usepackage{*TikZ*} for economists

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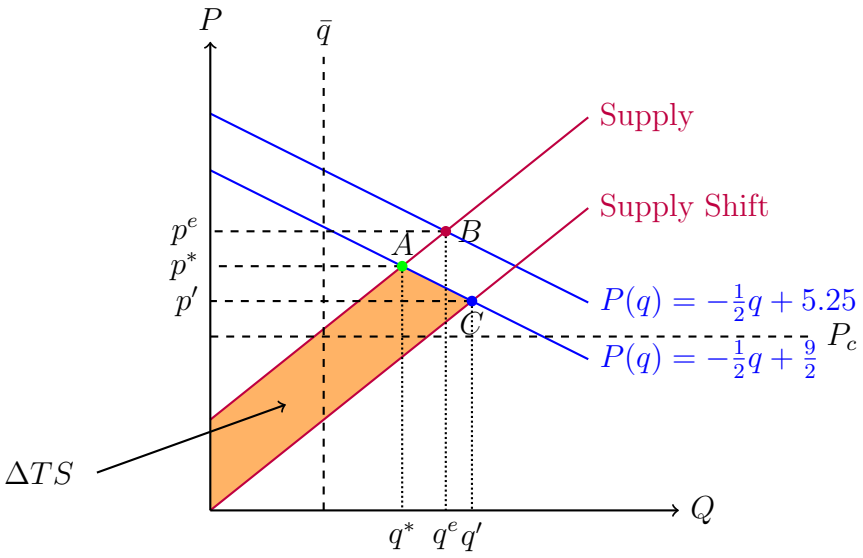


Abstract

This is a short guide on how to use the LaTeX package TikZ to quickly create some frequently used diagrams common to an undergraduate microeconomics class. Any comments or questions can be e-mailed directly to kevingoulding@gmail.com with subject heading "TikZ for economists".

Introduction

TikZ is a package that is useful for creating graphics by via coding direclty in your LaTek document. For example, rather than generating a graphic file (.pdf, .jpg, etc.) and linking to it in your LaTeX code, you include TikZ code in your LaTeX document that tells your compiler how to draw. There are several advantages to using TikZ code:

1. Less complicated file structure - all your figures are self-contained within your LaTeX document.
2. Beautiful results, with no loss of resolution when scaled up or down.
3. The ability to change diagrams by referencing variables within TikZ code.

Header

At the very top of you LaTeX document, always include:

```
1 \usepackage{tikz}
```

And, when you would like to begin a new TikZ diagram within your document, start (and finish it) with this code:

```
1 \begin{tikzpicture}
  % enter TikZ code here.
3 \end{tikzpicture}
```

A simple example

In this section, we will walk through the creation of the picture in Figure 1 at a high level, just to let you know in broad terms what is going on in the code shown below.

Starting the Figure

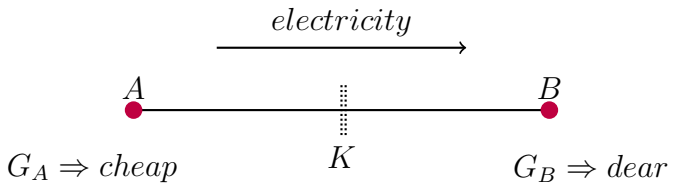
The first line of code (3) tells LaTeX to interpret the following code using the TikZ compiler. Here you also specify the scale of your image. This image has a scale value of 1.1, representing a 10% size increase over no scaling. Line 4 invokes a TikZ packages that allows you to calculate relative coordinate positions (see line 15 for an example of this).

Defining Coordinates

Lines 7-11 define the coordinates we will be using in this image as well as the specific labels we would like to place next to the coordinates. For example, line 8 says to define a coordinate A located at the cartesian coordinates (-2.5,2.5) and label the coordinate with a letter "A" above the coordinate. Later in the code we will be able to reference this coordinate simply as "A".

Notice that all the coordinate labels are surrounded by $, thus invoking LaTeX's math-mode. All code in math-mode (from the amsmath package) works here for labelling.

Figure 1: A two-node network




```
1  %                    TikZ code: Figure 1: A two-node network

3  \begin{tikzpicture}[scale=1.1,thick]
   \usetikzlibrary{calc} %allows coordinate calculations.
5
   % Define coordinates.
7      \coordinate [label= above:$A$]  (A) at  (-2.5,2.5);
       \coordinate [label= above:$B$] (B) at  (2.5,2.5);
9      \coordinate [label= above:$electricity$] (C) at  (0,3.25);
       \coordinate [label= above:$G_A \Rightarrow cheap$] (D) at  (-3,1.5);
11     \coordinate [label= above:$G_B \Rightarrow dear$] (E) at  (3,1.5);

13 % Draw lines and arrows.
       \draw (A) -- (B);
15     \draw[->] ($(A)+(1,0.75)$) -- ($(B)+(-1,0.75)$);
       \draw[densely dotted] (0,2.8) -- (0,2.2) node[below] {$K$};
17     \draw[densely dotted] (0.05,2.8) -- (0.05,2.2);

19  % Color in coordinates.
       \fill [purple] (A) circle (3pt);
21     \fill [purple] (B) circle (3pt);

23 \end{tikzpicture}
```

Drawing lines and arrows

Lines 14-17 essentially connects the coordinates with lines. Line 14 draws a line from coordinate A to coordinate B (as defined above). Line 15 calculates two new coordinates relative to coordinates

A and B, and connects them with an arrowed line by using the command [–¿]. The ability to calculate new coordinates in positions relative to other coordinates is a handy feature available in TikZ. For example, line 15 draws an (arrowed) line from a coordinate 1 unit to the right of coordinate A and 0.75 units above coordinate A to a new coordinate one unit to the left of coordinate B and 0.75 units above. Notice that these relative coordinate calculations need to be enclosed in $.

Lines 16 and 17 draw the small vertical lines above "K" in the diagram. Calling "densely dotted" changes the look of the line. Other types of lines are "dotted", "dashed", "thick" and several others. Because we called "thick" in line 4 of code, all these lines are a bit thicker than if we had not called the command. You can delete the option "thick" and do a visual comparison.

Coloring Coordinates

Lines 20 & 21 add the little note of color that you see in our diagram – the nodes in our network (coordinates A and B) are both small circles filled in with the color purple. This is accomplished with the "file" command. Note that colors other than purple can be invoked; feel free to try any of the usual colors (e.g. "green", "blue", "orange", etc.). The command circle draws a circle around coordinate A or B, and "(3pt)" determines the size of the circle.

A Few Things to Notice

TikZ code differs from LaTeX code in several ways:

1. In TikZ, each line must end in a semicolon.
2. Locations are specified via Cartesian Coordinates. Where is the origin? → The origin is horizontally centered on the page, but its vertical placement depends on the size of the entire picture. Ideally, the simple example shown above will give you an idea of how far a one-unit change represents. For example, the horizontal distance between node A and node B in Figure 1 is 5 units.
3. Similar to LaTeX code, most functions begin with a backward slash.

Defining Parameters

TikZ allows you to define parameter values and subsequently reference those values throughout your image (or the entire LaTeX) document. This feature enables you to update images quicker once you've set up your images as manipulations of parameters. The following is the TikZ code to define a parameter "inc" and set its value to 50.

```
1 \def\inc{50}
```

You will now be able to reference "inc" elsewhere in your figure. For example, the following code defines two parameters, then uses those parameter values to define a coordinate. In this case, x2 will be located at $(0, \frac{\text{inc}}{\text{pb}})$.

```
%Define parameters
\def\inc{50}     % parameter inc set = 50
\def\pa{19.5}    % parameter pa set = 19.5

% Define coordinates.
\coordinate (x2) at  (0,{\inc/\pb});
```

Plotting functions

TikZ allows you to plot functions. For example, see the following code.

```
\draw[domain=0.6:6] plot (\x,{10*exp(-1*\x-0.2)+0.3});
```

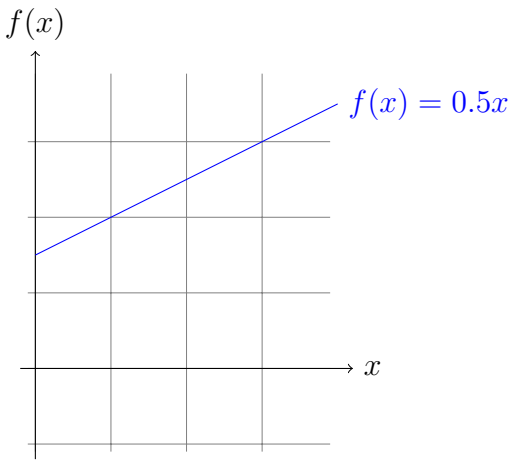
The code above plots the following function:

$$f(x) = 10e^{-x-0.2} + 0.3$$
$$\text{where } x \in [0.6, 6]$$

For the most part, functions can be specified using intuitive notation. For best results, install gnuplot on your computer, and you can access a larger set of functions.

