LaTeX and TikZ workshop

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1 Introduction

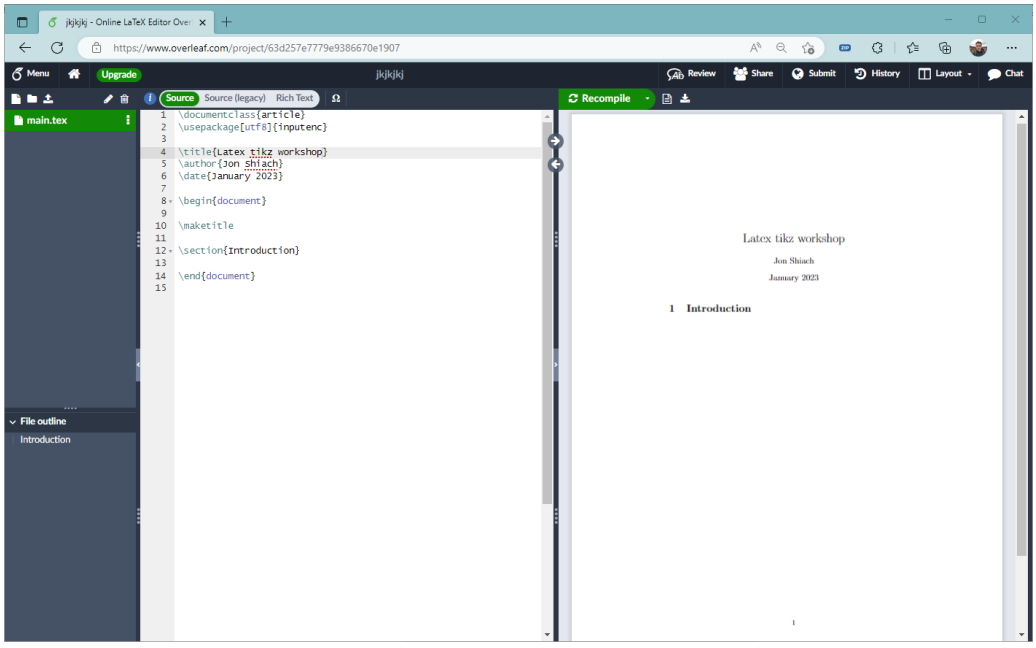
In this workshop we will introduce you to LaTeX and drawing diagrams using TikZ. LaTeX is a typesetting system that allows us to produce high quality documents and is particularly useful for computing and mathematics. LaTeX is a markup language similar to HTML where we enter text and commands into a source file, often known as a "tex" file since these have the extension `.tex`, which is compiled by a LaTeX compiler to produce an output, usually a PDF file.

LaTeX is open source so it is free to download and install (see https://www.latex-project.org/ for more information). In this session we will be using an online version of LaTeX called Overleaf which includes TikZ.

TikZ is used by loading its package into LaTeX and its documentation and further tutorials can be found at https://tikz.dev/.

2 Getting started

1. Go to https://www.overleaf.com/ and sign up for an account (your personal email will suffice).
2. Sign into your Overleaf account and start a new project by clicking on the **New project** icon and select **Blank project**. Give your project a suitable name such as 'Latex tikz workshop' and click on **Create**. This should create a blank project and you should see a screen similar to the one shown below.



The pane on the left is the source file and the output file is shown on the right.

3 Drawing basic shapes

1. First we need to load the `tikz` package. In the **preamble** which is the part of the source file above `\begin{document}` add the following commands.

```
% Load Tikz package
\usepackage{tikz}
\usetikzlibrary{shapes.geometric, arrows}
```

2. At the end of the source file just above `\end{document}` enter the following and recomplie the document.

```
\section{TikZ}

\subsection{Drawing shapes}

\begin{center}
    \begin{tikzpicture}
      \draw (0,0) -- (1,1);
    \end{tikzpicture}
\end{center}
```

   These commands do the following:

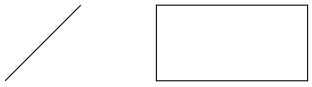
   - `\section{TikZ}` – creates a new section header with the heading 'Tikz'. Note how a number is added to the header, each time you add a new section heading LaTeX will automatically number it accordingly.
   - `\subsection{Drawing shapes}` – creates a new subsection header. Note how the section number is based on the parent section.
   - `\begin{center} ... \end{center}` – uses the `center` environment so that any context contained within the begin and end commands is centred on the page.
   - `\begin{tikzpicture} ... \end{tikzpicture}` – creates a TikZ environment so we can draw some shapes.
   - `\draw (0,0) -- (1,1);` – draws a straight line between co-ordinates $(0, 0)$ and $(1, 1)$. Unless stated, the distance units as in centimeters (cm). Other common units used are `em` (width of an uppercase 'M' in the current font) and `pt` (printer's foot approximately 0.3515mm).

