dplot’

In the preamble,

```
\usepackage{tikz-3dplot}
```

In the main document,

```
\tdplotsetmaincoords{70}{110}
\begin{tikzpicture}[tdplot_main_coords]
\draw[fill=black!5] (0.5,0.5,0.5) -- ++(0,-1,0) --
  ++(0,0,-1) -- ++(0,1,0) -- cycle;
\draw[fill=black!30] (0.5,0.5,0.5) -- ++(-1,0,0) --
  ++(0,0,-1) -- ++(1,0,0) -- cycle;
\draw[fill=black!10] (0.5,0.5,0.5) -- ++(-1,0,0) --
  ++(0,-1,0) -- ++(1,0,0) -- cycle;
\end{tikzpicture}
```



This is equivalent to ‘\MyCube{1}{110}{70}...’



3D image—‘tikz-3dplot’

```
\tdplotsetmaincoords{65}{130}
\begin{tikzpicture}[tdplot_main_coords]
\def\L{1.6}
\def\A{1}
\draw[-latex] (0,0,0) -- (0,{4*\L + 0.2},0);
\draw[-latex] (0,0,0) -- ({\L+0.2},0,0);
\draw[-latex] (0,0,0) -- (0,0,{\L+0.2});
\draw[domain=0:4,samples=49,smooth,thick,red,opacity=0.3]
  plot (0,{\x*\L},{\A*sin(360*\x)});
\draw[domain=0:4,samples=49,smooth,thick,blue,opacity
  =0.3] plot ({\A*sin(360*\x)},{\x*\L},0);
\foreach \y in{0.05,0.175,...,4.01}{
\draw[-latex,red,opacity=0.7] (0,{\y*\L},0) -- ++(0,0,{\A
  *sin(360*\y)});
\draw[-latex,blue,opacity=0.7] (0,{\y*\L},0) -- ++({\A*
  sin(360*\y)},0,0);
}
\end{tikzpicture}
```