See `http://www.texample.net/tikz/examples/tag/gnuplot/` for more of the capabilities of TikZ coupled with gnuplot.

The following example adds axes and a grid using the 'grid' specification with the 'draw' function.



```
\begin{tikzpicture}[domain=0:4]

% Draw grid lines.
\draw[very thin,color=gray] (-0.1,-1.1) grid (3.9,3.9);

% Draw x and f(x) axes.
\draw[->] (-0.2,0) -- (4.2,0) node[right] {$x$};
\draw[->] (0,-1.2) -- (0,4.2) node[above] {$f(x)$};

% Plot line with slope = 1/2, intercept = 1.5
\draw[color=blue] plot (\x,{1.5+0.5*\x}) node[right] {$f(x) = 0.5 x$};

\end{tikzpicture}
```

Coloring Area

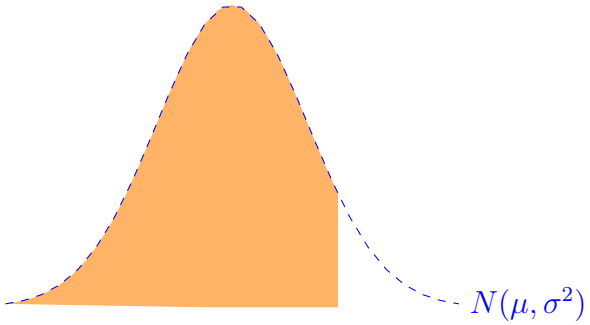
TikZ is capable of shading in areas of your diagram, bounded by coordinate or functions. This can be achieved by calling the 'fill' function as in the following example:

```
    \fill[orange!60] (0,0) -- (0,1) -- (1,1) -- (1,0) -- cycle;
```

This colors in a 1x1 square with orange (at 60% opacity). Basically, it will connect the listed coordinates with straight lines creating an outline that will be shaded in by the chosen color. Note the command 'cycle' at the end. This closes the loop by connecting the last listed coordinate back to the first.

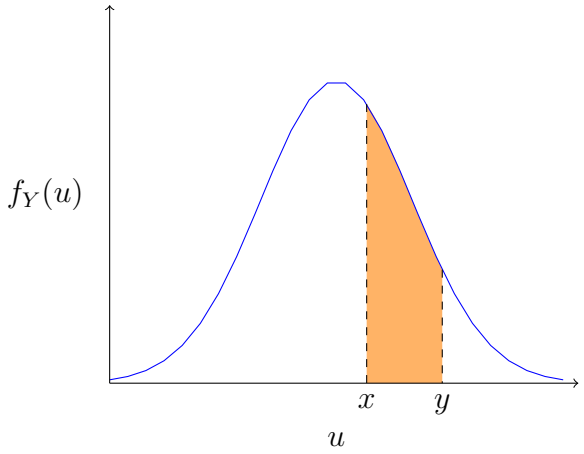
You can also bound the area to be shaded by a non-straight line. The following example shades in the area under a normal distribution bounded by 0 and 4.4:

```
% define normal distribution function 'normaltwo'
\def\normaltwo{\x,{4*1/exp(((\x-3)^2)/2)}}


% Shade orange area underneath curve.
\fill [fill=orange!60] (2.6,0) -- plot[domain=0:4.4] (\normaltwo) -- (4.4,0) --
    cycle;

% Draw and label normal distribution function
\draw[dashed,color=blue,domain=0:6] plot (\normaltwo) node[right] {$N(\mu,\sigma^2)
    $};
```



And, here is another example that includes axes and two interior bounds on the shading:

```
\begin{tikzpicture}
% define normal distribution function 'normaltwo'
    \def\normaltwo{\x,{4*1/exp(((\x-3)^2)/2)}}

% input x and y parameters
    \def\y{4.4}
    \def\x{3.4}

% this line calculates f(y)
    \def\fy{4*1/exp(((\y-3)^2)/2)}
    \def\fx{4*1/exp(((\x-3)^2)/2)}

% Shade orange area underneath curve.
    \fill [fill=orange!60] ({\x},0) -- plot[domain={\x}:{\y}] (\normaltwo) -- ({\y
        },0) -- cycle;

% Draw and label normal distribution function
    \draw[color=blue,domain=0:6] plot (\normaltwo) node[right] {};

% Add dashed line dropping down from normal.
    \draw[dashed] ({\y},{\fy}) -- ({\y},0) node[below] {$y$};
    \draw[dashed] ({\x},{\fx}) -- ({\x},0) node[below] {$x$};

% Optional: Add axis labels
    \draw (-.2,2.5) node[left] {$f_Y(u)$};
    \draw (3,-.5) node[below] {$u$};

% Optional: Add axes
    \draw[->] (0,0) -- (6.2,0) node[right] {};
    \draw[->] (0,0) -- (0,5) node[above] {};

\end{tikzpicture}
```

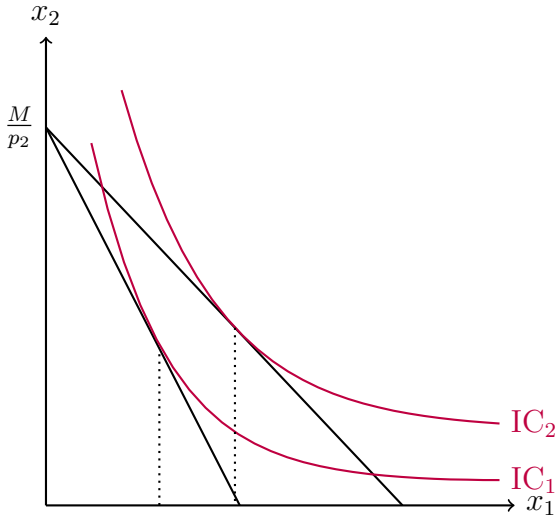


Some TikZ diagrams with code

The following diagrams were done in TikZ.

Budget Constraints and Indifference Curves

Figure 2: A Generic Price Change

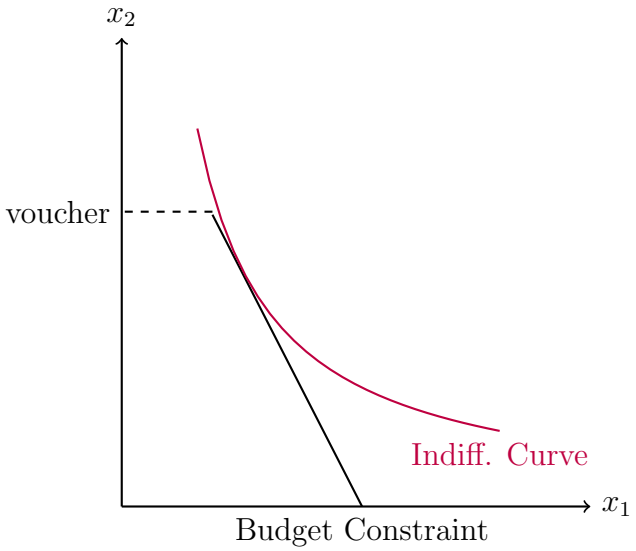



```
% TikZ code: Figure 2: A Generic Price Change

\begin{tikzpicture}[domain=0:5,range=4:5,scale=1,thick]
\usetikzlibrary{calc} %all

%Define linear parameters for supply and demand
```

```
\def\inc{50}     %Enter total income
\def\pa{19.5}    %Price of x1
\def\pb{10}    %Price of x2.
\def\panew{10.6}

\def\ica{\x,{10/\x}}
\def\icb{\x,{\sslp*\x+\sint}}
\def\demandtwo{\x,{\dslp*\x+\dint+\dsh}}
\def\supplytwo{\x,{\sslp*\x+\sint+\ssh}}


% Define coordinates.
\coordinate (x2) at  (0,{\inc/\pb});
\coordinate (x1) at  ({\inc/\pa},0);
\coordinate (x1') at  ({\inc/\panew},0);

%Draw axes, and dotted equilibrium lines.
    \draw[->] (0,0) -- (6.2,0) node[right] {$x_1$};
    \draw[->] (0,0) -- (0,6.2) node[above] {$x_2$};
    \draw[thick] (x1) -- (x2) node[left] {$\frac{M}{p_2}$};
    \draw[thick] (x1') -- (x2);
    \draw[thick,color=purple,domain=0.6:6] plot (\x,{10*exp(-1*\x-0.2)+0.3}) node[
        right] {IC$_1$};
    \draw[thick,color=purple,domain=1:6] plot (\x,{10*exp(-0.8*\x)+1}) node[right]
        {IC$_2$};

    \draw[dotted] (1.5,2) -- (1.5,0);
    \draw[dotted] (2.5,2.35) -- (2.5,0);

 \end{tikzpicture}
```

```
 %                          TikZ code: Figure 3: A Budget constraint that has a
    voucher for x_1
 \begin{tikzpicture}[domain=0:5,range=4:5,scale=1,thick]
\usetikzlibrary{calc} %all

%Define linear parameters for supply and demand
\def\inc{62}     %Enter total income
\def\pa{19.5}    %Price of x1
\def\pb{10}    %Price of x2.
\def\panew{10.6}

\def\ica{\x,{2/\x-20}}
\def\icb{\x,{\sslp*\x+\sint}}

\def\bcv{\x,{(-\pa)/(\pb)*\x+(\inc)/(\pb)}}
```