   If all has gone smoothly you should see the following

3. Add the following command to your TikZ environment.

```
\draw (2,0) rectangle ++(2,1);
```

   This draws a rectangle with the co-ordinates of the lower left corner at $(2, 0)$ and the co-ordinates of the upper right corner are at $(2, 0) + (2, 1) = (4, 1)$. The use of `++(a,b)` adds a and b to the x and y co-ordinates of the preceding point.



4. Add the following command to your TikZ environment.

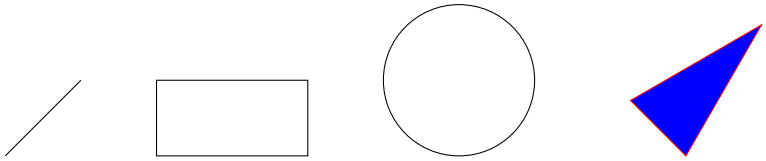
```
\draw (6,1) circle (1);
```

   This draws a circle centred at co-ordinates $(6, 1)$ with a radius of 1 (cm).

5. Add the following command to your TikZ environment.

```
\draw [red, fill=blue] (9,0) -- ++(60:2) -- ++(210:2) -- cycle;
```

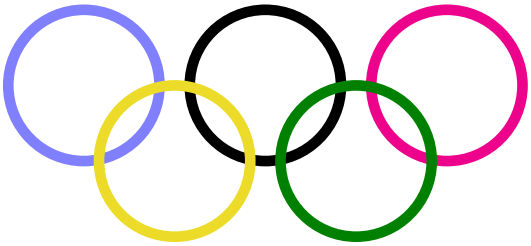
   This draws a triangle with red edges and filled in blue. The co-ordinates of the vertices are defined using and angle and distance such that `(x,y) -- ++(angle:length)` draws a straight line starting at (x, y) of length `length` where the angle of the line to the horizontal is `angle` degrees (an angle of 0 degrees is pointing towards the 3 o'clock position). The `cycle` command draws a straight line joining the last vertex to the first vertex.



3.1 Exercise

Try to recreate the following logos in TikZ

1. 

2. 

3. 

4 Nodes

A **node** is a shape with some text in it. Nodes are useful in creating TikZ diagrams since they allow us to place text where we want.

1. Add the following to your source file.

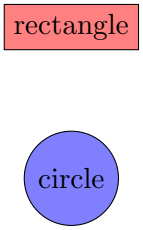
```
\subsection{Nodes}

\begin{center}
    \begin{tikzpicture}
        \node [rectangle, fill=red!50] (rectangle_node) {rectangle};
    \end{tikzpicture}
\end{center}
```

   This has created a node which consists of a red rectangle with the text 'rectangle'. Also, we have given this node the label `(rectangle_node)` so we can refer to it later.

2. We can position nodes using co-ordinates or relative to other nodes in our TikZ environment. Add the following command to your TikZ diagram

```
\node [circle, fill=blue!50, below of=rectangle_node, node distance=2cm]
    (circle_node) {circle};
```

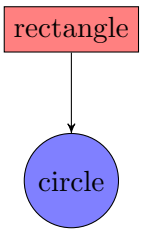
   This has added a blue circle with the text 'circle' and placed it below the red rectangle. The `node distance=2cm` option positions the node so that the centre of the circle node is 2cm away from the centre of the rectangle node.



3. We connect nodes with lines and arrows to form diagrams. Add the following command to your TikZ diagram

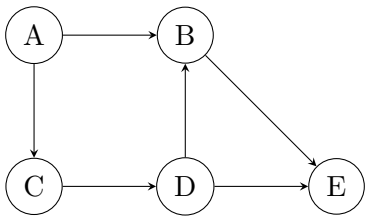
```
\draw [-stealth'] (rectangle_node) -- (circle_node);
```

   This has added an arrow joining the rectangle node to the circle node. The `stealth'` option defines the shape of the arrow.



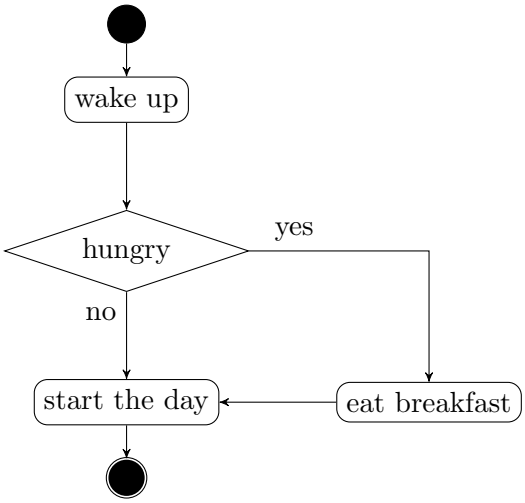
Exercise

Attempt to recreate the following diagram using nodes and arrows.



5 UML activity diagram

We are now going to use TikZ to produce the simply UML activity diagram below.



1. The start node is a simple filled circle. We can define the start node in the preamble so it can be used for multiple diagrams. Add the following command to your preamble.

```
% Define UML nodes
\tikzset{start/.style={circle, minimum width=0.5cm, draw, fill}}
```

   Now add the following commands at the bottom of your document (but before `\end{document}`).

```
\subsection{UML activity diagram}

\begin{center}
    \begin{tikzpicture}
        % Draw nodes
        \node [start] (start) {};
    \end{tikzpicture}
\end{center}
```

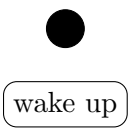
   Which should produce

2. We want a node for the 'wake up' activity. Add the following to the preamble.

```
\tikzset{activity/.style={rectangle,minimum width=1cm, minimum height=0.5cm,
    rounded corners=5pt, draw}}
```

   The 'wake up' node is placed below the start node.

```
\node [activity, below of=start, node distance=1cm] (wake) {wake up};
```

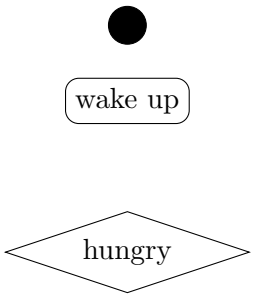


3. Next we have a decision node which is uses a diamond shape. Define a decision node in your preamble

```
\tikzset{decision/.style={diamond, minimum width=1cm, minimum height=1cm, draw}}
```

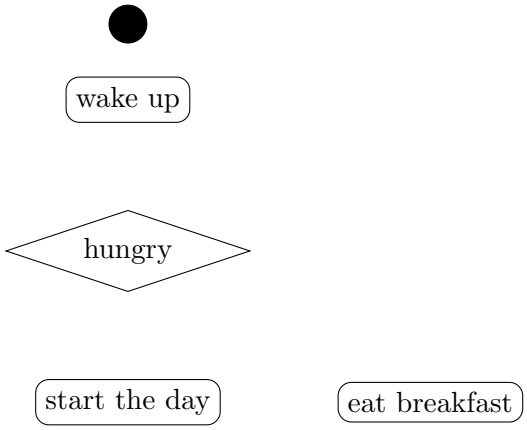
and then add the decision node beneath the 'wake up' node

```
\node [decision, below of=wake, node distance=2cm] (hungry) {hungry};
```



4. We have already defined an activity node so the 'start the day' and 'eat breakfast' nodes can be added to our diagram.

```
\node [activity, below of=hungry, node distance=2cm] (startday) {start the day};
\node [activity, right of=startday, node distance=4cm] (breakfast) {eat
    breakfast};
```