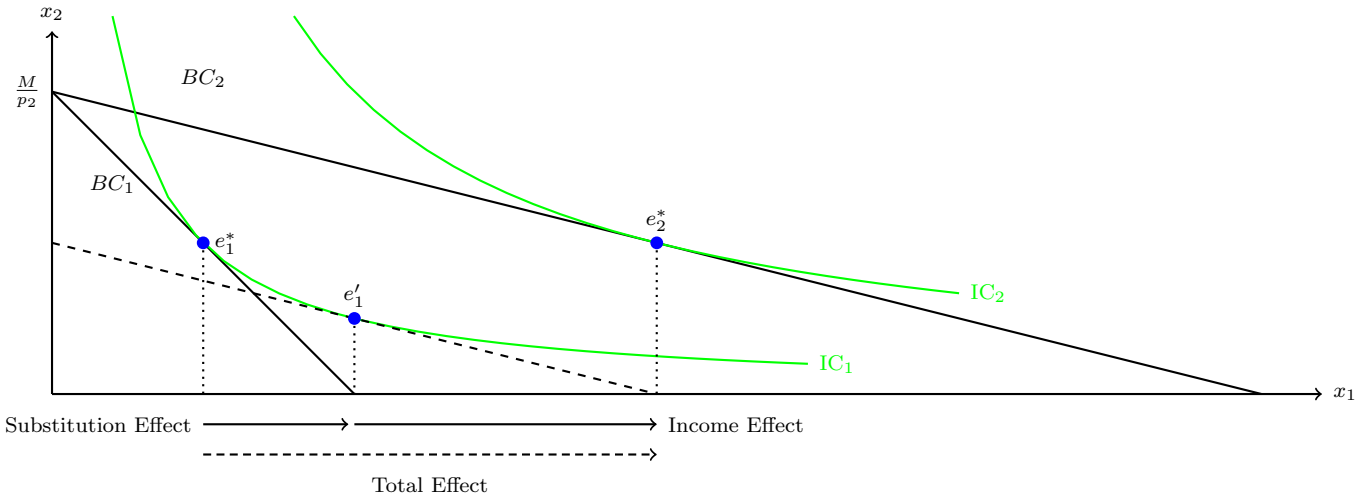
Figure 3: A Budget constraint that has a voucher for x_1




```
\def\bcx{\x,{(5)/\x}}

% Define coordinates.
\coordinate (x2) at  (0,{\inc/\pb});
\coordinate (x1) at  ({\inc/\pa},0);
\coordinate (x1') at  ({\inc/\panew},0);

%Draw axes, and dotted equilibrium lines.
    \draw[->] (0,0) -- (6.2,0) node[right] {$x_1$};
    \draw[->] (0,0) -- (0,6.2) node[above] {$x_2$};
    \draw[dashed] (1.2,3.9) -- (0,3.9) node[left] {voucher};
    \draw[thick,domain=1.2:\inc/\pa] plot (\bcv) node[below] {Budget Constraint};
    \draw[thick,color=purple,domain=1:5] plot (\bcx) node[below] {Indiff. Curve};

 \end{tikzpicture}
```

Income & Substitution Effects

Figure 4: A decrease in the price of x_1 by one-fourth

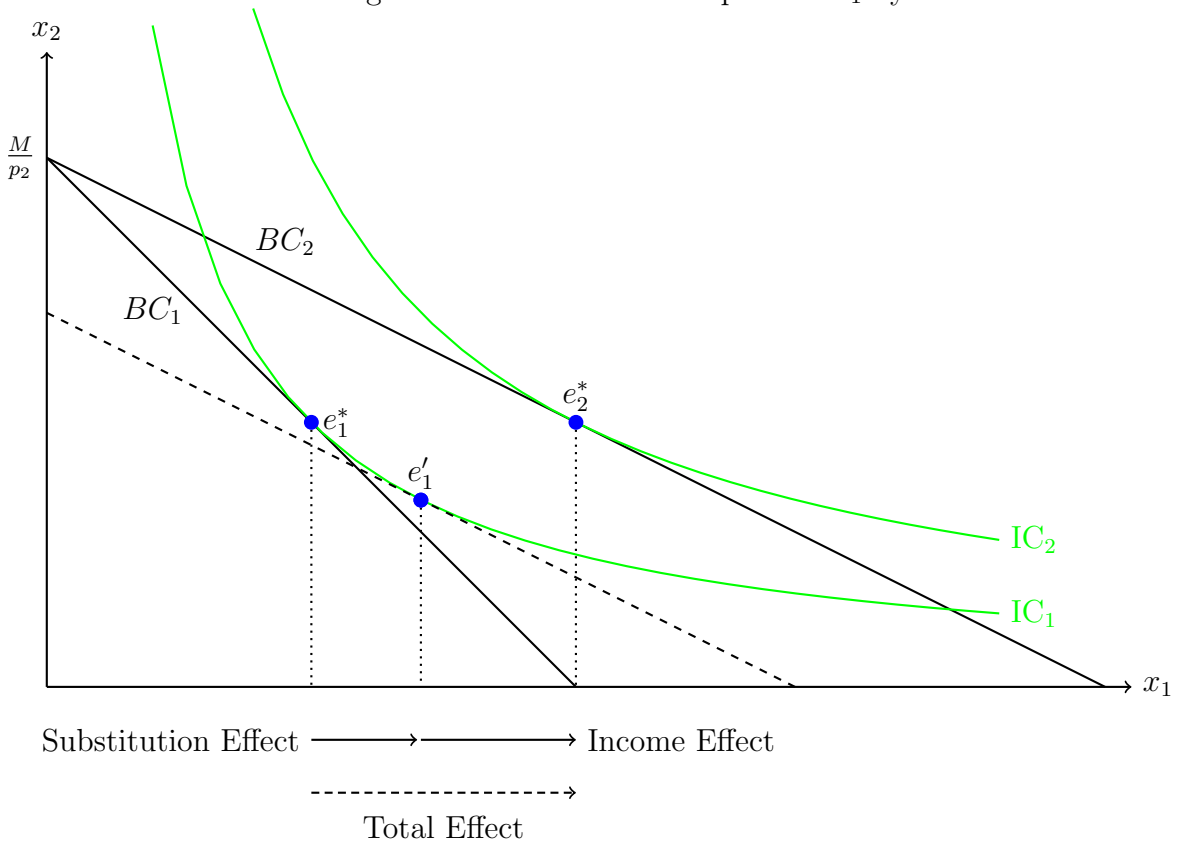



```
% TikZ code: Figure 4: A decrease in the price of x_1 by one-fourth

\begin{tikzpicture}[domain=0:100,range=0:200,scale=0.4,thick,font=\scriptsize]
\usetikzlibrary{calc} %all

%Define linear parameters for supply and demand
\def\inc{10}    %Enter total income
\def\pa{1}    %Price of x1
\def\pb{1}    %Price of x2.
\def\panew{0.25}

%\def\ica{\x,{10/\x}}
%\def\icb{\x,{\sslp*\x+\sint}}
%\def\demandtwo{\x,{\dslp*\x+\dint+\dsh}}
%\def\supplytwo{\x,{\sslp*\x+\sint+\ssh}}


% Define coordinates.
\coordinate (x2) at  (0,{\inc/\pb});
\coordinate (x1) at  ({\inc/\pa},0);
\coordinate (x1') at  ({\inc/\panew},0);

\coordinate[label= right:$e^*_1$] (p1) at  (5,5);
\coordinate[label= above:$e_1'$] (p2) at  (10,2.5);
\coordinate[label= above:$e^*_2$] (p3) at  (20,5);

%Draw axes, and dotted equilibrium lines.
```

```
    \draw[->] (0,0) -- (42,0) node[right] {$x_1$};
    \draw[->] (0,0) -- (0,12) node[above] {$x_2$};
    \draw[thick] (x1) -- (x2) node[left] {$\frac{M}{p_2}$};
    \draw[thick] (x1') -- (x2);
%       \draw[thick,color=purple,domain=0.6:100] plot(\x,{15*exp(\x)}) node[right] {IC$_1$};
    %\draw[thick,color=purple,domain=0.6:100] plot function(\x,{(2500)/(\x)}) node[right] {IC$_1$};
    \draw[thick,color=green,domain=2:25] plot (\x,{(25)/(\x)}) node[right] {IC$_1$};
    \draw[thick,color=green,domain=8:30] plot (\x,{(100)/(\x)}) node[right] {IC$_2$};

    \draw (2,8) node[label=below:$BC_1$] {};
    \draw (5,11.5) node[label=below:$BC_2$] {};

    \draw[dotted] (p2) -- (10,0);
    \draw[dotted] (p1) -- (5,0);
    \draw[dotted] (p3) -- (20,0);

    \draw[dashed] (0,5) -- (20,0);

    \draw[<-] (9.8,-1) -- (5,-1)node[left] {Substitution Effect};
    \draw[->] (10,-1) -- (20,-1) node[right] {Income Effect};
    \draw[->,densely dashed] (5,-2) -- (20,-2) ;
    \draw (12.5,-2) node[label=below:Total Effect] {};

        \fill[blue] (p1) circle (6pt);
        \fill[blue] (p2) circle (6pt);
        \fill[blue] (p3) circle (6pt);

\end{tikzpicture}
```

```
%                       TikZ code: Figure 5: A decrease in the price of x_1 by half.

\begin{tikzpicture}[domain=0:100,range=0:200,scale=0.7,thick]
\usetikzlibrary{calc}

%Define linear parameters for supply and demand
\def\inc{10}        %Enter total income
\def\pa{1}          %Price of x1
\def\pb{1}          %Price of x2.
\def\panew{0.5}     %New price for x1.

% Define coordinates.
\coordinate (x2) at  (0,{\inc/\pb});
\coordinate (x1) at  ({\inc/\pa},0);
\coordinate (x1') at  ({\inc/\panew},0);
```

Figure 5: A decrease in the price of x_1 by half.

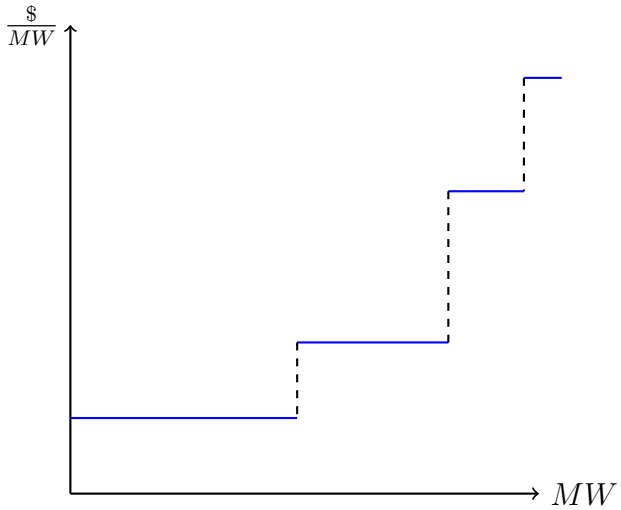



```
\coordinate[label=right:$e^*_1$] (p1) at  (5,5);
\coordinate[label=above:$e_1'$] (p2) at  (7.07,3.53);
\coordinate[label=above:$e^*_2$] (p3) at  (10,5);

%Draw axes, and dotted equilibrium lines.
      \draw[->] (0,0) -- (20.5,0) node[right] {$x_1$};
      \draw[->] (0,0) -- (0,12) node[above] {$x_2$};
      \draw[thick] (x1) -- (x2) node[left] {$\frac{M}{p_2}$};
      \draw[thick] (x1') -- (x2);

%Draw indifference curves
      \draw[thick,color=green,domain=2:18] plot (\x,{(25)/(\x)}) node[right] {IC
          $_1$};
      \draw[thick,color=green,domain=3.9:18] plot (\x,{(50)/(\x)}) node[right] {IC
          $_2$};

%Label budget constraint
      \draw (2,7.8) node[label=below:$BC_1$] {};
      \draw (4.5,9.1) node[label=below:$BC_2$] {};
```

```
%Draw dotted lines showing quantities.
      \draw[dotted] (p2) -- (7.07,0);
      \draw[dotted] (p1) -- (5,0);
      \draw[dotted] (p3) -- (10,0);

%Label Substitution, Income, and Total effects.
    \draw[dashed] (0,7.07) -- (14.14,0);
    \draw[<-] (7,-1) -- (5,-1)node[left] {Substitution Effect};
    \draw[->] (7.07,-1) -- (10,-1) node[right] {Income Effect};
    \draw[->,densely dashed] (5,-2) -- (10,-2) ;
    \draw (7.5,-2) node[label= below:Total Effect] {};

%Create points where IC tangentially intersects the budget constraint.
        \fill[blue] (p1) circle (4pt);
        \fill[blue] (p2) circle (4pt);
        \fill[blue] (p3) circle (4pt);
        \fill[blue] (7.07,3.53) circle (4pt);

 \end{tikzpicture}
 %                          TikZ code: Figure XX: A two-node network
```

Some Useful Diagrams

Figure 6: A piecewise-defined electricity bid

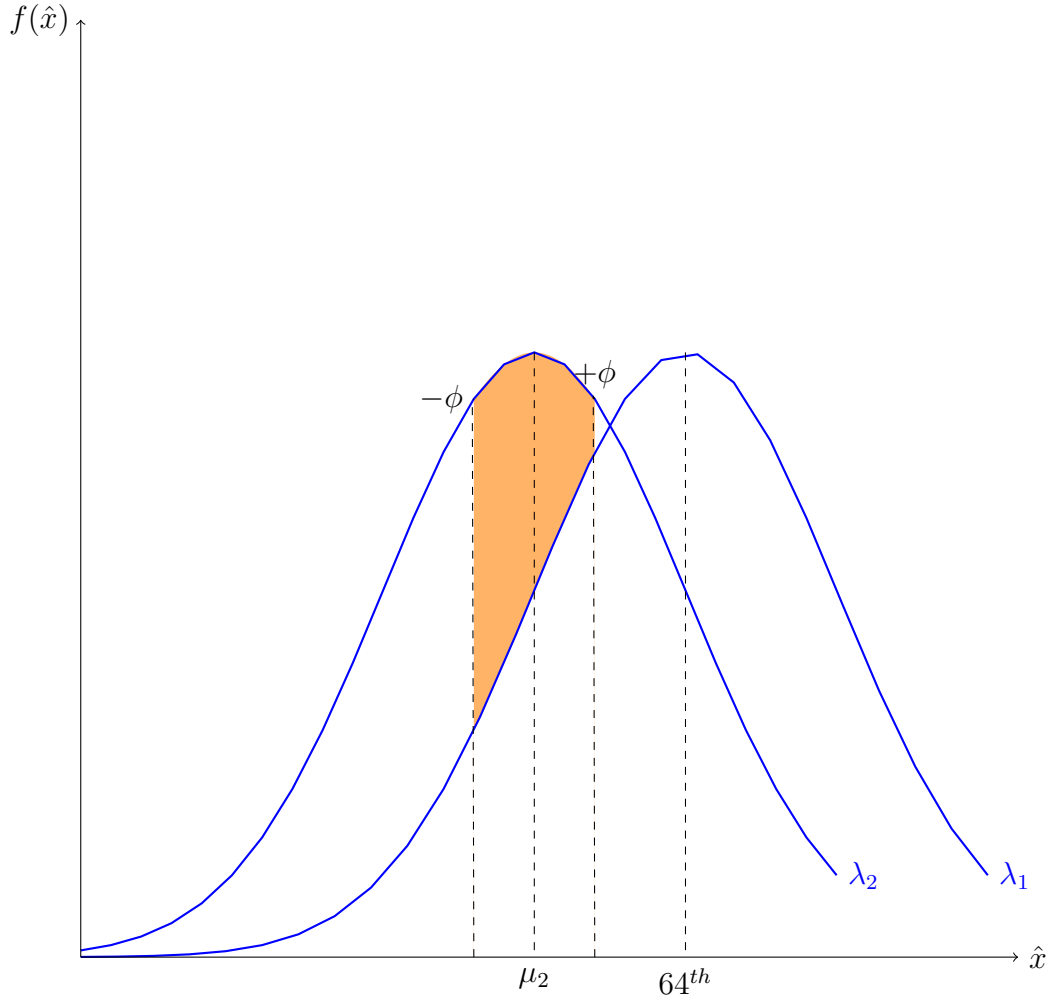



```
 %                          TikZ code: Figure 6: A piecewise-defined electricity bid

 \begin{tikzpicture}[domain=0:5,scale=1,thick]