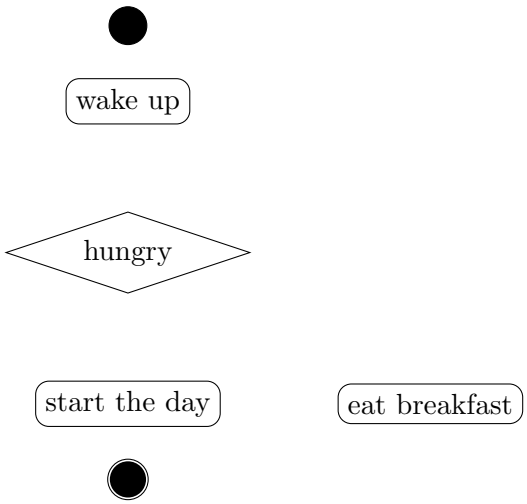


5. The last node we need to add is an end node. Define the end node in the preamble

```
\tikzset{end/.style={draw,fill,double=white,circle,inner sep=1pt, minimum width
    =0.5cm}}
```

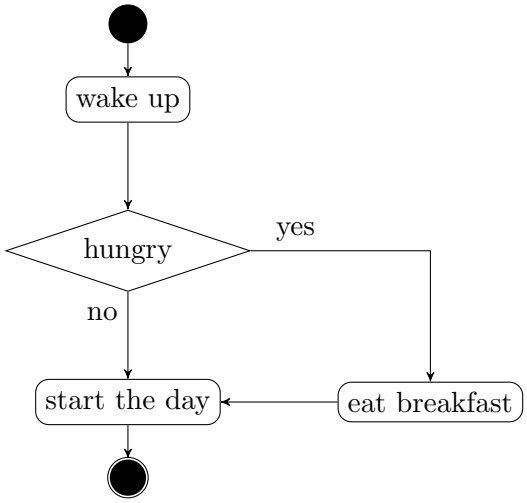
and add it beneath the 'start the day' node

```
\node [end, below of=startday, node distance=1cm] (end) {};
```



6. Finally we just need to add the connecting arrows

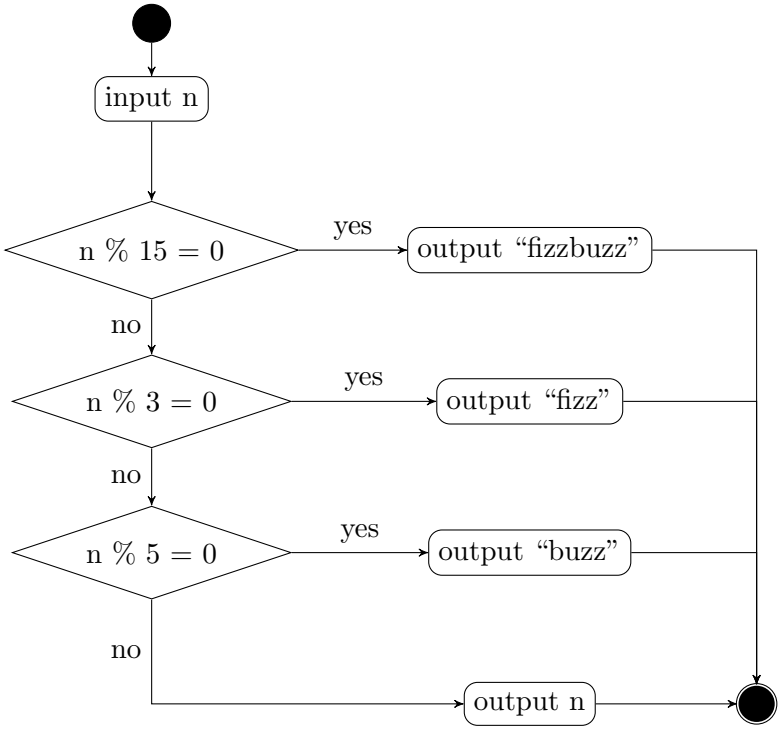
```
% Draw arrows
\draw [-stealth'] (start) -- (wake);
\draw [-stealth'] (wake) -- (hungry);
\draw [-stealth'] (hungry) -- node [near start, left] {no} (startday);
\draw [-stealth'] (hungry) -| node [very near start, above] {yes} (breakfast);
\draw [-stealth'] (breakfast) -- (startday);
\draw [-stealth'] (startday) -- (end);
```



Here we have added some nodes along the arrows joining the `(hungry)` node to the `(startday)` and `(breakfast)` nodes. Note that `-|` command defines a line that leaves the `(hungry)` node horizontally and enters the `(breakfast)` node vertically.