```

```
%Define bid quantities
\def\qone{3}     % step 1
\def\qtwo{2}     % step 2
\def\qthree{1}     % step 3
\def\qfour{0.5}    % step 4

%Define bid prices
\def\pone{1}       % step 1
\def\ptwo{2}     % step 2
\def\pthree{4}     % step 3
\def\pfour{5.5}    % step 4


% Define coordinates.

    \coordinate (lone) at  (0,{\pone});
    \coordinate (ltwo) at  ({\qone},{\ptwo});
    \coordinate (lthree) at ({\qtwo+\qone},{\pthree});
    \coordinate (lfour) at ({\qthree+\qtwo+\qone},{\pfour});

    \coordinate (rone) at ({\qone},{\pone});
    \coordinate (rtwo) at ({\qtwo+\qone},{\ptwo});
    \coordinate (rthree) at ({\qthree+\qtwo+\qone},{\pthree});
    \coordinate (rfour) at ({\qfour+\qthree+\qtwo+\qone},{\pfour});

    \coordinate (done) at ({\qone},0);
    \coordinate (dtwo) at ({\qtwo+\qone},0);
    \coordinate (dthree) at ({\qthree+\qtwo+\qone},0);
    \coordinate (dfour) at ({\qfour+\qthree+\qtwo+\qone},0);

%Draw axes
    \draw[->] (0,0) -- (6.2,0) node[right] {$MW$};
    \draw[->] (0,0) -- (0,6.2) node[left] {$\frac{\$}{MW}$};

%Draw bid steps
    \draw[thick,color=blue] (lone) -- (rone);
    \draw[thick,color=blue] (ltwo) -- (rtwo);
    \draw[thick,color=blue] (lthree) -- (rthree);
    \draw[thick,color=blue] (lfour) -- (rfour);

 %Draw dashed lines
    \draw[dashed] (ltwo) -- (rone);
    \draw[dashed] (lthree) -- (rtwo);
    \draw[dashed] (lfour) -- (rthree);

  \end{tikzpicture}
```

```
%                        TikZ code: Figure 7: The area between two curves
```

Figure 7: The area between two curves



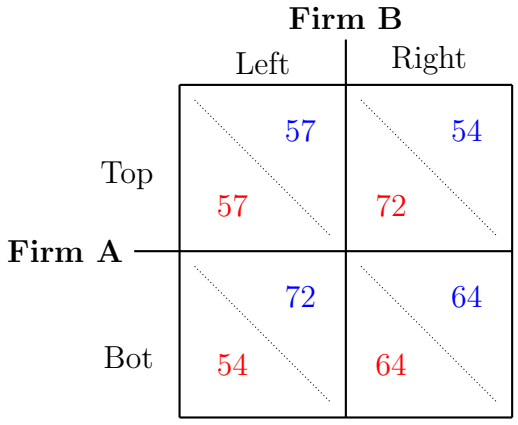

```
\begin{tikzpicture}[scale=2] %font=\scriptsize]

%Note: 64th percentile is 0.36 standard deviations to the right of mean.

%Define equations for the two normal distributions.
\def\normalone{\x,{4*1/exp(((\x-4)^2)/2)}}
\def\normaltwo{\x,{4*1/exp(((\x-3)^2)/2)}}

%Shade orange area
    \fill [fill=orange!60] (2.6,0) -- plot[domain=2.6:3.4] (\normaltwo) -- (3.4,0)
        -- cycle;
    \fill [fill=white] (2.6,0) -- plot[domain=2.6:3.4] (\normalone) -- (3.4,0) --
        cycle;

%Draw blue normal distributions
```

```
    \draw[thick,color=blue,domain=0:6] plot (\normalone) node[right] {$\lambda_1$};
    \draw[thick,color=blue,domain=0:5] plot (\normaltwo) node[right] {$\lambda_2$};

%Draw axes
    \draw[->] (0,0) -- (6.2,0) node[right] {$\hat{x}$};
    \draw[->] (0,0) -- (0,6.2) node[left] {$f(\hat{x})$};

%Define coordinates
    \coordinate (muone) at  (4,4);
    \coordinate (mutwo) at  (3,4);

%Draw dashed lines from mean to x-axis
    \draw[dashed] (muone) -- (4,0) node[below] {$64^{th}$};
    \draw[dashed] (mutwo) -- (3,0) node[below] {$\mu_2$};

    \draw[dashed] (2.6,0) -- plot[domain=2.59:2.6] (\normaltwo) node[left] {$-\phi
        $};
    \draw[dashed] (3.4,0) -- plot[domain=3.39:3.4] (\normaltwo) node[above] {$+\phi
        $};


\end{tikzpicture}
```

Game Theory Diagrams

See below, customizable diagrams for mapping strategic games.

Figure 8: A 2×2 Strategic form game

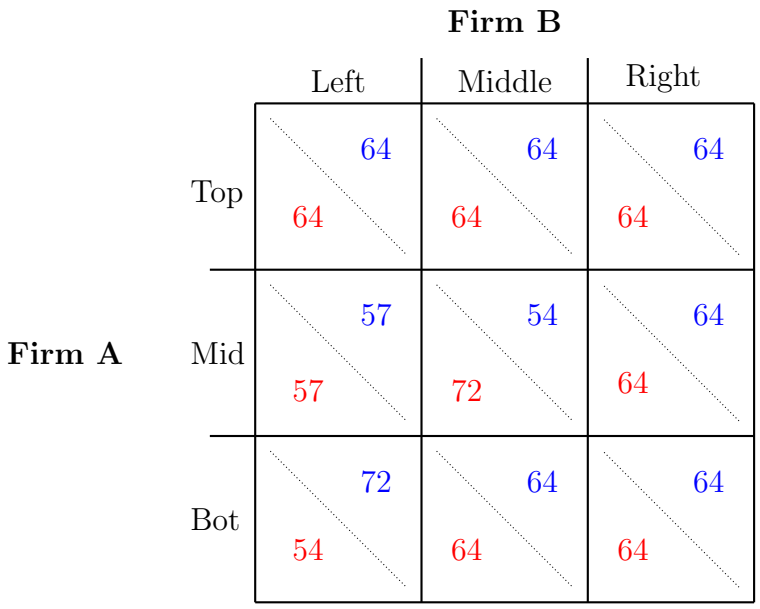



```
%                       TikZ code: Figure 8: A 2x2 Strategic form game

\begin{tikzpicture}[scale=2] %font=\scriptsize]
```

```
% Outline box
    \draw[thick] (0,0) -- (2.2,0);
    \draw[thick] (0,0) -- (0,2.2);
    \draw[thick] (2.2,2.2) -- (2.2,0);
    \draw[thick] (2.2,2.2) -- (0,2.2);
    \draw[thick] (-0.3,1.1) -- (2.2,1.1);
    \draw[thick] (1.1,0) -- (1.1,2.5);

% Payoff dividers
\draw[densely dotted] (.1,2.1) -- (1,1.2);
\draw[densely dotted] (.1,1) -- (1,0.1);
\draw[densely dotted] (1.2,1) -- (2.1,0.1);
\draw[densely dotted] (1.2,2.1) -- (2.1,1.2);

% Strategy labels
\coordinate[label=left:Top] (p1) at  (-0.1,1.6);
\coordinate[label=left:Bot] (p1) at  (-0.1,0.4);

\coordinate[label=above:Left] (p1) at  (0.55,2.2);
\coordinate[label=above:Right] (p1) at  (1.65,2.2);

\coordinate[label=above:\bf{Firm B}] (p1) at  (1.1,2.5);
\coordinate[label=left:\bf{Firm A}] (p1) at  (-0.3,1.1);

% The payoffs for both players:

    \fill[red]  (.35,1.4) node {$57$};
    \fill[blue]  (0.8,1.9) node {$57$};

    \fill[red]  (1.4,1.4) node {$72$};
    \fill[blue]  (1.9,1.9) node {$54$};

    \fill[red]  (0.35,0.35) node {$54$};
    \fill[blue]  (0.8,0.8) node {$72$};

    \fill[red]  (1.4,0.35) node {$64$};
    \fill[blue]  (1.9,0.8) node {$64$};

\end{tikzpicture}
```

```
% TikZ code: Figure XX: A 3x3 Strategic form game

\begin{tikzpicture}[scale=2]

% Outline matrix
    \draw[thick] (0,0) -- (3.3,0);
    \draw[thick] (0,0) -- (0,3.3);
    \draw[thick] (3.3,3.3) -- (3.3,0);
    \draw[thick] (3.3,3.3) -- (0,3.3);
```

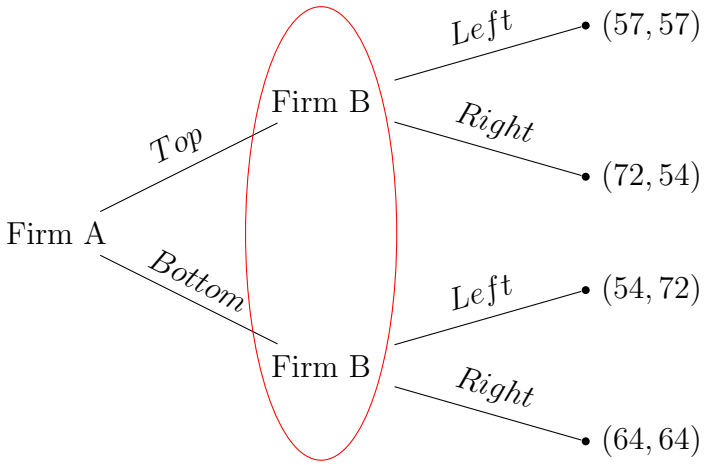
Figure 9: A 3×3 Strategic form game




```
    \draw[thick] (-0.3,1.1) -- (3.3,1.1);
    \draw[thick] (-0.3,2.2) -- (3.3,2.2);
    \draw[thick] (1.1,0) -- (1.1,3.6);
    \draw[thick] (2.2,0) -- (2.2,3.6);

\draw[densely dotted] (.1,2.1) -- (1,1.2);
\draw[densely dotted] (.1,1) -- (1,0.1);
\draw[densely dotted] (1.2,1) -- (2.1,0.1);
\draw[densely dotted] (1.2,2.1) -- (2.1,1.2);

\draw[densely dotted] (.1,3.2) -- (1,2.3);
\draw[densely dotted] (1.2,3.2) -- (2.1,2.3);
\draw[densely dotted] (3.2,.1) -- (2.3,1);
\draw[densely dotted] (3.2,1.2) -- (2.3,2.1);
\draw[densely dotted] (3.2,2.3) -- (2.3,3.2);


\coordinate[label=right:Top] (p1) at  (-0.5,2.7);
\coordinate[label=right:Mid] (p1) at  (-0.5,1.65);
\coordinate[label=right:Bot] (p1) at  (-0.5,0.55);

\coordinate[label=above:Left] (p1) at  (0.55,3.3);
\coordinate[label=above:Middle] (p1) at  (1.65,3.3);
\coordinate[label=above:Right] (p1) at  (2.7,3.3);

\coordinate[label=above:\bf{Firm B}] (p1) at  (1.65,3.7);
\coordinate[label=left:\bf{Firm A}] (p1) at  (-.8,1.65);
```

```
% Fill in pay-offs

    \fill[red]  (.35,1.4) node {$57$};  %Mid - Left
    \fill[blue]  (0.8,1.9) node {$57$};

    \fill[red]  (1.4,1.4) node {$72$};  %Mid - Middle
    \fill[blue]  (1.9,1.9) node {$54$};

    \fill[red]  (0.35,0.35) node {$54$};  %Bot - Left
    \fill[blue]  (0.8,0.8) node {$72$};

    \fill[red]  (1.4,0.35) node {$64$}; %Bot - Middle
    \fill[blue]  (1.9,0.8) node {$64$};

    \fill[red]  (2.5,0.35) node {$64$}; %Bot - Right
    \fill[blue]  (3,0.8) node {$64$};

    \fill[red]  (2.5,1.45) node {$64$}; %Mid - Right
    \fill[blue]  (3,1.9) node {$64$};

    \fill[red]  (2.5,2.55) node {$64$}; %Top - Right
    \fill[blue]  (3,3) node {$64$};

    \fill[red]  (1.4,2.55) node {$64$}; %Top - Middle
    \fill[blue]  (1.9,3) node {$64$};

    \fill[red]  (0.35,2.55) node {$64$};  %Top - Left
    \fill[blue]  (0.8,3) node {$64$};

\end{tikzpicture}
```

Figure 10: An Extensive-form game

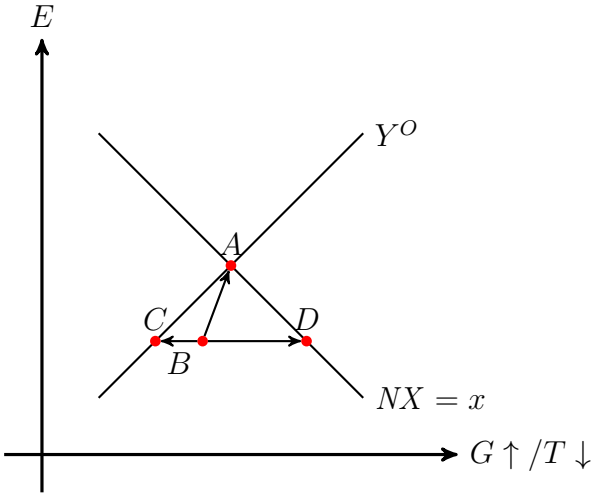


```
% TikZ code: Figure 10: An Extensive-form game

% Set the overall layout of the tree
\tikzstyle{level 1}=[level distance=3.5cm, sibling distance=3.5cm]
\tikzstyle{level 2}=[level distance=3.5cm, sibling distance=2cm]

% Define styles for bags and leafs
\tikzstyle{bag} = [text width=4em, text centered]
\tikzstyle{end} = [circle, minimum width=3pt,fill, inner sep=0pt]


% The sloped option gives rotated edge labels. Personally
% I find sloped labels a bit difficult to read. Remove the sloped options
% to get horizontal labels.
\begin{tikzpicture}[grow=right, sloped]
\node[bag] {Firm A}
    child {
        node[bag] {Firm B}
            child {
                node[end, label=right:
                    {$(64,64)$}] {}     % enter pay-offs for (Bottom, Right)
                edge from parent
                node[above] {$Right$}
            }
            child {
                node[end, label=right:
                    {$(54,72)$}] {}     % enter pay-offs for (Bottom, Left)
                edge from parent
                node[above] {$Left$}
            }
            edge from parent
            node[above] {$Bottom$}
    }
    child {
        node[bag] {Firm B}
        child {
                node[end, label=right:
                    {$(72,54)$}] {}     % enter pay-offs for (Top, Right)
                edge from parent
                node[above] {$Right$}
            }
            child {
                node[end, label=right:
                    {$(57,57)$}] {}     % enter pay-offs for (Top, Left)
                edge from parent
                node[above] {$Left$}
            }
        edge from parent
            node[above] {$Top$}
    };
```

```
51
\draw[red] (3.5,0) ellipse (1cm and 3cm);
53
\end{tikzpicture}
```

Taxes, Price ceilings, and market equilibriums

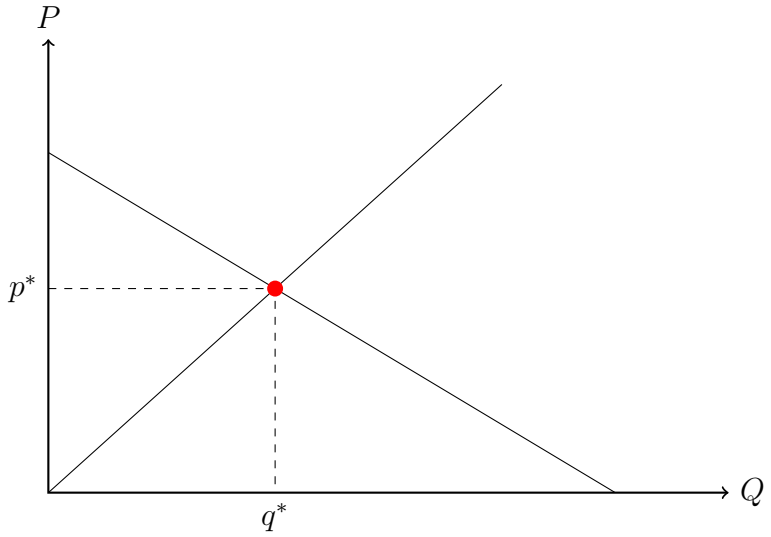
Figure 11: An economics example from texample.com




```
% TikZ code: Figure 11: An economics example from texample
    .com
2
% --> See TikZ code in .tex file backup or on texample.com.
```

```
1 % TikZ code: Figure 12: Market equilibrium - an alternate
    approach

3 \begin{tikzpicture}[scale=3]

5     % Draw axes
      \draw [<->,thick] (0,2) node (yaxis) [above] {$P$}
7         |- (3,0) node (xaxis) [right] {$Q$};

9     % Draw two intersecting lines
      \draw (0,0) coordinate (a_1) -- (2,1.8) coordinate (a_2);
11    \draw (0,1.5) coordinate (b_1) -- (2.5,0) coordinate (b_2);
```