5.1 Exercise

Reproduce the following UML activity diagram of the solution to the fizzbuzz problem using TikZ.



The % symbol is a special symbol used to denote a comment in LaTeX. To include it in a document we precede it with a backslash, e.g., `\%`. a % b is the remainder of a divided by b.

6 Solutions to exercises

6.1 Basic shapes

1.

```
\begin{tikzpicture}
    \draw [red,fill=red] (0,0) -- ++(2,0) -- ++(-1,1) -- cycle;
    \draw [red,fill=red] (0,2) -- ++(2,0) -- ++(-1,-1) -- cycle;
    \draw [red,fill=red] (0,0) -- ++(0,2) -- ++(-1,-1) -- cycle;
    \draw [red,fill=red] (2,0) -- ++(0,2) -- ++(1,-1) -- cycle;
\end{tikzpicture}
```

2.

```
\begin{tikzpicture}
    \draw [blue!50!white, line width=4pt] circle (1);
    \draw [black, line width=4pt] (2.4, 0) circle (1);
    \draw [magenta, line width=4pt] (4.8, 0) circle (1);
    \draw [yellow!90!black, line width=4pt] (1.2, -1) circle (1);
    \draw [green!50!black, line width=4pt] (3.6, -1) circle (1);
\end{tikzpicture}
```

3.

```
\begin{tikzpicture}
    \draw [fill] (0,0) -- ++(1,0) -- ++(120:0.8) -- ++(210:0.85) -- cycle;
    \draw [fill] (1.3,0) -- ++(1,0) -- ++(120:1.7) -- ++(210:0.85) -- cycle;
    \draw [fill] (2.6,0) -- ++(1,0) -- ++(120:2.6) -- ++(210:0.85) -- cycle;
\end{tikzpicture}
```

6.2 Nodes

```
\begin{tikzpicture}
    \node [draw, circle] (A) {A};
    \node [draw, circle, right of=A, node distance=2cm] (B) {B};
    \node [draw, circle, below of=A, node distance=2cm] (C) {C};
    \node [draw, circle, right of=C, node distance=2cm] (D) {D};
    \node [draw, circle, right of=D, node distance=2cm] (E) {E};
    \draw [-stealth] (A) -- (B);
    \draw [-stealth] (A) -- (C);
    \draw [-stealth] (B) -- (E);
    \draw [-stealth] (C) -- (D);
    \draw [-stealth] (D) -- (B);
    \draw [-stealth] (D) -- (E);
\end{tikzpicture}
```

6.3 UML activity diagram

```
\begin{tikzpicture}
    \node [start] (start) {};
    \node [activity, below of=start] (init) {input n};
    \node [decision, below of=init, node distance=2cm] (15) {n \% 15 = 0};
    \node [activity, right of=15, node distance=5cm] (fizzbuzz) {output ``fizzbuzz
    ''};
    \node [decision, below of=15, node distance=2cm] (3) {n \% 3 = 0};
    \node [activity, right of=3, node distance=5cm] (fizz) {output ``fizz''};
    \node [decision, below of=3, node distance=2cm] (5) {n \% 5 = 0};
    \node [activity, right of=5, node distance=5cm] (buzz) {output ``buzz''};
    \node [activity ,below of=buzz, node distance=2cm] (n) {output n};
    \node [end, right of=n, node distance=3cm] (end) {};
    \draw [-stealth'] (start) -- (init);
    \draw [-stealth'] (init) -- (15);
    \draw [-stealth'] (15) -- node [left] {no} (3);
    \draw [-stealth'] (15) -- node [above] {yes} (fizzbuzz);
```

```
    \draw [-stealth'] (3) -- node [left] {no} (5);
    \draw [-stealth'] (3) -- node [above] {yes} (fizz);
    \draw [-stealth'] (5) |- node [left, near start] {no} (n);
    \draw [-stealth'] (5) -- node [above] {yes} (buzz);
    \draw [-stealth'] (fizzbuzz) -| (end);
    \draw [-stealth'] (fizz) -| (end);
    \draw [-stealth'] (buzz) -| (end);
    \draw [-stealth'] (n) -- (end);
\end{tikzpicture}
```