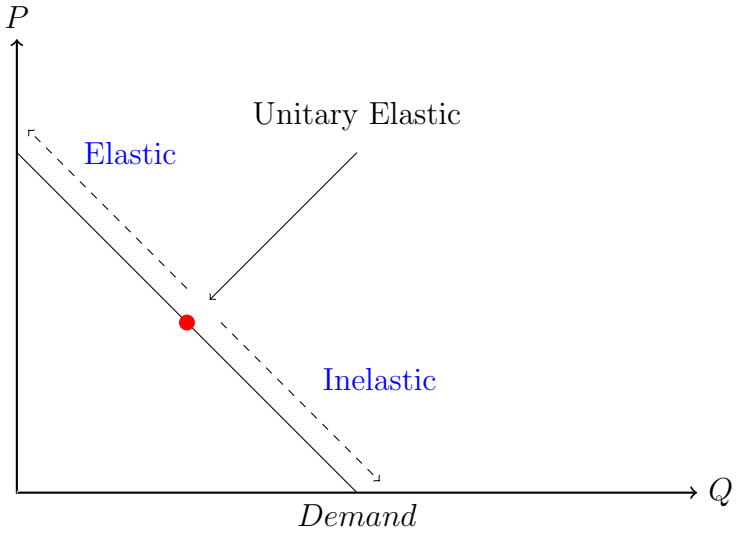
Figure 12: Market equilibrium - an alternate approach




```
    % Calculate the intersection of the lines a_1 -- a_2 and b_1 -- b_2
    % and store the coordinate in c.
    \coordinate (c) at (intersection of a_1--a_2 and b_1--b_2);

    % Draw lines indicating intersection with y and x axis. Here we use
    % the perpendicular coordinate system
    \draw[dashed] (yaxis |- c) node[left] {$p^*$}
        -| (xaxis -| c) node[below] {$q^*$};

    % Draw a dot to indicate intersection point
    \fill[red] (c) circle (1pt);

\end{tikzpicture}
```

```
%                          TikZ code: Figure 13: Price elasticity of demand

 \begin{tikzpicture}[scale=3]
    % Draw axes
    \draw [<->,thick] (0,2) node (yaxis) [above] {$P$}
        |- (3,0) node (xaxis) [right] {$Q$};

    % Draw two intersecting lines
    \draw[color=white] (0,0) coordinate (a_1) -- (2,2) coordinate (a_2);
    \draw (0,1.5) coordinate (b_1) -- (1.5,0) coordinate (b_2) node[below] {$Demand
        $};

    % Calculate the intersection of the lines a_1 -- a_2 and b_1 -- b_2
    % and store the coordinate in c.
```

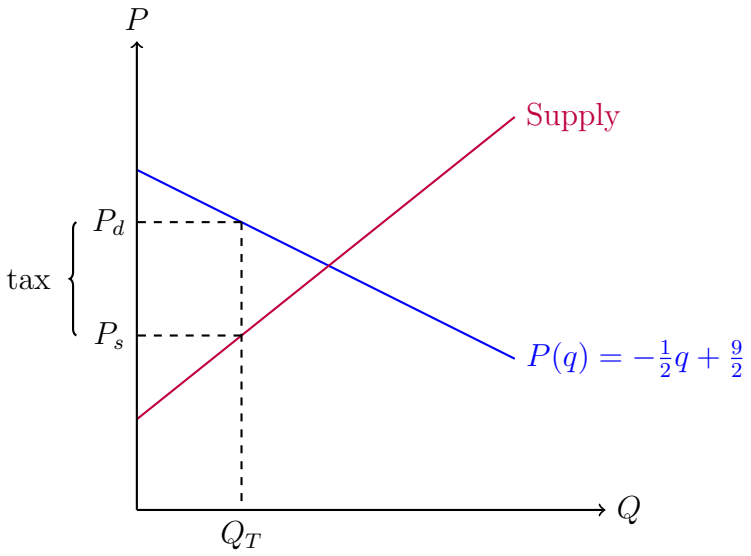
Figure 13: Price elasticity of demand




```
    \coordinate (c) at (intersection of a_1--a_2 and b_1--b_2);

    % Draw a dot to indicate intersection point
    \fill[red] (c) circle (1pt);

    \draw[->,dashed] ($(c)+(0,0.15)$) -- ($(c)+(-.7,0.85)$);
    \draw[->,dashed] ($(c)+(0.15,0)$) -- ($(c)+(.85,-0.7)$);

            \fill[blue]  (0.5,1.5) node {Elastic};
            \fill[blue]  (1.6,0.5) node {Inelastic};

    \draw[->] (1.5,1.5) node[label= above:Unitary Elastic] {} -- ($(c)+(.1,.1)$);

\end{tikzpicture}
```

```
 %                          TikZ code: Figure 14: An excise tax

\begin{tikzpicture}[domain=0:5,scale=1,thick]
\usetikzlibrary{calc} %allows coordinate calculations.

%Define linear parameters for supply and demand
\def\dint{4.5}     %Y-intercept for DEMAND.
\def\dslp{-0.5}    %Slope for DEMAND.
\def\sint{1.2}     %Y-intercept for SUPPLY.
\def\sslp{0.8}       %Slope for SUPPLY.

\def\tax{1.5}    %Excise (per-unit) tax

\def\demand{\x,{\dslp*\x+\dint}}
```

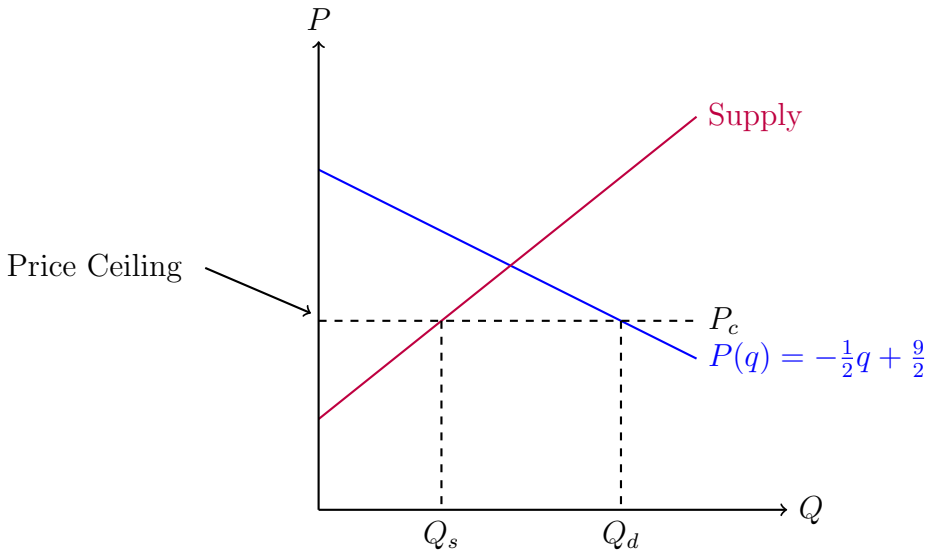
Figure 14: An excise tax




```
\def\supply{\x,{\sslp*\x+\sint}}
\def\demandtwo{\x,{\dslp*\x+\dint+\dsh}}
\def\supplytwo{\x,{\sslp*\x+\sint+\ssh}}


% Define coordinates.
    \coordinate (ints) at ({(\sint-\dint)/(\dslp-\sslp)},{(\sint-\dint)/(\dslp-\
        sslp)*\sslp+\sint});
    \coordinate (ep) at  (0,{(\sint-\dint)/(\dslp-\sslp)*\sslp+\sint});
    \coordinate (eq) at  ({(\sint-\dint)/(\dslp-\sslp)},0);
    \coordinate (dint) at (0,{\dint});
    \coordinate (sint) at (0,{\sint});

    \coordinate (teq) at  ({(\sint+\tax-\dint)/(\dslp-\sslp)},0); %quantity
    \coordinate (tep) at  (0,{(\sint+\tax-\dint)/(\dslp-\sslp)*\sslp+\sint+\tax});
       %price
    \coordinate (tint) at  ({(\sint+\tax-\dint)/(\dslp-\sslp)},{(\sint+\tax-\dint)
       /(\dslp-\sslp)*\sslp+\sint+\tax}); %tax equilibrium

    \coordinate (sep) at (0,{\sslp*(\sint+\tax-\dint)/(\dslp-\sslp)+\sint});
    \coordinate (sen) at ({(\sint+\tax-\dint)/(\dslp-\sslp)},{\sslp*(\sint+\tax-\
       dint)/(\dslp-\sslp)+\sint});

%DEMAND
    \draw[thick,color=blue] plot (\demand) node[right] {$P(q) = -\frac{1}{2}q+\frac
       {9}{2}$};
```

```
%SUPPLY
    \draw[thick,color=purple] plot (\supply) node[right] {Supply};

%Draw axes, and dotted equilibrium lines.
    \draw[->] (0,0) -- (6.2,0) node[right] {$Q$};
    \draw[->] (0,0) -- (0,6.2) node[above] {$P$};
    \draw[decorate,decoration={brace},thick] ($(sep)+(-0.8,0)$) -- ($(tep)
        +(-0.8,0)$) node[midway,below=-8pt,xshift=-18pt] {tax};

        \draw[dashed] (tint) -- (teq) node[below] {$Q_T$};
        \draw[dashed] (tint) -- (tep) node[left] {$P_d$};
        \draw[dashed] (sen) -- (sep) node[left] {$P_s$};

\end{tikzpicture}
```

Figure 15: A price ceiling

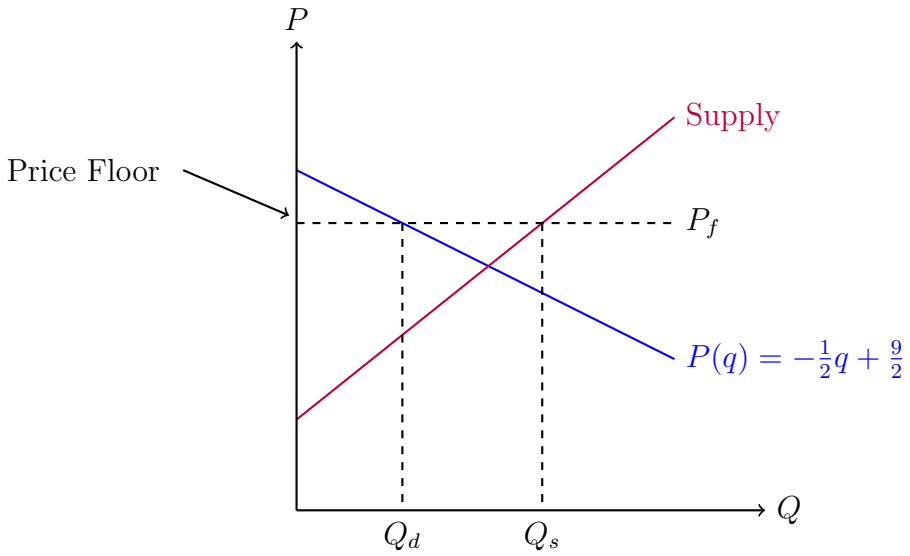



```
 %                          TikZ code: Figure 15: A price ceiling

\begin{tikzpicture}[domain=0:5,scale=1,thick]
\usetikzlibrary{calc} %allows coordinate calculations.

%Define linear parameters for supply and demand
\def\dint{4.5}     %Y-intercept for DEMAND.
\def\dslp{-0.5}    %Slope for DEMAND.
\def\sint{1.2}     %Y-intercept for SUPPLY.
\def\sslp{0.8}       %Slope for SUPPLY.
```

```
11
\def\pfc{2.5}      %Price floor or ceiling
13
\def\demand{\x,{\dslp*\x+\dint}}
15 \def\supply{\x,{\sslp*\x+\sint}}

17 % Define coordinates.
    \coordinate (ints) at ({(\sint-\dint)/(\dslp-\sslp)},{(\sint-\dint)/(\dslp-\
       sslp)*\sslp+\sint});
19     \coordinate (ep) at  (0,{(\sint-\dint)/(\dslp-\sslp)*\sslp+\sint});
    \coordinate (eq) at  ({(\sint-\dint)/(\dslp-\sslp)},0);
21     \coordinate (dint) at (0,{\dint});
    \coordinate (sint) at (0,{\sint});
23     \coordinate (pfq) at  ({(\pfc-\dint)/(\dslp)},0);
    \coordinate (pfp) at  ({(\pfc-\dint)/(\dslp)},{\pfc});
25     \coordinate (sfq) at  ({(\pfc-\sint)/(\sslp)},0);
    \coordinate (sfp) at  ({(\pfc-\sint)/(\sslp)},{\pfc});
27
%DEMAND
29     \draw[thick,color=blue] plot (\demand) node[right] {$P(q) = -\frac{1}{2}q+\frac
       {9}{2}$};

31 %SUPPLY
    \draw[thick,color=purple] plot (\supply) node[right] {Supply};
33
%Draw axes, and dotted equilibrium lines.
35     \draw[->] (0,0) -- (6.2,0) node[right] {$Q$};
    \draw[->] (0,0) -- (0,6.2) node[above] {$P$};
37
    %Price floor and ceiling lines
39     \draw[dashed,color=black] plot (\x,{\pfc}) node[right] {$P_c$};
    \draw[dashed] (pfp) -- (pfq) node[below] {$Q_d$};
41     \draw[dashed] (sfp) -- (sfq) node[below] {$Q_s$};

43 \draw[->,baseline=5] ($(0,{\pfc})+(-1.5,0.7)$) node[label= left:Price Ceiling] {}
    -- ($(0,{\pfc})+(-.1,0.1)$);

45 \end{tikzpicture}
```

```
1  %                          TikZ code: Figure 16: A price floor

3  \begin{tikzpicture}[domain=0:5,scale=1,thick]
\usetikzlibrary{calc} %allows coordinate calculations.
5
%Define linear parameters for supply and demand
7 \def\dint{4.5}     %Y-intercept for DEMAND.
\def\dslp{-0.5}    %Slope for DEMAND.
9 \def\sint{1.2}     %Y-intercept for SUPPLY.
\def\sslp{0.8}       %Slope for SUPPLY.
```

Figure 16: A price floor




```
11
\def\pfc{3.8}      %Price floor or ceiling
13
\def\demand{\x,{\dslp*\x+\dint}}
15 \def\supply{\x,{\sslp*\x+\sint}}

17 % Define coordinates.
    \coordinate (ints) at ({(\sint-\dint)/(\dslp-\sslp)},{(\sint-\dint)/(\dslp-\
       sslp)*\sslp+\sint});
19  \coordinate (ep) at  (0,{(\sint-\dint)/(\dslp-\sslp)*\sslp+\sint});
    \coordinate (eq) at  ({(\sint-\dint)/(\dslp-\sslp)},0);
21  \coordinate (dint) at (0,{\dint});
    \coordinate (sint) at (0,{\sint});
23  \coordinate (pfq) at  ({(\pfc-\dint)/(\dslp)},0);
    \coordinate (pfp) at  ({(\pfc-\dint)/(\dslp)},{\pfc});
25  \coordinate (sfq) at  ({(\pfc-\sint)/(\sslp)},0);
    \coordinate (sfp) at  ({(\pfc-\sint)/(\sslp)},{\pfc});
27
%DEMAND
29  \draw[thick,color=blue] plot (\demand) node[right] {$P(q) = -\frac{1}{2}q+\frac
       {9}{2}$};

31 %SUPPLY
    \draw[thick,color=purple] plot (\supply) node[right] {Supply};
33
%Draw axes, and dotted equilibrium lines.
35  \draw[->] (0,0) -- (6.2,0) node[right] {$Q$};
```

```
    \draw[->] (0,0) -- (0,6.2) node[above] {$P$};
37
    %Price floor and ceiling lines
39  \draw[dashed,color=black] plot (\x,{\pfc}) node[right] {$P_f$};
    \draw[dashed] (pfp) -- (pfq) node[below] {$Q_d$};
41  \draw[dashed] (sfp) -- (sfq) node[below] {$Q_s$};

43 \draw[->,baseline=5] ($(0,{\pfc})+(-1.5,0.7)$) node[label= left:Price Floor] {} --
   ($(0,{\pfc})+(-.1,0.1)$);

45 \end{tikzpicture}
```

Other Resources

Some useful resources for diagrams are as follows:

- `http://www.texample.net/tikz/examples/` - This site has many examples of TikZ diagrams from a variety of disciplines (including mathematics, economics, and electrical engineering), however not all the supplied code works perfectly right out of the box. This is a good place to see the capability of TikZ
- `http://sourceforge.net/projects/pgf/` - This is where you can acquire the latest version of TikZ.
- `http://cran.r-project.org/web/packages/tikzDevice/vignettes/tikzDevice.pdf` - tikzdevice is a package that allows you to generate tikz code directly from [R] statistical software for input into a LateX document.
- `http://www.tug.org/pracjourn/2007-1/mertz/mertz.pdf` - This is a 22-page tutorial on TikZ, that perhaps gives a more in depth treatment of some of the topics discussed here.
- `http://www.math.ucla.edu/~getreuer/tikz.html` - This has some more examples from a mathematician at UCLA.